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Production Inventory System with Different Rates of Production Considering Poisson Demand Arrivals

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Abstract

This paper represents a single product stochastic production inventory model with two different rates of production where demand arrives according to Poisson process. The model is built up based on matrix approach. In this current model, backlogs are permitted and assumed that the production will start from the inventory level where there are some predetermined backlogs. It is also assumed that the production rate is higher during the backlogs situation than the situation where there is no backlog. Some measures of the system performance in the steady state case are derived, some numerical illustrations are given and sensitivity analyses are provided.

Key words: Backlogs, Production Inventory, Stochastic Inventory system.

1. Introduction

During the last 40 years there has been a rapid growth of interest in scientific inventory control. Scientific inventory control is generally understood to be the use of mathematical model to obtain rules for operating inventory system. The subject has attracted such a wide interest that today every serious student in Mathematics. Management science and industrial Engineering areas are expected to have some experienced working with inventory Model. Originally, the development of Inventory models had practical application as an immediate objective to the large extent this is still true, but as the subject becomes older, better developed and more thoroughly explored, an increasing number of individuals are working with inventory models because they present interesting theoretical problems in Mathematics. For such individuals, practical application is not a major objective; although there is the possibility that their theoretical work may be helpful in practice at some future time.

2. Background of the Study

Many researchers have considered inventory model with the finite and infinite production rates. Dave and Choudhuri [5] considered finite rate of production. Bhonia and Maiti [1] have examined two models, in one model they considered production rate as a function of the on hand inventory and in another as a function of demand rate. Chaho-Ton Su. Change-Wang Lin & Chih-Hung Tsai [3] A deterministic Production Inventory model for deteriorating items with an exponential Declining Demand. Rein Nobel and Headen [13] have considered production inventory model with two discrete production modes. Perumal and Arivarignan [14] have considered a deterministic inventory model with two different production rates. A Krishnamoorthy andMohammad Ekramol Islam[7] considered (s,S) inventory system with postponed demands. Mohammad Ekramol Islam et.al [8] considered stochastic inventory system with different rates of production where backlogs were permitted. They also consider in that paper shelf-life of the inventoried items are infinity. Mohammad Ekramol Islam et.al [9] farther extended the result for perishable inventoried items.

In that paper switching time also considered and that has taken as a random phenomena. In both of their papers, they built up the models by using the concept of Kolmogorov differtial-difference equations. B. Sivakumar and G. Arivarignan [2] have considered an inventory system with postponed demands. Mohammad Ekramol Islam, K M Safiqul Islam and Shahansha Khan[10] have considered Inventory system with postponed demands considering reneging pool customers. Mohammad Ekramol Islam and Shahansha khan [11] have considered a perishable inventory model at service facilities for systems with postponed demands. Mohammad Ekramol Islam and Shahansha khan [12] further considered a perishable inventory systems with postponed demands considering reneging pool customers
In this paper, we have considered a stochastic production inventory system with two different rates of production with the possible slippage of production rate from one rate to another rate over time. For the stage (-N to 0) we have considered production rate μ_1 and that of the stage (0 to S) μ_2, where $\mu_1>\mu_2$. Such a situation is desirable since our production starts from a backlog situation and the model is built up by matrix approach.

3. Notations

$\lambda \rightarrow$ Arrival rate

$\mu_1 \rightarrow$ Production rate when inventory levels vary from –N to 0.

$\mu_2 \rightarrow$ Production rate when inventory levels vary from 0 to S.

N $\rightarrow$ Pre-determined backlogs quantity.

S $\rightarrow$ Maximum Inventory level.

I(t) $\rightarrow$ Inventory level at time t.

4. Assumptions

(1) Two different rates of production μ_1 and μ_2 are considered where $\mu_1 > \mu_2$.

(2) The process will continue producing at the rate μ_1 until the backlog vanishes and then will start producing at the rate μ_2 and will continue producing at the same rate up to order level (S) following exponential distribution.

(3) Production process will start when the inventory level reaches –N unit of items as a backlogs.

(4) When inventory level will reach the order level, production will be switched off

5. Methodology

In this model, the inventory system starts with a backlog and reaches in off mode at the inventory level S. Demand arrives at a rate λ following Poisson process. Inventory level will be depleted when customers demand will be satisfied. When inventory level reaches in the state $(-N+1,0)$ the very next demand converts the system on mode from off mode i.e, $(-N,1)$. In that stage, if further demand arrives that will be lost forever. The inventory level I (t) take the values in the set $A=\{-N,-N+1,\ldots\ldots,0,\ldots\ldots,S\}$

By our assumptions {I(t), t≥0} does not follow Markov Process. To get a two dimensional Markov process, we incorporate the process {δ(t), t≥0 } into {I(t), t≥0} process where δ(t) is defined by,

$$\delta(t)=\begin{cases}1 & \text{When production process is ON}\\ 0 & \text{Otherwise}\end{cases}$$

Now, {I(t), δ(t), t≥0}is a two dimensional continuous Markov Chain defined on the state space $E=(E_1\cup E_2)$ where, $E_1=\{(i,0): i=-N+1,-N+2,\ldots,S\}$ and
$E_2=\{(i,1): i=-N,-N+1,\ldots,S-1\}$

The infinitesimal generator matrix of the process $\bar{A}=(a(i,j:k,l);(i,j),(k,l)\in E)$

$$\tilde{A}=\begin{array}{r}S,0\\S-1,0\\S-2,0\\..\\1,0\\0,0\\..\\-N+1,0\\-N,1\\-N+1,1\\..\\0,1\\1,1\\..\\S-2,1\\S-1,1\end{array}\begin{bmatrix}-\lambda & \lambda & 0 & .. & 0 & 0 & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0\\ 0 & -\lambda & \lambda & .. & 0 & 0 & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0\\ 0 & 0 & -\lambda & .. & 0 & 0 & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0\\ .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & ..\\ 0 & 0 & 0 & .. & -\lambda & \lambda & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0\\ 0 & 0 & 0 & .. & 0 & -\lambda & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0\\ .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & ..\\ 0 & 0 & 0 & .. & 0 & 0 & .. & -\lambda & \lambda & 0 & .. & 0 & 0 & .. & 0 & 0\\ 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & -\lambda-\mu_1 & \mu_1 & .. & 0 & 0 & .. & 0 & 0\\ 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & \lambda & -\lambda & .. & 0 & 0 & .. & 0 & 0\\ .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & ..\\ 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0 & 0 & .. & \lambda-\mu_2 & \mu_2 & .. & 0 & 0\\ 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0 & \lambda & .. & \lambda & \lambda-\mu_2 & .. & 0 & 0\\ .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & .. & ..\\ 0 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & \lambda-\mu_2 & \mu_2\\ \mu_2 & 0 & 0 & .. & 0 & 0 & .. & 0 & 0 & 0 & .. & 0 & 0 & .. & \lambda & -\lambda-\mu_2\end{bmatrix}$$

The above matrix can be obtained using the following arguments;-

A. The arrival of demand makes a transition from

$$(i, j) \rightarrow (k = i-1, l = 0, j = 0) \text{ if } i = S, S-1 \ldots. -N+2.$$

$$(i, j) \rightarrow (k = i-1, l = j = 1) \text{ if } i = S-1 \ldots. -N+1$$

B. Production of an item makes a transition

$$(i, j) \rightarrow (k = i+1, l = j = 1) \text{if } i = -N \ldots S-2$$

C. A demand can convert the system from off mode to on mode and can make a transition from.

$$(i, j = 0) \rightarrow (k = i-1, l = j = 1, \text{ if } i = -N+1$$

D. One unit of production can convert the system from one mode to off mode and can make a transition

$$(i, j = 1) \rightarrow (k = i+1, l = j = o); \text{ if } \mathrm{i} = \mathrm{S}+1$$

Inventory level which represents negative sign indicates intangible items (i,e backlogs,)

6. Steady State Analysis

It can be seen from the structure of matrix $\breve{A}$ that the state space E is irreducible. Let the limiting distribution be denoted by $p_{i,j}$:

$$p_{i,j} = \underset{t \to \infty}{Lt} \Pr[I(t), \delta(t) = (i, j)], \ (k, l) \in E$$

The limiting distribution exists and satisfies the following equations-

$$p\widetilde{A} = 0 \qquad \text{and} \qquad \sum_{\mathrm{i=-N+1,0}}^{\mathrm{S}} \sum_{\mathrm{j}=-N,1}^{\mathrm{S-1}} p_{i,j} = 1$$

The first equation of the above yields the following set of equations:-

In off Mode

(i) $-\lambda p_{S,0} + \mu_2 p_{S-1,1} = 0$

(ii) $-\lambda p_{i,0} + \lambda p_{i+1,0} = 0; i = S-1 \ldots, -N+1$

(iii) $-\mu_1 p_{-N,1} + \lambda p_{-N+1,0} + \lambda p_{-N+1,1} = 0$

In On Mode

(i) $-(\lambda + \mu_2) p_{S-1,1} + \mu_2 p_{S-2,1} = 0$

(ii) $-(\lambda + \mu_2) p_{i,1} + \lambda p_{i+1,1} + \mu_2 p_{i-1,1} = 0 \ ; i = S-2, S-3, \ldots, 1$

(iii) $-(\lambda+\mu_2)p_{0,1}+\lambda p_{1,1}+\mu_1 p_{-1,1}=0$

(iv) $-(\lambda+\mu_1)p_{i,1}+\lambda p_{i+1,1}+\mu_1 p_{i-1,1}=0\ ;i=-1,-2,\ldots,-N+1$

The solutions are as follows

When the system is in off mode

$$p_{i,0}=\frac{1}{\rho_2}p_{(S-1,1)};i=S,S-1,\ldots,-N+1$$

When the system is in on mode

$$p_{S-2,1}=(1+\rho_1)p_{(S-1,1)}$$

$$p_{S-i,1}=(1+\rho_2)p_{(S-(i-1),1)}-\rho_2 p_{(S-(i-2),1)}\ \ ;i\geq 3,4,\ldots.,S$$

$$p_{(S-i,1)}=(\tau+\rho_1)p_{(S-(i-1),1)}-\rho_1 p_{(S-(i-2),1)}\ \ ;i=S+1$$

$$p_{S-i,1}=(1+\rho_1)p_{(S-(i-1),1)}-\rho_1 p_{(S-(i-2),1)}\ ;i=S+2,\ldots.,S+N$$

$$where,\rho_1=\frac{\lambda}{\mu_1},\rho_2=\frac{\lambda}{\mu_2},\tau=\frac{\mu_2}{\mu_1}$$

Where, $p_{(S-1,1)}$ can be obtained by using the following normalizing condition i.e.,

$$\sum_{i=-N+1}^{S}p_{i,0}+\sum_{i=-N}^{S-1}p_{i,1}=1$$

7. System Performance Measures

(a) Mean Inventory holds in the system

Let α_1 denote the average inventory level in the steady state. Then $\alpha_1=\sum_{i=1}^{S}ip_{i,0}+\sum_{i=1}^{S-1}ip_{i,1}$

(b) Expected backlogs hold in the system:

Let α_2 be the expected backlogs in the system in steady state. Then α_2 can be defined as:

$$\alpha_2=\sum_{i=-N+1}^{-1}|i|p_{i,0}+\sum_{i=-N}^{-1}|i|p_{i,1}$$

(c) Average number of Customer's lost to the system:

Let α_3 is the average number of customers lost to the system. Then α_3 can be defined as:

$$\alpha_3=\lambda p_{-N,1}$$

(d) The probability that a demand will be satisfied just after its arrival is,

$$\alpha_4=\sum_{i=0}^{S}p_{i,0}+\sum_{i=1}^{S-1}p_{i,1}$$

(e) Expected waiting time of a customer

$$E(T)=\sum_{n=0}^{2}[\frac{N-n}{\lambda}+\frac{n+1}{\mu_1}]q_{(n,0)}+\sum_{n=0}^{3}\frac{n+1}{\mu_1}q_{(-n,1)}$$

8. Steady State Cost Analysis of the model

Let us consider costs under steady state as given below: -

L = the initial set-up cost of the system.

C_1 = inventory carrying cost per unit per unit time.

C_2 = Backlog cost per unit time.

C_3 = Cost due to customer lost to the system

So, the expected total cost to the system is,

$E(TC) = L + C_1 \alpha_1 + C_2 \alpha_2 + C_3 \alpha_3$

$$= L + C_1 \left(\sum_{i=1}^{S} i p_{i,0} + \sum_{i=1}^{S-1} i p_{i,1} \right) + C_2 \left(\sum_{i=-N+1}^{-1} |i| p_{i,0} + \sum_{i=-N}^{-1} |i| p_{i,1} \right) + C_3 \lambda p_{-N,1}$$

Since the computation of the $\Pi's$ are recursive, it is very difficult to show the convexity of the total expected costs. However, it may possible for many cases to demonstrate the computability of the result and to illustrate the existence of local optima when the cost function is treated as function of only two variable which obviously a restricted case and hence avoided. Of course, it may possible to explore some of the very important characteristics of the system and also possible to do sensitivity analysis of the system.

9. Results

The results we have obtained in steady state case may be illustrated through the following numerical example:
Steady state probabilities in the system for the parameters of S = 10, N = 3, λ = 3, μ_1 = 5, μ_2 = 4, L = 100, C_1 = 6, C_2 = 4 and C_3 = 3 are as follows:

Table 1: Different system performances by using a given set of parameters

Mean inventory holds in the system	2.38591
Expected backlogs holds in the system	0.48549
Average customers lost to the system	0.21051
Probability that a demand will be satisfied just after arrival	0.47661
Total cost to the system	116.88895

10. Sensitivity Analysis

Table 2: Production rate μ_1 Vs Total cost

μ_1 value	α_1	α_2	α_3	Total Cost
5	2.38591	0.48549	0.21051	116.88895
6	2.37760	0.49503	0.21909	116.90299
7	2.65555	0.32571	0.12054	117.59776
8	2.54998	0.37984	0.15588	117.28688
9	2.75436	0.24349	0.08040	117.74132
10	2.96740	0.10266	0.00375	118.22629

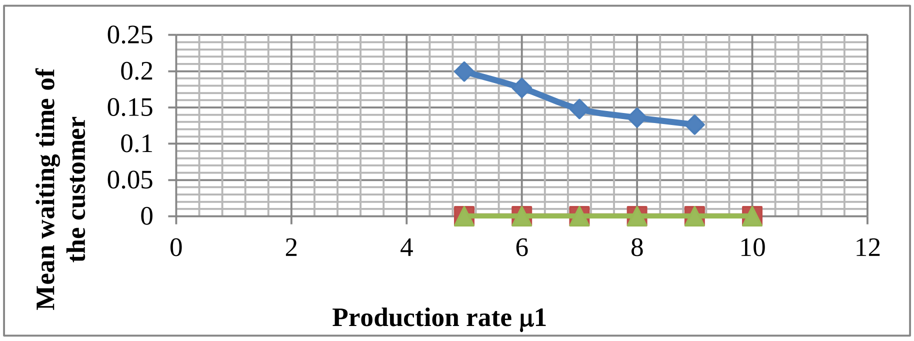

Fig. 1: Production rate Vs Waiting time

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Study of Process Parameters and Optimization of Process Variables for the Production of Urea by Using Aspen HYSYS

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Abstract

Being easily acceptable in the soil, owning availability of raw materials and easy transportation made urea a unique fertilizer. Two main reasons are involved in urea fertilizer to be the best of all fertilizers. Firstly, about 46 percent nitrogen is contained in it. Secondly, it is a white crystalline organic chemical compound. Urea is formed naturally as a waste product by metabolizing protein in humans as well as other mammals, amphibians and some fish. Urea is widely used in the agriculture sector both as a fertilizer and animal feed additive having the chemical $CO(NH_2)_2$. In this paper, production of urea by the reaction of ammonia and carbon dioxide is simulated by the Simulator software Aspen HYSYS v.7.1. It is performed to investigate effect of few important parameters like temperature of carbon dioxide, temperature of HP (high pressure) steam and LP(low pressure) steam on the composition of urea. When temperature of HP steam varies from 357^0C to 365^0C, composition of urea varies from 0.055 to 0.08. When temperature of LP (low pressure) steam varies from 287^0C to 316^0C, composition of urea varies from 0.055 to 0.782. Being a typical Stamicarbon process, different process parameters are studied to understand the whole plant properly which are related with one another and the relation with several graphical representations are shown. By analyzing the process variables, the profit is optimized by using HYSYS Optimizer and found that $790.8.

Keywords: Biuret, Simulation, Stripping, Prilling, Granulation

1. Introduction

Maintenance of high temperature and pressure is needed for the production of urea [**1**]. Urea is formed through the heterogeneous reaction of carbon monoxide and ammonia [**2**]. Urea prills are produced in the prilling towers where a solidification-cooling process takes place and the ambient air is used as the cooling air stream for this process [**3**]. The temperature of produced prills and caking tendency of the prilled urea can be reduced by the increase in heat transfer from the particles by using installation of induced fans [**4**]. Granulation being the most fundamental operations in particulate processing, insight into the complex dynamic state behavior of these units is still needed [**5**]. Having similar chemical properties of both prills and granules and also distinguishable physical and mechanical properties, urea has been made suitable for different application either as fertilizer or raw materials for chemical industry **[6**]. Urea granulation is favored over prilling due to the problems associated with prilling [**7**]. In this paper, modeling and simulation of high-pressure and low urea synthesis loop has been studied [**8**] Due to well established global warming concerns, technological attempts have been made to decrease reactive nitrogen (N) species emitted from the application of urea fertilizer to agricultural soils [**9**]. HYSYS is applied to model the most significant aspects of the urea production processes by the availability of modern flow sheeting tools [**10**].

2. Process Description

The raw material composition used for this simulation is: CO_2 gas 20% and liquid NH_3 80% in mole fraction
The block diagram of Urea production according to Stamicarbon stripping processs from CO_2 gas and Liquid NH_3 is shown in Fig. 1.

2.1 Reactions Involved

$$2\ NH_3 + CO_2 \leftrightarrow H_2N\text{-}COONH_4$$

Ammonium Carbamate

$$H_2N\text{-}COONH_4 \leftrightarrow (NH_2)_2CO + H_2O$$

Urea

$$2NH_2CONH_2 \leftrightarrow NH_2CONHCONH_2 + NH_3$$

Biuret

2.2 Industrial Production Process

Urea is synthesized from ammonia and carbon dioxide. The urea plant has 5 sections excluding utility system:
1. Synthesis section
2. Purification section
3. Concentration and prilling system
4. Recovery system
5. Process and condensate treatment system

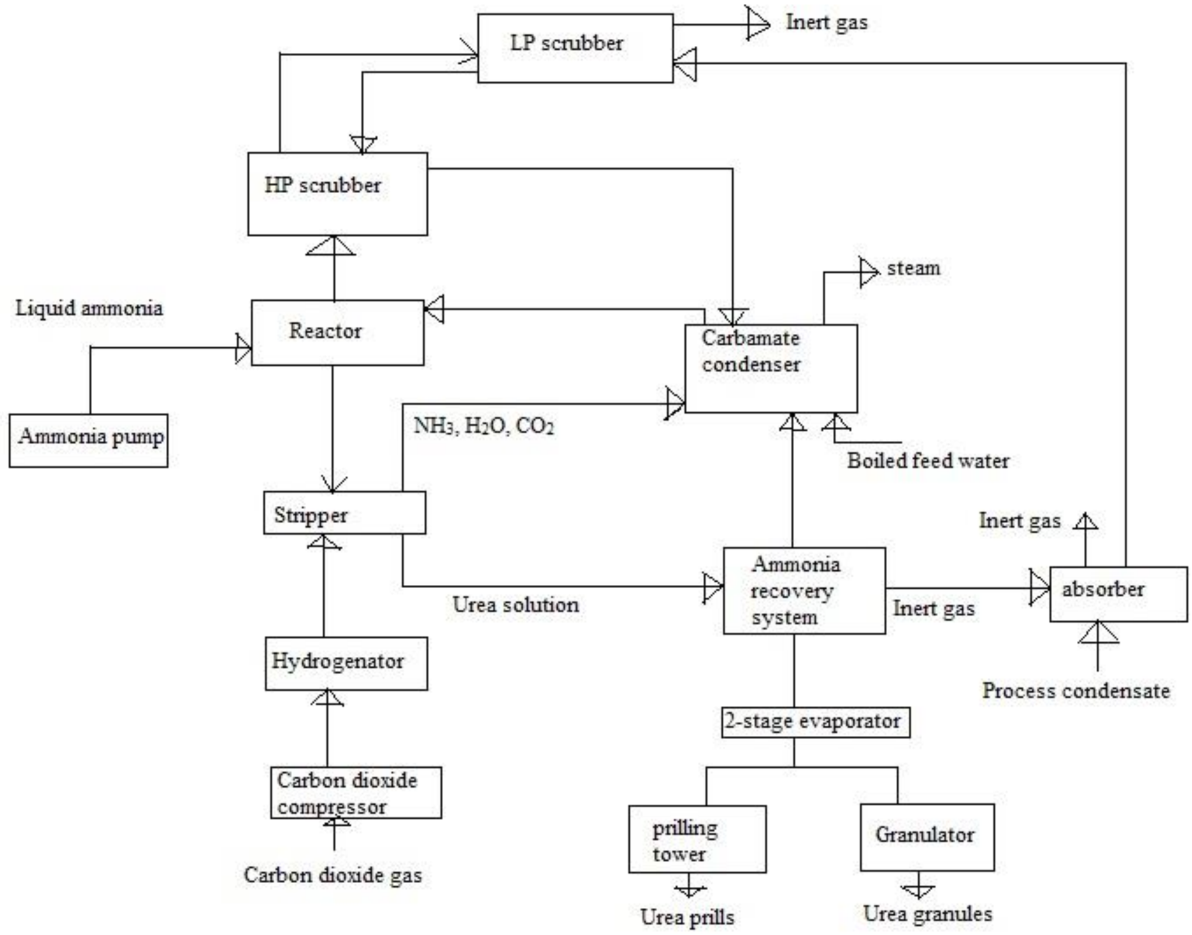

Fig. 1. Process block diagram of urea production.

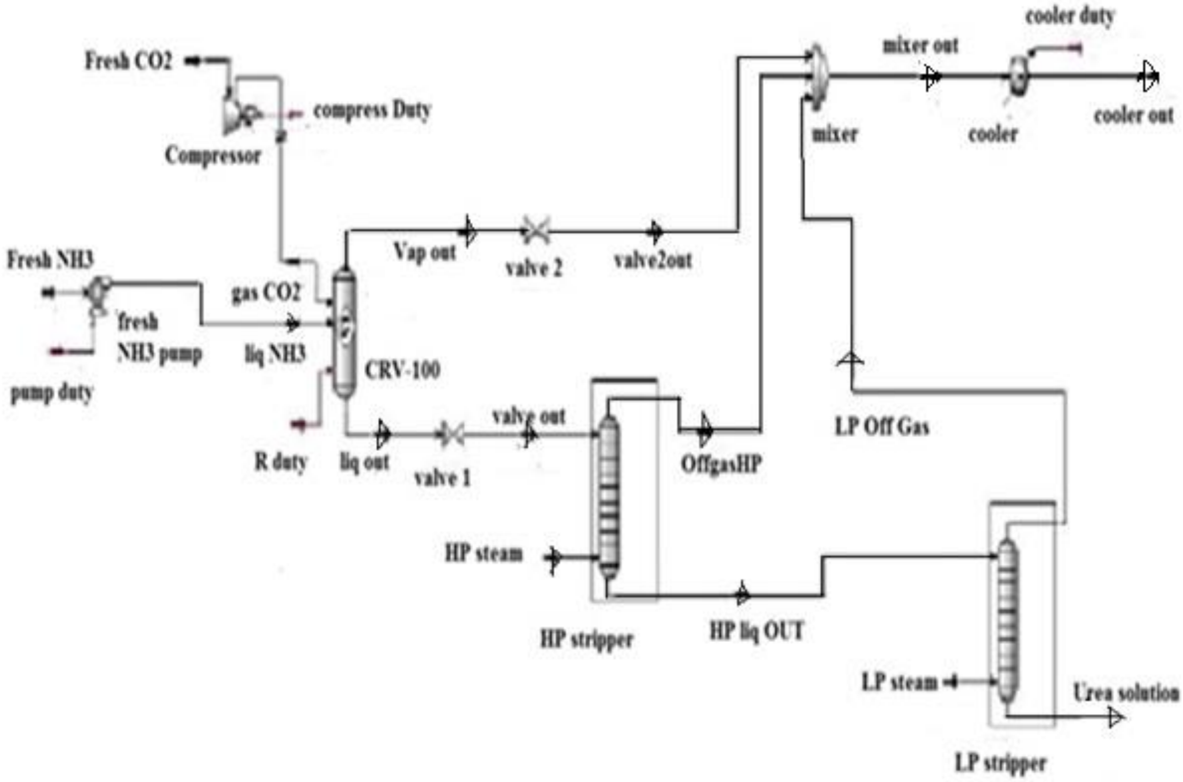

Fig. 2. Process flow diagram of urea production from ammonia and carbon dioxide.

2.3 Optimization

Table 1. Assumptions and data imported from HYSYS

Assumptions	Data imported from HYSYS
Selling Price of cooler Out product, Pcool = $0.471/kg	Mass of cooler out = M1= 3225 lb/hr
Selling Price of Urea solution, PU = $0.6/kg	Mass of urea solution out=M2= 200 lb/hr
Cost of HP steam Inlet, PHP = $ 0.20/kg	Mass of fresh CO2 = M3= 120 lb/hr
Cost of LP steam Inlet, PLP= $0.30/kg	Mass of NH3 = M4= 190 lb/hr
Cost of fresh CO2, Pco2 =$0.05/kg	Mass of HP steam= M5= 1250 lb/hr
Cost of fresh NH3, PNH3 = $ 0.06/kg	Mass of LP steam = M6= 1936 lb/hr
Cost of pump duty, Cp= $0.03/kg	Pump duty =Q1= 184.4 Btu/hr
Cost of Compressor duty, Cc = $0.02/kg	Compressor duty = Q2= -13.33 Btu/hr

Profit= (M1*Pcool) + (M2*PU)-(M3*Pco2)-(M4*PNH3)-(M5*PHP)-(M6*PLP) - (((Q1*Cp)+(Q2*Cc))/3600) =790.8

3. Results and Analysis

By comparing the process parameters and calculating the profit of this typical Stamicarbon process, more profit can be made from the real plant. From optimization it was found that maximum profit was $790.8.The whole process can be understood very clearly.

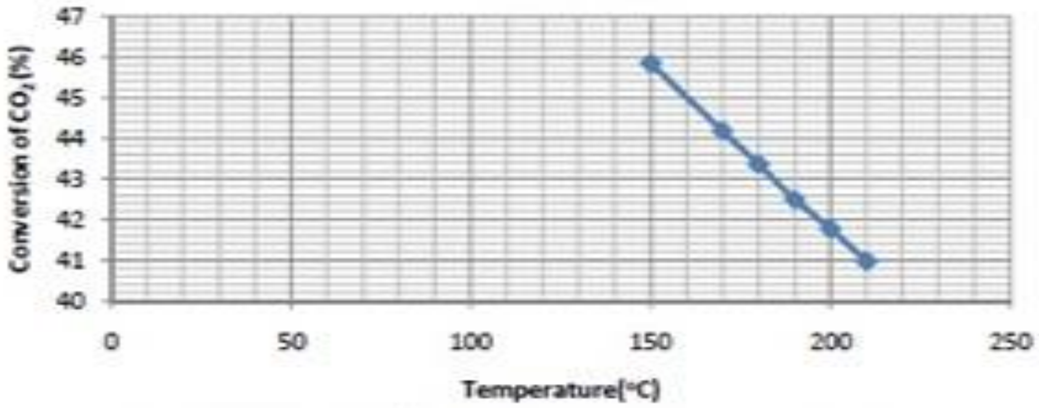

Fig. 3. Effect of temperature on CO_2 conversion.

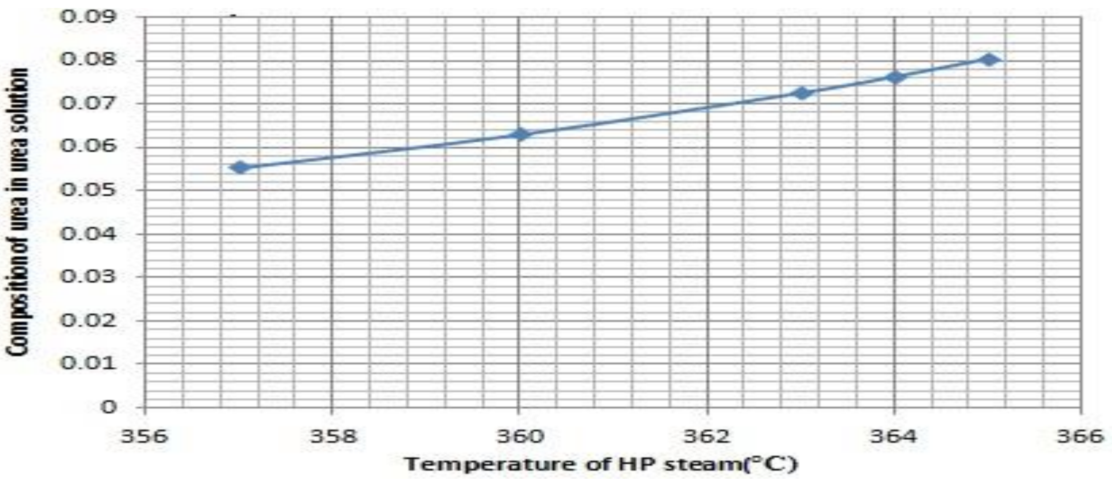

Fig. 4. Effect of HP steam temperature on composition of urea.

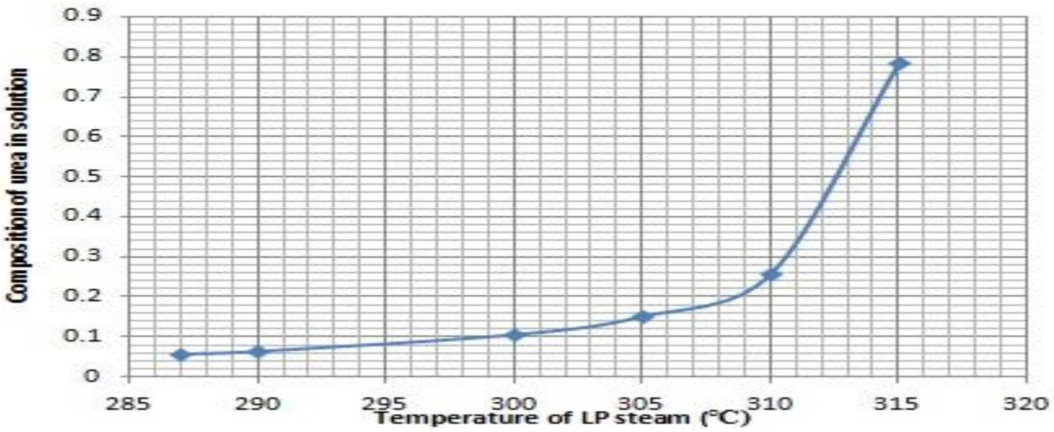

Fig. 5. Effect of LP steam temperature on composition of urea.

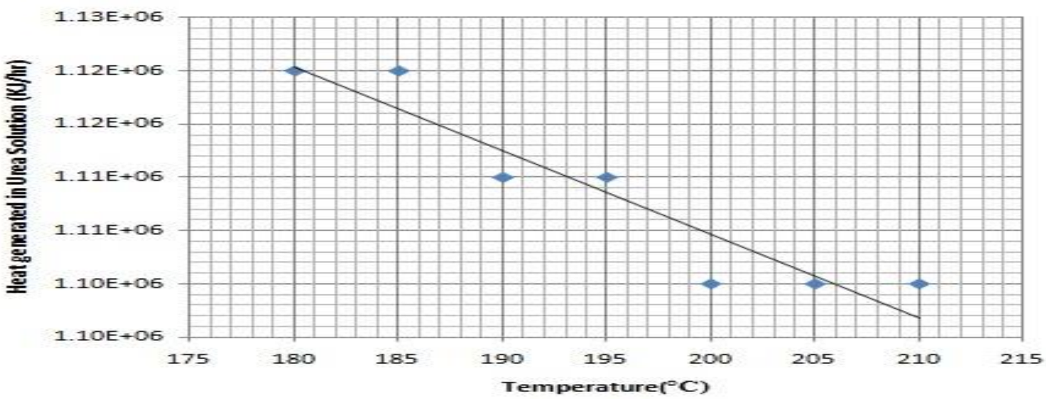

Fig. 6. Effect of CO_2 temperature on heat generated in urea solution.

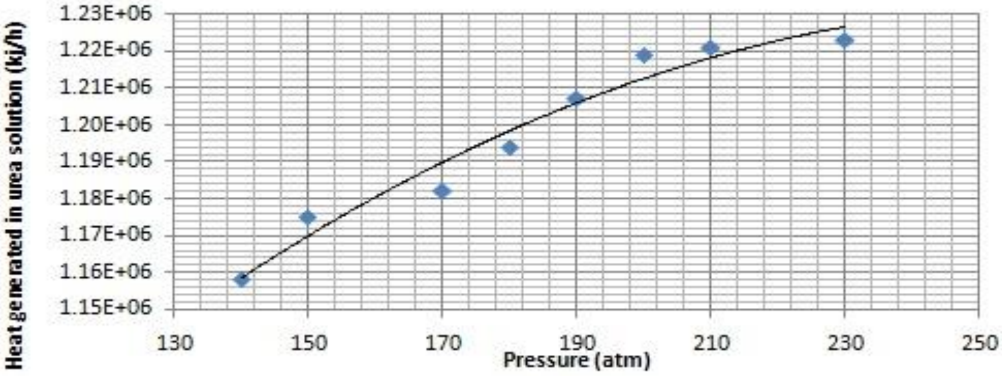

Fig. 7. Effect of pressure of CO_2 on heat generated in urea solution.

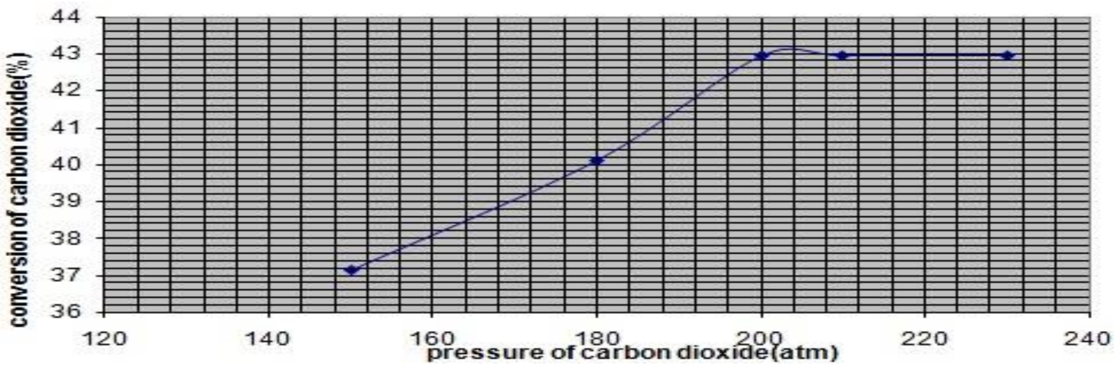

Fig. 8. Effect of pressure on CO_2 conversion.

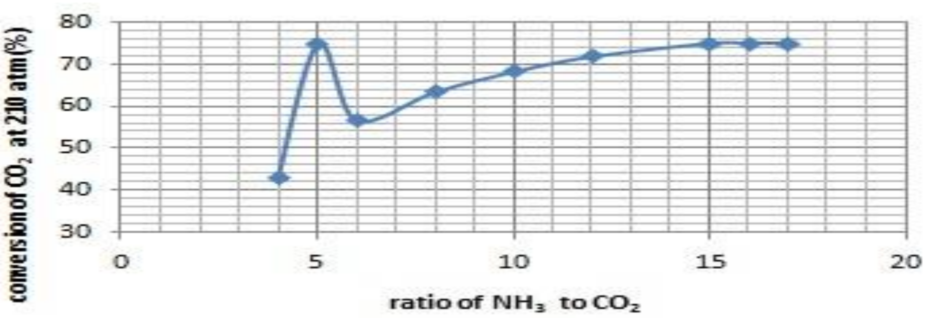

Fig. 9. Relation between rate of ammonia to carbon dioxide flow rate and conversion of carbon dioxide.

Fig. 3 shows the effect of temperature on the percentage conversion of CO_2 in the reactor (at 200 atm). As the temperature increases, the conversion of CO_2 decreases. Fig. 4 shows the effect of HP steam temperature on composition of urea (at 170 atm). As the HP steam temperature increases, the composition of urea also increases. Fig. 5 shows the effect of LP steam temperature on composition of urea. When the LP steam temperature reaches 310^0C, the composition of urea suddenly increases from 0.25 to 0.8. Fig. 6, shows the effect of temperature of CO_2 on heat generated in urea. Heat generated in urea solution decreases with the increase in temperature. Fig. 7, shows the effect of pressure of CO_2 on heat generated in urea solution. Generation of heat in urea solution is increased with the increase of CO_2 pressure. Fig. 8 shows the effect of pressure on the percentage conversion of CO_2 in the reactor. The conversion of CO_2 is seen constant after the pressure reaches 210 atm. Fig. 9 shows the effect of ammonia flowrate on composition of urea. Conversion of CO_2 at 210 atm is seen constant when the ratio of NH_3 to CO_2 is made 15.

4. Discussion

The reactor temperature and pressure are kept in the range 180^0C-190^0C and 120-150 bars respectively. So the fresh ammonia temperature and pressure should be chosen carefully. Similar process should also be maintained for fresh carbon dioxide. Production of urea and optimization is depended on the feed temperature and pressure. So feed temperature and pressure should be chosen cautiously.

5. Conclusion

Being an inexpensive and most concentrated nitrogenous fertilizer, urea is incorporated in mixed fertilizers as well as also used alone to the soil. Over 90% of the world's production of the substance is done for fertilizer related product. About 350 MMSCFD natural gas is required for the yearly production of about 3 million metric ton urea. A very competitive market has taken place due to the excessive use of urea. In order to produce urea at a low cost, Simulation analysis can be proved very handy in the optimization of urea production without conducting any real reactions or experiments. This job can be done pretty efficiently by optimizing several operating conditions.

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Inventory system at service-facility with N-policy consider reneging and rejection of pool customers

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Abstract

In this paper, we consider (S,s)inventory system. We assume that customer arrive to the system according a Poisson process with parameter $\lambda \rangle 0$. When inventory level depletes to s due to demands or service to a buffer customer, an order for replenishment is taken placed. The lead time is exponentially distributed with parameter γ .Any demand that takes place when the pool is full and inventory level is zero, is assumed to be lost forever. During the time of waiting in the pool customers can get impatience and leave the system with rate $\theta(1-\beta)$can stay in the pool with rate $\theta\beta$ Due to some reasons like to fail to show the proper documents, customer can get the rejection from the server during the time of taking the service with rate $\mu(1-\delta)$ or can get service with rate $\mu\delta$. The server will be on mode when the number of pool customer is $\geq N$, otherwise it is off mode. When inventory level is zero then arrival customer may enter the pool with $\theta(1-\beta)$ rate $\lambda\alpha$ and with rate will lost forever. Customers directly go to the pool (waiting room) that has finite capacity $M < \infty$.When number of customers reach to N , server becomes on mode to provide the service provided that the items are available in the stock. When number of waiting customers reach to $N-1$ again server becomes idle Customers are served as the basis of FIFS. In the present model, it is considered that during the time of waiting, customers can get impatient and can leave the system. Moreover the server has the authorization to reject the customers due to lack of eligibility or fail to show the proper documents to get services. The steady state probabilities are determined, some system characteristics are derived, numerical illustrationsare provided and sensitivity analysis is also made.

Key words: Reneging, Rejection, pooled customer and Inventory.

Introduction:

In inventory models the major objective consists of minimizing the total inventory cost and to balance the economics of large orders or large production runs against the cost of holding inventory and the cost of going short. Staring from a simple lot size formula a huge amount of research is done in inventory modeling. At the earlier research inventory control was treated as a separate identity from the service providing system. But the dimension is changed over the last three decades. Our model is on continuous-review inventory system with lost sales of customer that arrives during stock out. The lost sales situation arises in many cases, where the intense competition allows customer to choose another service point. This can be considered as a typical situation for being described by pure inventory Model. Lost sale are usually known as losses of customers. There is a huge amount of literature on loss system, especially in connection with telegraphic and communication system, where losses usually occur due to limited server capacity. But there is another occurrence of loses due to balking or reneging of impatient customers. Inventory system with service facilities was firstly considered by Sigman and simchi Levi[1]. Inthatpaer they considered M\G\1 queue with limited inventory system. An approximation procedures are use to find performance descriptions models, in which the interaction of queuing for service and inventory control in integrated. In a sequence of papers Berman and his coworkers [2-6] investigated the behavior of service systems with related to inventory system. Schwarz et al[7] characterized the earlier approaches in the following manner: They defined a Markovian system process and then used classical optimization methods to find the optimal control strategy of the inventory system. All those models assumed that the demand which arrives during time the inventory is zero is backlogged. The model varied with respect to lead-time distribution, the service time distribution, waiting room size, order size and reorder policy.

Islam and his co-workers [9-10] built some inventory models related to postponed demand, reneging pool customers and rejection of customers from the system in service facilities. In this paper we introduce Inventory system at service facility with N-policy. Consider reneging and rejection of pool customers. Customers direct go to the pool region and get service. The strategy of our investigation in this paper is as follows; we start the observation of Islam etal that paper the inventory system is started when the inventory levels is When the number of customers reach to N server becomes on mode to provide the service provided that the items are available in the stock. When number of waiting customers reach to $N-1$ again the server becomes idle. From the pool customers can get impatience and can leave the system with rate $\theta(1-\beta)$ and can stay in the pool with rate $\theta\beta$ Due to the same reasons like to fail to show the proper documents customer can get the rejection from the server.

Assumption:

1. Initially the inventory level is S
2. Interarrival times of demands are exponentially distributed with parameter λ.
3. Lead time is exponentially distributed with parameter γ.
4. Maximum pool capacity is M.
5. Demand that arrives when the pool is full, demand will be lost forever.
6. During the time of waiting in the pool; customers can get impatience and can leave the system with rate $\theta(1-\beta)$ can stay in the pool with rate $\theta\beta$.
7. Due to some reasons like to fail to show the proper documents, customers can get the rejection from the server at service epoch with rate $\mu(1-\delta)$ or can get service with rate $\mu\delta$.
8. The server will be on mode for the pool size if $j = N, N+1,.....,M$ and in off mode if $j \le N-1$.
9. When inventory level is zero then arrival customer may enter the pool with rate $\lambda\alpha$ and with rate $\lambda(1-\alpha)$ will lost forever.

Notation:

$I(t)$ = Inventory level at time t. ; λ = Arrival rate of customers to the system. γ = Lead time parameter. ; $N(t)$ = Number of customers in the pool. $X(t)$ = Represents the server'smode. ; μ = service rate of the system.

$\psi = [\mu(1-\delta)+\theta(1-\beta)]$; $\phi = [\lambda + \mu(1-\delta)+\theta(1-\beta)]$;

$\xi = [\lambda\alpha + \mu(1-\delta)+\theta(1-\beta)]$; $\eta = [\lambda + \mu + \theta(1-\beta)]$

Model and Analysis;

In this model, the inventory system is stared when the inventory levels is S and the system is in OFF mode. Demands follows Poisson Process with rate λ Inventory level will be deplete due to items provided to the customers from the pool customers can get impatience and can leave the system with rate $\theta(1-\beta)$ can stay in the pool with rate $\theta\beta$ and Due to some reasons like to fail to show the proper documents, customers can get the rejection from the server during the time of taking the service with rate $\mu(1-\delta)$ or can get service with rate $\mu\delta$.When inventory level reaches in the state $(-N+1,0)$ the very next demand converts the system on mode from off mode i.e., $(-N,1)$. In that stage, if further demand arrives that will be lost forever. The inventory level $I(t)$ take the values in the set $A = \{-N,-N+1,......,0,......,S\}$By our assumptions {I(t), t≥0} does not follow Markov Process. To get a two dimensional Markov process, we incorporate the process {δ(t), t≥0 } into {I(t), t≥0} process where δ(t) is defined by,

Now, {I(t), δ(t), t≥0}is a two dimensional continuous Markov Process defined on the state space $E = (E_1 \cup E_2)$ where, $E_1 = \{(i,0) : i = -N+1,-N+2,...,S\}$ and $E_2 = \{(i,1) : i = -N,-N+1,...,S-1\}$

Where $X(t) = \begin{cases} 0, & when\,server\,is\,off\ \mathrm{mod}\,e \quad j \ge N, N+1.....M \\ 1, & when\,server\,is\,on\ \mathrm{mod}\,e \quad j \le N-1 \end{cases}$

$\{I(t), N(t), X(t);\ t \ge 0\}$ is a three dimensional Markov process with state space

$E_1 = \{0,1,2,3,...............S\};\ E_2 = \{0,1,2,3,...............N, N+1,.......,M\};\ E_3 = \{0,1\}; E = E_1 \times E_2 \times E_3$

The infinitesimal generator can be obtained using the following arguments.

A) Arrival of customer makes a transition from
$(i, j, k) \to (l = i, m = j+1, n = 0)$ $i = 0.....S,\ J = 0,......N-2,\ \ ,k = 0\ \ l = i,\ \ m = j+1$

B) A demand can convert the system off mode to on mode makes a transition
$(i, j, k) \to (l = i, m = j+1, n = 1)$ $i = 0.....S,\ j = N-1,\ \ ,k = 0$

C) A customer demand can satisfied convert the system from on mode to off mode
$(i, j, k) \to (l = i, m = N, N-1,.....0, n = 0)$ $i = 0.....S,\ J = N........M,\ \ ,k = 1$

D) Due to the replenishment inventory , the system makes a transitions
$(i, j, k) \to (l = i+Q, m = j, n = k)$ $i = 0.....S,\ j = N......M,\ \ ,k = 1$

E) Due to the inventory, the system makes transitions.
$(i, j, k) \to (l = i+Q, m = j, n = k = 0)$ $i = 0.....S,\ J = 0......N-1,\ \ ,k = 0$

On Mode:

γ — $i = 0,1,2,..........S,\ \ l = i+Q$; j=N,..........M, m=j; K=1………, n=k

$\mu\delta$ — $i = 1,2,........S\ \ l = i-1$; $j = N+1..........M\ \ m = j-1$; $k = 1\ \ n = k = 1$

$\mu\delta$ — $i = 1,2,........S\ \ l = i-1$; $j = N\ \ m = j-1$; $k = 1\ \ n = k = 0$

$\mu(1-\delta)$ — $i = 0,2,.........S\ \ l = i$; $j = N+1......M\ \ m = j-1$; $k = 1\ \ n = k$

$\mu(1-\delta)$ — $i = 0,2,........S\ \ l = i$; $j = N\ \ m = j-1$; $k = 1\ \ n = k = 0$

$\theta(1-\beta)$ — $i = 1,2,........S\ \ l = i$; $j = N+1........M\ \ m = j-1$; $k = 1\ \ n = k$

$\theta(1-\beta)$ — $i = 0,1,.......S\ \ l = i$; $j = N\ \ m = j-1$; $k = 1\ \ n = k = 0$

λ — $i = 1,..........S\ \ l = i$; $j = N,...\text{M-1}\ \ m = j+1$; $k = 1\ \ n = k$

$\lambda\alpha$ — $i = 0\ \ l = i$; $j = N,...\text{M-1}\ \ m = j+1$; $k = 1\ \ n = k$

$-\gamma-\lambda-\theta(1-\beta)-\mu$ — $i = 1,...,s\ \ l = i$; $j = N,...M,\ m = j$; $k = 1,\ \ n = k$

$-\lambda-\theta(1-\beta)-\mu$ — $i = s+1,...S\ \ l = i$; $j = N,...M-1,\ m = j$; $k = 1,\ \ n = k$

$-\gamma-\lambda\alpha-\theta(1-\beta)-\mu(1-\delta)$ — $i = 0\ \ l = i$; $j = N,...M-1,\ m = j$; $k = 1,\ \ n = k$

$-\gamma-\theta(1-\beta)-\mu(1-\delta)$ — $i = 0\ \ l = i$; $j = M\ \ m = j$; $k = 1\ \ n = k$

$-\gamma-\theta(1-\beta)-\mu(1-\delta)$ — $i = 1,...,s\ \ l = i$; $j = M\ \ m = j$; $k = 1\ \ n = k$

$-\theta(1-\beta)-\mu(1-\delta)$ — $i = s+1,...,S\ \ l = i$; $j = M\ \ m = j$; $k = 1\ \ n = k$

$-\gamma-\theta(1-\beta)-\mu$ — $i = 1,2,...S,\ l = i$; $j = M,\ \ m = j$; $k = 1,\ \ n = k$

Off Mode:

γ — $i = 0,1,................s\ \ l = i+Q$; $j = 0,1..........\text{N-1}\ \ m = j$; $k = 0\ \ n = k = 0$

λ — $i = 1,................S\ \ l = i$; $j = 0,1..........\text{N-2}\ \ m = j+1$; $k = 0\ \ n = k = 0$

λ — $i = 1,................S\ \ l = i$; $j = \text{N-1}\ \ m = j+1$; $k = 0\ \ n = k = 1$

$\theta(1-\beta)$ — $i = 0,1,................S\ \ l = i$; $j = 0,1..........\text{N-1}\ \ m = j-1$

$\lambda\alpha$ — $i = 0\ \ l = i$; $j = 0,1..........\text{N-2}\ \ m = j+1$; $k = 0\ \ n = k = 0$

$-\gamma-\lambda-\theta(1-\beta)$ — $i = 1,...,s\ \ l = i$; $j = 0,...,N\ \ m = j$; $k = 0\ \ n = k$

$-\gamma-\lambda\alpha-\theta(1-\beta)$ — $i = 0\ \ l = i$; $j = 0,...,N-1\ \ m = j$; $k = 0\ \ n = k$

$-\lambda-\theta(1-\beta)$ — $i = \text{s}+1,...,\text{S}\ \ l = i$; $j = 0,...,N-1\ \ m = j$; $k = 0\ \ n = k$

$k=0 \qquad n=k=0$

Let us assumed $I(0)=S$ and $X(0)=0$

consider the transition probabilities: $P^{(S,0,0(i,j,k))}(t)=p\{I(t),N(t),X(t)=(i,j,0)\}|I(0),N(0),X(0)=(S,0,0)\}$

From now onwards we can write $P^{(i,j,k)(t)}$ for $P^{(S,0,0(i,j,k)(t))}$. The kolmogorve forward difference differential equation are given below.

When the system is OFF mode

$P^{(i,0,0)}=-\lambda P^{(i,0,0)}+\gamma P^{(i-Q,0,0)}+\psi P^{(i,1,0)}$; i = S..............s + 1 , j = 0

$P^{(i,j,0)}=-\lambda P^{(i,j,0)}+\psi P^{(i,j+1,0)}$; i = s.............1 , j = 0

$P^{(i,j,0)}=-\lambda\alpha P^{(i,j,0)}+\psi P^{(i,j+1,0)}$; i = 0 , j = 0

$P^{(i,j,0)}=\lambda P^{(i,j-i,0)}+\gamma P^{(i-Q,j,0)}+\psi P^{(i,j+1,0)}-\phi P^{(i,j,0)}$; i = S......s + 1 , j = 1

$P^{(i,j,0)}=\mu\delta P^{(i+1,j+1,1)}+\lambda P^{(i,j-i,0)}+\gamma P^{(i-Q,j,0)}+\psi P^{(i,j+1,0)}-\phi P^{(i,j,0)}$; i = s............1, j = 1...........N - 1

$P^{(i,j,0)}=\lambda P^{(i,j-i,0)}+\gamma P^{(i-Q,j,0)}+\psi P^{(i,j+1,0)}-\phi P^{(i,j,0)}$; i = s............1, j = 1...........N - 1

$P^{(i,j,0)}=\lambda\alpha P^{(i,j-i,0)}+\psi P^{(i,j+1,0)}-\xi P^{(i,j,0)}$; i = 0 , j = 1...........N

When the system is on mode

$P^{(i,j,1)}=\lambda P^{(i,j-i,1)}+\gamma P^{(i-Q,j,1)}+\psi P^{(i,m-1,1)}-\eta P^{(i,j,1)}$; i = S......s + 1 , j = 2........M - 1

$P^{(i,j,1)}=\lambda P^{(i,j-i,1)}+\gamma P^{(i-Q,j,1)}+\psi P^{(i,m-1,1)}-\eta P^{(i,j,1)}+\mu\delta P^{(i+1,M-i,1)}$; i = S - 1......s + 1 , j = 2........M - 1

$P^{(i,j,1)}=\lambda P^{(i,j-i,1)}+\gamma P^{(i-Q,j,1)}+\psi P^{(i,m,1)}-\eta P^{(i,j,1)}$; i = S , j = M

$P^{(i,j,1)}=\lambda P^{(i,j-i,1)}+\gamma P^{(i-Q,j,1)}+\psi P^{(i,m-1,1)}-\eta P^{(i,j,1)}$; i = S......s + 1 , j = 2........M - 1

$P^{(i,j,1)}=\lambda P^{(i,j-i,1)}+\gamma P^{(i-Q,j,1)}+\psi P^{(i,m,1)}-\eta P^{(i,j,1)}+\mu\delta P^{(i+1,M,1)}$; i = S - 1......s + 1 , j = 3........M - 1

$P^{(i,j,1)}=\lambda P^{(i,j-i,1)}+\gamma P^{(i-Q,j,1)}-\eta P^{(i,j,1)}$; i = S , j = M

$P^{(i,j,1)}=\lambda P^{(i,j-1,1)}+\psi P^{(i,j+1,1)}-\eta P^{(i,j,1)}+\mu\delta P^{(i+1,j+1,1)}$; i = s.....1 , j = N

$P^{(i,j,1)}=\lambda P^{(i,j-1,1)}+\psi P^{(i,j,1)}-\eta P^{(i,j,1)}+\mu\delta P^{(i+1,j,1)}$; i = s............1 , j = M

$P^{(i,j,1)}=\lambda\alpha P^{(i,j-1,1)}+\psi P^{(i,j+1,1)}-\xi P^{(i,j,1)}$; i = 0 , j = $N+1$...........M - 1

$P^{(i,j,1)}=\lambda\alpha P^{(i,j-1,1)}-\xi P^{(i,j,1)}$; i = 0 , j = M

Limiting Distribution:

The steady state probabilities for $(i,j)\in E$ of the system size are obtained by taking the limit at $t\to\infty$ on both sides of the above equations and solving them respectively .Note that under steady state condition

$\lim_{t\to\infty} P_{i,j,0}=0 \quad ; \lim_{t\to\infty} P_{i,j,1}=0$

And $\lim_{t\to\infty} P_{i,j,0}=q_{i,j,0} \quad ; \lim_{t\to\infty} P_{i,j,1}=q_{i,j,1}$

The limiting distribution exists and satisfies the normalize condition

$$\sum_{i=-1}^{S}\sum_{j=0}^{N-1} P_{i,j,0}+\sum_{i=1}^{S}\sum_{j=N}^{M} P_{i,j,1}=1$$

The balancing equation can be written as

When the is in off mode:

$$q^{(i,0,0)} = \frac{\gamma}{\lambda} q^{(i-Q,0,0)} + \psi\!\!\diagup_{\lambda}\, q^{(i,1,0)} \quad ; i = S.............s+1\ ,\ j = 0$$

$$q^{(i,\,j,0)} = \frac{\psi}{\lambda} q^{(i,\,j+1,0)} \quad ; i = s.............1\ ,\ j = 0 \qquad q^{(i,\,j,0)} = \frac{\psi}{\lambda\alpha} q^{(i,\,j+1,0)} \quad ; i = 0\ ,\ j = 0$$

$$q^{(i,\,j,0)} = \frac{\lambda}{\phi} q^{(i,\,j-i,0)} + \frac{\gamma}{\phi} q^{(i-Q,\,j,0)} + \frac{\psi}{\phi} q^{(i,\,j+1,0)} \quad ; i = S......s+1\ ,\ j = 1$$

$$q^{(i,\,j,0)} = \frac{\lambda}{\phi} q^{(i,\,j-1,0)} + \frac{\mu\delta}{\phi} q^{(i+1,\,j+1,1)} + \frac{\psi}{\phi} q^{(i,\,j+1,1)} \quad ; i = s......1\ ,\ j = 1........N-1$$

$$q^{(i,\,j,0)} = \frac{\lambda}{\phi} q^{(i,\,j-1,0)} + \frac{\psi}{\phi} q^{(i,\,j+1,1)} \quad ; i = s......1\ ;\ j = 1........N-1$$

$$q^{(i,\,j,0)} = \frac{\lambda\alpha}{\xi} q^{(i,\,j-1,0)} + \frac{\psi}{\xi} q^{(i,\,j+1,1)} \quad ; i = s......1\ ,\ j = 1........N-1$$

When the syatem is on mode

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\gamma}{\eta} q^{(i-Q,\,j,1)} + \frac{\psi}{\eta} q^{(i,\,m-1,1)} \quad ; i = S......s+1\ ,\ j = 2........M-1$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\gamma}{\eta} q^{(i-Q,\,j,1)} + \frac{\mu\delta}{\eta} q^{(i+1,\,M-1,1)} + \frac{\psi}{\eta} q^{(i,\,m-1,1)} \quad ; i = S-1......s+1\ ,\ j = 2........M-1$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\gamma}{\eta} q^{(i-Q,\,j,1)} + \frac{X}{\eta} q^{(i,\,m-1,1)} \quad ; i = S\ ,\ j = M$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\gamma}{\eta} q^{(i-Q,\,j,1)} + \frac{\mu\delta}{\eta} q^{(i+1,\,M,1)} + \frac{\psi}{\eta} q^{(i,\,m,1)} \quad ; i = S-1......s+1\ ,\ j = 3........M-1$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\gamma}{\eta} q^{(i-Q,\,j,1)} \quad ; i = S\ ,\ j = M$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\mu\delta}{\eta} q^{(i+1,\,j+1,1)} + \frac{\psi}{\eta} q^{(i,\,j+1,1)} \quad ; i = s......1\ ,\ j = N$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} + \frac{\mu\delta}{\eta} q^{(i+1,\,j,1)} + \frac{\psi}{\eta} q^{(i,\,j,1)} \quad ; i = s......1\ ,\ j = M$$

$$q^{(i,\,j,1)} = \frac{\lambda}{\eta} q^{(i,\,j-i,1)} \quad ; i = s......1\ ,\ j = M \qquad q^{(i,\,j,1)} = \frac{\lambda\alpha}{\xi} q^{(i,\,j-i,1)} + \frac{\psi}{\xi} q^{(i,\,j+1,1)} \quad ; i = 0\ ,\ j = N+1........M-1$$

$$q^{(i,\,j,1)} = \frac{\lambda\alpha}{\xi} q^{(i,\,j-i,1)} \quad ; i = 0\ ,\ j = M$$

System Performance Measures

(a) ***Mean Inventory holds in the system***

$$\alpha_1 = \sum_{i=1}^{S} \sum_{j=0}^{N-1} iP_{i,\,j,0} + \sum_{i=1}^{S} \sum_{j=N}^{M} iP_{i,\,j,1}$$

b) Expected number of customers reneging to the system

$$\alpha_2 = \sum_{i=0}^{S} \sum_{j=1}^{N-1} i\theta(1-\beta)P_{i,\,j,0} + \sum_{i=0}^{S} \sum_{j=N}^{M} i\theta(1-\beta)P_{i,\,j,1}$$

c) Expected number of customers rejection to the system*:*

$$\alpha_3 = \sum_{i=0}^{S} \sum_{j=N}^{M} \mu(1-\delta)P_{i,\,j,1}$$

d) The probability that a demand will be satisfied just after its arrival is,

$$\alpha_4 = \sum_{i=1}^{S} \sum_{j=0}^{N-1} P_{i,\,j0} + \sum_{i=1}^{S} \sum_{j=N}^{M} P_{i,\,J,1}$$

Steady State Cost Analysis of the mode:

Let us consider the costs under steady state as given below: -

L = the initial set-up cost of the system. C_1 = inventory carrying cost per unit per unit time.

C_2= Cost due to reneging per unit time. C_3=Cost due to rejection per unit time.
C_4 = Cost due to customer lost to the system So, the expected total cost to the system is,

$$E(TC) = L + C_1\alpha_1 + C_2\alpha_2 + C_3\alpha_3 + C_4\alpha_4$$

Numerical Illustrations:

The results we have obtained in steady state case may be illustrated through the following numerical example: Let Then we can get the following system performances by using the given set of parameters which is shown in table-1. $S=5$, $N=2$, $\lambda=4$, $\delta=0.8$, $\mu=5$, , $L=100$, $C_1=6$, $C_2=4$, $C_3=3$ and $C_4=2$.Then we can get the following system performance by using the given set of parameters which is shown in table-1.

Table 1: Different system performances by using a given set of parameters

Mean inventory holds in the system	0.72398146
Expected number of reneging customers in the system	0.1227514428
Expected number of rejectionscustomers in the system	0.11349607
Average customers lost to the system	0.11349607
Total cost to the system	105.175368

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Appendix

$\Pi^{(5,0,0)}$	0.00267620	$\Pi^{(4,0,0)}$	0.0100089	$\Pi^{(3,0,0)}$	0.06417534	$\Pi^{(2,0,0)}$	0.0024546	$\Pi^{(1,0,0)}$	0.0012776	$\Pi^{(0,0,0)}$	0.0001088
$\Pi^{(5,1,0)}$	0.0066905	$\Pi^{(4,1,0)}$	0.0250224	$\Pi^{(3,1,0)}$	0.1666008	$\Pi^{(2,1,0)}$	0.0153415	$\Pi^{(1,1,0)}$	0.00798605	$\Pi^{(0,1,0)}$	0.0023128
$\Pi^{(5,2,1)}$	0.01672626	$\Pi^{(4,2,1)}$	0.00494931	$\Pi^{(3,2,1)}$	0.00404775	$\Pi^{(2,2,1)}$	0.00211607	$\Pi^{(1,2,1)}$	0.02004473	$\Pi^{(0,2,1)}$	0.00051321
$\Pi^{(5.3.1)}$	0.0836320	$\Pi^{(4,3,1)}$	0.0091659	$\Pi^{(3,1,1)}$	0.00467090	$\Pi^{(2,3,1)}$	0.00676811	$\Pi^{(1,3,1)}$	0.00698716	$\Pi^{(0,3,1)}$	0.0289502
$\Pi^{(5,4,1)}$	0.4599589	$\Pi^{(4,4,1)}$	0.0036663	$\Pi^{(3,4,1)}$	0.0033364	$\Pi^{(2,4,1)}$	0.00233443	$\Pi^{(1,4,1)}$	0.001791	$\Pi^{(0,4,1)}$	0.3534654

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A Production Inventory Model for Different Classes of Demands with Constant Production Rate Considering the Product's Shelf-Life Finite

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Abstract

This paper unfolds how a model is developed on the basis of market demands and company's production pattern. It advances in quest of optimum cost considering the product's shelf-life finite. The paper discusses about a production inventory model where company produces items with a constant rate, but demands vary due to the customers' needs. Without having any sort of backlogs, production starts. Reaching at the desired level of inventories, it stops production. After that due to demands along with the deterioration of the items it initiates its depletion and after certain periods the inventory gets zero. It is assumed that the decay of the products is level dependent. The objective of this paper is to find out the optimum cost and time.

Key words:Production inventory, Shelf-life time, Demand class, Production rate.

1. Introduction

In minimizing inventory cost this paper develops an Inventory Model of Deterministic Demand of materials which have the definite shelf-life. The Model advances by considering the constant production rate, small amount of decay, varying demand pattern, while reaching in certain amount of inventory level the production stops. Harries [1] presented the famous economic order quantity (EOQ) formulae. Whitin [2] was the first researcher who develops the inventory model with decay for fashion goods. Ghare and Schrader [3] first pointed out the effect of decay and discovered EOQ model. Rosenblatt and Lee [4] assumed the time as important factor for stock. Jamal, Sarker and Mondal [5] used single and Ekramol [6,7] used various production stages. Abdullah and Chaudhuri [8] and Jia-Tzer and Lie-Fern [9] included the defective items with imperfect process and backorders in the model. Teng, Chern and Yang [10] considered fluctuating demand and Skouri and Papachristos [11] discussed continuous review model. Vinod [12] described time dependent deteriorating items and Brojeswar, Shib and Chaudhuri [13] discussed with rework able items and supply distribution. The important formulae from Naddor [14] and Whitin [15] has been introduced to develop this paper. Subsequently, the model is formulated by proving that the total variable is convex, which shows that the optimum inventory cost is minimal.

2. Assumptions

a. Production rate is constant which starts when inventory is zero and decay is vary small.
b. Inventory level is highest at $T = 3t$. From this point, the old items must be delivered early to avoid its decay. Since, the production stops while inventory is highest, inventory depletes quickly due to demand.

3. Notations

λ = Production rate and a_i = demand rate at time $T = (i-1)xt$ to ixt, where i= 1 to 3.

μ = Very small amount of constant decay rate for unit inventory. After the production stops μ is 'zero'.

$I(\theta)$ = Inventory level at instant θ and I_4 = average inventory while no production occurs in the lemma.

$Q = 0, Q_1, Q_2$ and Q_3 which depicts the inventory level respectively at $T = 0, t, 2t$ and $3t$.

$Q(T)$ = Inventory at time T, Q_n = inventory considering the demand pattern index n and m = An integer.

x = Demand size during time t, n = demand pattern index, K_0 = Set up cost and h = average holding cost.

q = Inventory level while production stops and S = inventory after production stops at the beginning.

dT = Small portion of T, $W = a =$ demand, while no production occurs and $V = \theta =$ small time segment.

$TC(Q_1)$ = Total cost in terms of Q_1 and Q_1^* = optimum order quantity.

4. Development of the model

At the beginning, while time $T = 0$, the production starts with zero inventory with the rate λ which remains constant for entire production cycle. But demands will vary time to time which is shown in the figure 1.

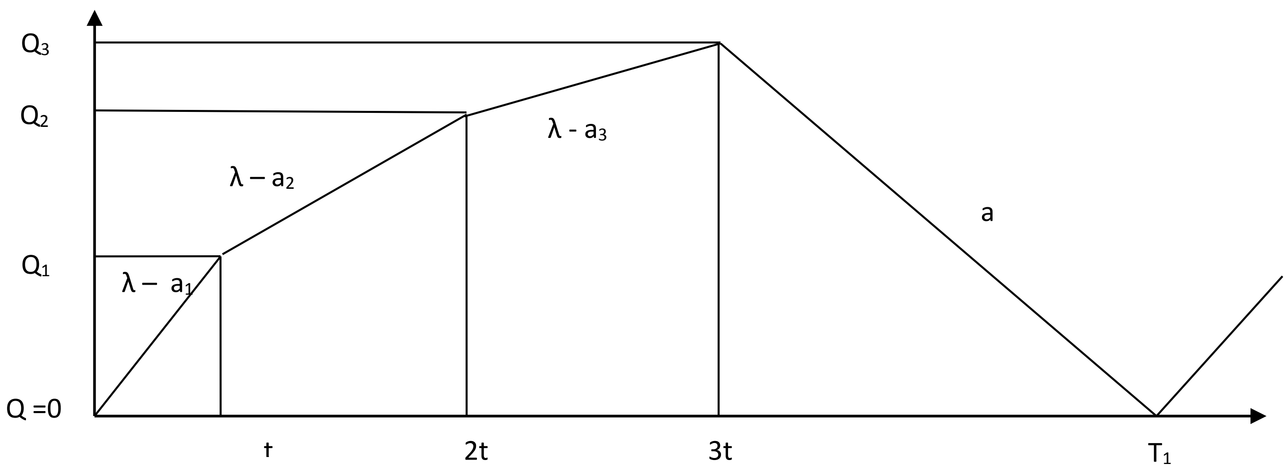

Fig. 1. Inventory level at various stages

From the above figure we get the value of t in different time segments and those are,

$$t = \frac{Q_1}{\lambda - a_1} = \frac{Q_2 - Q_1}{\lambda - a_2} = \frac{Q_3 - Q_2}{\lambda - a_3} \tag{1}$$

Therefore we get,

$$Q_2 = Q_1 + \frac{Q_1(\lambda - a_2)}{\lambda - a_1} \tag{2}$$

$$Q_3 = Q_1 + \frac{Q_1(\lambda - a_2)}{\lambda - a_1} + \frac{Q_1(\lambda - a_3)}{\lambda - a_1} \tag{3}$$

During $T = 0$ to t, inventory increases at the rate of $\lambda - a_1 - \mu I(\theta)$ and we get the differential equation as:

$$\frac{d}{d\theta}I(\theta)+\mu I(\theta)=\lambda-a_1$$

Applying the boundary condition $\theta=0$ and $I(\theta)=0$ we get the solution as,

$$I(\theta)=\frac{\lambda-a_1}{\mu}(1-e^{-\mu\theta})$$

Considering up to second degree of μ and using equation (1), total un-decayed inventory during $\theta=0$ to t,

$$I_1=\int_0^t I(\theta)d\theta=\left[\frac{\lambda-a_1}{\mu}(\theta+\frac{e^{-\mu\theta}}{\mu})\right]_0^t=\frac{Q_1{}^2}{2(\lambda-a_1)} \quad (4)$$

During $T=t$ to $2t$, applying the boundary condition at $\theta=t$, we consider, $I(\theta)=Q_1$.Then we get,

$$I(\theta)=\frac{\lambda-a_2}{\mu}+(Q_1-\frac{\lambda-a_2}{\mu})e^{\mu t}e^{-\mu\theta} \quad (5)$$

Being μ as a small quantity neglecting its higher power, the total un-decayed inventory during $\theta=t$ to $2t$ is,

$$I_2=\int_t^{2t} I(\theta)d\theta=t(\frac{\lambda-a_2}{\mu})+(Q_1-\frac{\lambda-a_2}{\mu})(t-\frac{\mu t^2}{2})$$

$$=\frac{Q_1{}^2(3\lambda-2a_1-a_2)}{2(\lambda-a_1)^2} \quad (6)$$

During $T=2t$ to $3t$, similar approach and boundary condition at $\theta=2t$, $I(\theta)=Q_2$ (say) being used, and μ being very small neglecting its higher power, we get the total un-decayed inventory as,

$$I_3=(\frac{Q_1}{\lambda\text{-}a_1})(\frac{\lambda-a_3}{\mu})+\{\frac{Q_1}{\lambda\text{-}a_1}-\frac{\mu Q_1{}^2}{2(\lambda-a_1)^2}\}\{Q_1+\frac{Q_1(\lambda-a_2)}{\lambda-a_1}-\frac{\lambda-a_3}{\mu}\}$$

$$=\frac{Q_1{}^2(5\lambda^2-7\lambda a_1-2\lambda a_2-\lambda a_3+2a_1{}^2+2a_1a_2+a_1a_3-Q_1\mu a_1}{2(\lambda-a_1)^3} \quad (7)$$

After reaching the desired level of inventories, the production stops and in this stage inventory reaches zero due to constant demand and negligible amount of decay.

Lemma: If the maximum inventory level is Q_3 and demand occurs in a uniform way, the amount of inventory will be as,

$$I_4=\frac{3Q_1\lambda-Q_1a_1-Q_1a_2-Q_1a_3}{2(\lambda-a_1)} \quad (8)$$

Proof: We know from Naddor [14], that the demand pattern can be generally represented as

$$Q(T)=S-x\sqrt[n]{T/t} \quad (9)$$

And on the basis of above equation from Naddor [9], we can express the average amount of inventory by

$$I_4 = \frac{q}{2} + \frac{1}{t} m \int_0^V (Q_n - Q_1) dT \qquad (10)$$

where, $Q_n = W - W \sqrt[n]{T/V}$ which can be compared with equation no (9). In our case we use the last time segment $T_1 - 3t$, the demand occurs uniformly and as we neglected decay i.e. $\mu \to 0$ and comparing as $I_1 \to I_4$, $q \to Q_3$, $t \to T_1 - 3t$, $V \to \theta$, $T \to t$, $W \to a$, $Q_3 \to ma$, i.e. $m \to Q_3/a$, and demand pattern index $n = 1$.

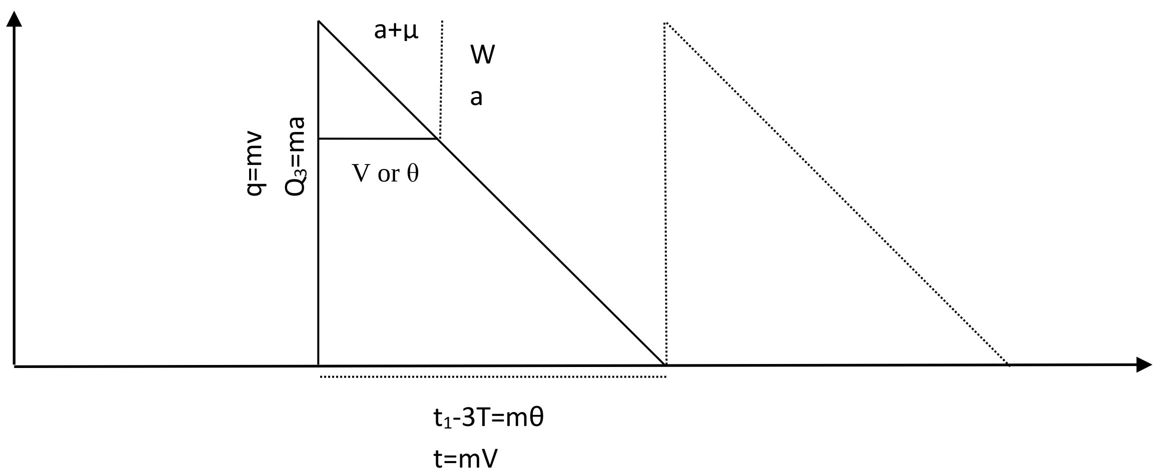

Fig. 2. Inventory level while no production occurs

Putting these values in the equation no (10), we get the following result,

$$I_4 = \frac{Q_3}{2} = \frac{3Q_1\lambda - Q_1a_1 - Q_1a_2 - Q_1a_3}{2(\lambda - a_1)} \qquad (11)$$

Hence, from the equation number (8) and (11) we get the proof.

Total time cycle

Now, total time cycle can be expressed as,

$$T_1 = 3t + (T_1 - 3t) = 3t + m\theta = \frac{3Q_1}{\lambda - a_1} + \frac{Q_3}{a}\left(\frac{a}{a+\mu}\right) = \frac{Q_1(3\lambda + 2a - a_2 - a_3)}{a(\lambda - a_1)} \qquad (12)$$

Total cost function

We use the equation no (6), (8), (9)and (10) to get the total cost, $TC(Q_1) = \frac{K_0 + h(I_1 + I_2 + I_3 + I_4)}{T_1})$

$$TC(Q_1) = \frac{K_0 a(\lambda - a_1)}{Q_1(3\lambda + 2a - a_2 - a_3)} + \frac{ha(\lambda - a_1)}{Q_1(3\lambda + 2a - a_2 - a_3)}\left\{\frac{Q_1^2}{2(\lambda - a_1)} + \frac{Q_1^2(3\lambda - 2a_1 - a_2)}{2(\lambda - a_1)^2} + \right.$$

$$\frac{Q_1^{\,2}(5\lambda^2 - 7\lambda a_1 - 2\lambda a_2 - \lambda a_3 + 2a_1^{\,2} + 2a_1a_2 + a_1a_3 - Q_1\mu a_1}{2(\lambda - a_1)^3} + \frac{3Q_1\lambda - Q_1a_1 - Q_1a_2 - Q_1a_3}{2(\lambda - a_1)}\}$$

$$= \frac{K_0 a(\lambda - a_1)}{Q_1(3\lambda + 2a - a_2 - a_3)} + \frac{haQ_1(9\lambda^2 - 14\lambda a_1 - 3\lambda a_2 - \lambda a_3 + a_1^{\,2} + a_1a_2 + a_1a_3)}{2(\lambda - a_1)^2(3\lambda + 2a - a_2 - a_3)} \qquad (13)$$

To determine the optimum order quantity Q_1^* and to verify that the equation no (13) is convex in Q_1, we must show that the first and second derivative of the equation (13) with respect to Q_1^* is zero and positive respectively. Hence, the convex properties imply that the first derivative $\frac{d}{dQ_1}TC(Q_1) = 0$ and the second derivative,

$$\frac{d^2}{dQ_1^{\,2}}TC(Q_1) = \frac{2K_0a(\lambda - a_1)}{Q_1^{\,3}(3\lambda + 2a - a_2 - a_3)} = \frac{2K_0a(\lambda - a_1)}{Q_1^{\,3}\{(\lambda - a_2) + (\lambda - a_3) + (\lambda + 2a)\}}$$

which is always positive as the quantity $K_0, a, Q_1, \lambda - a_1, \lambda - a_2, \lambda - a_3$ are positive.

Therefore, total cost is convex in Q_1. Hence, for optimum value of Q_1 the total cost function will be minimum and by Hadley and Whitin [15], we get the optimum order quantity Q_1^* as below,

$$Q_1^* = \sqrt{\frac{2K_0a(\lambda - a_1)^3}{ha(9\lambda^2 - 14\lambda a_1 - 3\lambda a_2 - \lambda a_3 + a_1^{\,2} + a_1a_2 + a_1a_3)}} \qquad (14)$$

5. Numerical illustration with sensitivity analysis

Let, the parameters, $K_0 = 100, h = 2, a_1 = 1, a_2 = 2, a_3 = 3, a = 2, \lambda = 6, \mu = 0.01$. Then from (13) and (14) we get the optimum order quantity Q_1^* = 8.07 units and total optimum cost $TC(Q_1^*)$ = 14.58 units. Total cost decreases if demand a_1, a and λ increases; total cost increases if the demand $a_2$and a_3 increases.

Order quantity (Q_1) verses total cost (TC)

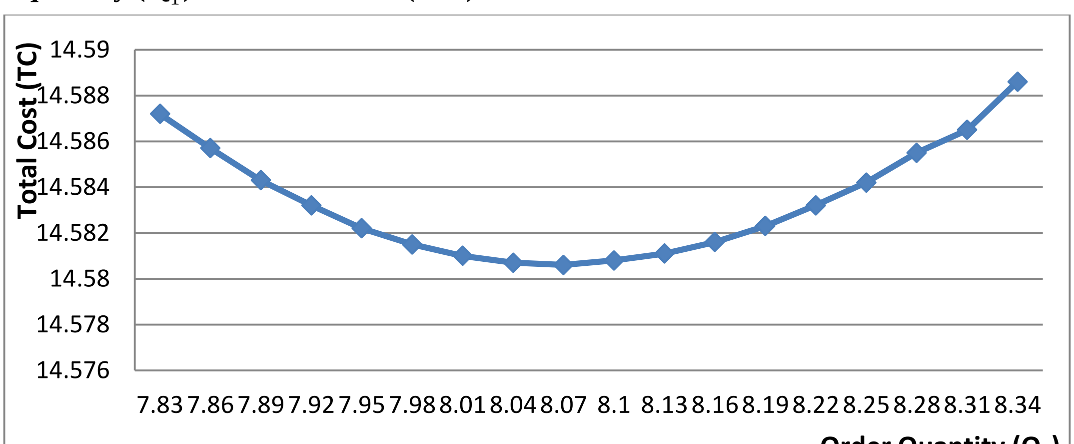

Fig. 3. Quantity Verses Total Cost

6. Conclusion

Total cost decreases in the first stage as it has sufficient inventory with respect to its demand increases. This cost increases during the second and third stages due to its reduced inventory level as the production stops at the end of this stages having increasing demand. Total cost increases in the fourth stage, while demand increases after no production. The Model could establish that with a particular order level (i.e. Q_1^* = 8.07 units) total cost is minimum (i.e. TC = 14.58 units). Before and after this point Total Cost increases sharply. This paper discussed that, in a varying demand pattern how a model is developed by receiving appropriate amount of order considering the market demands, product's shelf-life and company's production rate, which has ultimately ensured the optimum inventory cost.

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Analyzing and Developing the Quality Control System of a Renowned Battery Industry, Bangladesh: A Case Study

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Abstract

This paper intends to combine Hourly Data System (HDS) and quality control charts to improve process capability and sigma values of a renowned batteries industry, Bangladesh. The main focus of this work is to find C_p , C_{pk} *and Sigma values of the process. 'Minitab 17' software were applied to calculate X bar and S chart. Then number of hourly defective product was taken. Attribute control chart (U chart) for defect was applied through the same software. Overall, it was found that few causes were responsible for lowering process capability.. However, implementation of some recommendations have been given in this paper which can significantly improve the* C_p , C_{pk} *and Sigma values of the process.*

Keywords: C_p,C_{pk}, X bar and S chart,U Chart.

1. Introduction

Statistical process control is a technique used to monitor the process stability which ensures the predictability of the process. In 1920's Shewart introduced the control chart techniques that are one of the most important techniques of quality control to detect if assignable causes exist. [7] The widely used control chart techniques are X bar S chart for variable and U chart for non-conformities. A control chart, consists of three lines namely centre line, upper and lower control limit. These limits are represented by the numerical values. The process is either "in-control" or "out of control" depending on numerical observations.

A process capability index is another one used to indicate the performance of the process relative to requirements. C_p Is one of the most commonly used capability index. The natural tolerance of the process is computed as 6σ. The index simply makes a direct comparison of the process natural tolerance to the engineering requirements. [3] Assuring the process distribution is normal and process average is exactly centered between engineering requirements.

There are so many statistical software that enables an inspector to control the quality of a product in industry. This type of in process quality inspection not only makes the entire process fast and less costly but also determine and analyse whether or not the lot of production is acceptable, provide that the company is willing to allow up to a certain known number of defective parts. Among the statistical software, 'Minitab 17' is the best and most widely used in industry, because it has built-in capacity to analyse the control chart and process capability with different graphical window.[11]

Lead-acid batteries which are mainly applied to store energy and to get uninterruptible power supply in human demand such as telecommunication, traffic, industry and medical system.[9] This paper presents the experiences in practice of quality assurance in the battery plant production and emphasizes the integration of statistical quality control (SQC) software with the process and production control methods. Quality improvements were achieved by careful security of manufacturing process details. This quality improvements resulted in more consistent battery life at lower cost.

2. Methodology

The control chart may be classified into two types namely variable and attribute control chart. In monitoring the production process, the control of process averages or quality level is usually done by X bar charts. The process variability or dispersion can be controlled by either a control chart for the range or a control chart for standard deviation. So, Variable control chart is further classified into X bar R chart and X bar S chart. X bar S chart is used when sample size n >5 [8]. In this case, sample size is six.

Lead grids for positive and negative plates are cast in mold. The grid must be rigid, free from discontinuities and have specified weight and thickness. If the grids heavier than the specified weight are functionally accepted but increase the battery cost. On the other hand, if grids less than the specified weight are functionally not acceptable and reduce the quality of the battery. [10]
In order to investigate the manner of variation of quality of gird, a specific control chart X bar S chart was introduced because quality characteristics(weight of grid) is measurable and expressed in number. [5] Weight were measured six times a day per hour from 8.00am to 6.00 pm for eight days. [6] In an X bar S chart, X bar chart shows a change in subgroup mean and S chart shows a change in the variation within the subgroup. When all points plotted in a control chart are between control limits, the process is considered to be in control stage. When an X bar S chart shows the statistically control state, process capability was grasp by a histogram of raw data.

In this paper, U chart was used to count of non-conformities per unit in an inspected battery. A non-conforming unit is one which contains at least one nonconformity. Major non-conformities were found in the battery were [10]

A. Short Molding
B. Lead Tear
C. Grid Cracking
D. Grid Lugs misshaped

The some of the factors are,

a. Spray Vanishes
b. Mold Temperatures
c. Mold Physical condition
d. Machine Physical Condition

Sample size of the U chart may be either variable or constant. Normally a constant subgroup size is preferred. This chart would help to reduce the number of nonconformities per unit. The control chart for attributes are quite similar to the control chart for variables, that is, the Centre line and control limits are set in the same manner.[4] However, it is important to note that the purpose of using these two types of control chart are quite distinct.

3. Data Analysis and Result

Table 1. The detail data of grid weight measured

Sample No		*Observations TX1.4 Grid weight(grams)*				
1	122.4	122.6	122.8	122.6	122.6	123.2
2	122.2	122.8	122.6	122.8	122.8	122.8
3	122.6	122.8	122.4	122.6	122.6	122.8
4	122.6	122.6	122.2	122.6	122.6	122.4
5	122.8	123.2	122.6	122.8	122.8	122.6
6	122.6	122.6	122.6	123.2	122.8	122.8
7	122.4	122.4	122.8	122.8	122.6	122.8
8	122.8	122.8	123.2	122.6	122.8	123.4

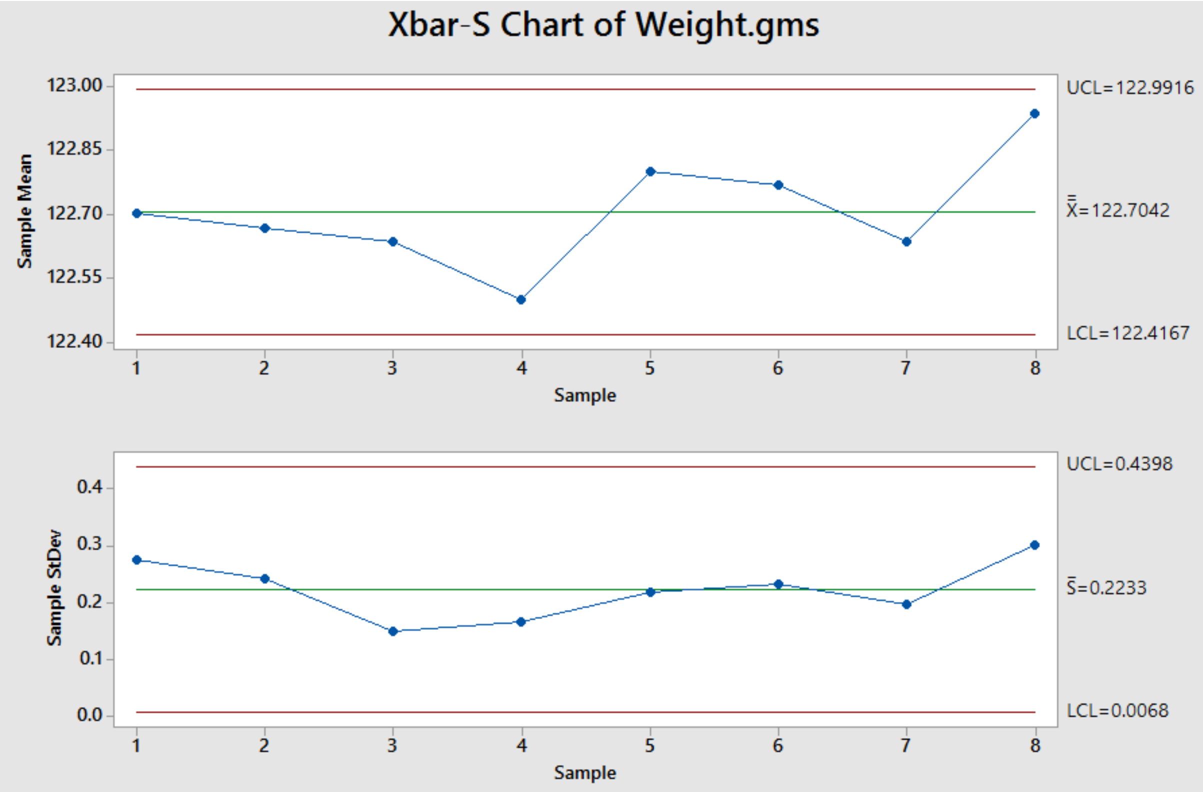

Fig. 1. X bar S chart for Grid Casting

Solid line in the centre of the chart for the X bar S chart, as shown in the figure 1, are obtained by

$$\bar{\bar{X}} = \frac{\Sigma x}{n} \text{ And } \bar{S} = \frac{\Sigma S}{n} \qquad (1)$$

Assuming normal distribution for data, control limits for the charts are established at ±3σ from the central value, as follows [2]

For X bar chart,

$$\text{Upper Control Limit (UCL)} = x + A_3S \qquad (2)$$

$$\text{Lower Control Limit (LCL)} = x + A_3S \qquad (3)$$

For S chart,

$$\text{Upper Control Limit (UCL)} = B_4S \qquad (4)$$

$$\text{Lower Control Limit (LCL)} = B_3S$$

Where the constant A_3, B3, B_4 are obtained from the standard statistical table. [1]

X bar chart is in control limit. S chart as well. No points is outside the control limits. The data was grouped into lots on each days with n=6.Thus the within-subgroup variation is composed of the daily variation including the variation both within and between lots. The variation between subgroup is the variation between days.

Table 1. The detail data for non-conformities

Sample Number	*Sample Size*	*Defects*
1	2	7
2	5	2
3	3	4
4	4	1
5	7	3

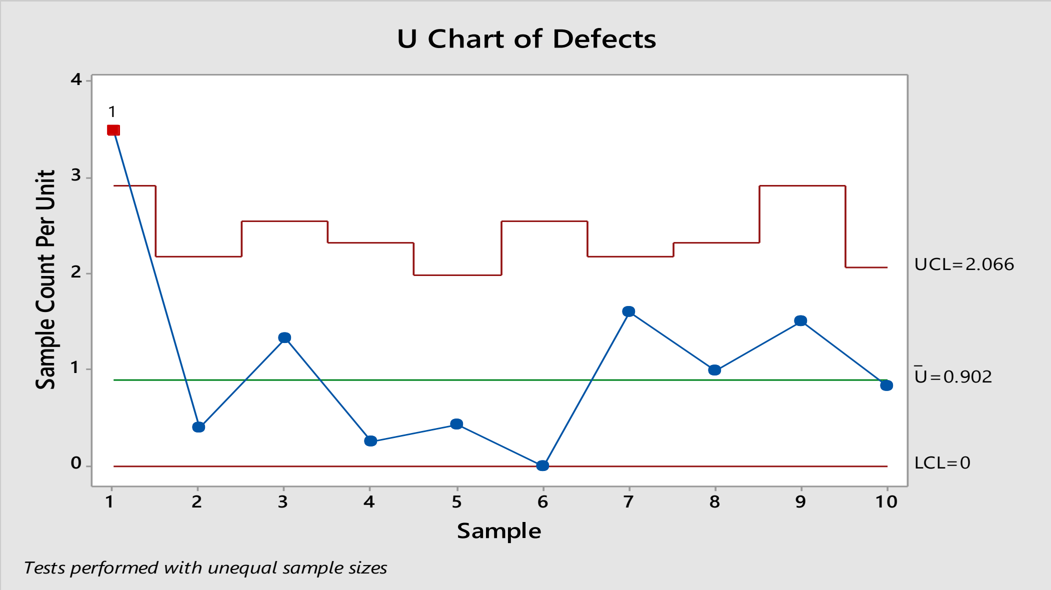

Fig. 2. U chart for defects of in grid casting

The central line is determined by,

$$\bar{u} = \frac{\bar{C}}{n}$$

(5)

Where, C=number of nonconformities in grid casting.

The figure shows approximately a normal distribution and all the point except one lies within the specified grid casting range. However, cracks, lead tear, short molding were found in samples even though most of them were in the specification limit. The standard deviation of the samples were found.

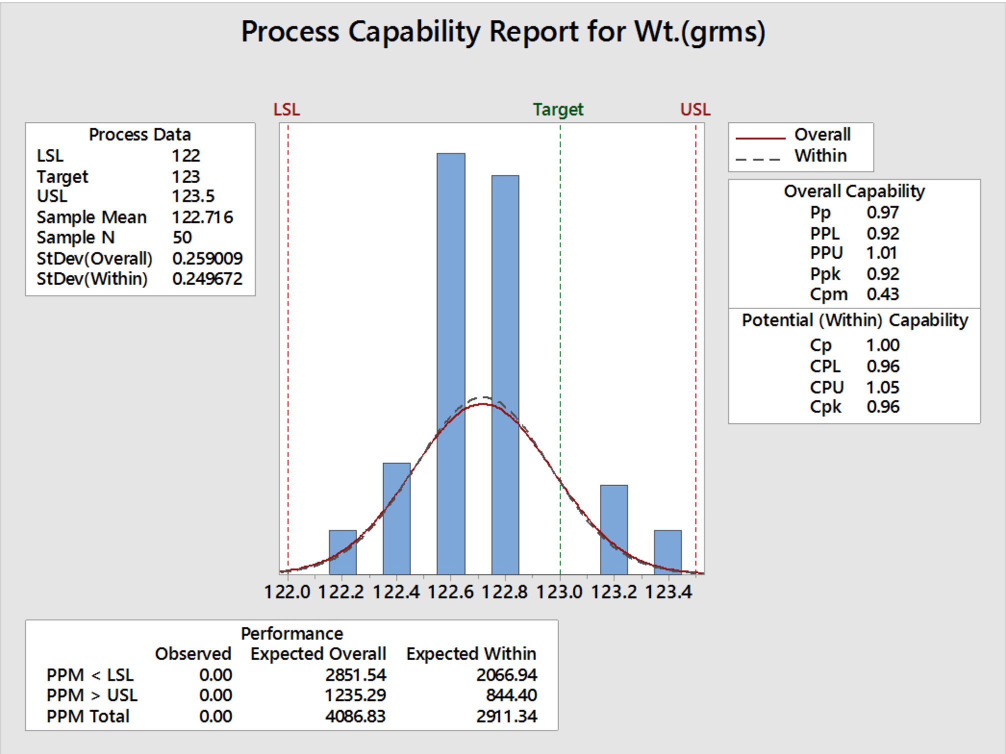

Fig. 3. Process capability of Grid Casting.

The histogram lies within the upper and lower limit of specification with margin. The process can be controlled by control lines calculated by process data. The control state is a state in which assignable causes are removed and process variation is only due to chance causes. The process is in control state and satisfying the specification. For preventing the occurrence of defectives the effort to improve the process capability. This will happen when the process has sufficient capability for the specification.

4. Conclusion

When the relation between a quality characteristics has been grasped sufficiently, next step is to control these process factors at certain level so that the target value of quality characteristics is kept in a desirable range. This step is called process control. The control chart serve as a helpful means to identify abnormal conditions of process and maintain process at a stable condition. The control chart cannot determine, if the process meets the specification or not process capability index gives a measure of it. In case of variable control X bar S chart, the limits are symmetrical about the central line and all point fall inside the $\pm 3\sigma$ limit. So process is in control. This control chart is used to improve process quality by determining the process capability index, which is found1.00 .It means that process is capable to meet the specification. In case of attribute chart, one point is way outside the specification limit. The main cause of it is temperature controlling system. Because of rough cooling in grid cracking occurs. So, proper cooling system has to be maintained to avoid the non-conformities. In case of C_{pk} which is 0.96, lower than 1, which indicates most of nonconforming units produced by the process are falling within the specification limit.

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Paper ID: IE-09

Technical study of the effect of CO_2 Laser surface engraving on the physical properties of denim fabric

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Abstract

Laser engraving is a technology used to design various patterns on fabric surface within a very short time. Laser engraving has successfully replaced some conventional dry processes which were used to make the fabric look faded and worn out. These dry processes were time consuming, health hazardous for both the worker and the end user and with a high rejection rate whereas the laser engraving technology is fast and very much accurate. But controlling the process parameters in laser engraving is very important. If the process parameters are not set and controlled correctly, the physical properties of the fabric can be changed drastically and can result in rejection of the fabric. Present study aims to study the effect of CO_2 laser parameters on 100% cotton denim fabric. Leg panels were formed from the fabric pieces and then the leg panels were exposed to different DPI (Dots per Inch) and Pixel time. The leg panels were treated using 20 DPI and 100 µS, 20 DPI and 150 µS, 20 DPI and 200 µS, 25 DPI and 100 µS, 25 DPI and 150 µS, 25 DPI and 200 µS. The treated panels were then washed with detergent and softener by following standard recipe. The physical properties of the treated denim leg panels were analyzed using standard test methods. The properties that were analyzed are hand feel, tearing strength, fabric weight, EPI (Ends per Inch), PPI (Picks per Inch) and crease recovery angle. The laser intensity has a great effect on the physical properties especially on the strength of the denim. The treated leg panels exhibits a significant difference in the properties than the untreated samples.

Keywords: CO_2 Laser, Laser intensity, Denim, Physical property of denim.

1. Introduction

In Bangladesh ready-made garments are the top export item and among which the share of woven item is maximum [1]. Among woven items, the denim garments possess a significant share. This denim is processed with several of wet washes [2] and dry processes [3]. Some of the dry processes are used to make the denim look like faded and worn out. But these conventional processes of dry processing are time consuming. Health hazardous for both the worker and the end user and their rejection rate is notably high [4]. The laser engraving is the best suited solution of this problem in terms of speed of the production and accuracy [4]. Apart from this, laser systems are also used in fashion design, pleating, cutting, modification of fabric surface [5] and to impart some special finish like antimicrobial finish [6]. The application of laser engraving technique can create unique appearances of textiles without chemical applications and is environmentally friendly compared to other conventional methods employed for creating the same effect [7]. Different types of laser treatments can be achieved by using different machines such as carbon dioxide laser (CO2 laser), neodymium-doped yttrium aluminium garnet laser (Nd: YAG) and diodes lasers [8]. Laser engraving is a subtractive method and can engrave simple or complex patterns and designs through laser beam scanning. CO2 laser is the most efficient and suitable for engraving materials that are not good conductors of heat and electricity because its wavelength can easily be absorbed by textiles [7]. A laser system generates monochromatic, coherent photons in a low-divergent beam. The beam is focused on the desired area of the fabric and within the focused region, the material is subject to a very intensive heating within a very small region. Laser energy is absorbed as heat and the material rapidly heats leading to melting as a phase change from solid to liquid takes place. Some of the molten liquid tries to move, driven by surface tension of the liquid. The remaining liquid heats very rapidly, boiling and releasing vapors another phase change takes place from liquid to gas [9]. Despite of having some safety issues [10] in laser processing, the process is very useful in textile cutting [11] and engraving [12].

2. Materials and methods

Materials

100% cotton denim leg panels were used. These comprised sized indigo dip-dyed denim fabric, GSM (Grams per Square Meter) 481, 3/1 warp faced twill, construction 76 x 57 / 12 x 11, fabric width 57 inch. The leg panels were treated in a laser system (VAV Technology) according to the intended DPI (Dots Per Inch) and Pixel Time (µs). Then the samples were washed with detergent (Hostapur WCTH, Germany) and softener (Resil AOEC, Resil, India) following standard recipe.

Methods

At first, the samples (leg panels) were treated in a laser system (VAV Technology) for 100 µs, 150 µs and 200 µs in 20 DPI and for 100 µs, 150 µs and 200 µs in 25 DPI. The design was developed with Photoshop software and then the leg panels were treated in the laser machine in the above mentioned conditions. After laser treatment, a normal washing was performed to remove size particles and other dirt and dusts from the leg panels. At first twill leg panels were desized using desizing agent. This pretreatment was conducted in liquor containing desizing agent, Luzyme (1 g/l). Material to liquor ratio was 1:10 and the process was performed in a small scale front loading industrial washing machine (Sutlick, Singapore). This treatment was carried out at temperature 60°C for 10 min and the pH of the bath was 7. Then the panels were washed using detergent, Hostapur WCTH (1 g/l) in the same machine for 5 minutes at 30º C. Then the panels were rinsed twice with cold water. After treating with detergent, the panels were softened with a softener. This treatment was conducted in a bath with a liquor ration of 1:10, containing Resil AOEC (2 g/l), acetic acid (40 gm.) to maintain pH 5.5 in room temperature for 7 minutes.

Washed and softened denim leg panels were squeezed to a wet pick-up of 70% at 200 rpm for 3- 4 min in laboratory scale hydro-extractor machine (Zanussi, Roaches International Limited, England), then dried at 70-74 °C for 18 min. in a steam dryer (fabcare, India). Treated denim leg panels were then analyzed to determine and compare their physical properties.

Testing and analysis

Treated denim leg panels were conditioned in 65% RH and 20°C for 24 hour before testing according to BS EN 20139 and ASTM D1776. Hand feel of the fabric was determined by holding the fabric between the thumbs and compared with the untreated sample. Tearing strength was determined according to ASTM D1424 - 09(2013). Fabric weight (GSM) was determined according to ASTM D 3776 and the weight change (%) was calculated from the difference in fabric weight before and after the treatment. Crease recovery angle of the treated fabric has been determined according to AATCC Test Method 66- 2014.

3. Results and discussion

Effect of laser treatment on feel of fabric

The handle of the fabric improves a lot after performing the laser engraving and normal washing process. But it is notable that, the hand feeling improves significantly with the increment in the DPI or pixel time of laser. For 25 DPI and 100 µs, the best feeling is achieved.

Effect of laser treatment on general fabric property

Effects of laser engraving treatment on EPI, PPI, Warp count, Weft count and GSM (Grams per square meter) are presented in the table below-

Table 1. Effect of laser treatment on the general specification of denim fabric

Treating Conditions	EPI (Ends/Inch)	PPI (Picks/ Inch)	Warp Count (Ne)	Weft Count (Ne)	Fabric Weight (GSM)
Control	76	57	12	11	481
20 DPIX100 µs	77	57	13	11	391 (-18.7%)
20 DPIX150 µs	78	58	14	12	368 (-23.5%)
20 DPIX200 µs	77	57	14	11	364 (-24.3%)
25 DPIX100 µs	77	57	14	12	350 (-27.2%)
25 DPIX150 µs	78	57	15	12	336 (-30.1%)
25 DPIX200 µs	77	58	15	12	318 (-33.9%)

Here (-) means decrement and (+) means increment in fabric weight

It is clear from table 1 that, the laser engraving imparts significant change in the fabric properties. The fabric weight (GSM) has been found reduced up to 33.9% as the laser melts and evaporates the surface materials and a part of the fiber from the denim fabric. The effect of decreasing of GSM is more prominent in case of increased DPI than increased pixel time. High DPI damages the higher portion of denim surface and that causes rapid decrement in the GSM of the fabric. But a very long pixel time may cause severe damage to the fabric which can result the burning of the fabric.

The changes in EPI, PPI, Warp count and Weft count are not so prominent. The weft count remains either same or increases a little as the laser ray burns a part away from the yarn and their weight per unit length reduces. This change of count is more prominent in warp way as the fabric is warp faced twill and the laser acts direct upon the warp yarns and thus the count of warp yarns are found increasing with the increment of laser intensity (DPI and pixel time).

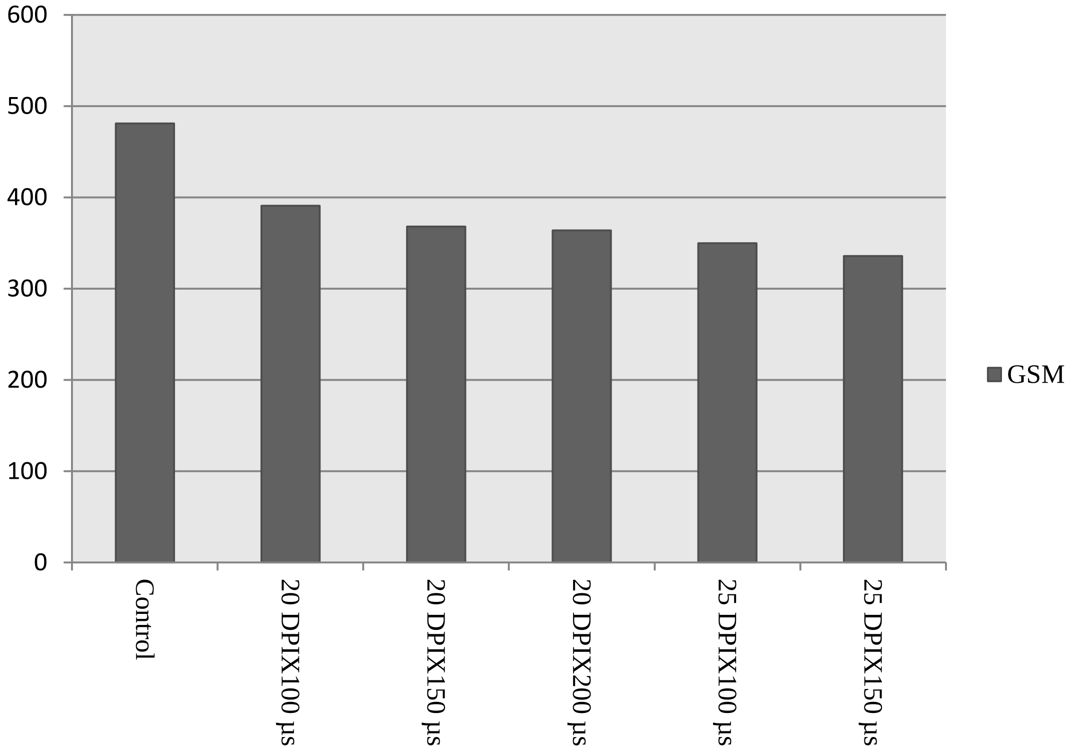

Fig. 1. Change in fabric GSM (Grams per Square Meter) in different process conditions

Effect of laser treatment on tearing strength of the fabric

Effects of laser engraving treatment on the tearing strength of the denim fabric are presented in the table below-

Table 2. Effect of laser treatment on the tearing strength of denim fabric

Treating Conditions	Tearing Strength (lb)	
	Warp	Weft
Control	8.78	9.16
20 DPIX100 µs	5.19	5.54
20 DPIX150 µs	5.15	5.36
20 DPIX200 µs	4.75	4.94
25 DPIX100 µs	3.55	3.80
25 DPIX150 µs	3.14	3.38
25 DPIX200 µs	2.99	3.07

Gradual increment in laser intensity (DPI and pixel time) causes gradual decrement in tearing strength of denim fabric. Increased pixel time and DPI causes damage to the fabric and thus the strength of the fabric falls. In 25 DPI and 150 µs the strength of the denim fabric is found minimum and which is 65.94% less than control in warp way and 66.48 % less than control in weft way. In case of 20 DPI and 100 µs the tearing strength experiences a huge decrement (40.89% in warp way and 39.48% in weft way) compared to the control sample. Then the tearing strength falls gradually in increasing laser intensity.

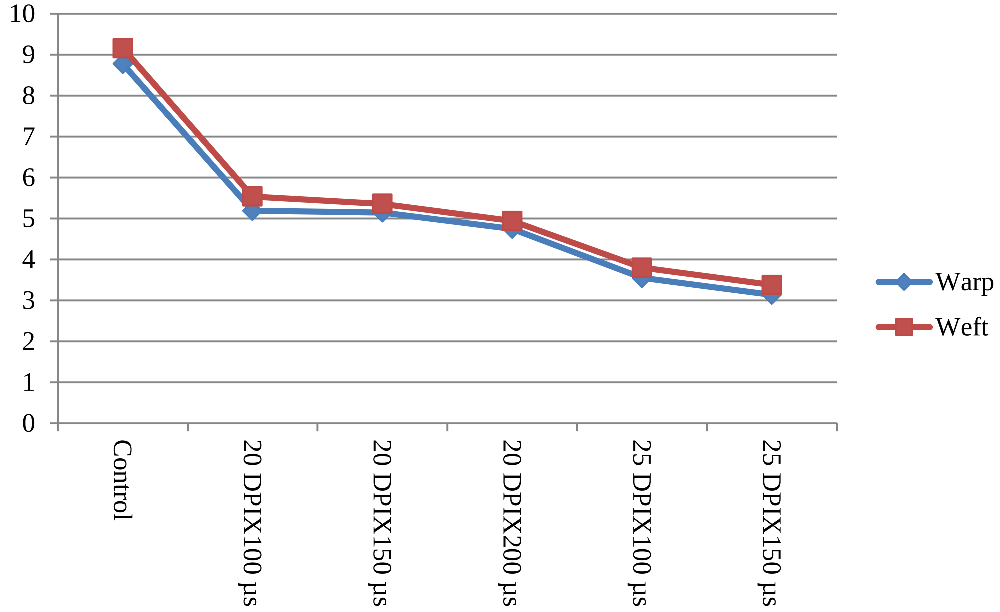

Fig. 2. Changes in warp way and weft way tearing strength of denim fabric in different process conditions

Effect of laser treatment on crease recovery angle of the fabric

Effects of laser engraving treatment on the crease recovery angle of the denim fabric are presented in the table below-

Table 3. Effect of laser treatment on the crease recovery angle of denim fabric

Treating Conditions	Crease recovery angle (Degree)	
	Warp	Weft
Control	70	65
20 DPIX100 µs	69	62
20 DPIX150 µs	67	61
20 DPIX200 µs	65	60
25 DPIX100 µs	60	57
25 DPIX150 µs	55	50
25 DPIX200 µs	52	48

In both warp and weft way, the crease recovery angle is found decreasing with the increasing laser intensity. A reduced crease recovery angle means the fabric becomes softer and more prone to crease. Thus in case of 25 DPI and 150 µs the crease recovery angle is minimum in both warp and weft way.

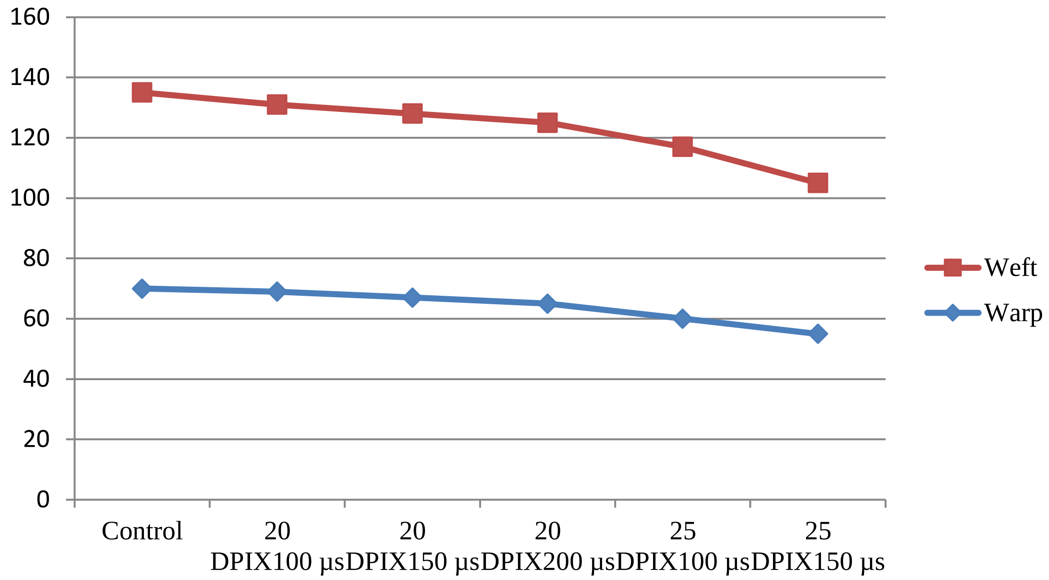

Fig. 3. Changes in warp way and weft way crease recovery angle of denim fabric in different process condition

4. Conclusion

The laser engraving treatment has a distinct effect on the physical properties of the denim fabric. Fabric appearance, crease resistance and more importantly, the strength of the fabric are significantly changed as a result of the treatment. The weight (GSM) of the fabric also changed in a notable extent. The decrement in GSM of the fabric makes the fabric light, comparatively dimensionally unstable as well as the strength of the fabric falls. We can see that, the tearing strength of the fabric is 65.94% and 66.48% less than the raw sample in warp and weft way respectively in the highest laser intensity. This also affects the crease recovery angle of the fabric. Of course the increasing intensity of the laser makes the fabric soft but, it makes the fabric weak and more prone to crease. So, it is eminent that, the increased laser intensity is required for a more prominent design on the surface of the fabric but, the increasing laser intensity makes the fabric weak, dimensionally unstable and more prone to crease. So a balance needs to be drawn. An optimum condition should be chosen to engrave the denim with laser without hampering the strength, GSM, crease recovery angle in large extent. The best condition should be chosen depending on the required performance of the end product.

Considering all the requirements and serviceability of the end product it can be said that, 20 DPI with 100, 150 and 200 µs can be used for this particular fabric. But increasing laser intensity than these conditions will reduce the serviceability of the end product in a large extent which is not acceptable.

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Demand Forecasting of Power Thresher in a Selected Company

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Abstract

The purpose of this study is to assess the present status of demand forecasting used by the manufacturer of agricultural machineries and to identify the best suitable method for forecasting. For this a renowned manufacturer of agricultural machineries has been selected to explore the current situation. At present their forecasting technique for particular month is on the basis of 10% allowance of previous year's corresponding month sale. We collected four years secondary sales data of Power Thresher to evaluate the performance of different forecasting techniques. For the verification, various established time series smoothing methods such as moving average, exponential smoothing, multiplicative and additive models are applied. The mean absolute deviation (MAD) is the comparative parameter here. Multiplicative model is best suited for forecasting demand since it gives lowest value of MAD. Establishment of selected method can reduce the deviation of demand and forecast the demand of products more precisely.

Keywords: Time series, Smoothing technique, Decomposition, MAD, Accuracy.

1. Introduction

Bangladesh Agro Machinery sector is on a significant growth path. This sector is packed with good tidings, both in terms of domestic market penetration and in terms of its contribution to the world agro equipment scenario. In fact, trends already point to an exponential rise in Bangladesh share in the global farm equipment market in years ahead. The performance of that sector is a result of efforts put in by both the government and the private sector towards promotion and adoption of mechanization in Bangladesh agricultural systems.

Forecasting product demand is crucial to any supplier, manufacturer, or retailer. Forecasts of future demand will determine the quantities that should be purchased, produced, and shipped. Demand forecasts are necessary since the basic operations process, moving from the suppliers' raw materials to finished goods in the customers' hands, takes time. In the competitive market environment manufacturers have to maintain finished goods inventories at a good standard to deliver their products to customers on time. That's why almost every organization involved needs to manufacture or at least order parts based on a forecast of future demand. The accuracy achieved in the forecasts has consequences for companies at all levels of the supply chain, from the retailer to the raw materials supplier [1]. In general practice, accurate demand forecasts lead to efficient operations and high levels of customer service, while inaccurate forecasts will inevitably lead to inefficient, high cost operations and/or poor levels of customer service. In many supply chains, the most important action we can take to improve the efficiency and effectiveness of the logistics process is to improve the quality of the demand forecasts [2].

Forecasting is used by companies to determine how to allocate their budgets for an upcoming period of time. This is typically based on demand for the goods and services it offers, compared to the cost of producing them. Forecasting is important because it contributes to better accountability, cost containment, productivity, profit, maximization, and customer and employee satisfaction [3]. Forecasting is important in operations management and in other functions within an organization [4]. Forecasts are vital to every business organization and for every significant management decision. Forecasting is the basis of corporate long run planning [5]. Forecasting is a planning tool that helps management in its attempts to cope with the uncertainty of the future, depend mainly on past data and analysis of trends. Forecasting uses historic data to determine the direction of future trends [6]. Time series modeling is widely used statistical methods of forecasting. A study is conducted by Andrew et al.[7] to develop a forecasting model for hotel occupancy rates. The results of the study indicated that time-series models did give accurate forecasts.

In this paper various forecasting methods such as simple moving average, three months moving average, weighted moving average, single exponential smoothing, double exponential smoothing, multiplicative and additive model are applied to evaluate the most suitable techniques for forecasting the demand that will give lowest value of mean absolute deviation (MAD).

2. Methodology

There are two main methods of forecasting [4] such as Subjective or qualitative methods and Quantitative methods. Quantitative forecasting methods use a mathematical expression or model to show the relationship between demand and some independent variable(s). There are two major types of quantitative forecasting methods for example Time series methods and Causal or explanatory methods. Time series models use time as the independent variable and project the “demand pattern” (that is the past relationship between demand and time) to estimate demand in the future [8]. There are two types of time series method. They are Smoothing method and Decomposition method.

Smoothing methods such as simple moving average, weighted moving average, exponential smoothing attempt to forecast by removing extreme changes in past data. This method, when properly applied, reveals more clearly the underlying pattern to the data series from randomness [9]. The underlying pattern can also be broken down into the sub pattern to identify the component factors that influence each of the values in a series. This procedure is called decomposition [9].

Mathematical representation of the decomposition approach is $Y_t = f(S_t, T_t, E_t)$ where Y_t is the time series value (actual data) at period t, S_t is the time seasonal component (index) at period t, T_t is the trend cycle components at period t and E_t is the irregular (remainder) component at period t. The exact functional form depends on the decomposition model actually used. The major advantage of multiplicative model is that the end user has an appreciation of how the forecast was developed; he or she may have more confidence in its use for decision making [10].

A case study research has been performed in Alim Industries Ltd. which was established in 1990 at the BISCIC Industrial Estate, Gutatikar, Sylhet. Since then the company is engaged in production, assembly, import and marketing of agricultural machineries. Power thresher is chosen from a variety of products in order to conduct a study of demand forecasting. The information as well as data have been gathered through questionnaire, interview, and past sales record from sales manager. Data have been analyzed by using various time series model such as simple moving average, three months moving average, weighted moving average, single exponential smoothing, double exponential smoothing, multiplicative model and additive model. The estimated forecasts were then compared with the actual sales to calculate the MADs. The MAD is the mean of the error made by the forecast model over a series of time periods, without regard to whether an error was an overestimate or an underestimate [4]. Mathematically

$$\text{MAD} = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n} \quad (1)$$

Where, A_t= actual demand in period t, F_t=forecast demand in period t, n=number of period being used,
Maximize accuracy and minimize bias are the two major criteria for selecting forecasting method. Here best suited forecasting technique has been selected on the basis of lowest mean absolute deviation (MAD).

3. Data collection and analysis

The case study deals with the demand forecasting of Power thresher. The company determines their products’ demand from previous year’s sales data. They forecast for a particular month on the basis of 10% allowance of previous year’s corresponding month sale. The company maintains a high level of inventory to avoid demand

Table 1. Sales data of power thresher

Months	2009	2010	2011	2012
January	87	108	84	112
February	373	238	325	298
March	975	885	798	890
April	860	758	832	820
May	202	347	364	307
June	103	119	96	118
July	145	128	125	119
August	155	136	122	172
September	57	23	47	36
October	87	113	105	98

November	345	243	317	321
December	44	107	79	86

uncertainties. The sales data of power thresher for the year 2009, 2010, 2011, and 2012 are given in table 1. After collecting sales data different forecasting techniques are used to calculate mean absolute deviation (MAD) for each year.

3.1 Calculation of MAD using time series smoothing

Different smoothing methods such as simple moving average, three months moving average, three months weighted moving average, single exponential smoothing, double exponential smoothing, and 36-months moving average have been used to forecast the demand of power thresher. Absolute deviations have also been calculated for the corresponding months of the year. The mean absolute deviations (MADs) found from these calculations are listed in table 2.

Table 2. Values of MAD using smoothing methods for power thresher

Type of smoothing	MAD for the year			
	2009	2010	2011	36 months
Simple moving average	248	198	220	222
Three months moving average	246	201	227	237
Three months weighted moving average	218	177	205	216
Single exponential smoothing	256	214	236	224
Double exponential smoothing	494	425	439	298

In smoothing method seasonal effects have not been considered, that's why the values of MAD found are very high. But there is a seasonal variation in demand of agricultural machinery. Figure-1 shows the variation of sales of power thresher in 2009, 2010, and 2011. Sales rise mainly in March, April and November. To reflect the seasonal variations in demand forecasting, decomposition analysis is crucial.

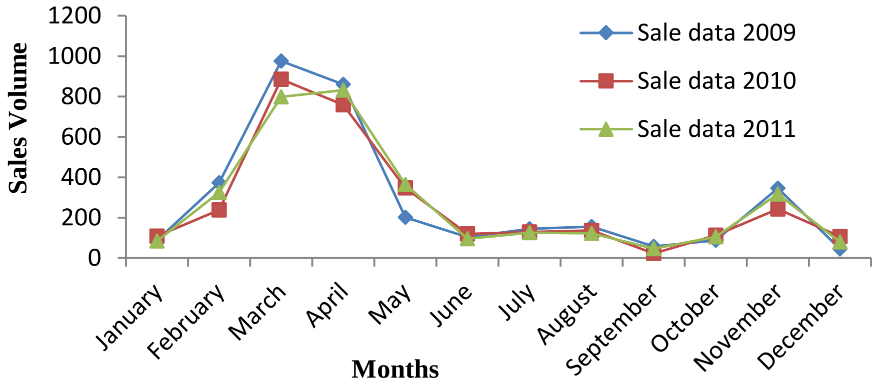

Fig. 1. Trend of sale for power thresher

3.2 Decomposition analysis for forecasting demand

The two common approaches of decomposition method are multiplicative model and additive model.

3.2.1 Multiplicative model

This model requires baseline demand and seasonal factors to get the forecast [13]. Baseline demand is calculated by taking average of each year demand. Baseline averages are used to forecast the baseline for next year by applying trend. This is shown in table 3.

Table 3. Calculation of baseline demand for Power thresher

Average demand of the year			Trend/year	Baseline demand for the year 2012
2009	2010	2011		
286.08	267.08	274.5	-5.79	269

Seasonal factor for each month is calculated by taking the ratio of actual data to baseline average for three different years. Average seasonal factor is calculated for each month which is shown in table 4. Forecast for each month of the year 2012 is predicted by multiplying baseline demand with the average seasonal factor that is shown in result and discussion section.

Table 4. Calculation of seasonal factors for Power thresher

Months	Seasonal factor for the year			Average seasonal factor
	2009	2010	2011	
January	0.30	0.40	0.31	0.34
February	1.30	0.89	1.18	1.13
March	3.41	3.31	2.91	3.21
April	3.01	2.84	3.03	2.96
May	0.71	1.30	1.33	1.11
June	0.36	0.45	0.35	0.39
July	0.51	0.48	0.46	0.48
August	0.54	0.51	0.44	0.50
September	0.20	0.09	0.17	0.15
October	0.30	0.42	0.38	0.37
November	1.21	0.91	1.15	1.09
December	0.15	0.40	0.29	0.28

3.2.2 Additive model

An additive seasonal variation simply assumes that the seasonal amount is a constant no matter what the trend or average amount is [13]. At first centered moving average of order 4 is calculated. Trend-cycle component is calculated by taking average of two consecutive centered moving average. The seasonal factors are computed by subtracting the trend-cycle components from the data (S= Y - T) that are shown in table 5. It is assumed that the time series is additive. So, forecasts are calculated by adding seasonal factor with the baseline demand that is shown in result and discussion section.

Table 5. Average seasonal factors calculation for power thresher

Months	Seasonal factor for the year			Average seasonal factor
	2009	2010	2011	
January	0.00	-143.25	-175.13	-159.19
February	0.00	-170.00	-94.13	-132.06
March	386.88	357.88	253.25	332.67
April	291.25	215.88	280.88	262.67
May	-229.25	-85.63	-74.38	-129.75
June	-136.38	-141.25	-169.50	-149.04
July	11.88	-14.00	-12.13	-4.75
August	42.00	35.25	23.38	33.54
September	-79.00	-91.38	-76.75	-82.38
October	-60.13	-12.13	-37.38	-36.54
November	205.38	113.88	0.00	159.62
December	-120.88	-56.25	0.00	-88.56

4. Result and discussion

The calculated Mean absolute deviations (MADs) of forecasted data by different forecasting techniques are plotted in figure 2. It is seen that three months weighted moving average gives lowest value of MAD for the year 2009, 2010, 2011 and 36-months average.

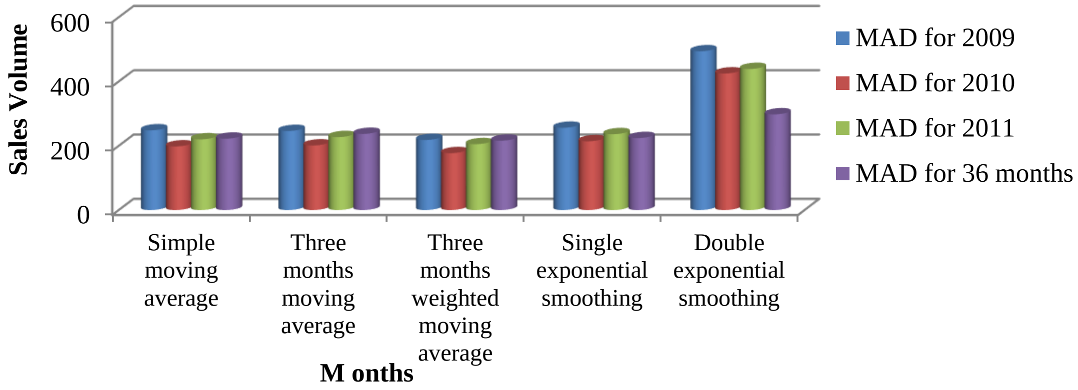

Fig. 2. Values of MAD using time series smoothing methods for power thresher

The forecast for each month of the year 2012 by multiplicative model along with actual sale is shown in figure 3. Forecast exceeds the actual sale in February and July. In October forecast is very close to actual sale. In rest of the month actual sales surplus the forecast due to conservative estimate. The maximum absolute deviation is occurred on August and its value is 38.

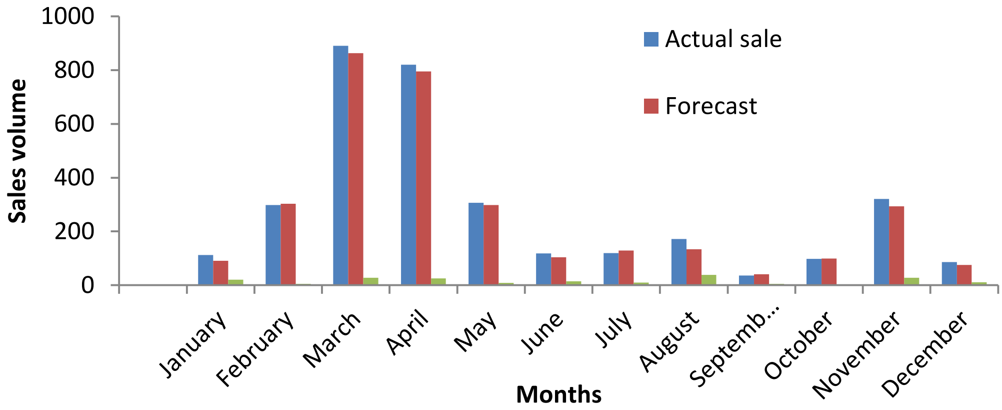

Fig. 3. Actual sales and forecast for the year 2012 by multiplicative model.

Figure 4 shows the comparison between actual sale and forecast for the year 2012 by additive model. In the month of February, March, April and May actual sales cross the forecast in a great amount. The absolute deviation between actual and forecast for at least five months is over 50. It indicates seasonal amount is not constant.

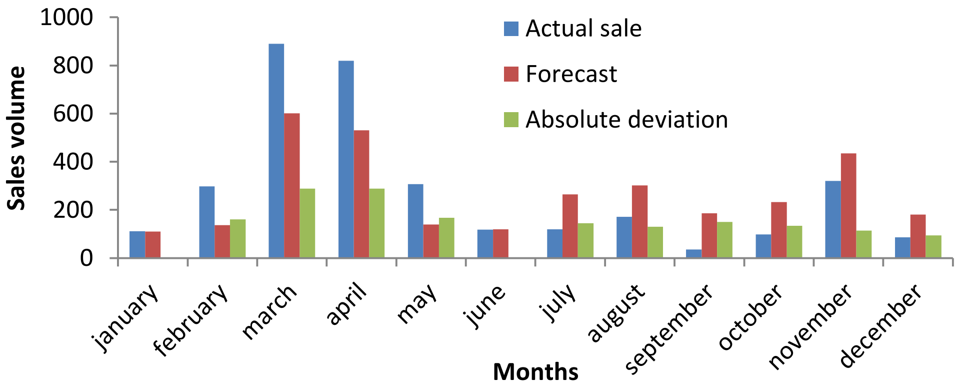

Fig. 4. Comparison between actual sale and forecast for the year 2012 by additive model

Mean absolute deviations (MADs) by multiplicative and additive model are calculated and found as 16 and 139 respectively. MAD of additive model is eight times more than multiplicative model. This is because constant nature of seasonal factor is not justified for those sales data. From the analysis it is said that multiplicative model is the best suited method for power thresher since it gives lowest MAD.

5. Conclusion

Forecasting plays a major role in decision making. In this study four years secondary sales data of power thresher have been collected from Alim Industries Ltd. Time series smoothing methods are used to forecast the sales of that product. Mean absolute deviations (MAD) are also calculated for each forecasting technique. The calculated MADs are found very high because of seasonal variation in their sales. To offset the seasonal effect, time series decomposition methods namely multiplicative and additive model have been used for forecasting demand for the year 2012. By comparing the actual sales data of the year 2012 with the forecasted data, it is found that multiplicative model shows the lowest mean absolute deviation. From the analysis it can be concluded that Multiplicative model is best suited to forecast the sales of the product since it gives lowest value of mean absolute deviation (MAD). With the help of proper forecasting technique, underproduction and overproduction of product can be avoided. It can also help in inventory management and thus reduces the cost of warehousing.

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An Approach to Enhance the Sigma Level in Cable Industry by Using QC Tools and DMAIC Methodology: A Case Study

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Abstract

The Six Sigma approach has been increasingly adopted worldwide in the manufacturing sector for enhancing quality performance, making the process robust to quality variations and reducing defects level to less than 3.4 per million process, product or service opportunities (DPMO). This paper deals with analyzing and improving the quality level of Bangladesh Cable Shilpa Limited (BCSL), a renowned cable industry of Bangladesh by employing a six sigma-DMAIC (Define–Measure-Analyze-Improve-Control) based methodology where different quality improvement tools viz. Control chart, Pareto chart, FMEA (Failure Mode and Effect Analysis) Chart, cause and effect diagram have been used. The existing sigma level of this industry is 2.7 has been calculated by using Minitab software which is not satisfactory at all. Here a six sigma based framework has been provided to identify, quantify and eliminate sources of variation in different operational processes and improve the performance by establishing sustainable quality control plans to enhance the existing sigma level.

Keywords: DMAIC, Control Chart, DPMO, Six Sigma, QC tools.

1. Introduction

Bangladesh Cable Shilpa Limited (BCSL), is one of the most successful optical fiber and telecommunication cable manufacturing industries of this country. BCSL maintains its own Standard Operating Procedures (SOP) for providing a better quality product. Bangladesh Cable Shilpa Ltd. usually produces four types of telecommunication wire according to the customer requirements. BCSL started its commercial production in 1971-72, now produces all types of telecommunication copper cables and satisfies a major portion of the annual demand of cables in Bangladesh and also exports in abroad [2].

Quality is specifically measured in terms of defect rates and is assessed in terms of customer's perspective. Six Sigma is a set of techniques and tools for process improvement. It was developed by Motorola in 1986 [11]. Jack Welch introduced the concept of quality in General Electric in 1995 for the first time ever [11]. Today, it is used in almost all kinds of industries. Six Sigma simply means a quality ensuring measure that strives for near perfection. Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects. A Six Sigma defect is defined as anything outside of customer specifications. Process sigma means the quality level of any particular process, can easily be calculated using a Six Sigma calculator. The term Six Sigma originated from the terminology associated with the statistical modeling of manufacturing processes. The real power of Six Sigma is simple because it combines people power with process power. If an organization is concern about quality and want to enhance the sigma level must have a well established quality plan which includes both quality measuring and controlling tools [1]. Six Sigma concepts helps measure the level of excellence in performance of any activity. This also measures the capability of the activity to perform defect free work. In fact, Six Sigma relies on normal distribution theory to predict defect rates of any activity being predicted. The level of sigma can be analyzed by two ways which are known as defected parts per million opportunities or defects per million opportunities (PPMO or DPMO). Six Sigma only can be achieved when it is possible to reduce the defect rate to 3.4 parts per million opportunities [4]. Over the years, Six Sigma has been evolved interestingly and become a customer-driven approach. The Six Sigma is a unique means of quality measurement, which can be applied irrespectively of the type, complexity and diversity of the processes and products. The attention is focused on the processes, as the final results depend on what happens during the processes [3]. Dr. Hurbert K. Rampersad and Brutu Madalina introduced Total Performance Scorecard (TPS) and also its application in the sales management [6][7].

The first job of implementing Six Sigma is to measure the current sigma level, so in our case we also had measured the current sigma level of BCSL and it was around 3 which is not satisfactory at all. The major issue of implementing six-sigma in any organization is the need of diagnosis of the critical causes responsible for the occurrence of the defects. Reducing those defects is the only way to increase the sigma level. Checking and eliminating defects is a continuous process and can be easily maintained by following DMAIC methodology which has been shown in the later portion of this paper.

2. Literature Review

The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and the reduction of the variations in the process, through the application of Six Sigma improvement projects. Six Sigma can be accomplished by implementing either DMAIC (Define, Measure, Analyze, Improve and Control or DMADV (Define, Measure, Analyze, and Design and verify).

Six- Sigma is a statistical measurement which is 3.4 defects per million and regarded as a management philosophy focused on eliminating mistakes, waste and rework. In addition to this, Six Sigma uses several statistical measures to analyze and interpret the data on processes and products. Historically a process was considered to be capable if specifications were +/− 3 standard deviations from the mean, which would result in about 3 defects per thousand opportunities if the process remained centered. Six Sigma follows a much more stringent approach to define process capabilities, and provides tools for mathematical computation of that capability. If a process is capable at six standard deviations, only 3.4 defects per million opportunities can be occurred (assuming a 1.5 standard deviation shift in the process mean) [5]. Six Sigma is a highly disciplined approach of decision making that helps people to focus on the improvement of the processes to make them as near perfect close to “zero defects” as possible [6].

More formally, Six Sigma can be described as an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific methods to make dramatic reductions in customer defined defect rates [1].

There are countless benefits of having employees trained on the Six-Sigma related processes. Some of the benefits include the followings: cost savings, increased productivity, lower frequency of defects, shorter cycle time, and improved customer satisfaction. One of the earliest success stories of Six Sigma had been begun with Motorola, the founders of Six-Sigma. At the Schaumburg, Illinois facility, ten years after implanting Six-Sigma, great successes had been seen. Like this two there are a plenty of stories of the success of the Six Sigma. Though Fredrick Taylor, Walter Stewart and Henry Ford played a great role in the evolution of Six-Sigma in the early twentieth century, it is Bill Smith, Vice President of Motorola Corporation, who is considered as the Father of Six sigma [7].

DPMO (Defects per Million Opportunities) is a measure of process performance. DPMO is the actual and observed number of defects which have been extrapolated to every 1,000,000 opportunities. Opportunities are actually the quality parameters against which the defects are identified. DPMO is not same as the defective Parts per Million (PPM) since it is possible that each unit (part) being appraised, may be found to have multiple defects of the same type or may have multiple types of defects. A part is defective if it has one or more defects. The number of defectives can never exceed the number of defects. If each part has only one characteristic that can be a defect, then DPMO and PPM will be the same. DPMO will always exceed or equal to PPM for a given yield or sigma level of performance.

$$DPMO = \frac{Number\ of\ defects \times 1{,}000{,}000}{Number\ of\ units \times Number\ of\ opportunities\ per\ unit}$$

Six-Sigma is composition of five steps which are represented shortly by DMAIC. Sequentially Define, Measure, Analysis, Improve and control are the steps which are mainly followed in six-sigma methodologies

The objective of this paper is to identify the problems that cause defects in various steps of production processes in a cable manufacturing industry and to improve the quality level of each manufacturing steps by reducing defects. This paper is mainly discussed with the six sigma based DMAIC cycle.

3. Methodology

The preface of implementing Six-sigma is very complicated job with several sequential steps which are related to observe carefully and concentrate deeply in all of the processes. These sequential steps have been discussed in the later portion of this study.

Data Analysis

Data has been collected from the factory of BCSL to pinpoint the problem. For the inspection of the quality level in the major four manufacturing stages of cable production (maintaining wall thickness, producing loose tube, inner sheet and outer sheet), data of the 15 consecutive days have been collected from the quality management department. Control chart has been used for assessing the ongoing quality of the cable industry. For BCSL, it has been plotted the X bar S chart in fig. 1,2,3,4 to illustrate the fluctuation of amperage for 15 consecutive days.

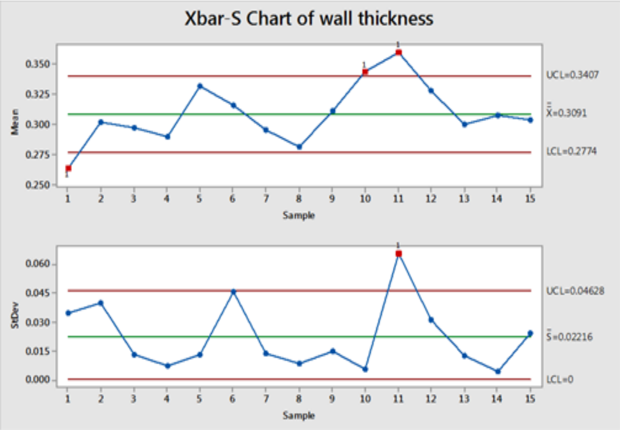


Fig. 1: X bar-S chart of wall thickness.

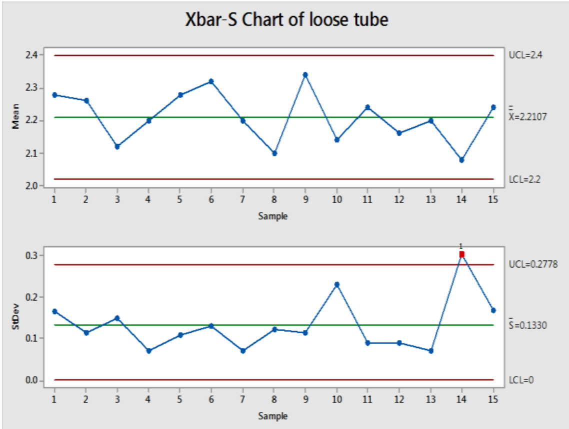


Fig. 2: X bar-S chart of loose tube.

X bar control chart has been used for the analysis of the quality data to examine the quality level of the major four manufacturing stages of cable production to know that whether the quality of those mentioned department is in under control or not. On the other hand S Charts have been employed to determine the process deviation from the mean (standard) or Target value.

An X bar Control Chart of maintaining wall thickness has been constructed as shown in Fig. 1, where UCL is 0.3407, Centre line is 0.3091 and the LCL is 0.2774. The wall thickness data of day 10 and 12 has been placed beyond the upper specification limit. The control limit has been fixed according to the customer satisfaction. The S-control chart has been selected to reduce the deviation of process at the same time. An X bar Control Chart of the production of loose tube has also been constructed as shown in Fig.2, in where UCL is 2.4, Centre line is 2.2107 and the LCL is 2.2. From X bar chart it is clear that all the loose tube data are within specification limit but in S Chart it can be shown that the loose tube data of day 14 is not in specification limit due to the process variability.

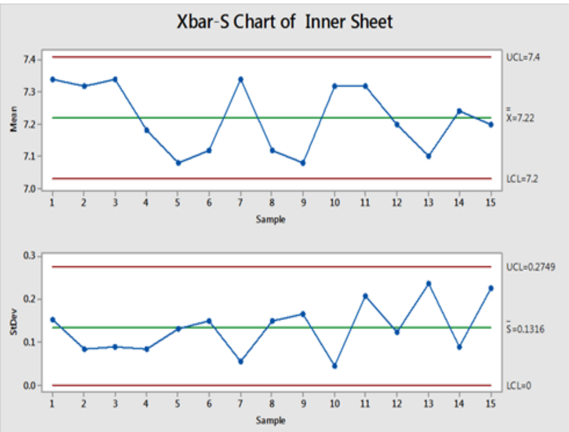


Fig. 3: X bar-S chart of inner sheet.

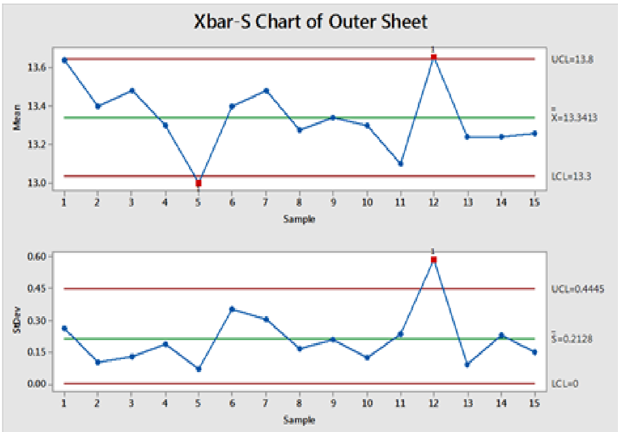


Fig. 4: X bar-S Chart of outer sheet.

X bar and S Control Chart of producing inner sheet has been constructed as shown in Fig. 3, where UCL is 7.4, Centre line is 7.22 and the LCL is 7.2 of the X bar control chart where all the data remains within the control limit. From S Chart it is clear that there is no process variation in this process as all the data remains in control limit. X bar and S Control Chart of producing outer sheet has also been constructed as shown in Fig. 4, where UCL is 13.8, Centre line is 13.3413 and the LCL is 13.3 of the X bar chart. Here two points are out of control in X bar Chart, but in S-chart there is one point plotted outside of the control limit.

DMAIC

to implement six-sigma it is needed to follow DMAIC approach step-by step. The DMAIC is a basic component of Six-Sigma methodology- a better way to improve process by eliminating the defect rate in the final product. The DMAIC methodology has five phases: define, measure, analysis, improvement, and control. These five phases of DMAIC have been followed as the solution maker in this study.

PROCESS DEFINATION

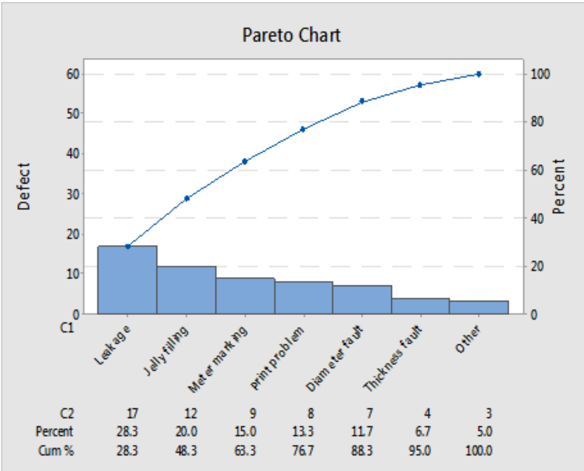
Define is the first phase of the DMAIC methodology of Six Sigma. The purpose of this phase is to define the problem, goals of the project and the process that needs to be improved to get higher sigma level. In this stage, the process which is needed to be improved is identified by proper investigation. Flowchart has become a key tool in the development of information systems, quality management systems, and employee handbooks. Here in this stage the processes are clearly identified and the critical processes for improvement are recognized.

PROCESS MEASUREMENT

In this measurement stage, different variables are identified for the accurate measurement of the Sigma Level and defects. As it has been tried to improve the sigma level of the organization, initially the present sigma level has been measured by using an Excel based sigma calculator and it was found that the present sigma level of the studied organization not satisfactory and it was 2.7 only. Hence, to improve this level, different quality improvement tools have to be employed and the organization should be needed to set a milestone to achieve.

Table 1: Sigma calculation

Total Checked	***470***
No. of Defectives	**49**
% Defectives	**10.43%**
DPO	**0.10425532**
DPMO	**104255.32**
Sigma level	**2.7**



. **Fig. 5:** Pareto Chart

Pareto Chart which is a bar graph has been used to graphically summarize and display the relative importance of the differences between groups of data. The lengths of the bars represent frequency and have been arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which areas are more significant. In this research, the major causes or types of defects were identified through Pareto Chart. The chart was constructed by the Minitab Software. Fig. 5 shows a pareto chart in which major sweing defects and their severity have been displayed.

PROCESS ANALYSIS

The purpose of this phase is to target the improvement opportunities by taking a closer look on the different processes. Process problems and inefficiencies have been identified by root cause analysis. At the measurement phase eight major types of defects have been identified and the target of this phase is to find out all the potential causes of those defects. It is a very important stage to consider because lack of proper analysis may lead the process in a wrong way which will cause deviation from the main functions of improvement. In this stage, different basic tools of quality are preferably used to analyze the real condition of the processes.

A cause - effect diagram is drawn to analyze the potential root causes of different problems occurred in different stages of the production process. Cause - Effect diagram is a chart that identifies potential causes for particular quality problems as shown in Fig 6. They are often called fishbone diagram. These causes could be related to the machines, workers, measurement, suppliers, materials, and many other aspects of the production process.

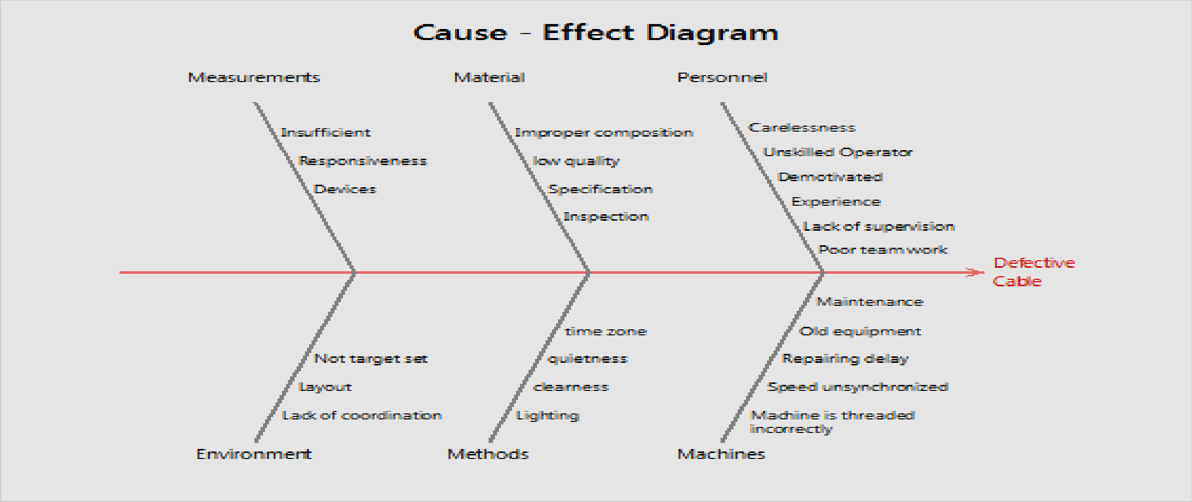


Fig. 6: Cause – Effect Diagram

Cause - Effect diagrams is constructed based on the root causes identified by the online inspection. Total 470 pieces were inspected directly and 49 defects were found. The causes behind the defects were also identified immediately. There are some vital causes shown in Table 2, which have the highest frequency of occurrence and are mainly responsible for the defects.

Table 2: Root Cause analysis

Sl No.	*Root Causes*	*Suggested Solution*
1.	Carelessness	Improve Supervision
2.	Lack of skills	Adequate training
3.	Poor team work	Proper interaction
4.	Maintenance	Make sure the machine work properly
5.	Old equipment	Change the old equipment over new ones
6.	Repairing delay	Repair as early as possible
7.	Insufficient	Make sure the cables are sufficient
8.	Devices	Check every devices before working
9.	Lighting	Provide adequate lighting
10.	Cleanness	All devices should be clean
11.	Low quality	Change into high quality materials
12.	Inspection	Proper inspection must be done
13	Low speed	Starts with low speed then gradually increase

PROCESS IMPROVEMENT

In this stage, improvement strategies are developed for achieving the desired goal. According to the analysis, perfect measures should be taken to progress the current situation. As the major concern is to implement six-sigma approach in the BCSL to improve current sigma level, it is highly needed to diagnose the critical issues responsible for this defect. For this reason, Pareto analysis is performed for different stages of production viz. maintaining wall thickness and producing loose tube, inner sheet and outer sheet to precisely identify the responsible factor of high defect and this is shown by Pareto charts in fig. 5.

PROCESS CONTROL

After taking appropriate actions for improving the process, it has been checked again whether it is under control or not, through checklist. On the basis of the results of this assessment, previous steps may be repeated several times to achieve the desired level. It is not possible always to get success at the first time, so recurring of all the steps will lead the process gradually at the preferred point. Here the major defects have been identified and partially reduced in amount. Now the real challenge is to sustain the improvements and improve the process continuously. So, this research made a sustainable control plan to sustain the improvements and make the process improving continuously.

4. Discussion

Minimizing defect is very important for ensuring the quality of products. The main purpose of this study is to increase quality level by decreasing the defects which will in turn raise the sigma level. As the minimization of defects is a continuous process further implementation of this methodology will help the company enjoying more reduction on defect rate and improvement on productivity. Though this case study has been conducted in a cable manufacturing organization, the procedures will be suitable for any manufacturing organization. During the study not all the information had been collected instantly, but some previous records have been also used for better understanding. Here in this paper, the direct implications of using six-sigma are not shown practically, but the pathways to implement them are discussed well. Due to time constraint, management could not be able to implement all of our suggestions. But they implemented some of our suggestions in short time-frame as a pilot run and found some improvement. All the charts and diagrams used here are drawn carefully to show the real scenario of the case organization. The organization is trying itself to improve its quality by reducing defects, but without using appropriate tools and techniques, it is almost impossible to make that happen. The management of BCSL has been satisfied with the Six Sigma – DMAIC based methodology discussed in this paper and ensured us that they will implement this procedure in large scale in recent future.

5. Conclusion

The six-sigma framework provides an impetus for establishing best quality practices in the organization. The primary reason for the success of Six Sigma is that it is not just a collection of tools, but it provides a systematic approach for quality and process improvement. This paper had identified the present sigma level and quality positions of the BCSl and compared it with the standard value. Future performance enhancement programs are based on a performance benchmark which has also been provided by this study.

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Paper ID: IE-16

Android Application Based MIS to Monitor and Manage Students Attendance

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Abstract

Management information system or MIS broadly refers to a computer-based system that provides managers with the tools to organize evaluate and efficiently manage departments within an organization. In order to provide past, present and prediction information, a management information system can include software that helps in decision making, data resources such as databases, the hardware resources of a system, decision support systems, people management and project management applications, and any computerized processes that enable the department to run efficiently. In this paper we mentioned about an android application based MIS to manage attendance of students of any educational institute. Now a day's people using android smart phone vastly. Lots of android application making us dependable on android based system and that is logical due to a small computing device, we focused on this matter and developed an android based MIS. Typically people use "RF-Tag" ID card or finger print scanner for time-attendance management system. There have some common difficulties in existing system that the "RF-Tag" reader and finger print scanner need high price and strong technical efficiency to setup. As we are thinking about educational institute, we see some times students can punch their friend's ID card for fake attendance. To reduce this common difficulties we work on a new attendance monitoring system. Most of people using smart phone so there have no such initial cost because, that device will be a vital part of our developed system. Using a software any android [1] mobile phone will replace "RF-Tag" reader. Also the attendance will be submitted directly by teachers so here have no option of miss management. The new system will make a virtual management link between students, teachers, and administration using some common used device. Also our developed MIS will send SMS notification to parents about their child progress. Our work will results an effective management system with help of familiar device and technology in reasonable automation cost.

Keywords: MIS, Android, E-Management, Automation.

1. Introduction

We can find many existing computerized student attendance management system, but it requires some costly hardware like RF tag card reader, finger print scanner to input attendance data or recording attendance at a register book then input it manually to MIS software. In our work we converted a commonly used android [1-3] smart phone as an attendance register and many things more. This will make the total system paperless. We made android mobile software and PC (Personal Computer) based online software that can collect daily attendance of an educational institute and produce some desired report of percent of attend/absent students. Teacher will use the android application at class room to input attendance of his class and simultaneously the data will be uploaded at online server using internet connectivity, he does not need to carry an attendance register book or any related papers. From the online database, higher authority will be able to monitor attendance details, generate various reports like daily attendance, class wise attendance, and statistics of attendance. The android application has some features like, teacher can find absent students name list from his previous submitted data and with students & guardian's contact number and teacher can call directly by a simple click. Also has a progress reporting option where the call duration with absent students list will be saved and uploaded at online with status of students. Similarly management can evaluate effort of teacher and observe his conversation details (Calling time, number, duration, etc.), there could be call record and remark writing option. The MIS is flexible according to requirements. Another useful option that any time authority will be able to send SMS notification to guardian to inform them about student's status. Our system will replace the current costly attendance management system and a daily used android mobile phone can brings MIS in palm. This system will be an enhancement of MIS.

2. Limitation of Existing Systems

From our observation we find out that the existing common attendance management system is use of "RF" tag ID card. In this system sometimes students punch another's card which is a common deception in the system and it become difficult to monitor that where has large number of student transaction. Another problem is technical difficulties due to maintenance and pricing. To overcome this limitation and making a low cost management system using the available resources of an institute we designed this management system.

3. Android Based MIS system design

Basically our designed system has three parts, an android application [1], and online database and a web application. This three component will work together and we are calling consist of this android based MIS. The technological support and resources that required in our system, those are mostly available at any institute. Personal computer is commonly used at any educational institute. Now a day most of people using android smart phones so we need only an internet online database server. Our implemented system has following components shown in "Fig:1"

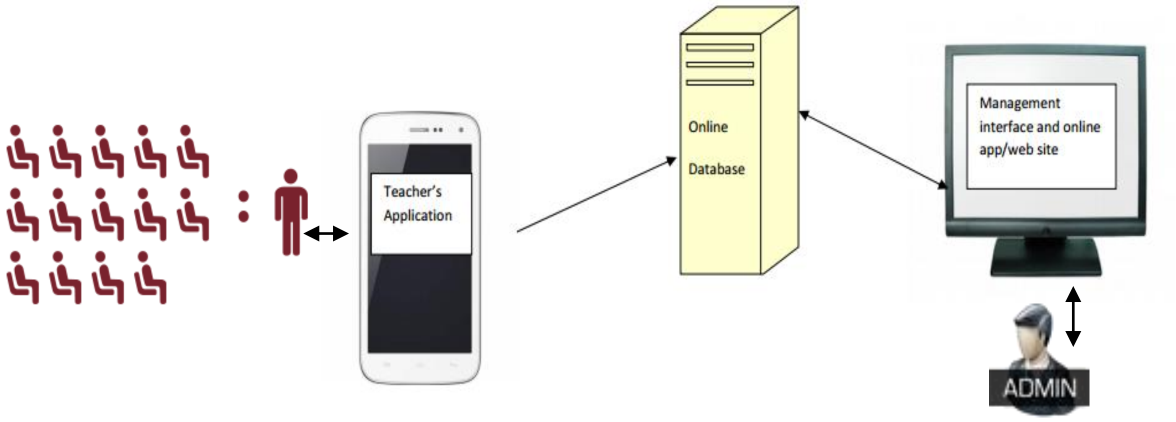

Fig. 1. Basic System Configuration

4. Required skill, tools for development and technique

From technical sense it required some skills on programming, data structure, web design, android app development and debates management system. In development process of this system we used common web programming techniques to develop online database and web application to handle database from personal computer. To develop android app we can use "Android Studio" or "Eclips". This two development studio mostly used for android programming. First of all it needs to design the database schema, flow chart and data structure of probable software. After doing this we developed the logic of android app and web site. Here also need to design a web site, it depends on user what will be the design and whatever user want. Android app development growing very fast and many programmer switched their skill in this sector. Despite it is new but in future android application will replace current pc based application. We used a bridge between data entry and data processor which is an android operating system powered smart phone. The smart phone access the online database using internet connection and transects data over there. So the processing online software get data which came from "RF-Tag" reader in traditional system. To setup SMS notification system we used bulk SMS service of mobile network operator. We connected their SMS sending API with our web application.

5. Working Procedure

We made this system user friendly as possible. First all information of students will be stored at online database which is only hard work needs to operate this system. After that the authorized person will be able to access web application and get all required report, attendance statistics, progress repost etc. Teachers will use our developed android app as replacement of traditional attendance register book. He will get all students data according to his selection and assigned subject at classroom by using internet connection. From his application he will check the name list of attend students. From this simple task the system will process a lot of report which mandatory for an educational institute. Teacher also can call the absent students from using android app and that data also will upload simultaneously to online server. Managing authority will access the web application and observe all those desired report.

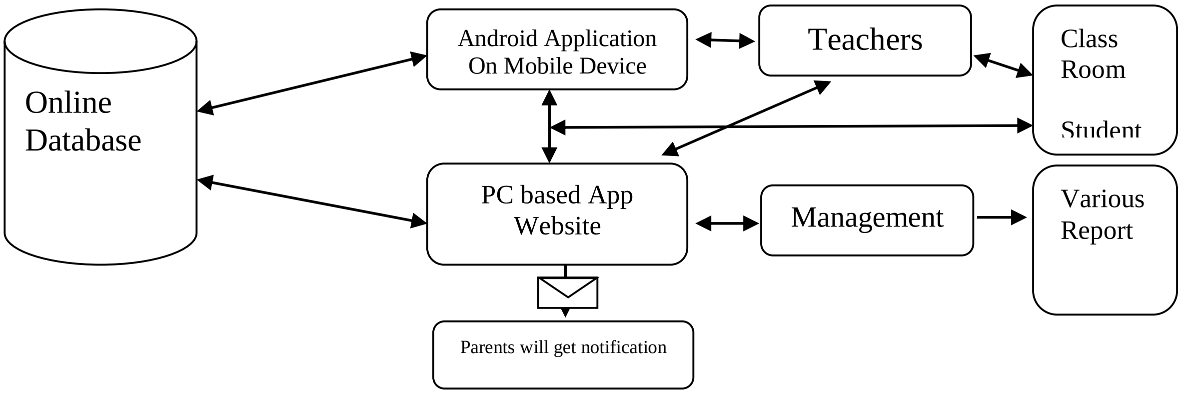

Fig. 2. System Architecture

6. Inputs of the system

Input at online database: (1) Student's basic information form PC. (2) Students and parents contact number. (From PC) (3) Teacher's authentication data to get access from android app. (4) Daily attendance from android apps. (5) Progress and communication report from android app. (6) Notice board data. (General notice, news, event) (7) Basic information of college Like: department information, teachers list and their contact, others contact information.

7. Output of the System (Web Application)

Output/Reports from Online Data using web application: (1) Department wise daily attendance and absent report. (2) Date to date or Monthly & Weekly attendance report with statistical curve. (3) Progress and phone call communication report submitted by teachers. (4) Printable various reports from online data that often need for various official purpose. (5) Semester migration. (6) Teachers routine, assigned subject list. Fig.-2 showing the real view of our developed online web application software which could be access from anywhere in the world. It needs only any web browser and internet connection.

8. Functionality of Android Application

All students will be able to access (Notice board, contact numbers of teachers and others, basic information of college) and they don't need any authentication. Teacher will be able using authentication (Password/ IMIE/Mobile Number) or any other method but very much secure. He can select and input daily attendance. He will be able to search date wise absent and attend students name list with their contact list. From that list he call make call by a click. When teacher will select progress report option and start calling students from absent list the app will record call time number and duration and save it to database have a remark field if teacher fail to reach those number.

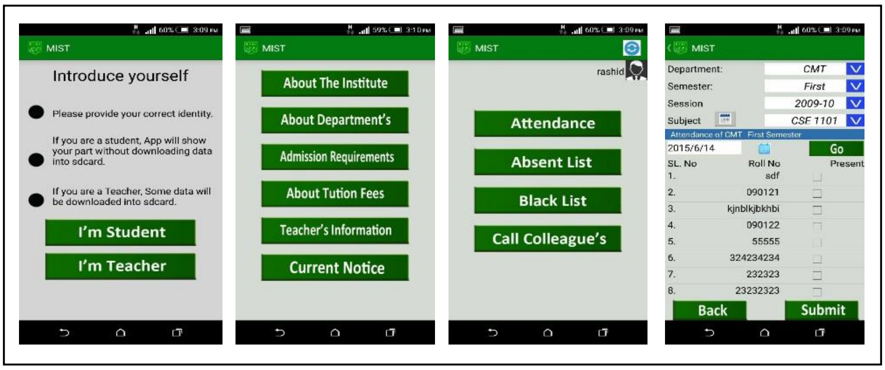

Fig. 3. GUI (Graphical User Interface) of Android Application

9. Technical Requirements and Costing

This android based attendance automation and management system has a few technical requirements like some personal computers, smart/android OS based mobile phone, internet connectivity, online database hosting. In this requirements list PCs and mobile phone almost on hand so we need only purchase a online hosting and have internet connectivity. Spreading of internet facility is a growing sector in Bangladesh so in very low cost it is possible to manage internet connection. Rather than "RF" tag, finger friend scanner our system is very low cost and has less maintenance requirements. We calculated that our android based MIS can reduce 50% of cost than a typical automated management system.

10. Advantages

As we mentioned previously that our projected cost and user friendly system will replace a large time attendance related problem and also the following advantages

- No extra device needed, a personally used phone will be a part of this system.
- User friendly software to use.
- Using of a familiar device in management will make users mind, less pressurized than a new hardware.
- After installing once, no further maintenance required.
- Very low operational cost.
- Easy to configure and training of users.
- Teachers, Parents, Management will be able to monitor student's status by a single click.
- Faster management and increase decision making capability.
- Stop corruption and less working tendency of staff.

11. Limitation and Recommendation

Despite some good features and low cost user friendly system it has some limitation like, to run this system we need all time internet connectivity and better Wi-Fi coverage else everything is perfect according to cost analysis. We also recommend and planed to include integrate this system with mobile messaging alert service to guardian.

12. Application & Implementation

One of a reputed private engineering college agreed with our system and they have already started using our "Android Based MIS for students attendance management" That college has 2000 students and 50 faculty members. They have already inputted their data and using the currently developed system as test user. We are getting very positive feedback from them.

13. Conclusion

We can strongly say that once people will be depended on small computing devices. From that sense we developed this management, based on android mobile and also based on electronic management. We can call that it is a futuristic management thinking that will today or tomorrow implemented all over the world. We integrated e-management and mobile computing together which is the future computing system for any management.

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Defects Reduction in Casting Process by Applying Six Sigma Principles and DMAIC Problem Solving Methodology (A Case Study)

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Abstract

DMAIC one of the Six Sigma methodologies used to improve quality by reducing defects through its several techniques. In this paper Six Sigma and DMAIC used as a defect reduction technique to reduce defects happening during the casting process. For this different type defects are identified, root causes are found and provide a way for minimizing the defects according to the DMAIC phases. Through DMAIC phases from many defects surface roughness is found as main defect and its root causes are found as pouring temperature too high and too coarse the molding sand grain size. For improving the condition, combination of design of experiments (DOE), and two way analysis of variance (ANOVA) are accomplished by Vassar Stats online two way ANOVA solver to find the significance of pouring temperature and grain size on surface roughness. With the help of IBM SPSS Software, boxplot is performed and through trial and error process an optimum solution is gained. At about 50% surface roughness defects are concentrated after performing DMAIC methodology which helped to reduce its defects per million opportunities (DPMO) from 609,302 to 304,651 and improve its Sigma level from 1.2 to 2.

Keywords: Six sigma, DMAIC, Casting process, Defects reduction, ANOVA

“1. Introduction”

In today’s world Competition has become much harder. TO be profitable and survive, well performance is required for every industries and organizations. As well as for different shapes and sizes products, making through the casting process, has to uphold the class of the products so that customers get delighted and excellently compete in market place. In general, one of the most vital concerns of the production which is based on casting process is the reduction of common quality defects such as surface roughness, gas porosity, shrinkage defects etc. in casting. From this theme, an organization not only wastes its means and times to rework the products, but also customer’s gratification and dependence is also reduced. This paper investigates quality issues of casting and provides a solution so that the common defects can be diminished. In order to complete it, most effective quality management and improvement methodology, Six Sigma used in this paper. In precise, the DMAIC (Define-Measure-Analyze-Improve-Control) problem-solving and improvement model of Six Sigma is followed. With the help of this model, several statistical and quality improvement tools such as fishbone diagram, Pareto chart, Design of Experiments (DOE) and two-way analysis of variance (ANOVA) have been used. As an early step, some of the relevant theories are briefly reviewed about Six Sigma and DMAIC, giving precise attention to the supports and the positive impact on performance that these approaches bring to organizations, and the manufacturing process studied.

“2. Literature Review on Six Sigma”

Six sigma was proposed by Motorola, in the mid-1980s, as an approach to improve production, productivity and quality, as well as reducing operational costs [1]. The Sigma’s name originates from the Greek alphabet and in quality control terms, Sigma (σ) has been traditionally used to measure the variation in a process or its output [2]. In the Six Sigma’s terminology, the “Sigma level” is denoted as a company’s performance [3]. Particularly, a Six Sigma level refers to 3.4 defects per million opportunities (DPMO) [4], or in other words, to have a process which only produces 3.4 defects per every one million products produced. Besides being a measure of variability and organization’s quality performance, Brue and Howes [5] mention that Six Sigma is also a management philosophy and strategy as well as a problem-solving and improvement methodology that can be applied to every type of process to eliminate the root cause of defects. In particular, some authors argue that the main benefits that an organization can gain from applying Six Sigma are: cost reduction, cycle time improvements, defects elimination, an increase in customer satisfaction and a significant raise in profits [3, 4, 6, and 7]. Markarian [8] suggests that not only can the process improvement generated by Six Sigma be used in manufacturing operations, as it is the case for the project presented in this paper, but it can also be expanded to improve business sectors such as logistics, purchasing, legal and human resources. In addition, Kumar et al. [9] state that although Six Sigma is normally used in defects reduction (industrial applications), it can also be applied in business processes and to develop new business models. Banuelas et al. [10] claim that other benefits such as (1) an increase in process knowledge, (2) participation of employees in Six Sigma projects and (3) problem solving by using the concept of statistical thinking can also be gained from the application of Six Sigma. To illustrate this point, during the utilization of Six Sigma in this research project, several tools and techniques were employed. One of the Six Sigma's distinctive approaches to process and quality improvement is DMAIC [11]. The DMAIC model refers to five interconnected stages (i.e. define, measure, analyze, improve and control) that systematically help organizations to solve problems and improve their processes. Dale et al. [6] briefly defines the DMAIC phases as follows:

• **Define** – this stage within the DMAIC process involves defining the team's role, project scope and boundary, customer requirements and expectations and the goals of selected projects [12].

• **Measure** – this stage includes selecting the measurement factors to be improved [2] and providing a structure to evaluate current performance as well as assessing, comparing and monitoring subsequent improvements and their capability [4].

• **Analyze** – this stage centres in determining the root cause of problems (defects) [2], understanding why defects have taken place as well as comparing and prioritizing opportunities for advance betterment.

• **Improve** – this step focuses on the use of experimentation and statistical techniques to generate possible improvements to reduce the amount of quality problems and/or defects [2].

• **Control** – finally, this last stage within the DMAIC process ensures that the improvements are sustained [2] and that ongoing performance is monitored. Process improvements are also documented and institutionalized [4].

DMAIC resembles the Deming's continuous learning and process improvement model PDCA (plan-do-check-act) [14]. Within the Six Sigma's approach, DMAIC assures the correct and effective execution of the project by providing a structured method for solving business problems [15]. Pyzdek [16] considers DMAIC as a learning model that although focused on "doing" (i.e. executing improvement activities), also emphasizes the collection and analysis of data, previously to the execution of any improvement initiative. This provides the DMAIC's users with a platform to take decisions and courses of action based on real and scientific facts rather than on experience and knowledge, as it is the case in many organizations, especially small and medium side enterprises (SMEs) [11].

"3. Casting process"

Casting process which is studied and investigated in this paper, are generally comprised of six main steps, namely: (1) mold-making, (2) clamping, (3) pouring, (4) cooling, (5) removal, and (6) trimming.

The process cycle for casting consists of six main stages, which are explained below.

"3.1 Mold-making"

The first step in the sand casting process is to create the mold for the casting. In an expendable mold process, this step must be performed for each casting. A sand mold is formed by packing sand into each half of the mold. The mold-making time includes positioning the pattern, packing the sand, and removing the pattern.

"3.2 Clamping"

Once the mold has been made, it must be prepared for the molten metal to be poured. The surface of the mold cavity is first lubricated to facilitate the removal of the casting. Then, the cores are positioned and the mold halves are closed and securely clamped together. It is essential that the mold halves remain securely closed to prevent the loss of any material.

"3.3 Pouring"

The molten metal is maintained at a set temperature in a furnace. After the mold has been clamped, the molten metal can be ladled from its holding container in the furnace and poured into the mold. Enough molten metal must be poured to fill the entire cavity and all channels in the mold. The filling time is very short in order to prevent early solidification of any one part of the metal.

"3.4 Cooling"

The molten metal that is poured into the mold will begin to cool and solidify once it enters the cavity. When the entire cavity is filled and the molten metal solidifies, the final shape of the casting is formed. The desired cooling time can be estimated based upon the wall thickness of the casting and the temperature of the metal. Most of the possible defects that can occur are a result of the solidification process.

"3.5 Removal"

After the predetermined solidification time has passed, the sand mold can simply be broken, and the casting removed. This step, sometimes called shakeout, is typically performed by a vibrating machine that shakes the sand and casting out of the flask.

"3.6 Trimming"

During cooling, the material from the channels in the mold solidifies attached to the part. This excess material must be trimmed from the casting either manually via cutting or sawing, or using a trimming press.

"4. Six Sigma and DMAIC Application"

"4.1 Define"

Casting is one of the most versatile forms of mechanical process for producing components because there is no limit to the size, shape and intricacy of the articles that can be produced by casting. But during casting process different types of defects are happened. Those defects are responsible for high machining cost, low product quality. So, identifying the most happening defects and reduce as many defects as possible will be the goal of these project. Numbers of casting defects were identified. The casting defects are as below. Among these the most happening casting defects were surface roughness, gas porosity and shrinkage defect.

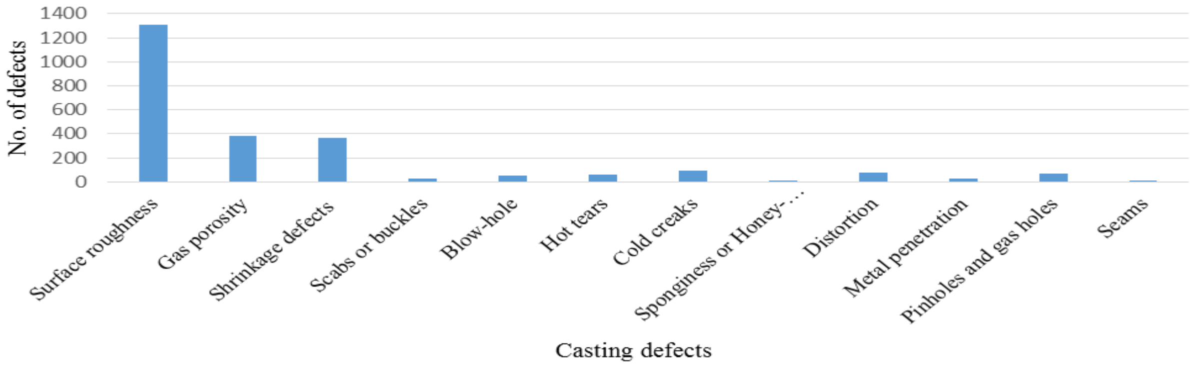

Fig. 1. Defects of casting

"4.2 Measure"

The "measure" phase of the DMAIC problem solving methodology consists of establishing reliable metrics to help monitoring progress towards the goals, which in this research consisted of reducing the number of defects in the casting process. Particularly, in this project the "measure" phase meant the definition and selection of effective metrics in order to clarify the major defects which needed to be reduced [2]. Also, a collection plan was adopted for the data to be gathered efficiently. One of the metrics defined was simply number of defects per type. In addition, two other metrics were used to compare the "before and after" states of the casting process when conducting the Six Sigma's project. These factors were quality level, which was measured through DPMO, and the Sigma level of the process. After defining the total number of defects, the DPMO and Sigma level of the casting process were calculated.

Table 1. Defect summary before the improvement

Types of defects	Number of defects	Percentage of defects
Surface roughness	1310	60.93
Gas porosity	385	17.90
Shrinkage defect	365	16.98
Others	90	4.19
Total	2150	100

As a next step, a Pareto analysis was carried out to identify the utmost occurring defects and priorities the most critical problem which was required to be tackled. The collected data was generated in the form of a Pareto chart, which is illustrated in Figure 2. The Pareto chart shown in Figure 2 indicated that the highest rate of defects was caused by Surface roughness. In particular, this type of defect contributed to over 60 percent of the overall amount of defects. Therefore, the improvement team and organization decided to initially focus on the reduction of the Surface roughness. The Surface roughness rate was then translated into the quality and Sigma levels as "Quality level 609302 DPMO" and "Sigma level 1.2 Sigma". The calculation of the DPMO and Sigma metrics allowed the improvement team and organization to have a more detail and operational definition of the current state of the casting process as well as the Six Sigma's goal in terms of the casting process improvement. These are shown in Table 2. The next stage in the Six Sigma project, and following the DMAIC methodology, consisted in analyzing the root causes of this particular problem, as well as identifying an appropriate solution.

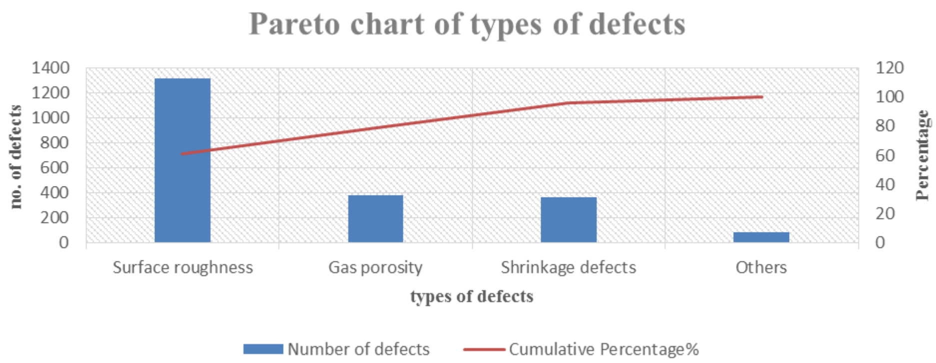

Fig. 2. Casting defects Pareto chart

Table 2. Casting process current and expected states

Major type of defects	Number of the major defect (units)		Quality levels (DPMO)		Sigma levels	
	C*	E*	C*	E*	C*	E*
Surface roughness	1310	655	6,09302	3,04651	1.2	2

C*= Current process performance;

E*= Expected process performance after the completion of the Six Sigma project

"4.3 Analyze"

This phase in the DMAIC improvement methodology involves the analysis of the system, in this case the casting process that produces product, in order to identify ways to reduce the gap between the current performance and the desired goals [11]. To do this, an analysis of the data is performed in this phase, followed by an investigation to determine and understand the root cause of the problem [7]. In order to gain an enhanced comprehension and understanding of the casting process an analysis was done through the whole process. Once that the inputs, outputs and sequence of the process were understood with the help of the flow chart, an analysis was carried out to identify the root cause of the Surface roughness. Several brainstorming sessions were conducted to identify based on the improvement team member's experience, possible causes as to why the Surface roughness problem in casting occurred. In order to illustrate and categorized the possible causes of the problem, a cause-and-effect diagram was constructed. The possible root causes brainstormed are illustrated in the cause and effect diagram shown in Figure 3.

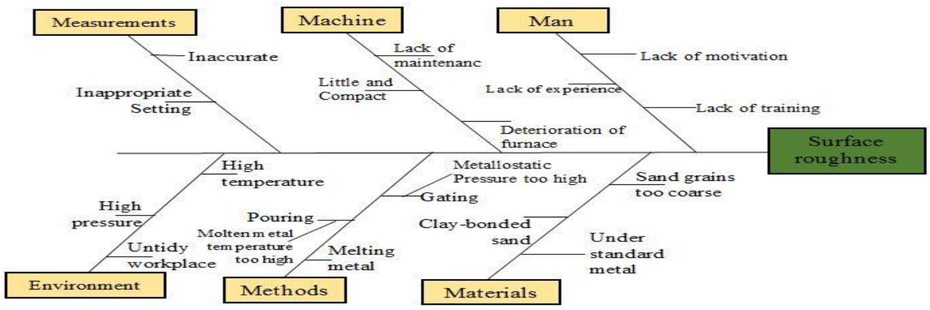

Fig. 3. Cause and effect diagram related to the surface roughness problem

In particular, it was determined that two process factors (i.e. pouring temperature and grain size of molding sand) had a direct effect on the number of Surface roughness. Therefore, the pouring temperature of molten metal and grain size of molding sand and their impact on the number of surface roughness produced was inspected in the following DMAIC's "improve" phase.

"4.4 Improve"

After the root cause(s) has/have been determined, the DMAIC's "improve" phase aims at identifying solutions to reduce and tackle them [2]. Stamatis [4] suggests the use of design of experiments (DOE), which is defined as a statistical technique to investigate effects of multiple factors, in the "improve" phase. According to Montgomery [17], benefits of DOE can be seen as enhancing process yields, decreasing variability and lowering the overall expenses. The DOE technique was used to investigate whether the assumed problem was statistically significant. In particular, an experiment was designed to investigate whether the parameters of both high temperature and too coarse grain size had a negative effect on the process, causing surface roughness. To do this and in order to analyze the experiment's results, two-way analysis of variance (ANOVA) was used. ANOVA is a statistical model for comparing differences among means of more than two populations [18]. However, if there are two sources of data (like in this case) that need to be investigated, two way ANOVA, which is a statistical methodology for analyzing the effect of two factors, is required [18]. The two factors which were mentioned earlier (i.e. pouring temperature and molding sand grain size) were investigated with four different ranges of temperatures; 700°c, 725°c, 750°c and 775°c respectively based on aluminum melting temperature which is 660°c and three distinct grain size; .030in, .015in and .0075in respectively. These parameters were defined based on the process knowledge. From this point, the experiment was conducted with two parameters (i.e. pouring temperature and grain size) at four levels. Pyzdek and Keller [3] suggest the two-way ANOVA with replication as the most effective tool to be used for this type of analysis. As the statistical test aimed at investigating whether the two factors (i.e. pouring temperature and grain size) resulted in surface roughness, a hypothesis that indicated that a variation in the number of defects would occur if the pouring temperature and grain size of molding sand were varied was formulated. The two way ANOVA with replication are shown in table-3.

Table 3. Two way ANOVA with replication

ANOVA Summary					
Source	SS	df	MS	F	P
grain size	1040.22	2	520.11	456.74	<.0001
temperature	12404.31	3	4134.77	3630.97	<.0001
grain size x temperature	2.45	6	0.41	0.36	0.8969
Error	27.33	24	1.14		
Total	13474.31	35			

The results presented in ANOVA summary table indicated that the molding sand grain size and pouring temperature both has the effect significantly, based on its significance level which is above 0.05. Therefore, the analysis helped to statistically conclude that both pouring temperature and grain size influenced for the amount of surface roughness. The next step was to determine the finest grain size based on temperature that would result in the lowest amount of defects. The numbers of defects from the experiment replications are summarized in the form of column chart in figure-4 and boxplots in figure-5. These figures denoted that 700°C temperature and grain size of .0075in provided the lowest amount of surface roughness. After the optimum parameters were defined, a trial was performed in order to test whether the optimum parameters (i.e. 700°C and .0075in) defined by the experiment were the best options to provide an improvement for the casting process and reduce defects.

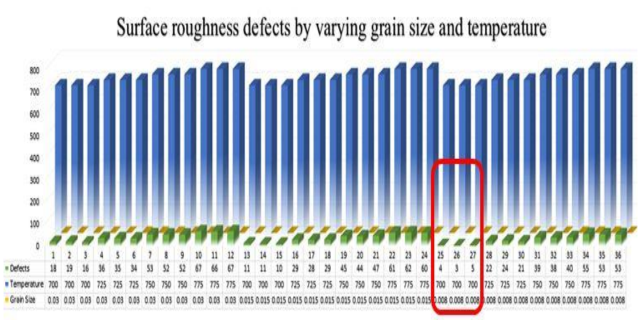

Fig. 4. Surface roughness defects by varying grain size and temperature

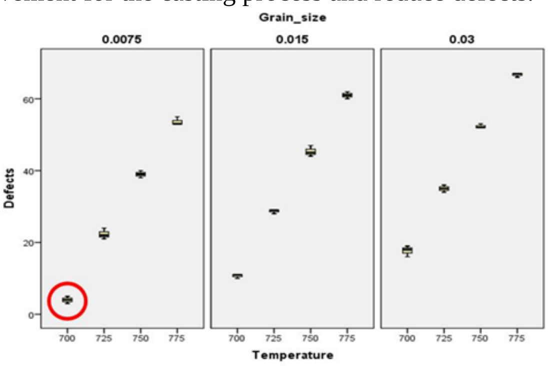

Fig. 5. Box plot of Surface roughness

Table-4 presents the results of the trial and a comparison between the "before and after" setting the new parameters. The results indicate that the optimum parameters identified in the experiment improved the casting process by reducing the amount of surface roughness by about 50%. This resulted in a reduction of DPMO from 609,302 to 304,651 and a Sigma level improvement from 1.2 to 2. Consequently, the initial targets set for DPMO and Sigma level, see Table3, were fulfilled.

Table 4. Percentage of defects between before and after the improvement

Types of defects	% of defects before the improvement	% of defects after the improvement
Surface roughness	60.93	29.465
Gas porosity	17.90	10.57
Shrinkage defect	16.98	9.75
Others	4.19	3.4
Total	100	53.185

It can be concluded that, by setting up the pouring temperate at 700°c and grain size at .0075in., not only reduced the amount of surface roughness defect but also reduced the other types of defects. The improvement also demonstrated that the utilization of Six Sigma and DMAIC problem solving methodology was effective and efficient to minimize the number of defects. A comparison between the "before and after" the Six Sigma improvement project presented in this paper is illustrated in Figure 6.

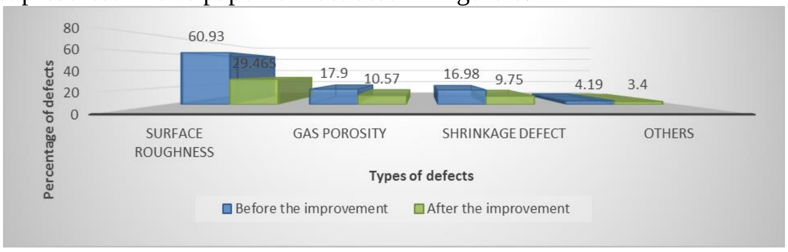

Fig. 6. "Before and after" states of conducting the Six Sigma project in the casting process

"4.5 Control"

The aim of the "control" phase is to sustain the gains from processes which have been improved by the six sigma process and controlling ongoing operations. So to keep going with this improved process the organization should concern about their pouring temperature of the molten metal so that it will not become too high and also about the grain size of molding sand that it will not become too coarse. By controlling these two things it can keep going through better surface finish.

"5. Results, Discussion and Conclusions"

This paper presented a successful study of defects reduction in casting process by applying Six Sigma principles and the DMAIC problem solving methodology. Therefore, the paper can be used as a reference for Manufacturing Industrialists to guide specific process improvement projects, in their organizations, similar to the one presented in this paper. After the analyses carried out in the "analyze" and "improve" phases of DMAIC, the improvement project presented in this paper found that the pouring temperature and grain size of molding sand had a statistically significant impact on the surface roughness defect. By considering this, a reduction in the amount of defects was obtained by determining the optimum pouring temperature and grain size, which were defined as 700°c and .0075in. respectively. This demonstrates that as long as the organization continues embracing Six Sigma within its continuous improvement culture and applies its concepts and principles to systematically solve quality problems, it is believed that benefits such as cost savings, increase in products' quality and customer satisfactions will be enhanced. The suggested methodology can be used for any type of selection problem involving any number of selection criteria. Application of this method in a wider range of selection problems in real-time manufacturing environment remains as a future research scope of this paper.

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Optimization of Cutting force in Turning AISI 1040 Steel: Using Taguchi Orthogonal Array and Genetic Algorithm

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Abstract

Turning is the well-known material removal process that removes the unwanted material from the outer diameter of the rotating cylindrical work piece. The cutting tool is moved parallel to the axis of rotation. In the turning process, a cutting force is generated by the cutting tool as it machines the work piece and it has the great effect on the machinability. The objective of this paper is to select an optimal combination of process parameters (Spindle Speed, Feed rate and Depth of cut) turning operation, resulting is an optimal value of cutting force. Taguchi orthogonal array and genetic algorithm is used for designing a high quality system. Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. In this paper Taguchi orthogonal array method and genetic algorithm is used to find the best combination of the machining parameters which gives optimal cutting force. Taguchi orthogonal array has been designed with three levels of these cutting parameters by using Minitab 16 software. Analysis of variance (ANOVA) is also conducted to determine the performance of experimental measurements and the effects of different parameters. For optimal value of cutting force, a correlation is established between cutting speed, Feed and depth of cut by regression analysis. Finally compare these results with the experimental result.

Keywords: Turning, Taguchi orthogonal array, ANOVA, Linear Regression, Genetic Algorithm.

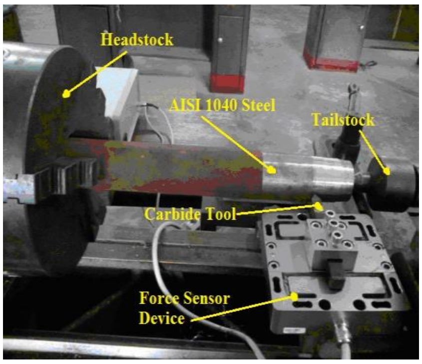
1. Introduction

Turning is a form of machining or a material removal process which is used to create rotational parts by cutting away unwanted material. Turning is the most widely used among all the cutting processes. The increasing importance of turning operations is gaining new dimensions in the present industrial age, in which the growing competition calls for all the efforts to be directed towards the economical manufacture of machined parts , The cost of machining amounts to more than 20% of the value of manufactured products in industrialized countries. Cutting force of turned components has greater influence on the quality of the product. Cutting force in turning has been found to be influenced in varying amounts by a number of factors such as feed rate, work material characteristics, work hardness, unstable built-up edge, cutting speed, depth of cut, cutting time and tool nose radius. Many studies have been made using Taguchi Method to optimize the turning parameter. Tarng. Y.S , S.C. Juang and C.H. Chang [1] proposes the use of grey-based Taguchi methods for the optimization of the Submerged Arc Welding (SAW) process parameters in hard facing with considerations of multiple weld qualities. They found that a grey relational analysis of the S/N ratios can convert the optimization of the multiple performance characteristics into the optimization of a single performance characteristic called the grey relational grade. Vijayan. P and V. P. Arunachalam [2] reported research in their work Taguchi‘s off-line quality control method applied for determines the optimal process parameters which maximize the mechanical properties of squeeze cast LM24 aluminum alloy. For this purpose, concepts like orthogonal array, S/N ratio and ANOVA were employed. Nihat Tosun Cogun and Gul Tosun [3] investigated the effect and optimization of machining parameters on the kerf (cutting width) and material removal rate (MRR) in wire electrical discharge machining (WEDM) operations. The experimental studies were conducted under varying pulse duration, open circuit voltage, wire speed and dielectric flushing pressure. The settings of machining parameters were determined by using Taguchi experimental design method. The level of importance of the machining parameters on the cutting kerf and MRR was determined by using analysis of variance (ANOVA). The optimum machining parameter combination was obtained by using the analysis of signal-to-noise (S/N) ratio. The variation of kerf and MRR with machining parameters is mathematically modeled by using regression analysis method. Sahoo. P. [4] used Response Surface Methodology (RSM) to develop a predictive

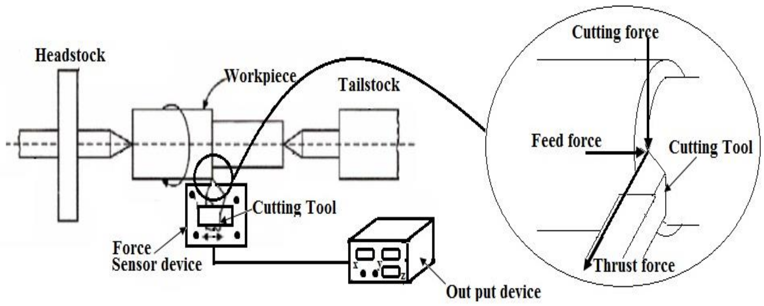
model of surface roughness in terms of machining parameters in turning based on experimental results and then used Genetic algorithm (GA) to optimize the machining parameter that results minimum surface roughness.
Saha [5] used genetic algorithm (GA) to obtain the optimum cutting parameters by minimizing the unit production cost for a given amount of material removal for the multi-pass face milling process. The cutting parameters optimized were: cutting speed, feed and depth of cut. Hasan Oktem ,Tuncay Erzurumlu and Mustafa C [6] developed a Taguchi optimization method for low surface roughness in terms of process parameters when milling the mold surfaces of 7075-T6 aluminum. Considering the process parameters of feed, cutting speed, axial and radial depth of cut, and machining tolerance, they performed a series of milling experiments to measure the roughness data. Regression analysis was performed to identify whether the experimental measurements represent a fitness characteristic for the optimization process. It is therefore imperative to investigate the machinability behavior of different materials by changing the machining parameters to obtain optimal results. The machinability of a material provides an indication of its adaptability to manufacturing by a machining process. Good machinability is defined as an optimal combination of factors such as low cutting force, good surface finish, low tool tip temperature, and low power consumption. Process modeling and optimization are the two important issues in manufacturing products. S/N ratio analysis is performed to find the optimum level of the optimum machining parameters from the experimentation is obtained. ANOVA is used to find the percentage of contribution of each parameter. Linear Regression model is used to find the relationship between their control and response parameters and correlations between them. Optimization algorithm is the process that is executed iteratively by comparing various solutions until the optimum or satisfactory solution. Accepting the best solution after comparing a few design solutions is the way of achieving optimization in many industrial design activities. Taguchi parameter design approach and Genetic Algorithm (GA) is used here to optimize the machining parameters. The selection of optimal cutting parameters, like depth of cut, feed and speed is a very important issue for every machining process, hence, the objectives of this paper is to find the best combinations of cutting parameters like speed (N), feed (f), depth of cut (d) to get the optimal cutting force and finally compare these results with the experimental results.

2. Experimental setup and conditions

For the measuring cutting force the experiments are carried out on a lathe machine which is origin in Sweden and the motor power of lathe is 3500 watt. A Photographic and schematic view of experimental setup shown in Fig.1 (a) and (b) respectively. In this experiment three different types of the force are measured with a Cutting force measurement device which is called Dynamometer, produce by Gunt Humburg Co. (Model no. FT-102).



(a)



(b)

Fig. 1 (a) Photographic and (b) Schematic view of Experimental Setup.

Cutting condition for the experimental setup is given below:
Cutting Environment : Dry
Work piece dimension: Diameter 50 mm and Length 400mm
Cutting tool : v type carbide insets
Cutting tool geometry : Side cutting edge angle-65 degree; End cutting edge angle-65 degree;
Nose radius-50 degree; Side relief angle-4 degree; End relief angle-4 degree

3. Taguchi orthogonal arrays of 3r rows for r = 2

There is an experiment having 3 factors which have three levels, then total number of experiment is (3^3) = 27. Then results of all experiments will give 100 accurate results. In Taguchi orthogonal array make list of nine experiments in a particular order which cover all factors. Those nine experiments will give 99.96% accurate result. By using this method number of experiments reduced to 9 instead of 27 with almost same

accuracy. A complete three-element orthogonal array with 3^r rows has $(3^r-1)/(3-1)$ columns and it is constructed in three steps:
Step 1: Write in the r columns specified by column numbers 1,2,5,14,..., $(3^r-1)/(3-1)+1$ a complete factorial plan in r factors each having three test levels represented by 0,1, and 2, respectively. In order to match Taguchi's display format, write this plan in such a way that the entries of the left-most columns change less frequently than do the entries of the right-most columns. Mark these columns as x_1, x_2, x_3,……., x_r respectively.
Step 2: As before the generators of the remaining columns are of the form $a_1x_1+a_2x_2+\dots\dots\dots+a_3x_3$ where x_1, x_2, x_3, …………x_r denote the r basic columns and the coefficients a a_1, a_2, a_3………, a_r for a particular column are given in the appropriate row of table . List the generators in the order of column numbers.
Step 3: Compute the entries of the remaining columns by using the entries of the r basic columns and the appropriate generators. All calculations are done in module 3 arithmetic. All these steps are shown in the Table 1, Table 2 ,Table 3 and Table 4.

Table 1: Coefficients of the generators of two-element orthogonal arrays of *2'* rows for r = 2

Column no	a_1	a_2	Column no	a_1	a_2	
1	1	0	7	2	0	First(3^{r-1})/(3-l) entries are 0 Next (3^{r-1}) entries are 1 Next (3^{r-1}) entries are 0 Next (3^{r-1}) entries are 1 Next (3^{r-1}) entries are 2
2	0	1	8	0	1	
3	1	1	9	1	1	
4	2	1	10	2	1	
5	0	0	11	0	2	
6	1	0				

Construction of an OA9 (3^3) Here N = 9= 3^2 so r =2.
Step 1: Write the r = 2 basic columns

Table 2: Basic column

Column No. / Row No.	1	2	3
1	0	0	-
2	0	1	-
3	0	2	-
4	1	0	-
5	1	1	-
6	1	2	-
7	2	0	-
8	2	1	-
9	2	2	-

Step 2: List the generators (see rows 1 to 3)

Table 3: Generators

Column no	Generator
1	x_1
2	x_2
3	x_1+x_2

Step 3: Complete the array (Column No. 3) using the generators identified in step 2.

Table 4: Complete Array

Column No. / Row No.	1	2	3
1	0	0	0
2	0	1	1
3	0	2	2
4	1	0	1
5	1	1	2
6	1	2	0
7	2	0	2
8	2	1	0
9	2	2	1

4. Experimental data analysis

In the experiment, three cutting parameters (Speed, Feed and Depth of cut) are considered with three different levels. All these cutting parameters with different level is shown in the Table 5.

Table 5: Cutting Parameters

Level	Speed in rpm	Feed in mm/rev	Depth of cut in mm
1	395	0.12	0.4
2	490	0.14	0.7
3	650	0.16	1

Taguchi method stresses the importance of studying the response variation using the signal-to-noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The Cutting force was considered as the quality characteristic with the concept of "the smaller-the-better". That is, it will be better if there is produced lower cutting force for turning operation. The S/N ratio for the smaller-the-better is given by the equation (i).

$$S/N = -10\log_{10}\sum_{i=1}^{n}(y_i^{\,2}/n) \qquad \text{(i)}$$

Where, n is the number of measurements in a trial and y is the measured value in a run. The S/N ratio values are calculated by taking into consideration the above equation and with the help of software Minitab 16. Three different types of cutting force (Feed force, Thrust force and Axial force) at different level with S/N ratio are shown in Table 6.

Table 6. Experimental data and S/N ratios for Cutting Force

Experiment No.	Speed, V in rpm	Feed, f in mm/rev	Depth of cut, D in mm	Cutting Force				S/N ratio
				F1 in KN	F2 in KN	F3 in KN	Mean F in KN	
1	395	0.12	0.4	0.10	0.09	0.10	0.096667	20.2841
2	395	0.14	0.7	0.17	0.19	0.17	0.176667	15.0446
3	395	0.16	1.0	0.19	0.19	0.18	0.186667	14.5759
4	490	0.12	0.7	0.15	0.13	0.11	0.13	17.6531
5	490	0.14	1.0	0.20	0.19	0.18	0.19	14.4169
6	490	0.16	0.4	0.11	0.14	0.13	0.126667	17.9048
7	650	0.12	1.0	0.14	0.13	0.15	0.14	17.0627
8	650	0.14	0.4	0.10	0.09	0.12	0.103333	19.6524
9	650	0.16	0.7	0.17	0.15	0.14	0.153333	16.2586

5. Result analysis and discussion

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore the optimal level of the machining parameters is the level with the greatest value.
Using Minitab-16 Table 7 and Table 8 are found.

Table 7. Response for S/Noise Ratios of Cutting Force

Level	Speed	Feed	Depth of cut
1	16.63	18.33	19.28
2	16.66	16.37	16.32
3	17.66	16.25	15.35
Delta	1.03	2.08	3.93
Rank	3	2	1

Table 8. Response for Means of Cutting Force

Level	Speed	Feed	Depth of cut
1	0.1533	**0.1222**	**0.1089**
2	0.1489	0.1567	0.1533
3	**0.1322**	0.1556	0.1722
Delta	0.0211	0.0344	0.0633
Rank	3	2	1

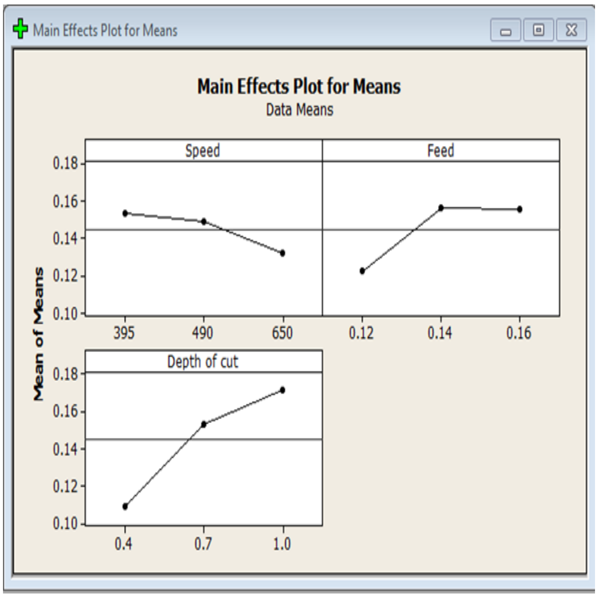


Fig. 2. Mean of cutting force form Data

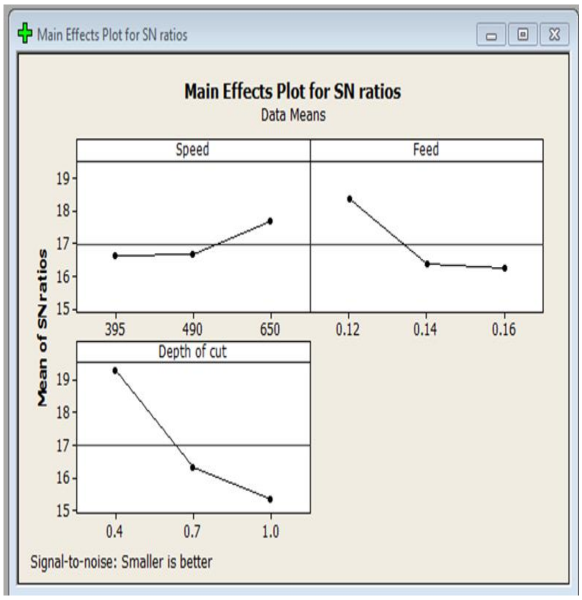


Fig. 3. S/N ratio of cutting force form Data

From Fig. 2. & Fig. 3. it is clear that cutting force is minimum at the 3rd level of cutting parameter speed (V), 1st level of parameter feed (f) and 1st level of cutting parameter depth of cut (D). The effect of cutting parameters are shown that when the speed is increased from 395 rpm to 650rpm, cutting force is decreased from 0.1533 KN to 0.1322 KN, when the feed rate is increased from 0.12 mm/rev to 0.16 mm/rev, cutting force is increased from 0.1222 KN to 0.1556 KN, when the depth of cut is increased from 0.4 mm to 1 mm, cutting force is also increased from 0.1089 KN to 0.1722 KN. So the best combinations of cutting parameters feed, speed and depth of cut to get the optimal cutting force are given below:

Spindle Speed: The effect of parameters spindle speed on cutting force values is shown above figure for S/N ratio. Its effect is increasing with increase in spindle speed. So optimum spindle the speed is level 3 i.e. 650 rpm.

Feed Rate: The effect of parameters feed rate on cutting force values is shown above figure S/N ratio. Its effect is decreasing with increase in feed rate. So the optimum feed rate is level 1 i.e. 0.12 mm/rev.

Depth of Cut: The effect of parameters depth of cut on cutting force values is shown above figure for S/N ratio. Its effect is decreasing with increase in depth of cut. So the optimum depth of cut is level 1 i.e. 0.4 mm.

From the above, the best combination of cutting parameters (speed, feed and depth of cut) is (650,.12,.4).

Analysis of variance (ANOVA) is the application of a statistical method to identify the effect of individual cutting parameter. Results from ANOVA can determine very clearly the impact of each cutting parameter on the process results. Table 9 shows the analysis of variance with arithmetic average of cutting force. This analysis is carried out for a 5% significance level i.e. for a 95% confidence level.

Table 9. ANOVA data table for Cutting Force

Source	DOF	SS	MS	F ratio	P	Contribution %
Speed	2	0.0007432	0.0003716	7.00	0.125	7.83
Feed	2	0.0022988	0.0011494	21.65	0.044	24.22
Depth of cut	2	0.0063432	0.0031716	59.74	0.016	66.83
Error	2	0.0001062	0.0000531			1.12
Total	8	0.0094914				

From the ANOVA Table 9 of Cutting Force with the suitable F values and contributions of the Factors for 95% confidence level show that the Depth of cut (F = 59.74 and 66.83%) and Feed (F=21.65 and 24.22%) are the two significant factors and other factor Speed (F = 7.00 and 7.83%) is the factor found to be insignificant.

5.1 Predicted cutting force for Taguchi method

The predicted cutting force at the optimal levels are calculated by using the following equation:

$$Y_{predicted} = Y_{\exp} + \sum_{n=1} (Y_{im} - Y_{\exp}) \quad \text{(ii)}$$

Where, Ypredicted - Predicted response value after optimization, Y_{exp}-Total mean value of quality characteristics, Y_{im} - Mean value of quality characteristic at optimal level of each parameter and i - Number of main machining parameters that affect the response parameter.

So, Ypredicted (Cutting force) = 0.1448 + (0.1322 – 0.1448) + (0.1222 – 0.1448) + (0.1089 – 0.1448)
= **0.0737 KN**

5.2 Regression model

The experimental results are used to obtain the mathematical relationship between process parameters (Speed, Feed and Depth of cut) and machine outputs(Cutting Force). The co-efficient of mathematical models is computed using method of general linear regression. For the linear regression equation minitab-16 software is used.

Table 10. Co-efficient of Linear Regression

Predictor	Co-efficient
Constant	-0.0022
Speed	-0.000085
Feed	0.833
Depth of cut	0.106

So the regression equation of Cutting Force, F = - 0.0022 - 0.000085 V + 0.833 f + 0.106 D

5.3 Predicted cutting force for regression model

For the optimal level of machining parameters V=650 rpm, f=0.12 mm/rev and D=0.4 mm. So the Cutting Force of the regression model is-

F = (- 0.0022 - 0.000085 *650 + 0.833 * 0.12 + 0.106 *0.4) = **0.08491 KN**

5.4 Cutting force for genetic algorithm based optimization

GA-based approaches are used for optimization of machining parameters. From the observed data for Cutting Force, the response function has been determined using Regression Model and fitness function is defined as

Minimizing, Cutting force (F) = - 0.0022 - 0.000085 V + 0.833 f + 0.106 D

Subject to:

395 rpm ≤ V ≤ 650 rpm;

0.12 mm/rev ≤ f ≤ 0.16 mm/rev; and

0.4 mm ≤ D ≤ 1 mm;

xil ≤ xi ≤ xiu

where xil and xiu are the upper and lower bounds of process variables xi, x1, x2, x3 are the cutting speed, feed, depth of cut respectively. Form this formulation and using MATLAB, the result of the fitness function and the variables is shown below in Table 11.

Table 11. Output value of the Genetic Algorithm

Machining Parameters	Output of Genetic Algorithm Method
Speed , V in rpm	647.0841
Feed , f in mm/rev	0.12
Depth of cut , D in mm	0.4
Minimum Cutting force , F in KN	0.08516

5.5 Comparisons of the results

The outcome of the calculations and formulation for the optimization of cutting force by the methods i.e. Prediction by Taguchi Method, Regression model and Genetic Algorithm is shown in Table 12. By using the optimal factor level combination suggested by Taguchi Methodology the experiments are conducted. It is found that the optimum experimental cutting force is 0.08333 (KN)

Table 12. Comparison of the Results of Cutting Forces by different methods

	Taguchi Method	Linear Regression Model	Genetic Algorithm	Experimental
Cutting Force	0.0737 (KN)	0.08491(KN)	0.08516(KN)	0.08333(KN)
Best Combination (V , f , D)	650 , 0.12 , 0.4	650 , 0.12 , 0.4	647.084, 0.12, 0.4	650 , 0.12 , 0.4

6. Conclusion

Several conventional techniques are used in the turning process for machining optimization problems. Taguchi L9 orthogonal array GA method is used in this paper for optimizing cutting parameters. In the Orthogonal array, the best combination of cutting parameters is obtained and the result is spindle speed, feed rate and depth of cut respectively 650 rpm, 0.12mm/rev and 0.4mm. From ANOVA it is also found that the Depth of cut has 66.83% and feed has24.22% contribution on cutting force. Optimum cutting force using Regression analysis model and GA is found 0.08491 KN and 0.085682 KN respectively. The experimental cutting force for the best combination of cutting parameters is 0.08333 KN.

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Performance Evaluation of a Supply Chain Network Distinctly by Some New Flexibility Indexes with the Real-World Applicability: A Case Study

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Abstract

Supply chain management, analysis, and improvement are becoming increasingly important. To develop and improve a supply chain network, the evaluation of its quantitative performance is a prerequisite that has to be consistent with the real-world situations. In this paper, we propose flexibility measures: demand flexibility, lead time flexibility, and product type flexibility as new indices to evaluate the quantitative performance of a specific type of supply chain network. To describe these measures some assumptions are made. Finally, numerical analysis is adopted to illustrate the performance of the supply chain by means of flexibility indexes distinctly in favor of searching an optimal supply chain network with respect to industrial case.

Keywords: Supply Chain Network, Flexibility Index, Performance Evaluation, Industrial Case.

1. Introduction

A supply chain network (SCN) is an integration of facilities, supplies, customer, information, communication, transportation, manufacturing, distribution, purchasing, and method of controlling inventory etc. In recent years, the importance of designing an optimal supply chain network is becoming necessary because of competitive business due to globalized market. Nevertheless, designing an optimal supply chain is a difficult and critical task because supply chain network design covers a wide range of areas including multiple layers, members, periods, products, and inventory decision [1]. Designing obviously includes the task of performance evaluation. Three types of performance measures are: resource measures (generally cost), output measures (generally customer responsiveness), and flexibility (how well the system reacts to uncertainty) measures [2]. Among these three we present the flexibility measure. The measurements of flexibility that are existent are: volume flexibility, delivery flexibility, mix flexibility, new product flexibility [2]. But in this paper we propose three new measurements of flexibility these are: demand flexibility, product type flexibility, and lead time flexibility to evaluate supply chain performance in favor of designing an optimal supply chain network. Firstly the formulation of these flexibility measurements is done and secondly the numerical analysis is adopted by taking the necessary data from two case companies named 1) Lafarge Surma Bangladesh Lt, and 2) Bangladesh Master Pack Limited.

2. Literature Review

The literature on the quantitative performance evaluation considering the real-world situation of the system is limited. Tinggui Chen et al. [1] present a new method for evaluating the performance of a supply chain network. The main index is cost factors, which include four categories: production costs, disruption costs, co-ordination costs, and vulnerability costs. Benita M. Beamon [2] presents an overview and evaluation of the performance measures used in supply chain models and also presents a framework for the selection of performance measurement systems for manufacturing supply chains. He presents four flexibility indices to evaluate the performance of a supply chain. Zuo-Jun Max Shen [3] presents a profit-maximizing supply chain design model in which a company has flexibility in determining which customers to serve. The company may lose a customer to competition if the price it charges is too high. Benita M. Beamon [4] presents a focused review of literature in multi-stage supply chain modeling and defines a research agenda for future research in this area. He also presents that, for years, researchers and practitioners have primarily investigated the various processes within manufacturing supply chains individually. Recently, however, there has been increasing attention placed on the performance, design, and analysis of the supply chain as a whole. This attention is largely a result of the rising costs of manufacturing, the shrinking resources of manufacturing bases, shortened product life cycles, the leveling of the playing field within manufacturing, and the globalization of market economies. Jayaraman and Pirkul [5] had considered total cost of supply chain as an objective function in their studies. However, there are no design tasks that are single objective problems. The design, planning, scheduling projects are usually involving trade-offs among different incompatible goals. Recently, multi objective optimization of SCNs has been considered by different researchers in literature. Altiparmak et al. [6] Leaving aside the procurement function (purchasing of raw materials), the SC network becomes a multi-echelon production/distribution system. Santoso et al. [7] the design of SC networks is a difficult task because of the intrinsic complexity of the major subsystems of these networks and the many interactions among these subsystems, as well as external factors such as the considerable uncertainty in product demands. Tsiakys et al. [8] in the past, this complexity has forced much of the research in this area to focus on individual components of supply chain networks. Recently, however, attention has increasingly been placed on the performance, design, and analysis of the supply chain as a whole. In the last decades, several optimization procedures have been developed to solve NP-hard problems. In the last decades, several optimization procedures have been developed to solve these problems. Recently, Amiri [9] presented a heuristic method based on the Lagrange relaxation technique to minimize the total cost of a two stages, un-capacitated SCN distribution network. Ilkka Sillanpää [14] presents an empirical study of measuring supply chain performance. The purpose of this paper is to create a supply chain measurement framework for manufacturing industry. The key elements for the measurement framework were defined as time, profitability, order book analysis and managerial analysis. The measurement framework is tested by measuring case SC performance. Suggestions for future research are multiple case studies in different manufacturing industry areas and positivistic-based SC performance research. The remaining of this paper is organized as follows. Section 3 describes the illustration of supply chain network and formulation of different measurements of flexibility. In section 4, numerical analyses are adopted with respect to industrial cases. The conclusion and future work are shown in section 5. Section 6 represents references.

3. The Method for Evaluating Supply Chain Network Performance

3.1 Illustration of a Supply Chain Network

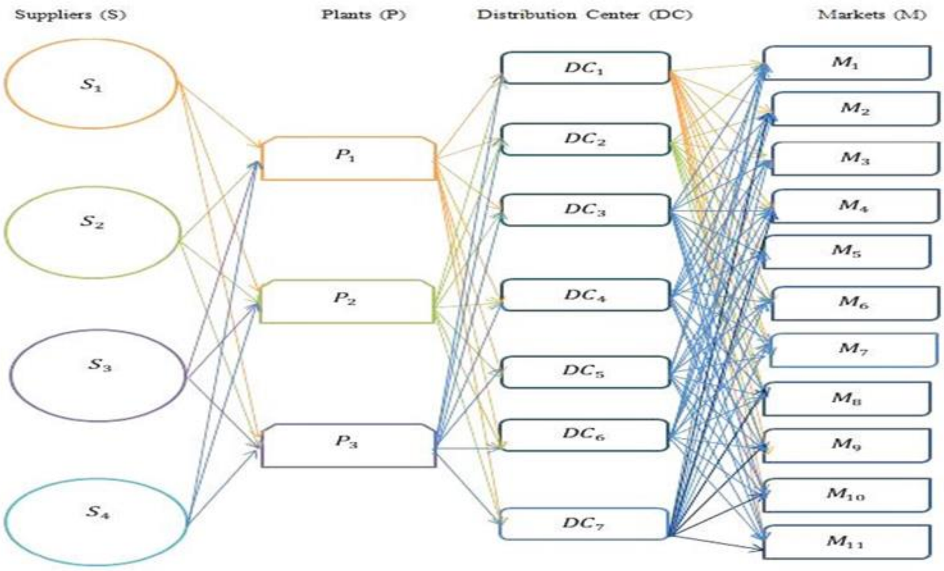

Fig. 1. Existing supply chain network of Lafarge Surma Bangladesh Lt

The topological structure of a supply chain is shown in figure 1. We all know that, purchasing, distribution, planning, marketing, and manufacturing organizations along the supply chain operated independently. But every organization has its own objective so these are often conflicting [1]. Therefore, an optimal, stable, and efficient supply chain is always necessary. Illustration of a supply chain is shown in figure 1. In figure 1, we can see that if we want to deliver a product directly from plant to the market then a direct connection between the plants to the market is needed. Furthermore, as depicted in figure 1, there, distribution centers, and transportations in the supply chain network.

3.2 Supply Chain Performance Evaluation

3.2.1 Demand flexibility (F_D)

The generalization of demand flexibility is to measure of the range of demand of product that will be demanded by customer at a certain time period. For any manufacturing system demand fluctuation incurs generally cost to the business. Demand could be greater or less than the volume that the manufacturer produces. But we consider here that the market demand is always equal to the volume that is transferred to the market stage from the manufacturing stage through the supply chain. For the establishment of supply chain demand flexibility measure we are interested in how much the market demand can be met considering the range of product that are produced profitably by the manufacturer. Here we also assume that the production of product is approximately equal to the demand. So that inventory does not affect the profit of the manufacturer when the demand is in a profitable range.

Demand flexibility measure, F_D measures the proportion of demand that can be met by the existing supply chain. Let us consider that demand volume (D) is a random variable of an approximate normal distribution. Again consider that the maximum and minimum market demand is D_{max} and D_{min} respectively. If the demand volume data are available then we can consider mean demand and demand variance as $\bar{D}$ and S_D^2, respectively, where

$$\bar{D} = \frac{\sum_{t=1}^{T} d_t}{T} \qquad (1)$$

And

$$S_D^2 = \frac{\sum_{t=1}^{T} (d_t - \bar{d})^2}{T-1} \qquad (2)$$

Where d_t the demand during time period t and T is the number of periods we assume.

Demand flexibility can be written as

$$F_D = P\left(\frac{D_{min} - \bar{D}}{S_D} \leq D \leq \frac{D_{max} - \bar{D}}{S_D}\right) \qquad (3)$$

Or

$$F_D = \Phi\left(\frac{D_{max} - \bar{D}}{S_D}\right) - \Phi\left(\frac{D_{min} - \bar{D}}{S_D}\right) \qquad (4)$$

Where $0 < F_D < 1$, and F_D represents the long-run proportion of demand which can be met by the supply chain. The demand flexibility above represents the performance of supply chain the manufacturer uses.

3.2.2 Lead Time Flexibility (F_L)

The scope of delivering a product considering extended lead time and reduced lead time are important in supply chain management. This ability facilitates supply chain to accurate orders and special orders etc. Lead time flexibility can be expressed as the percentage of lead time that can be either extended or reduced. Although reduction of lead time is at most a rare case in the real world situation, it might be considered as a favorable case for the manufacturer. If there are p= 1, 2, 3, ….., P products in the system then the total lead time that is deviated from the actual lead time can be given by the quantity

$$\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^e - t^*) - (T_p^d + L_d^n - t^*)\} \text{ for the case of extension of lead time}$$

And

$$\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^r - t^*) - (T_p^d + L_d^n - t^*)\} \text{ for the case of reduction of lead time}$$

Where,

t^* = time when order is placed, T_p^d = exact delivery time of product, L_p^n = normal lead time, L_p^e = extended lead time, L_p^r = reduced lead time.

The lead time flexibility can be expressed in percentage form as

$$F_L = \frac{\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^e - t^*) - (T_p^d + L_d^n - t^*)\}}{\sum_{p=1}^{P}(T_p^d + L_p^n + L_p^e - t^*)} \times 100\% \text{ (for the extension of lead time)} \qquad (5)$$

This simplifies to

$$F_L = \frac{\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^e) - (T_p^d + L_d^n)\}}{\sum_{p=1}^{P}(T_p^d + L_p^n + L_p^e - t^*)} \times 100\% \tag{6}$$

$$F_L = \frac{\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^r - t^*) - (T_p^d + L_d^n - t^*)\}}{\sum_{p=1}^{P}(T_p^d + L_p^n + L_p^r - t^*)} \times 100\% \text{ (for the reduction of lead time)} \tag{7}$$

This simplifies to

$$F_L = \frac{\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^r) - (T_p^d + L_d^n)\}}{\sum_{p=1}^{P}(T_p^d + L_p^n + L_p^r - t^*)} \times 100\% \tag{8}$$

3.2.3 Product Type Flexibility (F_{pt})

Conceptually the product type flexibility is same as the process and job flexibility of a system. This can be expressed as the percentage of number of additional products type that can be produced at a certain time period. Additional products mean the extra products that have to be produced with the initial or existing product type. Here assumption should be made that an additional product will take the same labor and time as the previous product one. Let P_j^i is the initial number of product type, P_k^a isthe additional number of product type, and there are j= 1, 2, 3,..…, J types of initial product and k= 1, 2, 3,…., K types of additional product. Then the product type flexibility can be calculated as

$$F_{pt} = \frac{(\sum_{j=1}^{J} P_j^i + \sum_{k=1}^{K} P_k^a) - \sum_{j=1}^{J} P_j^i}{\sum_{j=1}^{J} P_j^i + \sum_{k=1}^{K} P_k^a} \tag{9}$$

This simplifies to

$$F_{pt} = \frac{\sum_{k=1}^{K} P_k^a}{\sum_{j=1}^{J} P_j^i + \sum_{k=1}^{K} P_k^a} \tag{10}$$

4. Numerical Analysis

4.1 Demand flexibility (F_D)

We collect some data from Cement Company named Laferge Surma Bangladesh Lt in where Market wise Demand Volume in Metric ton is like as in table 1. The manufacturer supplies product using its supply chain at eleven markets:

Table 1. Market wise Demand Volume in Metric ton *(Source: Lafarge Surma Bangladesh Lt)*

Market	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9	M_{10}	M_{11}
Demand	4100	3600	3300	2800	3600	3100	3500	3300	3400	3400	3700

So, for this system

$$\bar{D} = \frac{\sum_{t=1}^{T} d_t}{T} \cong 3436.36 \tag{11}$$

And

$$S_D = \sqrt[+]{S_D^2} = \sqrt[+]{\frac{\sum_{t=1}^{T}(d_t - \bar{d})^2}{T-1}} \cong 335.48 \tag{12}$$

The system has the maximum and minimum profitable demand is 4100 and 2800 metric ton respectively per unit time period so the demand flexibility can be determined by:

$$F_D = \Phi\left(\frac{4100-3436.36}{335.48}\right) - \Phi\left(\frac{2800-3436.36}{335.48}\right)$$
$$\Phi(1.98) - \Phi(-1.90)$$
$$0.9474 \tag{13}$$

4.2 Lead Time Flexibility (F_L)

Laferge Surma Bangladesh Lt is able to deliver its product approximately within two days after ordering by its customer that means lead time is two days. The company has single type of product so p=1. Letting the ordering dates by the customer are: 1, 8, 15, and 22 in a certain month (ordering dates are the first day of consecutive weeks of a certain month) and both the extension and reduction of lead time is one day then we can show these data at a glance as in table 2.

Table 2. Ordering time, delivery time, and lead time *(Source: Lafarge Surma Bangladesh Lt)*

Ordering time	Time to deliver T_p^d	Normal Lead time L_p^n (day)	Extended lead time L_p^e (day)	Reduced lead time L_p^r (day)
1	3	2	1	1
8	10	2	1	1
15	17	2	1	1
22	24	2	1	1

So the lead time flexibility is

$$F_L = \frac{\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^e - t^{*}) - (T_p^d + L_d^n - t^{*})\}}{\sum_{p=1}^{P}(T_p^d + L_p^n + L_p^e - t^{*})} \times 100\% \text{ (when lead time extended)} \quad (14)$$

$$= 20\%$$

And

$$F_L = \frac{\sum_{p=1}^{P}\{(T_p^d + L_p^n + L_p^r - t^{*}) - (T_p^d + L_d^n - t^{*})\}}{\sum_{p=1}^{P}(T_p^d + L_p^n + L_p^r - t^{*})} \times 100\% \text{ (when lead time reduced)} \quad (15)$$

$$= 20\%$$

4.3 Product Type Flexibility (F_{pt})

Bangladesh Master Pack Lt Produces five types of Bag: FIBC, WPP Bag, Jumbo Bag, Bulk container, and Builder Bag initially but now wants to produce other tree types of Bag so if it has a supply chain like figure 1 then that supply chain will have a performance.

Table 3. Initial and additional number of product and product type *(Source: Bangladesh Master Pack Limited)*

Initial number of product type P_j^i					Additional number of product type P_j^a		
FIBC	WPP bag	Jumbo bag	Bulk container	Builder bag	P_1	P_2	P_3
350	300	200	350	300	250	350	400

So, we get

$$F_{pt} = \frac{\sum_{k=1}^{K} P_k^a}{\sum_{j=1}^{J} P_j^i + \sum_{k=1}^{K} P_k^a} \cong 0.4 \quad (16)$$

So the product type flexibility of supply chain of Bangladesh Master Pack Limited is approximately 40% when the approximate number of monthly production of FIBC, WPP Bag, Jumbo Bag, Bulk container, and Builder Bag are: 350, 300, 200, 350, 300 respectively with the additional number of products P_1= 250, P_2= 350, P_3= 400.

5. Conclusion

In this paper, we present some new measures for evaluating the performance of a supply chain network. The main index is flexibility measures, which includes some categories among these, we propose three categories: demand flexibility, lead time flexibility, and product type flexibility. Additionally, to describe these flexibility indices some assumptions are made. Finally, numerical analysis is adopted to illustrate its efficiency and effectiveness in searching for an optimal scheme in supply chain network design.

The future work may be focus on the following two aspects: (1) how to find out other flexibility indices need further study; (2) other influence factors such as customer satisfactory may also affect the decision making of a supply chain network design. As a result, how to quantify these indices is another direction that may be explored in future.

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Best Supplier Selection Using Analytical Hierarchy Process (AHP) of a Furniture Industry in Bangladesh

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Abstract

Supplier selection is one of the most important functions of Supply Chain Management. In this competitive global world markets, companies are under pressure to find ways to minimize production and material costs in order to survive and sustain their competitive position in their respective markets. Since a qualified supplier is a main element and a good resource for a buyer in reducing such costs, evaluation and selection of the potential suppliers has become an important function of supply chain management. Supplier should be compared based on their impact on the supply chain surplus and total cost. Supplier selection decision should not be driven based solely on the price. Many other characteristics such as lead time, reliability, quality also affect the total cost of doing business with a supplier. In such a case, multi criteria decision making tool may be used. In this study, a multi criteria decision making tool known as Analytical Hierarchy Process (AHP) has been used for solving such a multi criteria supplier selection problem. In this paper we apply Analytical Hierarchy Process (AHP) to select the best supplier of a furniture industry in Bangladesh.

Keywords: Supply chain management, Analytical Hierarchy Process (AHP), Multi criteria decision.

1. Introduction

In modern supply chain management suppliers are considered not only a supplier of raw materials rather they are considered as a part of that organization. The supplier evaluation process not only helps defending the shortage of materials for production but also helps in maintaining the buyer-seller relationship and many other business aspects. In early times cost was the prime priority. Minimizing cost and maximizing revenue through value addition of suppliers and other management aspects such as, quality management, distributions, competitive pricing etc. are to be incorporated as the criteria of supplier selection [1] But now a days supply quality, supply lead time, supplier reliability, supplier flexibility etc. are considered as important along with cost. Selecting the right supplier significantly reduces purchasing costs, improves competitiveness in the market and enhances end user satisfaction [2]. Thus supplier selection is the evaluation of different criteria and various supplier attributes, it can be considered as a multiple criteria decision making (MCDM) problem. Since these are qualitative terms a quantitative conversion is needed for comparison among alternatives. Different approaches are available for these purposes. Analytical Hierarchy Process (AHP) is a multi-criteria decision-making tool that has been used in almost all the applications related with decision-making [3]. AHP, developed by Saaty, addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives. The relevant data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion [4]. In our study we incorporate eight criteria-Quality, Pricing, Lead Time, Supply Capability, Payment Term, Country of Origin, Uncertain Demand Capability and Conduct Media. We compare among four alternative suppliers with respect to these eight criteria.

2. Literature review

Analytical hierarchy process (AHP) is a mathematical tool for taking decisions in case of multiple constraint function. It is a mathematical approach for converting qualitative terms into quantitative measure. This tool is used by business organizations and researchers for such type of decisions. This tool is also extensively used for supplier selection in business organizations. Özkan et al. [5] used the AHP to choose the best supplier for computer and printer purchasing for General Directorate of Land Registry with respect to 4 main criteria and 16 sub criteria. They compare between the alternatives and the criteria and select best supplier by rating them. Dain et al. [6] proposed a five step AHP model to the supplier selection decision for strategic development of lean suppliers at a large German industrial company. They established a pre-filter based on Spekman (1989) in order to reduce the number of detailed supplier evaluations if suppliers meet the minimum requirements for supplier development. Tanmoy et al. [7] proposed a novel heuristic approach as an optimization technique to solve the multi criteria decision making problem for supplier selection. The initial solution of the problem had been achieved using AHP and thereafter the quality of the solution is improved using the proposed heuristic technique. Damle et al. [8] used a pair wise comparison among three alternative suppliers based on three criteria. They used four pair of quality for their comparison. Mustafa [9] used fuzzy AHP for supplier selection problem. The Fuzzy AHP model had been utilized to solve the supplier selection problem of a manufacturing company, to determine the best supplier among 3 alternatives. These alternative suppliers had been inspected with respect to 5 criteria namely; quality, origin of the raw material, cost, delivery time, and after sales services. In Fuzzy AHP model, the pair wise comparisons of both criteria and the alternatives were performed through the linguistic variables, which were represented by triangular numbers. Shahroodi et al. [10] used six criteria for supplier selection for a manufacturing firm. Narendra et al. [11] had used Analytical Hierarchy Process (AHP) and Weighted Sum Model (WSM) for supplier selection of Coke Energy Ltd. India. Firstly, the weights of criteria had been calculated by using AHP, and then by implementing Weighted Sum Model (WSM), assessment of suppliers had been done. In our model we use eight criteria as mentioned above for selection of supplier for a furniture company-Hatil Complex Ltd. of Bangladesh. These criteria's are very important for a firm. We then compare among the alternative suppliers with respect to these criteria.

3. Methodology

Analytic Hierarchy Process (AHP), since its invention, has been a tool at the hands of decision makers and researchers; and it is one of the most widely used multiple criteria decision-making tools. This is an Eigen value approach to the pair-wise comparisons. It provides a means of measure the quantitative as well as qualitative performances. The AHP method is based on three principles:

a) Identifying problem and structure of the model
b) Comparative judgment of the alternatives and the criteria
c) Relative weight evaluation

In the first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex multi-criteria decision-making problem into a hierarchy of interrelated decision criteria, decision alternatives. The second step is the comparison of the alternatives and the criteria. The pairwise judgment starts from the second level and finishes in the lowest level, alternatives. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level. In AHP, multiple pairwise comparisons are based on a standardized comparison scale of nine levels.

It should be noted that the quality of the output of the AHP is strictly related to the consistency of the pairwise comparison judgments. First the consistency index (CI) needs to be estimated. This is done by adding the columns in the judgment matrix and multiply the resulting vector by the vector of priorities (i.e., the approximated eigenvector) obtained earlier. This yields an approximation of the maximum eigenvalue, denoted by $\lambda_{\max}$. The consistency ratio CR is obtained as the ratio of the CI and the random index (RI) [12].

$$CR = CI / RI \quad (1)$$

Table 1. Random index (RI) for the factors used in the decision making process

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

If C.R. $\leq$ 0.10, the calculation of relative criteria importance (alternative priority) is considered acceptable. In the opposite case, the decision maker has to analyze the reasons for unacceptably high evaluation inconsistency. (Saaty, 1980).

4. Supplier Selection with AHP

In this study, we consider eight criteria for four suppliers. The eight criteria are marked in the following way:

C_1 - Quality
C_2 - Pricing
C_3 - Lead Time
C_4 - Supply Capability
C_5 - Payment Term

C_6 - Country of Origin
C_7 - Uncertain Demand Capability
C_8 - Conduct Media
Now, the importance of attributes could be assigned as presented in the table 2.

Table 2. The criteria attribute comparison

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	weight
C_1	1	2	3	4	4	5	5	7	0.3384
C_2	0.5	1	2	2	2	3	3	4	0.1910
C_3	0.33	0.5	1	1	1	2	2	3	0.1182
C_4	0.25	0.5	1	1	1	1	1	2	0.0846
C_5	0.25	0.5	1	1	1	1	1	2	0.0846
C_6	0.20	0.33	0.5	1	1	1	1	1	0.0658
C_7	0.20	0.33	0.5	1	1	1	1	1	0.0658
C_8	0.14	0.25	0.33	0.5	0.5	1	1	1	0.0515

$$\lambda_{\max} = 8.108 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0154 \qquad CR = \frac{CI}{RI} = 0.011 < 0.10(\textit{acceptable})$$

The alternative suppliers could be marked in the following way:
A_1 - Supplier no. 1
A_2 - Supplier no. 2
A_3 - Supplier no. 3
A_4 - Supplier no. 4
The corresponding alternatives comparison matrices for each attribute and their respective priorities are presented in tables 3-10.

Table 3. Matrix of alternative relative importance compared to C_1 (Quality) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	2	3	0.5	0.2575
A_2	0.5	1	2	0.25	0.1486
A_3	0.33	0.5	1	0.16	0.0788
A_4	2	4	6	1	0.5151

$$\lambda_{\max} = 4.0301 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.01 \qquad CR = \frac{CI}{RI} = 0.01 < 0.10(\textit{acceptable})$$

Table 4. Matrix of alternative relative importance compared to C_2 (Pricing) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.5	2	0.33	0.1517
A_2	2	1	4	0.5	0.2971
A_3	0.5	0.25	1	0.16	0.0757
A_4	3	2	6	1	0.4754

$$\lambda_{\max} = 4.0303 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0101 \qquad CR = \frac{CI}{RI} = 0.01 < 0.10(\textit{acceptable})$$

Table 5. Matrix of alternative relative importance compared to C_3 (Lead Time) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.33	2	0.5	0.1517
A_2	3	1	6	2	0.4754
A_3	0.5	0.16	1	0.25	0.0757
A_4	2	0.5	4	1	0.2971

$$\lambda_{\max} = 4.0303 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0101 \qquad CR = \frac{CI}{RI} = 0.01 < 0.10(\textit{acceptable})$$

Table 6. Matrix of alternative relative importance compared to C_4 (Supply Capability) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	2	0.33	1	0.1818
A_2	0.5	1	0.16	0.5	0.0906
A_3	3	6	1	3	0.5458
A_4	1	2	0.33	1	0.1818

$\lambda_{\max} = 4 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0 \qquad CR = \frac{CI}{RI} = 0 < 0.10(\mathit{acceptable})$

Table 7. Matrix of alternative relative importance compared to C_5 (Payment Term) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	3	2	1	0.3472
A_2	0.33	1	0.5	0.33	0.1071
A_3	0.5	2	1	0.5	0.1984
A_4	1	3	2	1	0.3472

$\lambda_{\max} = 4.0203 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0068 \qquad CR = \frac{CI}{RI} = 0.0076 < 0.10(\mathit{acceptable})$

Table 8. Matrix of alternative relative importance compared to C_6 (Country of Origin) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.5	0.33	2	0.1517
A_2	2	1	0.5	4	0.2971
A_3	3	2	1	6	0.4754
A_4	0.5	0.25	0.16	1	0.0757

$\lambda_{\max} = 4.0303 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0101 \qquad CR = \frac{CI}{RI} = 0.0113 < 0.10(\mathit{acceptable})$

Table 9. Matrix of alternative relative importance compared to C_7 (Uncertain Demand Capability) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.5	0.5	0.33	0.1205
A_2	2	1	1	0.5	0.2328
A_3	2	1	1	0.5	0.2328
A_4	3	2	2	1	0.4139

$\lambda_{\max} = 4.0236 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0079 \qquad CR = \frac{CI}{RI} = 0.0089 < 0.10(\mathit{acceptable})$

Table 10. Matrix of alternative relative importance compared to C_8 (Conduct Media) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	2	3	3	0.4464
A_2	0.5	1	2	2	0.2728
A_3	0.33	0.5	1	1	0.1404
A_4	0.33	0.5	1	1	0.1404

$\lambda_{\max} = 4.021 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.007 \qquad CR = \frac{CI}{RI} = 0.0079 < 0.10(\mathit{acceptable})$

Now, all alternatives are multiplied by the weight of the single decision criteria and then the obtained results are summarized in the following table. The alternative with the highest value obtained is A_4 (Supplier no. 4) that is the optimal alternative.

Table 11. Synthesized data of supplier selection

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	Total
Weight	0.3384	0.1910	0.1182	0.0846	0.0846	0.0658	0.0658	0.0515	
A_1	0.2575	0.1517	0.1517	0.1818	0.3472	0.1517	0.1205	0.4464	
Weight * A_1	0.0871	0.0290	0.0179	0.0154	0.0294	0.0100	0.0079	0.0230	0.2197
A_2	0.1486	0.2971	0.4754	0.0906	0.1071	0.2971	0.2328	0.2728	
Weight *A_2	0.0503	0.0567	0.0562	0.0077	0.0091	0.0195	0.0153	0.0140	0.2288
A_3	0.0788	0.0757	0.0757	0.5458	0.1984	0.4754	0.2328	0.1404	
Weight *A_3	0.0267	0.0145	0.0089	0.0462	0.0168	0.0313	0.0153	0.0072	0.1669
A_4	0.5151	0.4754	0.2971	0.1818	0.3472	0.0757	0.4139	0.1404	
Weight *A_4	0.1743	0.091	0.0351	0.0154	0.0294	0.0050	0.0272	0.0072	**0.3846**

From the above table it can be concluded that supplier no. 4(A_4) gives a fair result than the other 3 suppliers. So supplier no. 4 (A_4) is the best supplier. Comparatively supplier no. 3(A_3) gives the worst result. So the worst supplier is supplier no. 3 (A_3).

9. Conclusion

The AHP process incorporates both intangible qualitative criteria along with tangible quantitative criteria. In this paper, AHP process is used to determine the best supplier for purchasing raw materials in a Furniture Industry. Using AHP technique, we find that the alternative A_4 is determined as the best supplier alternative, while A_2 is determined as second best alternative and A_3 is the worst alternative. The AHP technique can further be applied in more critical vendor selection problem by involving more conflicting criteria and sub-criteria such as risk management, supplier profile, supplier reputation etc. However, in this paper, AHP technique is used for supplier selection problems, other multi criteria decision making techniques such as fuzzy AHP, Technique for Order Preference by Similarly to Ideal Solution (TOPSIS), Fuzzy Analytic Network Process (ANP) etc. can also be used and compared with the obtained results.

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Renovation of Automation with Human Resources in Industrial Sector in Bangladesh

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Abstract

The world of micro computing known as automation is an ocean of innovation that has been broaden rapidly in the last 15 years. In recent days, many new technologies have been using in industrial and home automation. Almost 90% of industries are using automation in developed countries while this percentage in under developed countries is only 30-45%. The industries are becoming more computerized for ensuring more safety, low labor cost, better product quality with improved efficiency. The sole motto of this paper is to demonstrate the accomplishment of automation and the possibilities of combination of human resources and automation in industrial and home automation in Bangladesh. This study also shows a comparison of country's present situation of automation with the developed countries in the world. In Bangladesh, about 46% of industries are automated however, the safety is not monitored, and quality is not maintained properly.

Keywords: Automation, man power, industry, high-technology, Bangladesh.

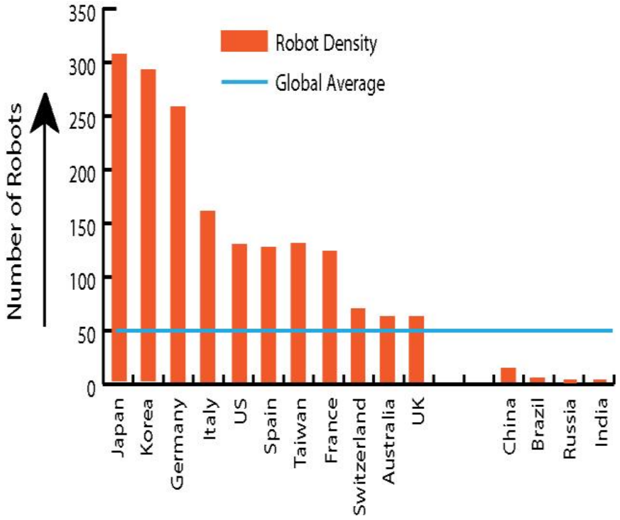
1. Introduction

Automation is the sovereign monitoring of a task by a device or system and is considered as the prime mover of industrial success in this modern era. [1] Automation and robotics are the two sector of micro computing. Micro computing is such a technology where the device contains a processor or a microcontroller supported with multiple types of sensor and it is controlled through a program. Technological development directly affects the living standard of human being. Human life is now more comfortable than the old ages. During the last 15 years, technology has reached in a position that people did not think even in their dream however, some people make it possible.

In the 19th century, HG Wells first gave the concept of automation through his writing of science-fiction cartoons magazine named Jetsons. After that, Westinghouse Electric developed the first computer based automation system in 1966 named ECHO IV. [2] They are also the pioneer of AC electrical system. The revolutionary innovation in this sector came in 1971 when, Intel Corporation lunched 4 bit microprocessor called Intel-4004. [3] At the same time Texas instrument engineer Gary Boone and Michael Cochran created the first microcontroller named TMS1000. [4] In 1975, Pico Electronics developed X10 protocol for communication among with electronic devices used for home automation. [5] In addition to these, Microchip Corporation commercially introduced PICXXXX series Microcontrollers with their EEPROM technology in 1993. [6] The dot.com boom created a great step for communicating Pc to Pc through using FTP and HTTP protocol in 1993. During the Last few years, many automation technologies has been developed based on Microcontroller and Microprocessor such as Programmable Logic Controller (PLC), Remote Terminal Unit (RTU), Artificial neural network (ANN), Programmable automation controller (PAC), Raspberry Pi, and Arduino. This paper presents the prospect of integration of automation with human resources towards a massive industrial development in Bangladesh.

2. Present condition of automation and economic growth corresponding to the world

Almost every developed country in the world is following the policy of less labor, high production and better efficiency. High production rate with better efficiency and low labor cast is possible through only using industrial robot. Therefore, the application of industrial robot is increasing rapidly. Japan is the highest industrial robot user and has been using over 300 robots per 1000 manufacturing employees where, the global average is approximately 50 as illustrated in Figure 1 [7]. The developed countries in the world are using almost 149 robots against 1000 employee and contributing about 50% global manufacturing outputs as depicted in Figure 2 [7]. On the other hand, total emerging sectors holds only about 11 robots against 1000 employee with 50% of world's output. For cope space with increasing product demand, we are expecting about 1.5 million Robots driven job including the new industrial activity and expanding the existing industries in next two years.



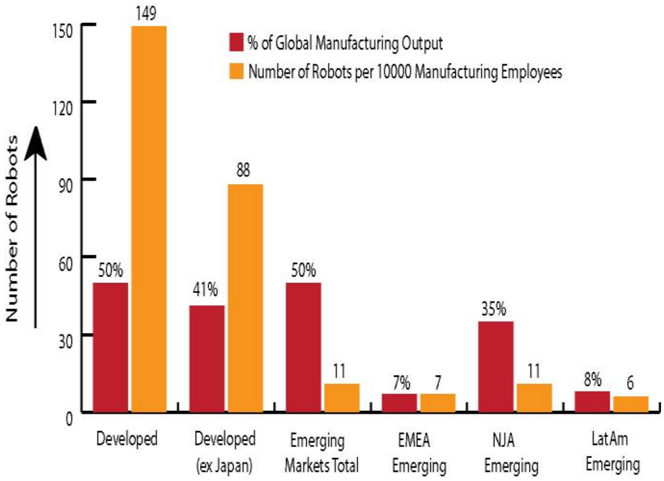


Fig. 1. Robot density of some selected countries [7] **Fig. 2.** Global output and robots per employee [7]

The market of automation is increasing very fast has reached to approximately 62%. Robotics demand with respect to the market in Japan has increased to 18%, in China to 17%, in Western Europe to 17%, in Noth America to 15%, in Other Asia to 24% and in other to 8%. The Market of Industrial Automation is about USD 152 billion globally while, the market of Factory Automation and Process Automation are USD 72 billion and USD 83 billion respectively as presented in Figure 3 [7]. The yearly shipment of multipurpose industrial robots in Japan, China, USA, Korea and Germany are 25110 units, 36560 units, 23679 units, 21307 units, and 18297 units respectively. Recently, PLM, DSC, SCADA, and ERP contribute the most of the revenue in automation market.

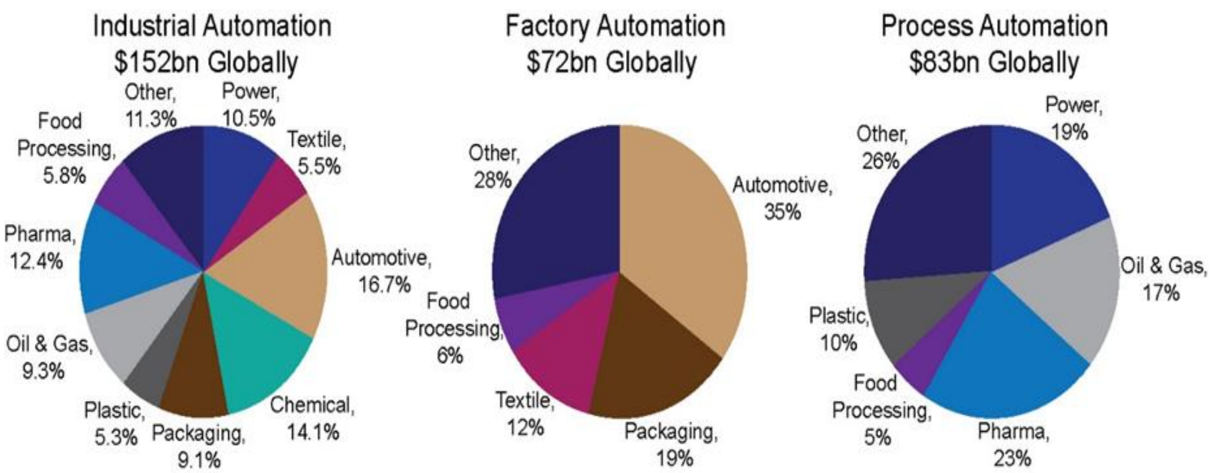


Fig. 3. Automation markets by revenue [7]

3. Present condition of industry in Bangladesh

Bangladesh is developing country and the economy is dominated by a diversified private sector, alongside state-owned enterprises. However, over the last 15 years the country has made a revolutionary change in its industrial sector. The contribution of manufacturing sector in GDP growth has increased to USD 28.4904 Billion in year 2014 from USD 7.4906 Billion in year 2000. On the other hand, in case of industrial sector, the amount of contribution in GDP has increased to USD 46.1249 Billion in year 2014 from USD 11.8905 Billion in year 2000. Table 1 [8] shows that, the share of industry in percentage of GDP growth increased over the past years and expected to increase to a value 37% in year 2021.

It is very difficult to exact time period when the use of automation had been started in Bangladesh. After the British period, the East Pakistan had almost 1930 industries comprising 660 small scale industries and 1270 large scale industries until 1971. The modernization of these industries had been started probably at the end of 19th centuries. Although most of the largest industries in Bangladesh are using industrial robot for manufacturing and production, it is a very little amount.

Table 1. Projection of growth and shares of different sectors in GDP [8]

	FY2011	FY2012	FY2013	FY2014	FY2015	FY2021
	Growth Rate(%)					
Agriculture	5.0	4.5	4.4	4.3	4.3	4.5
Industry	9.2	9.6	9.9	10.5	11.5	12.0
Of which Manufacture	9.5	9.8	10.1	10.7	11.7	14.0
Services	6.6	6.8	7.1	7.3	7.8	8.0
GDP	6.7	7.0	7.2	7.6	8.0	10.0
	Share as % of GDP					
Agriculture	18.4	17.7	16.9	16.2	15.5	15.0
Industry	28.7	28.9	30.4	31.3	32.0	37.0
Of which Manufacture	18.2	18.7	19.6	20.4	21.1	28.0
Services	52.9	52.9	52.7	52.5	52.5	48.0

4. Human resources in Bangladesh

Bangladesh is a densely populated country in South Asia. The population density in the country increased to 1217.74 in the year 2014 with a growth rate of 1.22%. Up to July 1, 2015, total population is estimated about 160411249 of which about 56.8% is young and energetic and expected to increase 201947716 in year 2050. Therefore, we have a great opportunity to make use of these huge human resources.

However, it is not easy to use these resources appropriately with a handsome salary. Although the workers of Bangladesh engage with hard and dangerous work yet they get the lowest wage among the world. A worker working in garment sectors gets about BDT 17000 in China, about BDT 8000 in Cambodia, whereas BDT 5300 in Bangladesh. In addition, the minimum wage for a 19 years old worker is BDT 2596. Still the owners of the garment sectors in Bangladesh are not willing to increase the wages of worker in an excuse of loss. This problem can be solved through industrial automation. At the same time it will secure the valuable lives of people.

Labor force is of a country is considered as similar to the paddle of cycle. The economic development of a country fully depends on its labor force. Bangladesh has a large population and comparatively less skill labor force as estimated about 77.6097 Million of which 41.8 million between 29 to 15 ages. The demographic statistics of the worker is presented in Figure 4 [9]. The most interesting fact is that industrial labor is increasing and agriculture labor is decreasing. As of World Bank report, industrial labor has increased by 4.2% and agriculture labor has decreased by 14% in the year 2005. In recent days, developed countries are using automation for production. Therefore, have to install automation as well as we have to be skilled our human resource. In Bangladeshi least number of worker are high skilled and professional. Therefore, this affects the product quality as well as the production rate. It can be possible to increase the product quality and production with a less risk by simulating the labor force with automation. Through the vision of 2021, Government of Bangladesh is focusing on education sector for making a skilled man power but the benefit of the program will start a few years later. The solution of this problem can be industrial automation.

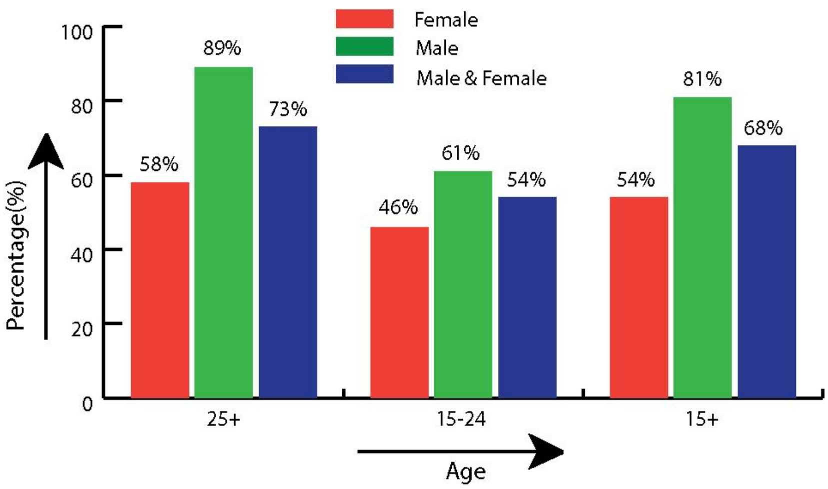


Fig. 4. Workforce data according to age and sex distribution [9]

5. How the automation can be developed in industrial sector of Bangladesh?

Currently, automation is a key of industrial success. If we want be a competitor in world market, we have to produce quality product comparatively with low production cost. We have a large number of labor forces. However, they are not professionally skilled for better production with less time consumption. In the country, almost 52% of the total workers are less-skilled and only 32% are skilled. This huge un-skilled worker reduces the remittance of the country. Although we hire technology from the other developed country but the problem is that no skill man power for operate such machines. Therefore, Government has to concern about this sector. Government should increase training sector, though some private institutes such as Bangladesh automation technologies, PLC Bangladesh are also working to develop skilled man force. As the market of automation is increasing, so the government should establish robotics industries. Robot has already rolling the manufacturing sector as well as production sector. The use of robots in developed countries in manufacturing technology is shown in Figure 5 [10].

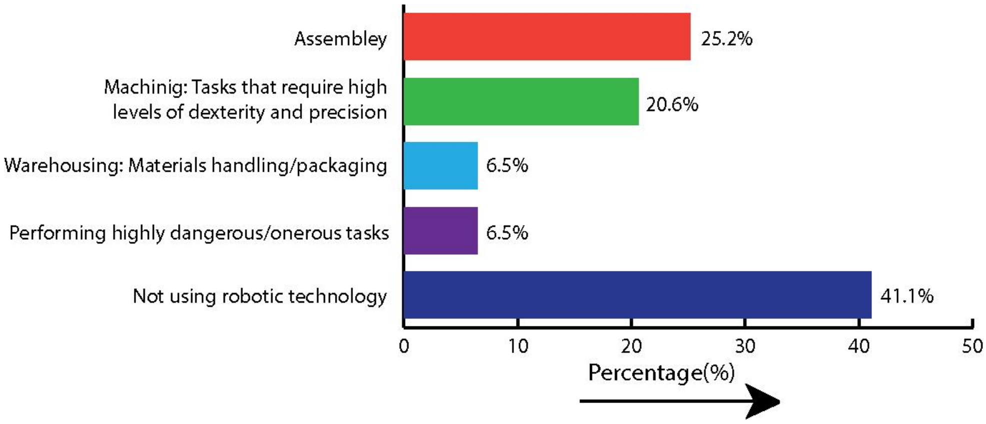


Fig. 5. The road map of using robots in industrial sector [10]

6. Lewis turning point

The model was developed by the famous economist Arthur Lewis from the dual aspects of developing economy consisting of agricultural sector and industrial sector. The industrial sectors are the driving force of economic growth that is supported by human force mainly drawn from agricultural sectors. The low wage of these migrant labors is the reason of increase savings in industrial sector and for expansion. However, a situation will be raised when the labors are no more interested to migrate from the underdeveloped and agricultural sector to modern industrial sector with this low wage. This is known as the Lewis turning point.

Almost all the developed and developing countries like China, India, and Bangladesh are facing Lewis turning point crisis. The effect of Lewis turning point has already affected the product value. The value of product is increasing rapidly and the inflation is also increasing proportionally. China has the world's largest job market and hence the effect of Lewis turning point is affecting China job market. The increased wages of the labor and the labor shortest problem have already stricken in china GDP growth. Because of the technical education the labor are becoming more skilled and they are demanding high salary which affect the country's job market. The recent industrial occupation category and their hourly wage are illustrated in Figure 6 [10].

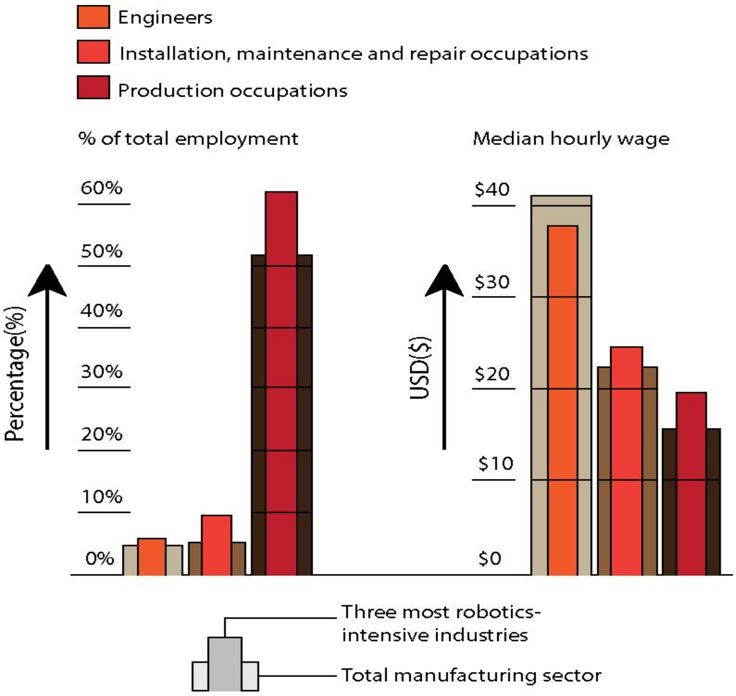


Fig. 6. Employment, robotics and wages [10]

7. Possible solution and effects of Lewis turning point in Bangladesh

The solutions will be come through the increasing use of industrial robots. Developed countries are starting to walk with the theory of installing industrial robot for keeping their market value of product comparing to the developing country. Industrial robots give better efficiency, better product quality with less of wages comparative to the human resources.

We have to consider the following factors that affect the Lewis turning point effects on Bangladesh.

- The population growth rate is decreasing in the country. It has been estimated that over the last 15 years the rate decreased from 1.84% to 1.22%.
- The poverty headcount ratio is decreasing. It decreased from 48.9 % in year 2000 to 31.51 % in year 2010 as shown in Figure 7.
- The GDP per capita based on purchasing power parity (PPP) is increasing. The amount increased from USD 1293.58 in year 2000 to USD 3135.5 in year 2014.
- The most important thing is that education growth has increased dramatically. It has increased 63.62% in year 2001 to 79.94% in year 2012.

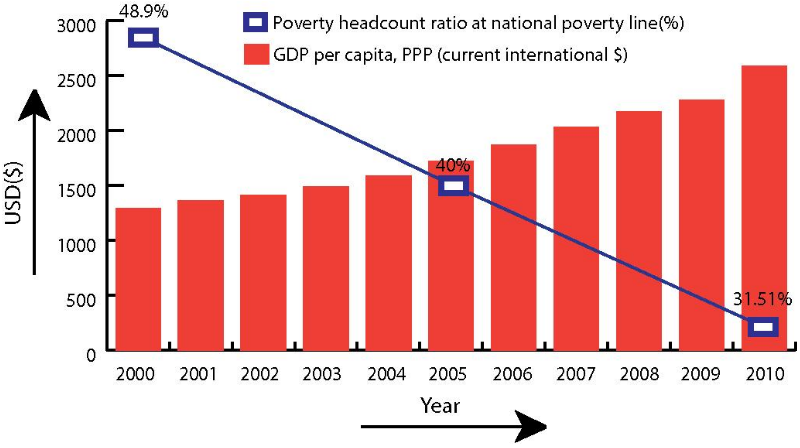


Fig. 7. Per capita GDP in Bangladesh

8. How to ensure sustainable industrial growth?

Due to the decrease of the poverty headcount ratio and the increase of GDP per capita based on purchasing power parity (PPP), people has obtained medium range of purchasing ability. As far the wages of the labor is increasing, after a short period Bangladesh will face Lewis turning point crisis as like as China. Therefore, we need to create an environment where the labor will robot and the driver will be human. So, we must think that how could we do this?

It can be perceived through making skill labor force with high technical knowledge. Without this Bangladesh will not able to be a part of world economy. We need to establish more and more technical institutions and must ensure proper training. Government should make an industrial guide line as well as a proper wages system and should care about the natural resource considering its significant effect on industrial sector. The next age will be the age of robotics; therefore we have to give much emphasis on industrial automation in Bangladesh.

9. Conclusion

The economic success and the internal development of a nation depend upon the development of industrial sector. The industrial sector of Bangladesh is upgrading rapidly. However, the industrial work is largely dependent on human workers, hence the product quality and quantity are low than expectation. The industrial robots can replace the human worker to improve the output of the industry. However, fully industrial automation in Bangladesh is quite impossible due to technical and financial barrier. The country has a massive man power and almost 60% of them are young. Therefore, the successful deployment of the combination of automation and human resource would bring a milestone result in country's industrial sector as well as textile and high-technology.

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Ready-Made Garment (RMG) Industry in Bangladesh: Economic Contribution and Potentiality

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Abstract

The Ready-Made Garment (RMG) industry of Bangladesh has a lion share in foreign exchange and became a potential financial player in the national Economy. Bangladesh is now the second largest apparel exporting country after China in the world. Although after the tragic collapse of Rana Plaza, Bangladesh's RMG sectors have lost their fame slightly to the buyers, trade unions and other garments related organizations temporarily, a more glittering future is waiting for the RMG garment industry of Bangladesh as hinted by facts and international surveys. This sector accounts for about 81% of the total export income and employs 4.4 million people directly and 20 million indirectly. Undoubtedly, RMG sector has a potentiality to play as a key driving force of Bangladesh's economy in future. The intention of this paper is to prepare a statistical database with these RMG related information to enhance the bright future of this sector and to forecast the total RMG export for FY 2020-2021.

Keywords: Ready-Made Garments, Economic Potentiality, Forecasting, Semi-Average Method.

1. Introduction

The Ready-Made Garment (RMG) sector has been the largest exporting industry in Bangladesh, which acts as the backbone of the national economy. The tremendous success of readymade garment exports from Bangladesh over the last two decades has surpassed the most optimistic expectations which have been expanded almost uninterruptedly since the late 1970s [7]. The percentage of RMG to total exports has increased considerably over last two decades in Bangladesh [2]. It increased from 12% in 1985 to over 80% in 2014, making it the most important sector for the Bangladesh economy. Its contribution to the economy of Bangladesh, and in providing employment, is indeed remarkable. As may be expected, the industry has faced numerous challenges in the growth process, which averaged more than 15% per year. Despite all the adverse publicity, RMG exports growth during the last fiscal year 2013-2014, was 13.8% [9]. The apparel exports of Bangladesh has been concentrated to two major destinations- EU and North America [8, 15]. It is encouraging to note that over the last five years, remarkable progress has been achieved in diversifying the RMG exports ton on- traditional markets [8]. This diversification of exports destination, with growing exports, is a healthy sign for RMG sectors. The simplification of GSP rules of origin are positive signs for this sector. That is why the RMG sector of Bangladesh is optimistic that the new wave of opportunities and the growth momentum will energize the RMG industry to add new success stories in the coming years [7]. The literature on the RMG industry is limited. Mohammad Ekramul Islam et al. [1] present the economic recession and its impact on the Bangladesh's economy with special references of RMG and remittance sectors. In this paper, they exploited the ways, concept and techniques which help them a lot to overcome the difficulties and able to stabilize their economic improvement. Ahsan Firoz [4] has carried out a research on the design of readymade garments industry for fire safety and explores the ways that how workplace can be taken free from any unexpected occurrences of Ready-Made Garments sectors. Ahmed et al. [5] presented that the workplace safety is not sufficient in RMG sectors in developing countries. Akhter et al. [6] showed that most of worker of garments industries in Bangladesh are female and there need more improvement for health and safety. In Dhaka apparel summit [7], it is estimated that Bangladesh RMG will reach to 2021- $ 50 Billion on the 50th Anniversary of Bangladesh. With the estimation of the RMG export in FY 2020-2021 the present RMG export, present number of worker, the number of RMG industries, the present contribution and potentiality of RMG sector are explored in this apparel summit. The apparel story [8] explores the budget for FY 2014-15 and how this can be met. The objective of this paper is to explore the economic roles that the RMG sector has on the national economy of Bangladesh and finally forecasting the future of the Ready-Made Garments (RMG) sector in Bangladesh.

2. Methodology

This paper has basically used the data from Bangladesh Garments Manufacturer and Export Association (BGMEA) and Export Promotion Bureau (EPB). As an initial input, it has been prepared a detailed structure of the relevant areas in which export-oriented RMG sector of Bangladesh was contributing. Different Books, Journals, Newspapers, Magazines, Internet etc. has also been used for supporting this work. Personal interview may also be conducted with the important personalities of these sectors. Finally, semi-average method is used to forecast the total RMG export. The rest of this is organized as follows. Section 3 describes the growth of RMG sector in Bangladesh. In section 4, we analyze the statistical data and forecast the total RMG export up to fiscal year 2020-2021. Section 6 concludes the paper.

3. Growth of the RMG Industry

Could one have predicted the growth of the RMG industry in Bangladesh? After the liberation of Bangladesh it inherited a devastated economy with industrial production close to nil. The jute sector, which was the major foreign exchange earner, saw no further growth in the immediate aftermath of independence [7]. Following tables show that how the RMG sector gradually established a firm base from which to grow.

Table 1. Export of RMG sector in million US $ contrasting the total export of Bangladesh

Fiscal Year (FY)	Total Export of RMG (Knitwear & Woven)	Total Export of Bangladesh	% of RMG's to Total Export
2004-2005	6417.67	8654.52	74.15
2005-2006	7900.80	10526.16	75.06
2006-2007	9211.23	12177.86	75.64
2007-2008	10699.80	14110.80	75.83
2008-2009	12347.77	15565.19	79.33
2009-2010	12496.72	16204.65	77.12
2010-2011	17914.46	22924.38	78.15
2011-2012	19089.73	24287.66	78.60
2012-2013	21515.73	27018.26	79.63
2013-2014	24491.88	30176.80	81.16

(Source: BGMEA Website, 2014)

The export of RMG increased exponentially from 1984 to 2014. This exponential increase can be accounted for by increase in demand in the Bangladeshi exports in EU and USA markets. Moreover, Bangladesh is also exporting RMG in the non-traditional markets in an attempt to increase its revenue and stance in the global market. The percentage of the contribution of RMG to total exports has increased considerably over the last two decades. It increased from 12% in 1985 to over 80% in 2014, making it the most important sector for the Bangladesh economy. It also provides employment to around 4.2 million Bangladeshis, mainly women from low income families which affect their social status [1]. It has by now become a huge industry, earning the lion's share of the country foreign exchange and created the largest job opportunities for our countrymen specially provided the largest formal employment for the women [7]. Of the estimated 4.2 million people employed in this sector, about 50 percent of them are women from rural areas [1]. In 2000, the industry consisting of some 3000 factories employed directly more than 1.5 million workers of whom almost 80% were female [1, 11, 12]. The number of workers in garments sectors is increased day by day. In 1985-86 the total workers were 20 million [1]. In 2007-08 the number of garments workers in Bangladesh is 2.50 million [1]. The number of garment factories increased almost 11 times from 1992 to 2014.Though the number of factories increased consistently from 1992 to 2013, the number of garments factories is decreased 19% from 2013 to 2014 which is shown in bracket in table 3. This percentage of decrement is resulted after the Tazreen fire and Rana Plaza incident. Despite all the potential on the demand side, the question remains that, will Bangladesh be able to take advantage of the increased opportunities? The ability of Bangladesh to supply is an equally important issue in the changed global sourcing scenario. A comparison of the infrastructure in selected countries is presented in table 4 for comparison.

Table 2. Cumulative Value of % growth of RMG Export in Bangladesh

Fiscal Year (FY)	Total Export of RMG (Knitwear & Woven) in million US $	% Growth of Export of RMG	Cumulative Value of % growth of RMG Export
2004-2005	6417.67	11.40	11.40
2005-2006	7900.80	18.77	30.17
2006-2007	9211.23	14.27	44.44
2007-2008	10699.80	13.91	58.35
2008-2009	12347.77	13.35	71.7
2009-2010	12496.72	1.19	72.89
2010-2011	17914.46	30.24	103.13
2011-2012	19089.73	6.16	109.29
2012-2013	21515.73	11.28	120.57
2013-2014	24491.88	12.15	132.72

(*Source: BGMEA Website, 2014)*

Table 3. Year wise Number of Workers Employed in RMG Sectors (In Million) in Bangladesh and number of Garment Factories

Fiscal Year	Number of Garment Factories	% of growth	Employment In million Workers	% of growth
2004-2005	4107	3.65	2.00	0
2005-2006	4220	2.68	2.20	9.09
2006-2007	4490	6.01	2.40	8.33
2007-2008	4743	5.33	2.80	14.29
2008-2009	4925	3.70	3.50	20
2009-2010	5063	2.76	3.60	2.78
2010-2011	5150	1.69	3.60	0
2011-2012	5400	4.63	4.00	10
2012-2013	5600	3.57	4.00	0
2013-2014	4536	(19)	4.00	0

(Source: BGMEA website, 2014)

Table 4. Comparison of infrastructure quality 2014-2015

Country/Region	Country Ranking	Overall Infrastructure Score	Electricity	Roads	Railroads	Port
Bangladesh	109	2.8	2.5	2.9	2.4	3.7
India	71	3.7	3.4	3.8	4.2	4.0
China	28	4.4	5.2	4.6	4.8	4.6
Cambodia	95	3.4	3.0	3.4	1.6	3.6
Myanmar	134	2.3	2.8	2.4	1.8	2.6
Pakistan	129	3.3	2.1	3.8	2.5	4.4
Sri Lanka	73	5.0	4.8	5.1	3.7	4.2
Thailand	31	4.1	5.1	4.5	2.4	4.5

(Source: The global competitiveness report 2014-2015 (2014 world economic forum); Ranking among 144 countries. The rankings are in descending order with ''1'' as the best performer)

4. Analysis of Statistical Data and Findings

There are in total 5615 units in the RMG sector of Bangladesh [7]. Out of them, 2723 are woven factories, 1383 knit, 629 W/K, and 880 sweater factories. Consequently, woven factories make up 48%, knit 25%, W/K 11%, and sweater 16% of the factories in the industries [7]. Therefore, it can be seen that woven comprises of the highest unit with sweater the least producing unit. The main components of RMG are the woven and knit which comprises approximately the three-fourths of the total in terms of the factories.

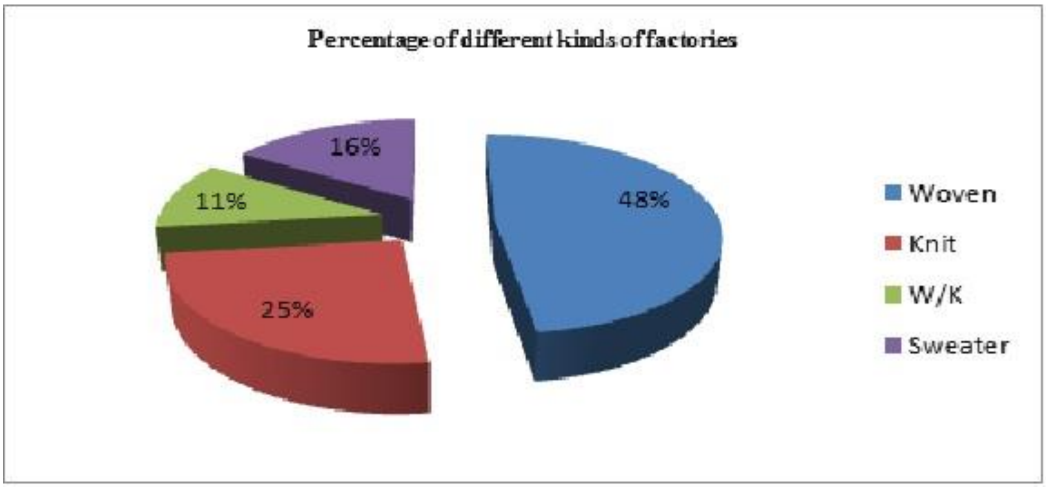

Fig. 1. Percentage of the different kinds of factories *(Source: BGMEA website, 2014)*

Figure 2 shows that the growth of the total export of RMG in FY 2013-2014 is comparatively smaller than the other fiscal years and this is may be because of the Tazreen fire and Rana Plaza Tragedy but growth could be fallen tremendously although that had not happened which indicates that the RMG sector of Bangladesh has a bright future.

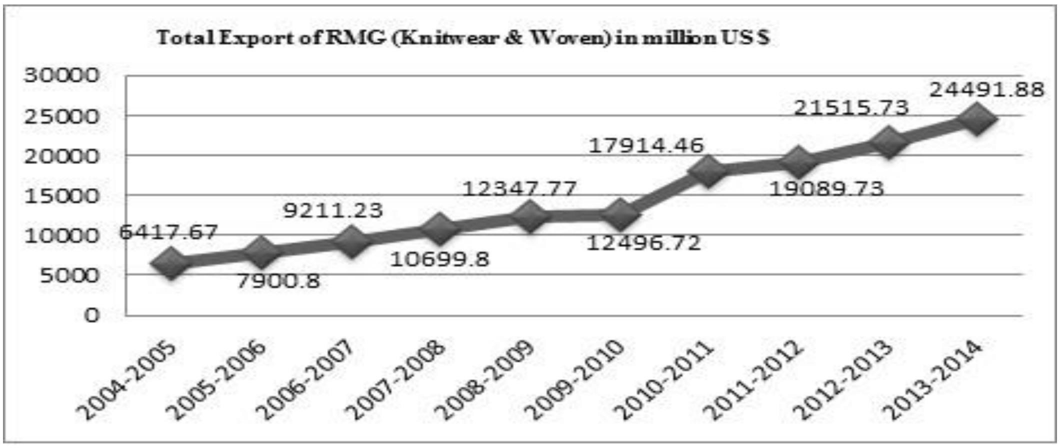

Fig. 2. Total export of RMG (Knitwear& Woven) in million US $ *(Source: BGMEA website, 2014)*

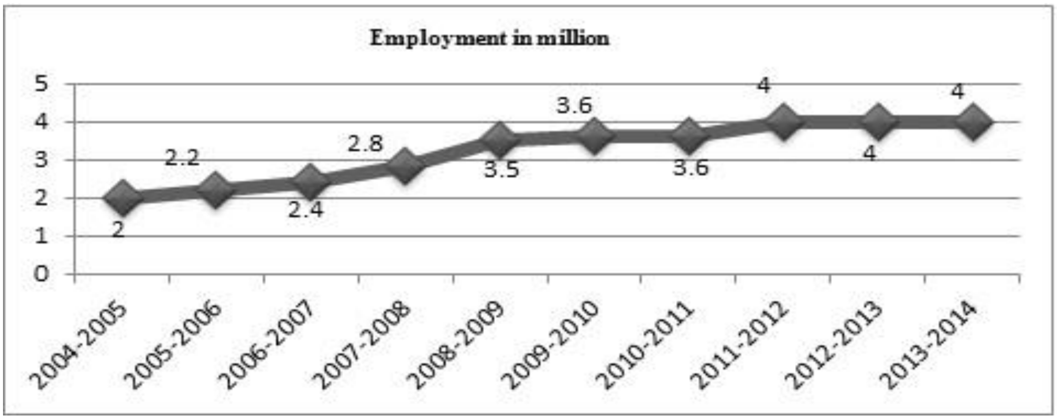

Fig. 3. Employment of RMG in Million Workers *(Source: BGMEA website, 2014)*

The number of RMG industries has been increasing dramatically since the late 1970s causing the tremendous growth of RMG employment [13]. Up to FY 2011-2012 the number of employment has increased but through last three FY RMG employments is approximately constant.

The total RMG export in FY 2004-2005 was 6417.67 million USD which increased to 24491.88 million USD in FY 2013-2014, shown in table 5. So the percentage increase is 73.8%. The total RMG export for the FY 2020-2021 can be calculated by the Semi-average forecasting method as-

$$B_f = \frac{[\text{Semi-average trend value of } X_{f-2}] - [\text{Semi-average trend value of } X_2]}{X_{f-2} - X_2} \quad (1)$$

Or

$$B_f = \frac{[S^f_{f-2}] - [S^f_2]}{X_{f-2} - X_2} \quad (2)$$

Total RMG export can be calculated by-

$$X_f(E) = S^f_2 + B_f\,(X_f - X_2) \quad (3)$$

Where,

S^f_2 and S^f_{f-2} = Semi-average trend value, $X_f(E)$ =RMG export , X_f = Fiscal year, f = Number of fiscal year

Table 5. RMG export data from 2004-2014

No of FY 'f'	Fiscal year X_f f=1,2,...,10	RMG export in million USD $X_f(E)$	Semi-total	Semi-average trend value S^f_2 or * S^f_{f-2}
1	2004-2005	6417.67		
2	2005-2006	7900.80		
3	2006-2007	9211.23	46577.27	9315.45
4	2007-2008	10699.80		
5	2008-2009	12347.77		
6	2009-2010	12496.72		
7	2010-2011	17914.46		
8	2011-2012	19089.73	95508.52	*19101.70
9	2012-2013	21515.73		
10	2013-2014	24491.88		

(Source: BGMEA website, 2014)

Analyzing the total export data from table 5 by using the semi-average method it has been forecasted that the total export of RMG might be about 24815.36 million USD in Fiscal Year 2020-2021 as shown in table 6 if the trend of increasing the RMG exports remains as like as the export shown in table 1

Table 6. Forecasted RMG export in million USD up to FY 2020-2021

No. of FY 'f'	Fiscal year X_f f=11,12,…,17	Semi-average trend value S^f_2	Semi-average trend value S^f_{f-2}	B_f	RMG export in million USD $X_f(E)$
11	2014-2015	9315.45	19101.70	1398.04	21897.78
12	2015-2016	9315.45	20981.92	1166.65	20981.92
13	2016-2017	9845.67	20981.92	1237.36	23456.63
14	2017-2018	9845.67	21905.61	1139.56	23520.39
15	2018-2019	10998.35	22136.29	1012.54	24161.38
16	2019-2020	10998.35	22860.82	988.54	24837.89
17	2020-2021	12009.77	23107.95	853.71	24815.36

The RMG industries can achieve better result than the forecasted export if it can be ensured the workplace safety, realistic solution of child labor issue with ILO, UNICEF & US Embassy, successfully faced global recession, and after all creating the opportunity using the strengths of RMG industries.

5. Conclusion

From the illustration above we can say that Bangladesh has repeatedly demonstrated its flexibility and ability to overcome all odds. Truly speaking, Ready-Made Garment sector is an excellent example of what the country can achieve. Despite all challenges, with accompanying global ups and down, the country has positioned itself as the second largest apparel exporter within just three decades and about one-fourth of the national earning is from the RMG sector. Therefore, we can evidently say that the vision 2021 for Bangladesh's RMG is attainable if the RMG sector can ensure the workplace safety, realistic solution of child labor issue with ILO, UNICEF & US Embassy, successfully faced global recession, and after all creating the opportunity using the strengths of RMG industries. After all, the RMG is a confidential sector that can exploit its potential in terms of the foreign exchange while overcoming the challenges it faces in upcoming years.

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Flow Sheet Development and Simulation with Optimization of Industrial Scale Natural Gas Processing Plant by Using Aspen-Hysys

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Abstract

Bangladesh has a gas field discovery success ratio 3.1:1 of which two of the gas fields are located in offshore area. Bibiyana gas field has been selected for the study of flow sheet development and simulation with optimization of industrial scale natural gas processing plant by using Aspen-Hysys as it is a world class gas reservoir. Flow sheet development and simulation of 150 MMSCFD natural gas producing Bibiyana gas plant was done by means of Aspen-Hysys. The steady state simulation was performed based on both the design and physical property data of the plant. The main purpose of optimization was cost minimization by regulating the process stream flows and heat duty and hence profit maximization. The objective function, Profit, was calculated from the difference of sales gas, LPG and condensate selling revenue and condenser or reboiler duty costs. Hysys Optimizer has been used to optimize the present process which resulted in more than 8.5% increase in profit with negligible change in optimized methane composition (around 99.46 %). In addition, LPG was also recovered with a production rate of around 1746 barrel/day.

Keywords: Natural Gas; Aspen-Hysys; Gas Processing; Separation; Simulation; Optimization.

1. Introduction

Natural Gas is among the top most used energy sources in the world. Since natural gas can be processed and distributed easily, the demand is growing rapidly [Rahman and Tamim, 2012]. Hence, fast and efficient gas processing and optimization are needed. Natural gas processing plants are used to purify the raw natural gas extracted from underground gas fields and brought up to the surface by gas wells.

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as 'pipeline quality' dry natural gas. Many removal processes can be adopted, for example, amine base process for the removal of carbon di oxide [Kinigoma and Osharode, 2013] or by Benfield process [Chowdhury and Chowdhury, 2013]. Furthermore, Dehydration of Natural Gas which is another important step in gas processing. Deethanization and also depropanization can be enhanced by using dividing wall column [Long and Lee, 2012]. Nitrogen-removal processes using liquid solvents, adsorption, and cryogenic processing are currently available, but all of these methods require recompression of the methane product, which penalizes their economics. However, the Use of three column system requires less compression and higher methane recovery (around 98%) than other methods available [MacKenzie *et al.* 2012].

Analysis of industrial scale Natural Gas plant includes many complicated aspects which are mainly assessed by simulation programs. Aspen HYSYS is an easy-to-use process modeling environment that enables optimization of conceptual design and operations and removes process bottlenecks. Simulation of plant model and optimization of natural gas processing plant that reduces process loss and maximizes profit can be developed though Aspen-Hysys [Roy and Amin, 2011]. The role of Hysys is to provide a capable and accurate design. Aspen Hysys introduced the novel approach of steady state and dynamic simulations in the same platform. It has become the defacto standard in industry, and today enjoys universal acceptance [Amber *et al.* 2012]. Simulator response modeling relates key process variables to plant performance satisfying the remaining unknown information from the material balance equations [Bullin and Hall, 2000]. In a gas simulation process, the inlet conditions (Composition, pressure and temperature) affect the throughput and quality of products. However, to counter such problems, about 80 % of the bumps can be reduced by using Hysys [Ramzan *et al.*]. Owing to such performance, Hysys simulation has been used to optimize process condition for maximum profit.

2. Simulation of gas process unit

For the Bibiyana plant simulation, there are five major units which processes the raw natural gas. These are: **separation unit**, **dehydration unit**, **heat exchanger**, **de-ethanizer** and **final purification & CO_2 removal units**. The simulation process is based on Bibiyana gas production process and following are the description of units of the process:

2.1 Separation unit: Gas is drawn from three wells: Well-1, Well-2, Well-3 respectively in simulation of the processing plant. The feed Composition can be found in datasheet. Then the feed gas is passed through the pressure control valve to relief some pressure & then fed into 3 'three phase separators' (H-110A, H-110B, H-110C) to separate each valve out stream in heavy liquid, light liquid & vapor streams. Most of the liquids are separated at this separation unit. The 3 heavy liquid streams(mostly H_2O) is removed & the 3 light liquid streams are mixed together in a mixer & then entered into a distillation column(D-320) through an expansion valve, the bottom liquid product is liquefied petroleum gas(LPG) & is stored in a tank(F-210). The overhead product of D-320 is mixed with refined gas stream to prepare the very final product.

2.2 De-hydration unit & heat-exchanger unit: There are three vapor streams of the separators(H-110A, H-110B, H-110C) which are mixed in a mixer and passed through the dehydration unit for water removal. The dehydration unit consists of an absorption tower (D-310) where Tri Ethylene Glycol is used to absorb water. The overhead vapor product of (D-310) contains dehydrated hydrocarbons which is passed through two heat exchangers (E-230) & (E-250) so that temperature is decreased. The tube out of E-250 heat exchanger is then entered into a separator (H-140). Then expander (G-152) lowers streams temperature using Joule-Thomson principle of pressure relief & then three phase separator separates the remaining water in the mixed inlet more precisely. Heavy liquid is removed & light liquid (H-150 liq out) and vapor(H-150 vap out) is used for further processing.

On the other hand, bottom product of the absorption tower(D-310) is passed through an expansion valve (K-131) & a two phase separator(H-130) ,bottom product of which is used as a tube side inlet of heat exchanger (E-240). The tube side outlet is then entered into a column(D-330) whose bottom product is make-up Glycol solution & is entered into the shell side of the heat-exchanger(E-240) & heat-exchanger(E-230). Between the heat-exchangers a pump is used to increase the pressure. The shell outlet of E-230 is mixed with TEGlycol feed to use in the absorption tower (D-310)

2.3 De-ethanizer unit: The liquid stream of the three phase separator(H-150) is then used in the de-ethanizer which is a distillation column (D-340). Bottom product of the column(D-340) is LPG which is passed through the heat-exchanger(E-101) to prepare 'Final LPG' at low temperature. Stream(H-150 vap out) is mixed with the over-head vapor product of (D-340). Mixed stream out (M-231) is entered into the shell side of the heat exchanger (E-250) to increase the temperature.

2.4 Purification & CO_2 removal unit: Stream (M-251 shell out) is then undergone through CO_2 removal process. In this stage, we used principles of liquefaction to separate CO_2. Using cooler (E-100) we cooled shell out stream and this cool gas stream is passed to a separator (V-100) preceded by a valve (VLV-100). Then the final product stream enters compressor & then again thorough consecutive separations and thus CO_2 from natural gas has been decreased significantly (less than 0.03%). CO_2 can also be removed using absorption process where MEAmine solution is used to absorb CO_2.

3. Optimization of gas processing plant simulation

After performing the whole simulation process, profit optimization was done. Optimization was done by controlling two main prospect. One is the flow of the revenue earning stream and the other is the duty corresponding to cost of the process. The main purpose of optimization was cost minimization. The objective function, Profit, was calculated from the difference of sales gas, LPG and crude gasoline (a stream having many of the properties of gasoline) selling revenue and condenser or reboiler duty costs. . Some energy was also extracted from an expander (G152) that was included with the revenue too. In the process, the profit is a function of both cost of heat duty and the revenue of flow rates of products i.e. sales gas, LPG and crude gasoline. The objective function is given as :

$$\text{Profit} = \text{Total revenue} - \text{Total cost}$$

Several user defined variables were considered as primary variables; i.e.: outlet stream pressures of absorption, de-methanization and de –ethanizaion units, compressors and valves to name a few.

3.1 Optimization effect: This part illustrates on the optimization function and optimized condition of the final simulation. Here, the optimizer spread sheet (Fig 3.1) lists all the variables relating with price. This spread sheet was formed by opening the spreadsheet of Hysys Optimizer® tool. Then functions were listed in the functions tab of the tool. By means of Hysys Optimizer® which uses both static and dynamic simulation modeling tool, optimization is achieved. Hysys uses the dynamic analysis of a process system that provides understanding of process system which is not possible with steady state modeling. Following is the mathematical formulation:

Table3.1: Market Value of Products and utilities: (Prices estimated from the year book of Petrobangla and Bangladesh Energy Regulatory Commission)

Natural Gas	9.580 taka/m^3
LPG	56 taka/kg
Crude Gasoline	42470taka /m^3
Heating or Cooling Duty	0.737 taka/KWh

Revenue Calculation:
Sales gas volume = B1 Sales gas price per unit volume, B2=9.580 tk/m^3
LPG sales volume= B3 Sales LPG price per unit volume, B4 = 56 taka/kg
Crude Gasoline sales volume= B5 Crude Gasoline sales price per unit volume, B6= 42470 taka/m^3

$$\text{Revenue, } B7 = B1\times B2+B3\times B4+B5\times B6$$

Cost Calculation:
Expander Duty = D1 , D320 Re-boiler Duty= D2 ,D330 Re-boiler Duty= D3, D330 Condenser Duty = D4
D340 Re-boiler Duty = D5 , D340 Condenser Duty = D6, L231 Pump Duty = D7, Cooling Duty = D8
Heating Duty = D9, E100 Heat Duty = D10, Compressor Duty = D11, E104 Duty = D12, Price per KWh, D13 = 0.737 $, Total Cost,

$$D14 = (D1+D2+D3+D4+D5+D6+D7+D8+D9+D10+D11+D12) \times D13, \text{ Profit} = B7-D13$$

Before Optimization

	A	B	C	D
1	SALES GAS	1.574e+005 m3/h	EXPANDER DUTY	1719 kW
2	SALES GAS PRICE	9.580	D330 REB DUTY	403.8 kW
3	LPG	6880 kg/h	D230 REB DUTY	418.6 kW
4	LPG PRICE	56.00	D340 REB DUTY	3.489e+004 kW
5	CRUDE GASOLINE	8.362 m3/h	D330 COND DUTY	20.43 kW
6	PRICE	4.247e+004	D340 COND DUTY	3.093e+004 kW
7	REVENUE	2.248e+006 m3/h	L231 PUMP DUTY	9.797 kW
8			COOLQ DUTY	2.450e+004 kW
9			HEAT Q DUTY	9111 kW
10			E100 HEAT DUTY	2.450e+004 kW
11			COMPRESSOR DL	1.217e+004 kW
12			E104 DUTY	444.1 kW
13			PRICE	0.7370
14			TOTAL COST	1.000e+005 kW
15				
16				
17			PROFIT	2.148e+006

After Optimization

	A	B	C	D
1	SALES GAS	1.745e+005 m3/h	EXPANDER DUTY	2014 kW
2	SALES GAS PRICE	9.580	D330 REB DUTY	403.8 kW
3	LPG	7134 kg/h	D230 REB DUTY	418.5 kW
4	LPG PRICE	56.00	D340 REB DUTY	3.457e+004 kW
5	CRUDE GASOLINE	8.362 m3/h	D330 COND DUTY	20.43 kW
6	PRICE	4.247e+004	D340 COND DUTY	3.032e+004 kW
7	REVENUE	2.426e+006 m3/h	L231 PUMP DUTY	9.797 kW
8			COOLQ DUTY	2.446e+004 kW
9			HEAT Q DUTY	-2.051 kW
10			E100 HEAT DUTY	2.446e+004 kW
11			COMPRESSOR DL	1.441e+004 kW
12			E104 DUTY	1277 kW
13			PRICE	0.7370
14			TOTAL COST	9.459e+004 kW
15				
16				
17			PROFIT	2.332e+006

Figure 3.1: Spread Sheet Values of the simulation after optimization

4. Results and discussions

After the optimization, both flow rates of LPG and Sales Gas were increased. Consequently, theoretical increase in revenue and total profit was about 8 percent as shown in the spread sheet of Figure 3.1. Following tables shows the before and after condition of the process which shows the variability in composition due to optimization. Comparing these tables shows the efficacy of optimization since the desired components compositions varies in a positive way. Even though the methane fraction lowered but the sales flow increased hence the revenue.

Table 4.1: Composition of significant components of sales gas before optimization*

Name of Components	Composition	Name of Components	Composition
Water(H_2O)	5.95E-06	Methane(CH_4)	0.995707
N_2	2.11E-03	Ethane	9.29E-04
CO_2	2.70E-04		

Table 4.2: Composition of significant components of LPG(Liquified Petroleum Gas)*

Name of Components	Composition in LPG	Name of Components	Composition in LPG
Propane	0.236602	n-Heptane	0.144678
i-Butane	0.154207		
n-Butane	0.15947		

Table 4.3: Optimized composition of significant components of sales gas

Name of Components	Composition	Name of Components	Composition
N_2	2.11E-03	Propane	2.61E-04
CO_2	5.41E-04	i-Butane	1.21E-04
Methane(CH_4)	0.994594	n-Butane	1.61E-04
Ethane	1.78E-03	i-Pentane	1.71E-04

Table 4.4: Optimized composition of significant components LPG(Liquified Petroleum Gas)

Name of Components	Composition in LPG	Name of Components	Composition in LPG
Propane	0.241527	n-Hexane	9.74E-02
i-Butane	0.153288	n-Heptane	0.143707
n-Butane	0.158469	n-Pentane	5.73E-02
i-Pentane	9.15E-02		

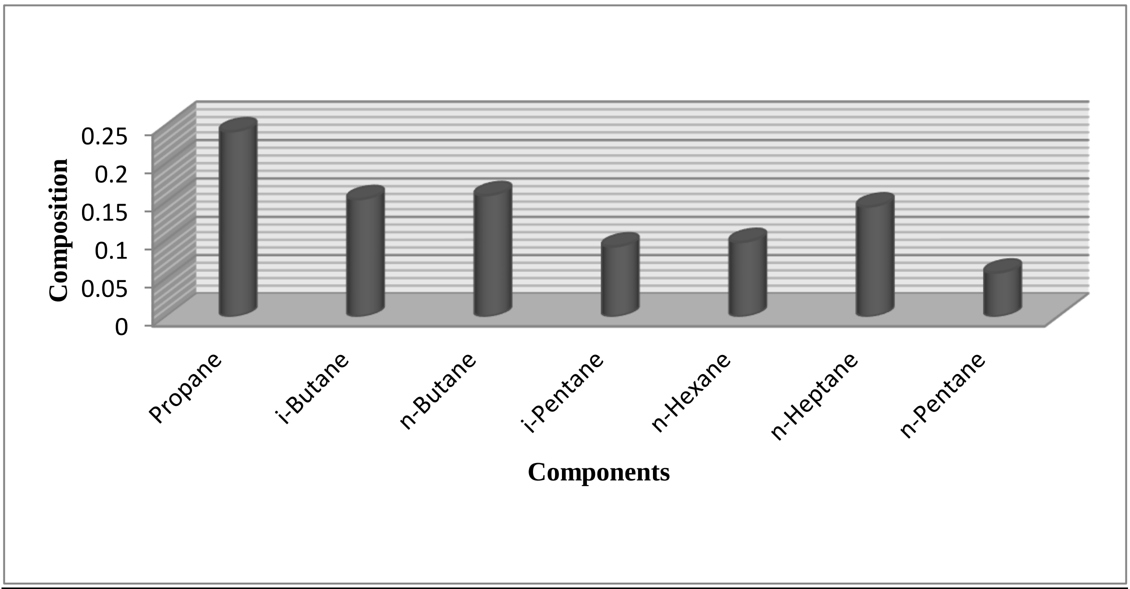

Figure 4.1: Graphical representation of LNG components

* Tablular Data were taken from Bibiyana Gas Fields of Bangladesh

5. Process flow diagram

Following is a depiction of part of the simulated process on Hysys.

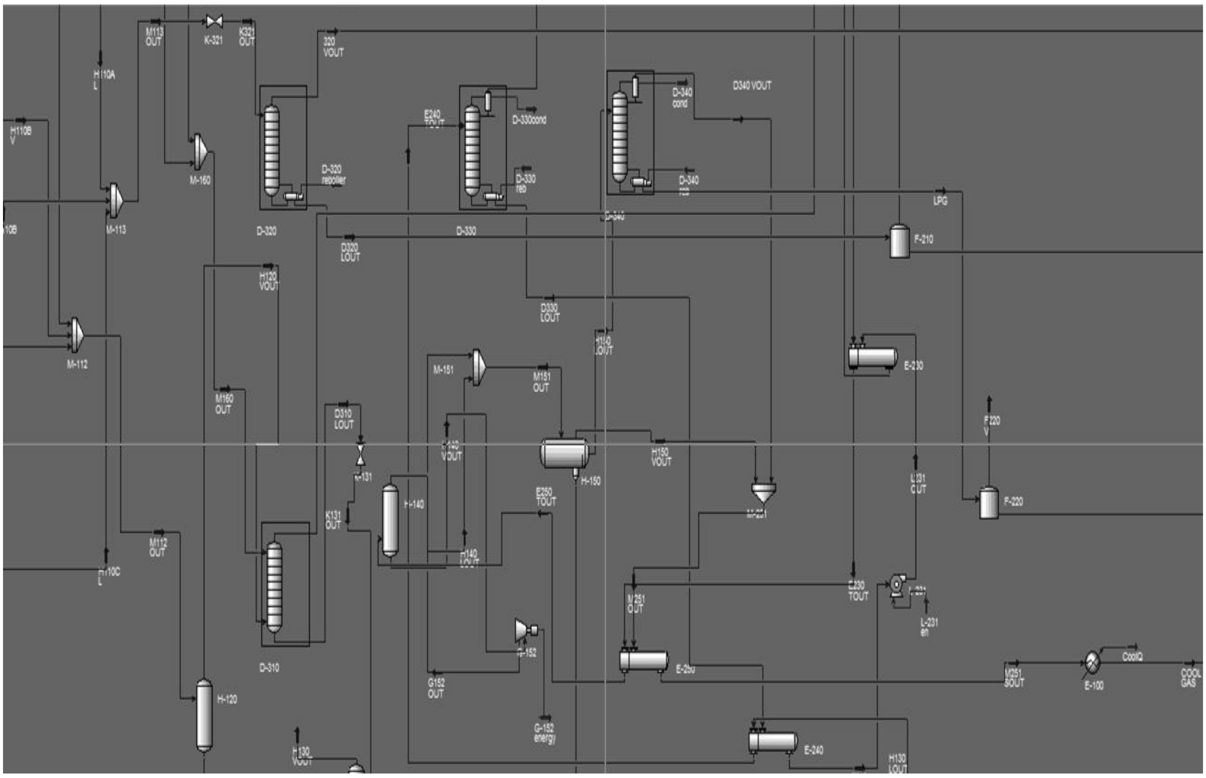

Figure 5.1: PFD of a part of the simulation process

6. Conclusion

At present time natural gas is a major source of energy. Most of the industries are run by energy using natural gas as their main source. Near about 95% of the natural gas is used as fuel gas. So, it is a major prospect to focus on and develop for the betterment of energy utilization. The model for natural gas processing plant is developed in this paper. Different process can be used to meet the specification required for processing of natural gas. Environmental constraints and the need to reduce cost require innovative processes. The process used here derived from earlier processes, but tend to offer significant reductions in investment and operating costs. In the longer term, new concepts such as gas permeation can be expected to play a growing role and the natural gas processing will keep changing. In this plan, the composition of sales gas is satisfactory. The percentage removals of unwanted elements are good enough to run the process. Furthermore, profit was maximized by means of optimization. Optimization provides a better process with higher benefits.

7. Acknowledgment

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Nomenclature

Symbol	Meaning
HC	Hydrocarbon
H	Two and three phase separator
E	Heat Exchanger
M	Mixer
LPG	Liquefied petroleum gas

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Modeling and Optimization of Aggregate Production Planning by Time-varying Acceleration Coefficients PSO

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Abstract

The aim of this paper is to apply Time-varying Acceleration Coefficients PSO (TVACPSO) for modeling and optimization of aggregate production planning problem. TVACPSO is a modified and updated form of Particle Swarm Optimization (PSO). Most practical decisions made to solve APP problems usually consider total costs; we have eliminated other objective functions of APP in this case. There was several variables problem with constraints which was solved in MATLAB. The proposed approach attempts to minimize total costs with reference to inventory levels, labor levels, and overtime, subcontracting and backordering levels. An industrial case is presented to demonstrate the feasibility of applying the proposed method to real APP problems. Consequently, the proposed TVACPSO approach yields an efficient APP compromise solution.

Keywords: Aggregate production planning (APP), Time-varying Acceleration Coefficients PSO (TVACPSO), cost minimization.

1. Introduction

Aggregate production planning is a process by which a company determines ideal levels of capacity, production, subcontracting, inventory, stock out & even pricing over a specified time horizon. It uses intermediate-range capacity planning that typically covers a time horizon (2 to 12 months), although some companies it may extend to as much as 18 months. The planning horizon is often divided into periods. For example, a one year planning horizon may be composed of six one-month periods plus two or three month periods. In other words, It is concerned with planning overall production of all products combined over a planning horizon for a given (forecast) demand schedule. The goal of aggregate is to achieve a production plan that will effectively utilize the organization's resources to satisfy expected demand. Planner must make decisions on output rates, employment levels and changes, inventory levels and changes, back orders, and subcontracting in or out. Aggregate planning might seek to influence demand as well as supply. If this is the case, variables such as price, advertising, and product mix might be used. If changes in demand are considered, then marketing, along with operations, will be intimately involved in aggregate planning. Aggregate planning is essentially a big-picture approach to planning. The purpose of aggregate production planning is to achieve a production plan that will effectively utilize the organizations resource to satisfy expected demand. There are many solving procedure for APP problem but in this paper we have used a new algorithm Time-varying Acceleration Coefficients PSO (TVACPSO). TVACPSO is a modified and updated form of Particle Swarm Optimization (PSO). The algorithm of PSO emulates from behavior of animals societies that don't have any leader in their group or swarm, such as bird flocking and fish schooling. PSO algorithm is a multi-agent parallel search technique which maintains a swarm of particles and each particle represents a potential solution in the swarm. All particles fly through a multidimensional search space where each particle is adjusting its position according to its own experience and that of neighbors. In a PSO method, all particles are initiated randomly and evaluated to compute fitness together with finding the personal best (best value of each particle) and global best (best value of particle in the entire swarm). In this study, TVACPSO is a relatively new approach for solving optimization problem is employed to solve the proposed APP problem due to its simplicity, speed, and robustness.

2. Literature Review

Aggregate production planning is the problem to determine the resource capacity needed to meet demand in the production line. Shorten product life cycle in market & fickle customer perceptions push the researchers to choose this broad area to research. Wang and Fang (2001) [1] modeled an APP with fuzzy variables and in this study the decision variables, the demands and subcontracting cost are accepted as triangular fuzzy numbers. Tang et al (2000) [2] formulated a multi-product APP problem as a fuzzy quadratic programming with both fuzzy demand and fuzzy constraint appears in the same model. A fuzzy multi-product APP problem was solved Fung et al. (2003) [3] and the APP problem has only one objective (minimizing the total cost) and only the demands and the capacities are defined as fuzzy. For solving the multi-product APP problem in a fuzzy environment a fuzzy multi-objective linear programming model was developed by Wang and Liang (2004) [4]. Wang and Liang (2005) [5] handled a fuzzy multi-product APP problem and is modeled as a multi-objective linear programming problem and all of the objectives are defined as fuzzy with imprecise aspiration levels. Ning et aI. (2006) [6] established a multiproduct aggregate production planning (APP) decision making model in fuzzy random environments. Baykasoglu and Gocken (2006) [7] proposed a multi-objective tabu search (TS) based solution method to solve fuzzy goal programs. Tavakkoli-Moghaddam et al. (2007) [8] presented a fuzzy APP model for make-to-stock environments. Ling (2008) [9] developed a fuzzy multi objective linear programming (FMOLP) model with piecewise linear membership function to solve integrated multi product and multi time period production/ distribution planning decisions (PDPD) problems. Torabi et al (2009) [10] presented a fuzzy hierarchical production planning comprised of two decision-making levels. Chen and Huang (2010) [11] proposed a solution procedure that is able to find the fuzzy objective value of the fuzzy APP model. Based on ranking methods of fuzzy numbers and tabu search Baykasoglu and Gocken (2010) [12] proposed a direct solution method to solve fuzzy multi-objective aggregate production planning problem. Ramezanian et al (2012) [13] presented a mixed integer linear programming (MILP) model for general two-phase aggregate production planning systems. Zhang et al (2012) [14] built a mixed integer linear programming (MILP) model to characterize mathematically the problem of APP with capacity expansion in a manufacturing system including multiple activity centers. Some meta-heuristic algorithms were also employed to solve APP problems. Raa et al (2013) [15] presented a mixed integer linear programming formulations for the planning problem and a metaheuristic solution approach based on the models. Chakrabortty and Hasin (2013) [16] used three distinct scenarios simultaneously with different genetic algorithm options for solving multiple objectives of fuzzy linear programming models including escalating factors. Chen and Huang (2014) [17] investigated multiproduct, multi-period APP problems with several distinct types of fuzzy uncertainties. Particle Swarm Optimization (PSO) is another relatively new bio-inspired algorithm that may be used to find optimal or near-optimal solutions to numerical and quantitative problems. It was originally developed by a social psychologist, James Kennedy and Russel Eberhart (1995) [18]. El Mounayri et al. (2003) [19] used PSO to predict parameters of surface roughness in end milling. Prakasvudhisarn (2004) [20] used PSO to determine minimum tolerance zones of all basic form features for discrete parts inspection. Some researchers applied PSO to solve optimization problems with constraints. Hu et al. (2003) [21] modified the PSO to solve constrained nonlinear problems by preserving only feasible solutions. In 2002, A. Salman [22] published a paper on the use of particle swarm optimization for task assignment problem. Again H. J. Escalante et al [23] worked on particle swarm model design. In 2007, M. F. Tasgetiren et al [24] researched on the use of PSO algorithm for make span and total flow time minimization in flow shop sequencing problem.

3. Algorithm

3.1. Time-varying Acceleration Coefficients PSO

PSO has multiple particles, and every particle consists of its current objective value, its position, its velocity, its personal best value, that is the best objective value the particle ever experienced, and its personal best position, that is the position at which the personal best value has been found. Time-varying Acceleration Coefficients PSO (TVACPSO) does not only change the inertia weight w, but also the acceleration coefficients, i.e., the personal c_1 and global best weight c_2, over time. The idea is to have a high diversity for early iterations and a high convergence for late iterations. TVACPSO uses the following iteration to determine the velocities:

Step1: Assume the number of particles.
Step2: Initialize the position of the particles.
Step3: Evaluate the objective function for each particle.
Step4: Set the initial velocities of each particle.

Step5: Find the personal best and global best position
Step6: New velocities calculation for each particle by using the following equation,

$$v^{(i)}(n+1) = w_{(n)}v^{(i)}(n) + c_1r_1^{(i)}(n)[x_p^{(i)}(n) - x^{(i)}(n)] + c_2r_2^{(i)}(n)[x_g(n) - x^{(i)}(n)],$$
$$n = 0, 1, 2, ..., N-1,$$

Where the personal best weight c_1 and the global best weight $c_2$at every iteration n are calculated using the following equations:

$$w_{(n)} = w_s - (w_s - w_e)\frac{n}{N}$$
$$c_1(n) = c_{1s} - (c_{1s} - c_{1e})$$
$$c_2(n) = c_{2s} - (c_{2s} - c_{2e})\frac{n}{N}$$

where $c_1(n)$ is the personal best weight at iteration n, $c_2(n)$ is the global best weight at iteration n, c_{1s} is the personal best weight designated for the first iteration, c_{1e} is the personal best weight designated for the last iteration N , c_{2s} is the global best weight designated for the first iteration, and c_{2e} is the global best weight designated for the last iteration N .

Step7: Find updates position for each particle by using the following equation

$$x^{(i)}(n+1) = x^{(i)}(n) + v^{(i)}(n+1),\ n = 0, 1, 2, ..., N-1,$$

Step8: Continue this process from step 3 to step 8.

4. Problem Formulation

4.1. Problem Description & Notation

The following notations were employed for formulating the APP problem:

N	Types of products
T	Planning horizon
z	Total production cost
D_{nt}	Forecasted demand for nth product in period t (units)
a_{nt}	Regular time production cost per unit for the nth product in period t (Tk./unit)
Q_{nt}	Regular time production for nth period in period t (units)
b_{nt}	Overtime production cost per unit for the nth product in period t (Tk./unit)
O_{nt}	Overtime production for nth period in period t (units)
c_{nt}	Subcontracting cost per unit for the nth product in period t(Tk./unit)
S_{nt}	Subcontracting volume for nth period in period t (units)
d_{nt}	Inventory carrying cost per unit for the nth product in period t(Tk./unit)
I_{nt}	Inventory level in period t for nth product (units)
e_{nt}	Backorder cost per unit for the nth product in period t (Tk./unit)
B_{nt}	Backorder level for nth period in period t (units)
g_t	Regular-time wages in period t (Tk./man-day)
W_t	Workforce level in period t (man-days)
k_t	Cost to hire one worker in period t (Tk./man-days)
H_t	The number of workers hired in period t (man-days)
m_t	Cost to layoff one worker in period t (Tk./man-days)
F_t	The number of worker laid off in period t (man-days)
i_{nt}	Hours of labor per unit of nth product in period t (man-hour/unit)
r_{nt}	Hours of machine usage per unit of nth product in period t (machine-hour/unit)
δ	Regular time per worker (man-hour/man-day)
α_t	The fraction of regular-time workforce available for use in overtime in period t

V_{nt} Warehouse spaces per unit of nth product in period t (ft^2/unit)
W_{tmax} Maximum labor level available in period t (man-days)
M_{tmax} Maximum machine capacity available in period t (machine-hours)
V_{tmax} Maximum warehouse available in period t (ft^2)

4.2. Objective Function

$$\text{Min } z = \sum_{n=1}^{N}\sum_{t=1}^{T}(a_{nt}Q_{nt}+b_{nt}O_{nt}+c_{nt}S_{nt}+d_{nt}I_{nt}+e_{nt}B_{nt})+\sum_{t=1}^{T}(k_t H_t+m_t F_t+g_t W_t)$$

4.3. Constraints

Constraint on carrying inventory,

$$I_{n(t-1)} - B_{n(t-1)} + Q_{nt} + O_{nt} + S_{nt} - I_{nt} + B_{nt} = D_{nt} \quad \text{for } \forall n, \forall t$$

Constraint on labor level,

$$W_t = W_{t-1} + H_t - F_t \quad \text{for } \forall t$$

$$\sum_{n=1}^{N} i_{nt} Q_{nt} \le \delta W_t \quad \text{for } \forall t$$

$$\sum_{n=1}^{N} i_{nt} O_{nt} \le \alpha_t \delta W_t \quad \text{for } \forall t$$

$$W_t \le W_{tmax} \quad \text{for } \forall t$$

Constraint on Machine capacity and Warehouse space,

$$\sum_{n=1}^{N} r_{nt}(O_{nt} + Q_{nt}) \le M_{tmax} \quad \text{for } \forall t$$

$$\sum_{n=1}^{N} V_{nt} I_{nt} \le V_{tmax} \quad \text{for } \forall t$$

Non-negativity constraints on decision variables,

$$Q_{nt}, O_{nt}, S_{nt}, I_{nt}, B_{nt}, W_t, H_t, F_t \ge 0$$

5. Case Description

In this study required data was taken from CCKL, one the leading company in RMG sector in Bangladesh.Tables1and 2 summarize the forecast demand, related operating cost, and capacity data. Other relevant data are as follows:

1. Initially there is no backorder (B_{n0}=0) and initial inventory (I_{n0}) of product 1 is 500 units and product 2 is 200 units.
2. Regular time per worker (δ) is 8 hours. Beginning workforce level (W_0) is 1,000 man-days.
3. The cost associated with regular, hiring and layoffs are Tk.195, Tk.205, Tk.115, per worker per day, respectively.
4. Setup cost for period 1 is 220 and period 2 is 210.
5. Hours of labor per unit of any periods are fixed to 0.033 man-hours for product 1 and 0.05 man hours for product 2.Hours of machine usage per unit for each of the two planning periods is 0.1 machine hours for product 1 and 0.08 machine hours for product 2. Warehouse spaces required per unit are 1 square feet for product 1 and 1.5 square feet for product 2. Setup time for product 1 is 0.6 machine-hours and product 2 is 0.5 machine-hours.
6. Faction of regular workforce level available for overtime for both periods is 0.4.

Table1: Forecasted demand, maximum labor and machine and warehouse capacity data

Item (Units)	Periods	
	1	2
D_{1t} (pieces)	1400-1500	3000-3100
D_{2t} (pieces)	1600-1700	800-900
$W_{t\,max}$	225	225
$M_{t\,max}$	400	500
$V_{t\,max}$	1000	1000

Table2: Related operating cost data

Product	a_{nt} (Tk./Unit)	b_{nt} (Tk./Unit)	c_{nt} (Tk./Unit)	d_{nt} (Tk./Unit)	e_{nt} (Tk./Unit)
1	22	40	27	3.5	42
2	20	40	30	4	47

6. Results and Findings

The APP decision problem presented here was solved by Time Varying Acceleration Coefficient PSO (TVACPSO). It was run in MATLAB 2010a by a PC with configuration Intel (R) Core(TM) i3-2310M CPU @ 2.10 GHz, 2 GB RAM. We have used w_s =0.9, w_e =0.4, c_{1s} =2.5, c_{2s} =0.5, c_{1e} =0.5 and c_{2e} = 2.5. The optimal value when applying TVACPSO to minimize the total costs was **Tk. 2, 82, 249**. In this problem TVACPSO excelled in all criterion. It had the better objective function value in shortest time. In this case, only one objective function which is cost related is considered. But in practice, the firms may be operating under competing criteria and the primary objective may not necessarily be only minimizing cost. Finally, the TVACPSO approach is useful for solving APP decision problems and can generate better decisions within very short time.

7. Conclusion & Future Works

The results show that TVACPSO is much more effective in this type of case. Besides, fewer parameters selection has made it much easier to work with TVACPSO. In future we can work with total uncertain condition. Besides some modifications regarding velocity upgrade or velocity clamping can be made which will result in even faster performance. And obviously there's an option that we can perform some comparative study of TVACPSO with standard PSO and different modified form of PSO. Also TVACPSO may compare with other optimization algorithms and find suitable options for solving engineering optimization problems.

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The Implementation of Different Forecasting Techniques for Demand Forecasting in Jute Product Section in Bangladesh

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Abstract

This paper illustrates a case study of forecasting method selection based on its error determinants for a jute products manufacturing industry in Bangladesh. The historical demand data of jute yarn for the year 2010, 2011, 2012, and 2013 from Akij Jute Mills, Akij Group Ltd. in Noapara, Jessore were used to forecast for the upcoming periods. The analysis shows that, the Mean absolute percent error (MAPE) value of the Naïve forecast is 26.55, simple moving average varies between 27-35 for the 1 year, 6 month and 3 month, the exponential smoothing value ranging from 28-30 with smoothing constant α =0.1 to 0.9 and the least square linear regression is 25.83. In summary, the weighted moving average gives the best performance of forecast with the minimum MAPE value of 16.29. This study will provide an outline for the Bangladeshi manufacturers to select the best forecasting method for their industry.

Keywords: Forecasting, forecasting error, jute industry.

1. Introduction

The forecasting is a technique that is used to predict future event and occurrences. It is one of the key tools for the management decision making. Therefore, every organization typically contains a forecasting function for planning and controlling their operations. Availability of future value makes easy for future planning and decision making activities [1]. Different methods are developed to forecast and the selection of the best technique is based on various measures of performance. In general, accuracy of the forecasting is measured in each case using different criteria such as MSE, MAD and MAPE etc.

Time series forecasting have passed much precise experiment for the last quarter century. Hooker (1921) first introduced moving-averages which consider several period averages to predict the future event [2]. On the other hand, Roberts (1959) first developed the exponentially weighted moving average for identifying small modifications in the mean of a process [3]. Brown (1950) expanded simple exponential smoothing to detached data and promoted methods for trends and seasonality [4]. Pegels (1969) presented a simple and suitable taxonomy of the trend and the seasonal patterns depending on their linearity and nonlinearity [5]. Business firms prepare sales forecasts using method that provides accuracy of their predictions. Business firms commonly use subjective, extrapolation and naive techniques in various forecasting situations [3]. As forecasting errors are the main concern, business firms are using computers and seasonal adjustments in more for reducing these errors [6]. Kolmogorov (1941), Levinson (1947) and Wiener (1949) were the pioneers in the field of linear prediction who described the methodology of using in multivariate processes [7-9]. The least-squares method was expressed by Legendre (1805) while, Gauss (1809) provided such type of prediction which is used in forecasting [10]. The short-term and long-term study shows that, daily seasonality differences accounted for a large portion of the variance which makes urgent the consideration of seasonality when forecasting [11]. The foremost purpose of this study is to validate the feasibility of forecasting methods namely Naïve Approach, Simple Moving Average, Weighted moving average, Exponential Smoothing, and Linear Least Square Regression for choosing the most suitable one.

2. Importance of forecasting in industries in Bangladesh:

In general, every industry in Bangladesh uses forecasting technique for various purposes. Forecasting is needed to predict future sells and inventory management. Some industries may work on the order basis but they need to ensure the availability of all raw materials just in time. Most of the manufacturing industries in Bangladesh do not produce all the raw materials what they need. In this case, to acquire these materials they need proper method in order to avoid the excess cost. Forecasting certainly is a way to solve this problem. On the other hand, supplier type industries supply their materials to various industries. So they need to maintain proper inventory management system which is impossible without following forecasting technique. Industries which do not operate in order basis, forecast market demand of their products. In Bangladesh all the industries, suppliers or manufacturers either operate or do not operate in order basis, need to follow forecasting technique.

3. Methodology

This paper involves comparing five different forecasting methods and selecting the one based on various measures of forecasting accuracy namely Mean absolute deviation (MAD), Mean square error (MSE) and Mean absolute percent error (MAPE). The sample demand data for forecasting were collected from Akij Jute Mills, Akij Group Ltd. in Noapara, Jessore. Quantitative techniques are used here as they are based on the idea that past demand data can be used to predict future demand. Among the quantitative techniques Naïve Approach, Simple Moving Average, Weighted moving average, Exponential smoothing and Linear Least Square Regression are used. Trends, seasonal and random components of demand are incorporated to calculate the seasonality index which is used in each technique. Required calculations are performed to analyze relevant data and make the forecast. Various equations used for our research purpose are listed below.

Naive Forecasts:

$$\text{Forecast next period, } F_{t+1} = F_t \qquad (1)$$

Where, F_t = Previous actual value

Simple moving average:

$$F_t = MA_n = \frac{\sum A_i}{n} \qquad (2)$$

Where, F_t = Forecast for time period i

MA_n = Moving average with n periods

A_i = Actual value with age i

i = Age of the data (i = 1, 2, 3…….)

n = Number of periods in moving average

Weighted Moving Average:

$$F_{t+1} = w_t A_t + w_{t-1} A_{t-1} + \cdots\cdots\cdots\cdots + w_{t-n} A_{t-n} \qquad (3)$$

Where, $w_t + w_{t-1} + \cdots\cdots\cdots\cdots + w_{t-n} = 1$

t = The current period

F_{t+1} = The forecast for next period

n = The forecasting horizon (how far back we look),

A = The actual sales figure from each period.

w = The importance (weight) we give to each period

Exponential smoothing:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \qquad (4)$$

Where, F_t = Forecast for period t

F_{t-1} = Forecast for the previous period

α = Smoothing constant

A_{t-1} = Actual demand

Least square Linear Regression Analysis:

$$Y = \alpha + \beta X \qquad (5)$$

Addressing Seasonality in the Model:

$$C_i = \left(\sum_{j=-2}^{1} d_{i-j} + \sum_{j=-1}^{2} d_{i-j} \right) \Big/ 2 \tag{6}$$

$$r_i = \frac{d_i}{C_i} \tag{7}$$

$$u_{t,i/12+i} = \left(\sum_{j=0}^{N-1} r_i + 12_j \right) \Big/ N \tag{8}$$

$$S_t = \frac{n \times ut}{\sum ut} \tag{9}$$

Addressing both Trend and Seasonality in the Model:

$$Y_t = X_t \times S_t \tag{10}$$

Error, $E_t =$ Actual – forecast (11)

Mean Absolute Deviation, $MAD = \frac{\sum_{t=1}^{N} |E_t|}{N}$ (12)

Mean Squared Error, $MSE = \frac{\sum_{t=1}^{N} E_t^{\,2}}{N}$ (13)

Mean Absolute Percent Error, $MAPE = \frac{\sum_{t=1}^{N} \left| \frac{E_t}{Y_t} \right|}{N} \times 100$ (14)

4. Result and Discussion

From demand data of Jute Yarn in the year 2010, demand was steady 1-4 weeks, than it sharply increased to a value 726 ton at week 5, it continued steady till week 8 and suddenly it decreased to a value 503 ton as presented in Table 1.

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Table 1. The demand data of Jute yarn of Akij Jute Mill (2010-2013)

Year	Week												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2010	403	405	427	420	726	729	745	757	503	505	507	509	510
2011	680	695	670	685	940	970	992	995	770	725	750	765	710
2012	711	723	727	730	1056	1065	1077	1099	844	833	827	824	820
2013	990	995	993	991	1577	1586	1589	1598	1250	1245	1237	1230	1225
Year	Week												
	14	15	16	17	18	19	20	21	22	23	24	25	26
2010	480	470	460	455	565	569	575	579	585	587	592	578	560
2011	650	664	633	620	700	705	712	727	732	750	755	767	778
2012	775	767	765	760	990	992	994	995	993	975	977	976	978
2013	1187	1180	1178	1175	1319	1329	1327	1337	1345	1365	1367	1375	1377
Year	Week												
	27	28	29	30	31	32	33	34	35	36	37	38	39
2010	498	490	487	485	478	990	992	997	999	427	419	415	412
2011	787	745	737	732	706	702	1001	1050	1080	1097	600	604	607
2012	979	960	962	963	967	1275	1285	1287	1290	1295	895	890	845
2013	1380	1282	1283	1287	1290	1790	1793	1795	1797	1799	1097	1060	1050
Year	Week												
	40	41	42	43	44	45	46	47	48	49	50	51	52
2010	522	517	505	500	530	533	537	545	567	520	546	555	569
2011	609	703	702	705	715	635	681	603	607	627	617	615	621
2012	820	982	984	987	989	991	993	995	994	985	983	981	979
2013	1036	1240	1252	1265	1243	1340	1342	1343	1347	1133	1123	1120	1128

It was quite steady from week 9-17 and in week 18 a medium increased in demand was found then it was quite same till week 31. The trend of demand found in weeks 32-35 was highest and here the seasonality found. After that it sharply decreased and continued with slight fluctuations. The trend of demand in 2011 was quite same as 2010 with little variations. Here demand in each week was above 600 ton, seasonality trends were found in weeks 5-8 and 33-36 and in both cases that was increasing trends. In week 18-32, 37-40, 41-44 and 47-52 the demands were steady and the demands in the remaining weeks fluctuated slightly. Demand data 2012 showed that the trend was quite same like year 2010 and 2011 however, here the average demand increased and both the lowest and highest demands were greater than the previous years. Seasonality trends were found in weeks 5-9 and 32-36. In week 37-40 demands fluctuated and in case of other trend demands were very steady.

Demand data 2013 showed great change in demand at every week and these values were greater than the previous years. The lowest value of demand was above 1000 ton. The trends of data were similar to the previous years but it varied slightly from the demand data 2012. Here demand data from week 41-53 fluctuated heavily.

Table 2 shows the various measure of forecasting accuracy using different approaches. MAD value in different methods varies 209.94 to 487.63, MSE value varies 52047.65 to 294600.20 and MAPE value varies 16.29 to 35.70. Among these methods weighted moving average displays the minimum value in each case which is an indication of greater accuracy and implies the suitability of this method.

Table 2. Accuracy measurements of different forecasting methods

Forecasting Model		MAD Value	MSE Value	MAPE Value
Naïve Approach		363.5962	156659.2	26.55625
Simple Moving Average				
1 Year moving Average		487.6331	294600.2	35.70618
6 month moving average		391.1026	195637.3	28.77705
3 month moving average		374.3141	173320.3	27.78583
Weighted moving average		209.9423	52047.65	16.2936
Exponential smoothing				
	α=0.1	422.67	244408.34	30.64
	α=0.2	403.05	213711.98	29.50
	α=0.3	394.87	201738.28	29.00
	α=0.4	387.99	194513.50	28.55
	α=0.5	386.68	190005.67	28.55
	α=0.6	383.71	186271.45	28.38
	α=0.7	382.27	183335.37	28.34
	α=0.8	381.16	181028.22	28.31
	α=0.9	380.23	179250.41	28.29
Linear Least Square Regression		361.2609	182250.7	25.8384

5. Conclusions

Forecasting is the best renowned method used in various firms to predict the future event. To select a suitable method among various methods is very essential for a firm. This paper selects weighted moving average as the best method which yields a MAPE value 16.29. As the firm does not apply any particular method for forecasting their demand, this method can be useful for them to predict their actual demand. The analysis of various techniques for demand forecasting in this paper can be a guide for other firms to select their appropriate forecasting method.

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Optimization of Turning Parameters for Cutting Force and Chip Thickness Ratio in Dry Turning Process: An Experimental Investigation

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Abstract

The aim of this paper is to determine the best turning process parameters that give the optimal magnitude of chip thickness ratio and cutting forces of cylindrical mild steel bar under turning operation. There were total 27 experimental combinations for the three machining parameters i.e. Spindle speed, Feed rate and Depth of cut in three levels. From the obtained experimental data, two separate general equations were developed for both chip thickness ratio and generated force, where chip thickness ratio and force are the responses of the three considered cutting parameters. In developing equations, the theory of multiple regression analysis was used. The Analysis of Variance Approach (ANOVA) was employed to verify the significance of the equations in practical implementation and the developed equations were found to be significant physically and statistically. Finally Genetic Algorithm (GA) was adopted to determine the best level of the parameters.

Keywords: Turning process parameters, optimization, cutting force, ANOVA, GA.

1. Introduction

Turning, Milling, and Drilling is the most common secondary metal shaping technology [1]. Turning is a form of machining or a material removal process, which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of re-shaped material that is attached to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speed. The cutter is typically a single-point cutting tool that is also attached in the machine. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desired shape. In turning process, the speed and motion of the cutting tool and rotating work piece are specified through several parameters. These parameters are selected for each operation based upon the workpiece material, tool material, tool size and more. The most important turning parameters that can affect the process are cutting speed, depth of cut, feed rate etc.

The forces acting on a single point cutting tool are of fundamental importance in the design and of cutting and machine tools. The resultant cutting force P acting on the tool is considered to be as vector sum of three components of forces mutually at right angles. Feed force (F_x) acts in a horizontal plane but in the direction opposite to the feed. Thrust force (F_y) acting in the direction perpendicular to the generated surface. Cutting forces (F_z) is in the direction of the main cutting motion. The relationships among these forces depend upon cutting variables. Resultant force, P $=\sqrt{(F_x^2 + F_y^2 + F_z^2)}$. Power consumption is directly proportional to the resultant force generated.

During the turning process, when force is applied by cutting tool against the workpiece, the uncut layer deforms first elastically followed by plastic deformation due to the shearing action near the cutting edge of the tool. Shearing takes place along a shear zone and shear is highest at the shear plane. After passing out the shear plane, the deformed material slides along the tool face as chip as cutting progresses. Chip thickness ratio, $r = t_1/t_2$; where t_1= chip thickness before cutting and t_2= chip thickness after cutting. The value of chip thickness ratio is always less than 1. If the ratio r is larger i.e. close to 1, the cutting action is good defined by good surface finish. The ratio is affected by process parameters.

The high tech industries require, generally, high dimensional accuracy and good surface integrity of the fabricated parts, being the machining an essential manufacturing process for reaching these requirements [2]. There are several strategies which have been used with some success in the development of machinability of different materials, namely the optimization of cutting parameters [3, 4], chip breaking [5, 6], tool vibration [7,

8], cryogenic cooling [9], high pressure coolant [10], and others for meeting the demand of high tech industries. Chip thickness ratio is the important index of machinability [11] which is usually judged by cutting temperature; pattern and mode of chip formation; surface finish; tool wear and tool life [12]. Another researcher also said that Machinability of both materials and tools can be evaluated in terms of roughness, flank wear, cutting force, chip thickness ratio, and shear angle [13]. During the turning of the hard martensitic stainless steel it was found that it produced saw tooth chips in all operating parameters which increased the cutting forces [14] which is another great important machinability index. During the conduction of study on cutting AISI 420 steel using PCBN tool, it was observed that the tool wear was found due to abrasion and cutting temperature [15].
Environment awareness and the cost pressure on business organization have led to a rethinking of conventional flood cooling [16]. The last few decades, different cooling systems during machining process have been developed such as cryogenic cooling, solid lubricants, minimum quantity lubrication, high pressure coolant and also dry cooling [17]. After handsome amount of literature review, authors have selected two machinability indices which are the cutting force and the chip thickness ratio. These two machinability indices then have been optimized by selecting appropriate level of the turning process parameters such as depth of cut, feed rate, and spindle speed in dry condition.
When the chip thickness ratio is large, the cutting condition defined by surface finish is good and when the generated force is less, energy consumption is less. The chip thickness ratio depends on the turning parameters like depth of cut, spindle speed, feed rate etc. For obtaining good cutting conditions, the important affecting parameters need to be designed optimally. An investigation is made for searching the optimum and efficient combination of the affecting parameters of chip thickness ratio and force generated.

2. Experimental design

The experimental investigations were conducted to determine the optimal combination of the turning process parameters (Depth of cut, feed rate and spindle speed) on basis of the two response parameters (generated force and Chip thickness ratio). All the experimental tests were performed in a lathe machine whose specifications are demonstrated in table1. HSS single point cutting tool, widely used for machining carbon steel alloy, whose specifications are tabulated in the table 2 were used to perform the experiment in dry condition on the work piece whose specifications are demonstrated in the table 3. The most prominent turning process parameters which are depth of cut, feed rate and spindle speed were selected as control parameters, and each parameter was designed to have three levels, denoted as level 1, 2, and 3, mentioned in table 4. The experiments were designed by considering three control parameters and its levels. By this experimental design total 27 experimental runs were obtained and those are shown in table 5.

Table 1. Machine specifications

Characteristics	Size	Characteristics	Size
Bed Length	8.5 ft.	Spindle hollow	90 mm
Width of Bed	450 mm	Metric threads	1-14 mm
Height of center	400 mm	Number of feed rate	30
Swing over Bed	800 mm	Range of feed rate	0.033-0.5 mm
Swing over cross slide	530 mm	Number of spindle speed	9
Swing in gap	1200 mm	Spindle speed range	30-720 RPM
Admit between centers	1500 mm	Electric motor	5 Hp, 1440 RPM

Table 2. Cutting tool specifications

Characteristics	Size	Characteristics	Size
Tool material	High Speed Steel (HSS)	Side relief angle	6 degree
Tool type	Single point cutting tool	End cutting edge angle	8 degree
Back rack angle	10 degree	Side cutting edge angle	8 degree
Side rack angle	10 degree	Nose radius	2 mm
End relief angle	6 degree	Major cutting edge angle	71 degree

Table 3. Work piece specifications

Characteristics	Type	Characteristics	Size
Material	Mild Steel (MS)	Diameter	40 mm
Shape	Cylindrical	Length	1.5 ft.

Table 4. Parameters and its levels

Parameters	Level 1	Level 2	Level 3
Depth of cut (mm)	0.415	0.56	0.68
Feed Rate (mm/rev.)	0.08	0.14	0.28
Spindle speed (RPM)	245	490	650

3. Experimental results and decisions

The turning tests in dry condition were performed on a lathe machine according to the experimental design. During the turning process, the generated force and the chip thickness were measured with digital dynamometer and digital slide calipers respectively for each experimental run and those were also recorded for the further analysis. All data were recorded in the table 5.

Table 5.Experimental data table

No. of experiment	**Depth of Cut (mm)** x_{ai}	**Feed rate (mm/revolution)** x_{bi}	**Spindle speed (rpm)** x_{ci}	**Force Generated (KN)** y_{ai}	**Chip thickness Ratio** y_{bi}
01	0.415	0.08	245	0.16	0.860
02			490	0.15	0.880
03			650	0.13	0.915
04		0.14	245	0.19	0.875
05			490	0.18	0.900
06			650	0.17	0.930
07		0.28	245	0.24	0.880
08			490	0.22	0.905
09			650	0.21	0.910
10	0.56	0.08	245	0.29	0.790
11			490	0.27	0.813
12			650	0.25	0.821
13		0.14	245	0.28	0.844
14			490	0.27	0.861
15			650	0.25	0.870
16		0.28	245	0.30	0.820
17			490	0.29	0.830
18			650	0.28	0.850
19	0.68	0.08	245	0.34	0.653
20			490	0.32	0.671
21			650	0.31	0.690
22		0.14	245	0.43	0.674
23			490	0.41	0.692
24			650	0.38	0.710
25		0.28	245	0.52	0.722
26			490	0.49	0.740
27			650	0.44	0.763

Multiple regression analysis

The complexity of most scientific mechanics is such that in order to be able to predict an important response, a multiple regression model is needed. When this model is linear in the coefficient, it is called a multiple linear regression model. The depth of cut (mm), feed rate (mm/rev), and spindle speed (rpm) as turning process parameters were considered in the development of the mathematical models for the responses i.e. chip thickness ratio and the generated force. The coefficients of determination between the turning process parameters and the responses for the mild steel bar turning process performed by the lathe machine were also obtained by the multiple linear regression analysis.

The estimated response is obtained from the equation, $\hat{y} = b_0 + b_a x_a + b_b x_b + b_c x_c + \dots\dots\dots\dots + b_k x_k$; where,$\hat{y}$ is the estimate of the response variable, $x_a, x_b, x_c \dots\dots x_k$are the explanatory variables

andb_0, b_a, b_b ... . b_k are estimates of the explanatory variables. The mathematical model for the generated force during turning process is as follows:$\widehat{y_a} = b_0 + b_a x_a + b_b x_b + b_c x_c$; where, $\widehat{y_a}$ is the estimate of the generated force, $x_a, x_{b,} x_c$ are the explanatory variables i.e. depth of cut (mm), feed rate (mm/rev), and spindle speed (rpm) respectively and b_0, b_a, b_b, b_c are estimates of the explanatory variables.The mathematical model for the chip thickness ratio during turning process is as follows: $\widehat{y_b} = b_0 + b_a x_a + b_b x_b + b_c x_c$; where, $\widehat{y_b}$ is the estimate of the chip thickness ratio and all other terms are same as the previous definition.
By using the most popularly used statistical analysis software package MINITAB, the following equations were obtained on the basis of the data table 5:
$\widehat{y_a} = -0.1071776379595 + 0.79320020501288x_a + 0.16164457721730x_b - 0.00014941495564x_c$..**(1)**
$\widehat{y_b} = 1.10907107499039 - 0.62732429036086x_a + 0.01444122008191x_b + 0.00009551097505x_c$…**(2)**
Sum square regression, SSR = $\sum_{i=1}^{27}(\widehat{y_i} - \bar{y})^2$
Sum square error, SSE = $\sum_{i=1}^{27}(y_i - \widehat{y_i})^2$
Sum square total, SST = SSR + SSE
Mean square regression, MSR = SSR/k
Mean square error, MSE = SSE/n-(k+1)
n = total number of experiments, k = number of parameters considered.
Coefficient of multiple determinations,
In response to generated force i.e. equation 1,R^2 = SSR/SST = 80.053%
In response to chip thickness ratio i.e. equation 2,R^2 = SSR/SST = 82.9898%
The quantity of R^2 indicates the measure of the proportion of variability explained by the fitted model. Both the fitted model in response of force generated and chip thickness ratio is acceptable, since R^2>80% for both the cases respectively.

Analysis of variance approach (ANOVA)

The problem of analyzing the quality of the estimated regression line is handled by an analysis of variance (ANOVA) approach. In this approach, the total variation in the dependent variable is subdivided into meaningful components that are then observed and treated in a systematic fashion. The general table of the different parameters of ANOVA is given in table 6.

Table 6. General parameters of ANOVA

Source	Sum of Squares	Degree of freedom	Mean Squares	*F-value*
Regression	SSR	k	MSR=SSR/k	MSR/MSE
Error	SSE	n-(k+1)	MSE=SSE/n-(k+1)	
Total	SST	n-1		

Table 7. Analysis of variance in response of force

Source	Sum of Squares	Degrees of freedom	Mean Squares	*F- value*
Regression	0.209688437	k=3	0.069896	30.76
Error	0.052247	n-(k+1) = 27-4	0.00227161	
Total	0.261935437	n-1 = 27-1		

Table 8.Analysis of variance in response of chip thickness ratio

Source	Sum of Squares	Degree of freedom	Mean Squares	*F-value*
Regression	0.13226	k=3	0.053123	7.66
Error	0.027109	n-(k+1)=27-4	0.0069291	
Total	0.159369	n-1=27-1		

For degrees of freedom n-(k+1) = 23 and k = 3, the critical value of the *F*-Distribution is 3.03 at 95% confidence interval. In above models, both the obtained *F*-values from experimental data in response of force generated and chip thickness ratio are greater than the critical value obtained from *F*-Distribution. Therefore the models present statistical and physical significance for the turning parameters of generated force and chip thickness ratio respectively.
The relationship of the process parameters on the response are demonstrated in the fig 1. Some parameters have the strong relationship with the response and it is indicated by the rate of change of curve. From the fig 1, it is clear that depth of cut has the strong relationship with the generated force and the chip thickness ratio. The mean generated force is increased with increase of the depth of cut. On the other hand, the chip thickness ratio is decreased with increase of depth of cut. All other factors have the moderate relationship with the generated force and the chip thickness ratio.

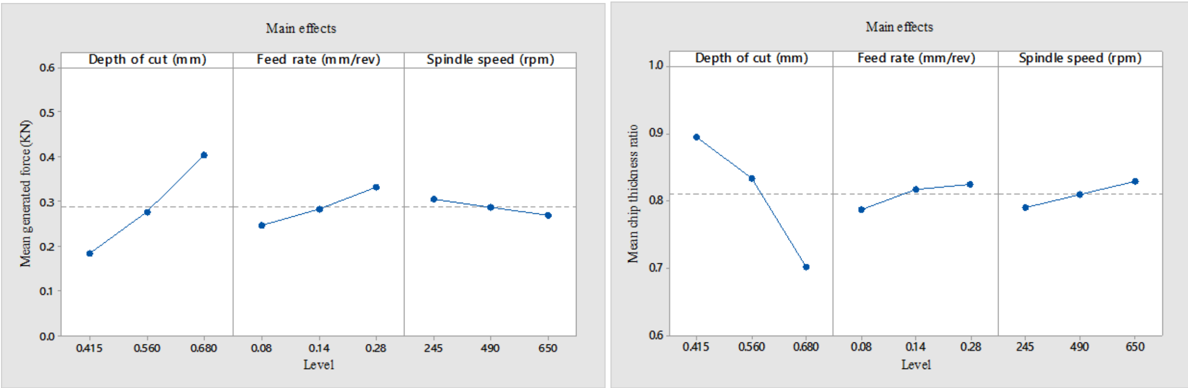

Fig 1: Main effects of process parameters

Genetic algorithm

Genetic algorithm (GA) is a method for solving both constrained and unconstrained optimization problems based on a natural selection process that mimics biological evolution. GA is a very effective way of quickly finding a reasonable solution to a complex problem. The GA repeatedly modifies a population of individual solutions. At each step, the GA selects individuals at random from the current population to be parents and uses the parents to generate the children for the next generation. Over successive generations, the population evolves toward an optimal solution.

In above modeled equations, the number of decision variable is three at each equation and each variable has the defined upper and lower limit i.e. level 1 and level 3. So the search space is known but very large and complex. In this situation, the GA can be used to find out the optimal solutions for the above models.

The less the force generated the less is the power consumption, so equation of $\widehat{y_a}$ is a minimization problem. Solving with Genetic Algorithm (GA), the following results are obtained,$\widehat{y_a}$= 0.13781427538676855 KN, x_a= 0.415 mm, x_b= 0.08 mm/rev., x_c = 650 RPM.

The more the chip thickness ratio the better the surface finish, so equation of $\widehat{y_b}$ is a maximization problem. Solving with Genetic Algorithm (GA), the following results are obtained, $\widehat{y_b}$= 0.9148564934304552, x_a= 0.415 mm, x_b= 0.28 mm/rev., x_c = 650 RPM.

4. Conclusion and recommendation

The chip thickness ratio and the cutting force are the important index of machinability measure. How are these indices of machinability measure influenced by the turning process parameters and what is the optimal combination of the turning process parameters for getting desired machinability were the main objectives in this research. It has been observed that the chip thickness ratio and the cutting force are strongly correlated with the turning process parameters, depth of cut, feed rate and spindle speed. From the experimental data, it has been also observed that (i) the generated force is increasing with the increase in depth of cut and this change is strongly significant whereas the chip thickness ratio is decreasing with the increase in depth of cut and this change is also strongly significant;(ii) the generated force is increasing with the increase in feed rate and this change is moderately significant whereas the chip thickness ratio is increasing with the increase in feed rate and this change is weakly significant; (iii) the generated force is decreasing with the increase of spindle speed and this change is moderately significant whereas the chip thickness ratio is increasing with the increase in spindle speed and this change is weakly significant.

To know about the effect of turning process parameters on the machinability indices is vital important for the manufacturing engineers to set the optimal level of process parameters in order to get the desired quality of the machined products along with lower power consumption. Finally, optimal combination of the process parameters has been also determined for both generated force and chip thickness ratio by adopting genetic algorithm. The optimal combination for low generated force is depth of cut (0.415 mm), feed rate (0.08 mm/rev) and spindle speed (650 RPM) and for high chip thickness ratio is depth of cut (0.415 mm), feed rate (0.28 mm/rev) and spindle speed (650 RPM).

The obtained equation 1 and equation 2 can be used to predict the turning process parameters to generate desired surface finish and energy consumption, since fitness (R^2) and physical significance (F-value) of both equations are acceptable. This methodology is very simple and systematic for identifying the optimal combination of process parameters and the output of the research can be used in practical purpose for better performance of the manufacturing process.

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Solving a Transportation Problem of a Typical Dairy Firm Considering Fuzzy Environment

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Abstract

Generally material supplying quantity, product demand, conveyance capacity, transportation cost and others transportation related parameters are hardly specified. But in real life practice, it is found that they may be varied from one period to another period. So this variation should be considered for taking appropriate decision.In this paper a new approach has been proposed for special type of perishable product for the minimization of transportation cost considering an additional restriction on time. Primarily triangular fuzzy numbers are considered for each of the parameters then precise ranges valuesare also considered for each of the parameter. Based on second assumption randomly random value is generated from the range and evaluate the model. Then obtained results are compared with each other for taking feasible decision regarding on transportation problem.

Keywords: Perishable items, Triangular fuzzy number, Random number and Precise range value.

1. Introduction

Transportation has contributed much to the development of economic, social, political and other fields for uplifting their condition. So now-a-days transportation cost is a sector of extreme interest for business persons and researchers to get a more improved and efficient system. Actually, in real problems approximated number instead of crisp one are used for input parameters because it is impossible to use fixed value to describe complicated transportation problems. Empirical surveys reveal that Linear Programming (LP) is one of the most frequently applied OR technique in real world transportation problems. The idea of Linear Programming was introduced by**Lilien and Tingley(1987).**The idea offuzzy set was first proposed by**Zadeh L.A. (1965).** Introducing a concept 'Approximate Reasoning' Zadeh successfully showed that vague logical statements enable the formation of algorithms that can be use vague data to derive vague inferences. Recently**, Gaurav Sharma, S.H. Abbas and Vijay Kumar Gupta (2012)** represented the transportation problem for a company to reduce transportation cost and solved the transportation problem with the help of dual simplex and two phase method.**S. Narayanamoorthy, S.Saranya and S. Maheswari (2013)** proposed a new algorithm of Russell's method for the initial basic feasible solution to a transportation problem. And we have solved the transportation cost minimization problem with an additional restriction and mixed constraints in which coefficients of objective functions, additional restriction function, and demand, supply and conveyance capacity are expressed as TFNs. Then it has been solved by MATLAB(R2011a) considering five cases of data format and made a comparison among them.

2. Mathematical Statement

Here, all the parameters that is needed to be considered and which have effect on the transportation cost have been considered as Triangular Fuzzy Number (TFN) to cope up with the uncertain behavior of parameters and get a result which is more realistic. We have tried to optimize the total cost of transportation of total products of an industry within a certain time considering uncertainty by this following way using LP model. There are one source, seven destinations and three type of convenience as shown in the figure 4. As illustrated in the figure, the entity labeled **S1** denotes only one supplier, those labeled **D1-D7** denote the destination zones and entities labeled **E1-E3** denote three types of conveyance.

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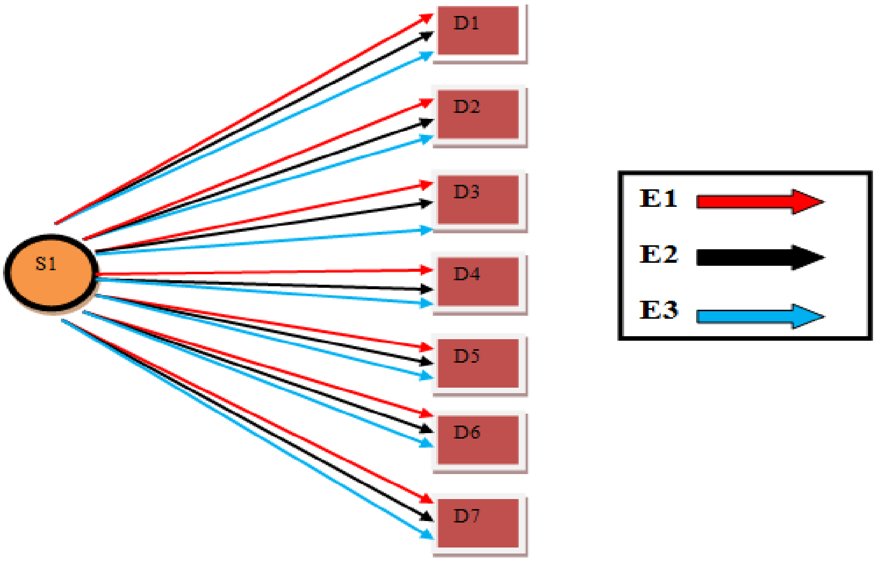

Figure 1: Transportation Model

Presented below is the formulation of the transportation problem. A short description of the data of values, constraints and parameters are presented in this section. The principal set of indices used to denote the entities and the interactions between entities in the supply chain is given in Table 1

Table 1: Indices Used in the Formulation

Index	Meaning	Total
M	Supplier	1
N	Destination zone	7
K	convenience	3

Parameters

O_i = Origins/sources (i=1, 2, 3,……. m)
D_j = Destinations (j=1, 2, 3,……. n)
a_i= Amount of homogeneous product which we want to transport to destinations D_j.
b_j = Demands for units of product to be satisfied at n destinations D_j
e_k = Units of product which can be carried by K different modes of transportation (k =1,2,3,….,K)
C_{ijk} = Cost associated with transportation of a unit of the product from source i to destination j by means of k-th conveyance
t_{ijk} = Delivery time of unit item of transportation from i-th zone to j-th zone by means of k-th conveyance
T = Total delivery time

Decision variables

x_{ijk} = The unknown quantity to be transported from origin Oi to destination Dj by means of the k-th conveyance.
A general single objective transportation model with mixed constraints, written as follows-

$$\text{MinimumZ} = \sum_{i\in I}\sum_{j\in J}\sum_{k\in K} c_{ijk}x_{ijk}$$

Subject to

$$\sum_{j\in J}\sum_{k\in K} x_{ijk} = a_i \qquad i = 1,2,3 \ldots\ldots\ldots m$$

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$$\sum_{i\in I}\sum_{k\in K} x_{ijk} = b_j \qquad j = 1,2,3 \ldots\ldots\ldots n$$
$$\sum_{i\in I}\sum_{j\in J} x_{ijk} = e_k \qquad k = 1,2,3 \ldots\ldots\ldots k$$
$$x_{ijk} \geq 0$$

As we want to transport perishable goods for which restriction on total delivery time is necessary. We are now adding an additional restriction to the above model that the total delivery time $(\sum_i \sum_j \sum_k t_{ijk}\, x_{ijk})$ is not more than T units. As delivery time, demand and supply amount are somewhat uncertain, imprecise and vague in nature. So in real life situation, to depict this nature, all the parameters in the above model may be taken as fuzzy numbers.Then the above model in fuzzy environment for perishable product may be rewritten as-

$$\text{Minimum } Z = \sum_{i\in I}\sum_{j\in J}\sum_{k\in K} \widetilde{c_{ijk}} x_{ijk}$$

Subject to

$$\sum_i\sum_j\sum_k \widetilde{t_{ijk}}\, x_{ijk} \leq \tilde{T} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$
$$\sum_{i\in I}\sum_{k\in K} x_{ijk} = \tilde{a_i} \qquad (i = 1,2,3 \ldots\ldots\ldots m) \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$\sum_{i\in I}\sum_{k\in K} x_{ijk} = \widetilde{b_j} \ (j = 1,2,3 \ldots\ldots\ldots n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$
$$\sum_{i\in I}\sum_{j\in J} x_{ijk} = \widetilde{e_k} \ (k = 1,2,3 \ldots\ldots\ldots k) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$
$$x_{ijk} \geq 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Here, $\tilde{A}$ denotes Triangular Fuzzy Number (TFN) value of any variable A.TFN $\tilde{A}$ is parameterized by a triplet(a_1,a_2,a_3) where
a_1 = pessimistic value and the lower limit of the variable A
a_2 = most likely value of the variable A
a_3 = optimistic value and the upper limit of the variable A

3. Solution Technique

To solve the transportation problem MATLAB(R2011a) is used based on linear programming method. Equation are mentioned as follows:-

Minimize**,**
$Z=\tilde{c}_{111}x_{111}+\tilde{c}_{112}x_{112}+\tilde{c}_{113}x_{113}+\tilde{c}_{121}x_{121}+\tilde{c}_{122}x_{122}+\tilde{c}_{123}x_{123}+\tilde{c}_{131}x_{131}+\tilde{c}_{132}x_{132}+\tilde{c}_{133}x_{133}+\tilde{c}_{141}x_{141}+\tilde{c}_{142}x_{142}+$
$\tilde{c}_{143}x_{143}+\tilde{c}_{151}x_{151}+\tilde{c}_{152}x_{1522}+\tilde{c}_{153}x_{153}+\tilde{c}_{161}x_{161}+\tilde{c}_{162}x_{162}+\tilde{c}_{163}x_{163}+\tilde{c}_{171}x_{171}+\tilde{c}_{172}x_{172}+\tilde{c}_{173}x_{173}$

Subject to,
$\tilde{t}_{111}x_{111}+\tilde{t}_{112}x_{112}+\tilde{t}_{113}x_{113}+\tilde{t}_{121}x_{121}+\tilde{t}_{122}x_{122}+\tilde{t}_{123}x_{123}+\tilde{t}_{131}x_{131}+\tilde{t}_{132}x_{132}+\tilde{t}_{133}x_{133}+\tilde{t}_{141}x_{141}+\tilde{t}_{142}x_{142}+$
$\tilde{t}_{143}x_{143}+\tilde{t}_{151}x_{151}+\tilde{t}_{152}x_{152}+\tilde{t}_{153}x_{153}+\tilde{t}_{161}x_{161}+\tilde{t}_{162}x_{162}+\tilde{t}_{163}x_{163}+\tilde{t}_{171}x_{171}+\tilde{t}_{172}x_{172}+\tilde{t}_{173}x_{173} \leq \tilde{T}$
……………… (1)

$x_{111}+x_{112}+x_{113}+x_{121}+x_{122}+x_{123}+x_{131}+x_{132}+x_{133}+x_{141}+x_{142}+x_{143}+x_{151}+x_{152}+x_{153}+x_{161}+x_{162}+x_{163}+x_{171}+$
$x_{172}+x_{173}=\tilde{a}_1$……………. (2)

$x_{111}+x_{112}+x_{113} = \widetilde{b_1}$ ……………. (3)
$x_{121}+x_{122}+x_{123} = \widetilde{b_2}$ …………… (4)
$x_{131}+x_{132}+x_{133} = \widetilde{b_3}$……………. (5)
$x_{141}+x_{142}+x_{143} = \widetilde{b_4}$ ……………. (6)
$x_{151}+x_{152}+x_{153} = \widetilde{b_5}$ ……………. (7)
$x_{161}+x_{162}+x_{163} = \widetilde{b_6}$ ……………. (8)
$x_{171}+x_{172}+x_{173} = \widetilde{b_7}$ ……………. (9)

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$x_{111}+x_{121}+x_{131}+x_{141}+x_{151}+x_{161}+x_{171} = \tilde{e_1}$ .... (10)
$x_{112}+x_{122}+x_{132}+x_{142}+x_{152}+x_{162}+x_{172} = \tilde{e_2}$ .... (11)
$x_{113}+x_{123}+x_{133}+x_{143}+x_{153}+x_{163}+x_{173} = \tilde{e_3}$ .... (12)

4. Data Collection and Analysis

To keep pace with the criterions of selection of data source, data needed for the transportation problem have been collected from nationally and internationally renowned PRAN DAIRY LIMITED for the specific dairy item 'Processed Pasteurized Milk' of 500ml packet because it has a restricted life time, specific customers demand

Table 2: Data of quantity of demand of 7 destination zones

SL	Destination zone	Quantity of products transported from Narsingdi, Liter
1	Dhaka	18000-21500
2	Chittagong	10000-12000
3	Sylhet	4000-5000
4	Rajshahi	3000-3600
5	Khulna	3000-3650
6	Rangpur	4500-5500
7	Barisal	5000-6000

Table 3: Data of time required to transport product by 3 types of conveyance from Narsingdi to 7 destination zones

SL	Destination Zone	Time required to transport from Narsingdi, Hour		
		Conveyance 1	Conveyance 2	Conveyance 3
1	Dhaka	2-3	2-3	1.5-2
2	Chittagong	8-9	8-9	7.5-8
3	Sylhet	4.5-5	4.5-5	4-5
4	Rajshahi	7.5-8	7.5-8	7-8
5	Khulna	8-9	8-9	7.5-8
6	Rangpur	9-10	9-10	8.5-9
7	Barisal	8-9	8-9	7.5-8

Table 4: Data of costof transporting product by 3 types of conveyance from Narsingdi to 7 destination zones

SL	Destination zone	Cost incurred to transport from Narsingdi, Taka		
		Conveyance 1	Conveyance 2	Conveyance 3
1	Dhaka	4000-5000	3900-4900	3800-4800
2	Chittagong	16000-17000	15900-16900	15800-16800
3	Sylhet	9000-10000	8900-9900	8800-9800
4	Rajshahi	15000-16000	14900-15900	14800-15800
5	Khulna	16000-17000	15900-16900	15800-16800
6	Rangpur	18000-19000	17900-18900	17800-18800
7	Barisal	16000-17000	15900-16900	15800-16800

Table 5: Data of daily production capacity of the plant

Source	Production capacity per day, Liter
Narsingdi	50000-60000

Table 6: Data of capacity range of the conveyance

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Conveyance No.	Capacity, Liter
Conveyance 1	3000-3050
Conveyance 2	2500-2530
Conveyance 3	1500-1525

5.Results

Now, to find the optimum value of transportation cost and the optimum quantity (liter) of products (processed pasteurized milk) transported to 7 destinations from 1 source after fulfilling the given constraints, we use MATLAB(R2011a) software. Here, we have considered 5 formats of the data. To show the differences of the result that means optimum transportation cost and optimum quantities of product transported to 7 destinations by 3 types of conveyance, we have solved transportation problem firstly considering three values taken from the triangular membership function of the parameters (Optimistic, Most likely, Pessimistic) separately which are at last used as fixed values. Then at the 4th case, we have multiplied the 3 values of triangular membership function by their weight and then take a single value to use in the programming. Last the 5th case is our main consideration where we have taken a range of possible values for each of the parameters and solved the problem by taking into account possible uncertainty in the source supply, destinations demand, conveyances capacity, and unit cost of product, unit time for delivery and restricted delivery time. By doing this we have got a result more practical than other considerations which is shown in the Table 7.

Table 7: Comparison among the Results

Cases	Optimum transportation cost, Taka	Case considering randomly generated value within the range	Optimum transportation cost, Taka	Difference between Cases considering precise value and randomly generated value, Taka	Decreased Percentage of TC of random case compare to precise cases %
Optimistic	109230	Randomly Generated Values within the Range	107210	2020	1.85
Most Likely	118220			11010	9.31
Pessimistic	140900			33690	23.91
Weighted Average	120520			13310	11.04

6. Conclusion

The main objective of the paper is to present a solving technic for transportation problem in fuzzy environment which has considered uncertainty visible in the total transportation process from source to destination. Moreover, the special feature is to optimum the cost of transportation of a time sensitive product. By considering all needed factors we have collected our data from PRAN DAIRY LIMITED for Processed Pasteurized Milk and then solve the linear programming model to find the optimum cost of transportation and optimum quantities transported to each destination by conveyances of different capacities. But the limitation is hereonly fixed operating cost and trip related cost have been included in transportation cost but vehicle related cost, quantity related cost and overhead cost haven't been concluded. More work can be done on this model that can be on the time restriction function to get a more acceptable result from the transportation problem solving. Additionally, amulti-objective linear transportation problem which minimizes not only the transportation cost but also it includes other factors such as optimization of transportation time or minimization of deterioration amount can be solved using the proposed technic of solving the transportation considering the pattern of collected data concerning of transportation problem. Moreover, optimized result in uncertain environment of the transportation problem can be gained by any fuzzy solver such as Fuzzy Programming Technique, Fuzzy Decisive Method etc.

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The Importance of the Information Technology Application on Supply Chain Management

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Abstract

Information technology draws a huge impact and advantages which has already taken place and brought a great change and development in the field of supply chain management in each types of factories and industries. Now a days with the comparison of rapid technological changes and high competitiveness the success factor of the companies are depend on the collecting the consumer needs and regarding their existing opportunities in order to satisfy their customer demands in time so information technology plays a key role factor in this purpose. Collection of certain amount of information it is necessary for the companies to control or maintain operational and the strategic issues of supply chain management in a tactical level. By using those data and the help of better information technology can helps the companies to improve their existing supply chain management which directly positively impact on increasing the production, qualities of the products and brings out the better serviceability and helps to build up better relationship between customers and the manufactures. The purpose of this research paper is mainly focus on the importance of the information technology application on supply chain management, assigning different problems related with supply chain management and try to find out the competitive solutions of that identified problems by the help of the application of information technology in order to make the total supply chain management system more sophisticated and more modest in the respect of current international trade market and improves the internal collaboration between the different stages of the supply chain management and increase the overall efficiency of the service level of the company.

Keywords: Supply chain management, Information technology, Inter-organizational systems, E-commerce, Supply chain collaboration, Information sharing, Case study

1. Introduction

Supply Chain Management is a foremost concern in many industries as Companies comprehend the importance of building an integrated relationship with their suppliers and customers. According to the Global Supply Chain Forum (GSFC), Supply Chain Management is defined as “the integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customer and other stakeholders.”(Chan & Qi, 2003)Information technology is a crucial segment of any business or organization, and under goes constant change.

Supply chain management is a growing and rapidly evolving area of employment being shaped by international competition. If resources - people, money, machinery, facilities, material and information - are to be used wisely, supply chain management personnel must be familiar with computer technology, quantitative methods, and planning and problem-solving technique useful in analyzing business systems. For the better control and make the supply chain system more flexible information technology plays an important role in this purpose and also information technology helps to better sinking among the different stages of supply chain management system which helps the organization to cope up with their full filling the issues of customer demand and be able to sustain or maintain equilibrium balance in their productions or services. IT gives information flow which makes the supply chain stronger and more flexible without reducing its efficiency. The following figure demonstrates the process of full filling the customers demand in supply chain management systems. This flow diagram is also partially demonstrates the flows of information between the different stages of supply chain management and provides a potential realization to the applications of the importance of information technology in supply chain management system.

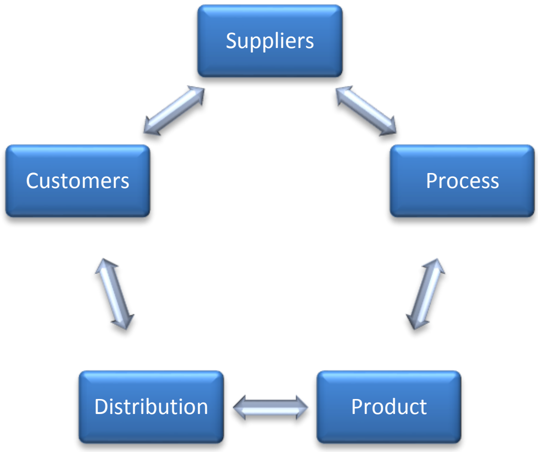

Fig. 1. The process flow diagram of satisfying the customer demand in supply chain management.

Information systems to organizational performance is changed effectively and nowadays information systems for organizations, are the creator of value information systems play the role of integration and coordination between different parts of the supply chain and the performance of this system has a direct impact on the efficiency of supply chain performance.
As for IT systems, when discussing the use of IT in SCM, we refer to the use of inter organizational systems that are used for information sharing and processing across organizational boundaries. Thus, besides internal IT systems such as Enterprise Resource Planning systems we also consider identification technologies such as RFID from the scope of this study
IT and SCM: Recently with development of IT, the concepts of supply chain design and management have become a popular operations paradigm. The complexity of SCM has also forced companies to go for online communication systems. For example, the Internet increases the richness of communications through greater interactivity between the firm and the customer. This illustrates an evolution in supply chain towards online business communities.
Supply chain management emphasizes the long-term benefit of all parties on the chain through cooperation and information sharing. This confirms the importance of IT in SCM which is largely caused by variability of ordering.

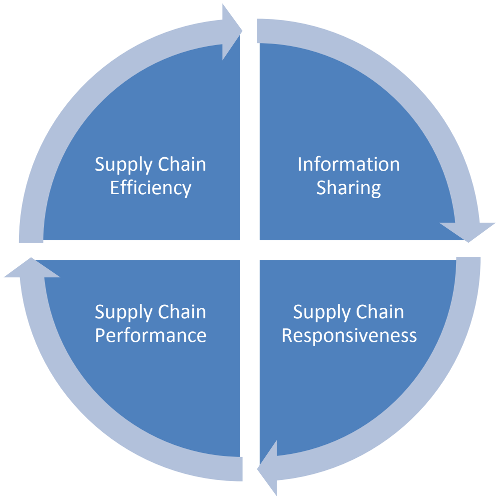

Fig. 2. Information sharing and the role of information technology in supply chain

2. Theoretical framework

Over the last 100 plus years of the history of supply chain management has evolved from an initial focus on improving relatively simple, but very labor-intensive processes to the present day engineering and managing of extraordinarily complex global networks. Information technology, industrial engineering and operations research have their roots in logistics. Supply chain management, is result of logical progression in logistics management. Logistics management has been created by adding construction, manufacturing, supplies and orders into distribution management (Droodchi & Nikmehr, 2007). Karbassian in a survey performed in 2003 concluded that supply chain management were studied as a serious discussion in the scientific community, from the early 1980s and many researchers, provides framework and model for that.

An effective supply chain are considered as the key to creating network of sustainable competitive by improving relations inside and outside the organization. Wu and others have shown, using resource-based view that supply chain capabilities by using information technology (IT) cause distinctions in companies compared to competitors and inimitable to competitors ,in this study the impact of IT development and IT to theoretical convergence on supply chain capabilities marketing and financial performance were assessed.

The Study of Mishra, (2012) thoroughly focused on the role of Information technology (IT) in supply chain management. It also highlights the contribution of IT in helping to restructure the entire distribution set up to achieve higher service levels and lower inventory and lower supply chain costs. The broad strategic directions which need to be supported by the IT strategy are increasing of frequency of receipts/dispatch, holding materials further up the supply chain and crashing the various lead times. Critical IT contributions and implementations are discussed. Fundamental changes have occurred in today's economy.

The Study of (Dong et al., 2009) in this study, the researchers aimed to better understand the value of information technology (IT) in supply chain contexts. Grounded in the resource-based theory in conjunction with transaction cost economics, they developed a conceptual model that links three IT-related resources (backend integration, managerial skills, and partner support) to firm performance improvement. The model differs from previous studies by proposing a moderating effect of competition on the resource-performance relationships.

The technological resource alone, however, does not hold the answer to IT value creation. In fact, managerial skills, which enable adaptations on supply chain processes and corporate strategy to accommodate the use of IT, are shown to play the strongest role in IT value creation. Furthermore, backend integration and managerial skills are found to be more valuable in more competitive environments.

While commodity-like resources have diminishing value under competition, interactional and managerial resources become even stronger. Overall, their results shed light on the key drivers of IT-enabled supply chains, and provide insights into how competition shapes IT value.

The research of (Olugbode et al., 2008) aimed to study the effect of information systems on firm performance and profitability using a case-study approach on Beale and Cole Company that was experiencing significant levels of growth in its business. The researches realized that it's existing operational practices and ICT infrastructure were incapable of efficiently sustaining their level of growth. A thorough analysis of the operational systems was carried out covering both the manual systems and those supported by its computerized accounting system.

The study of (David et al., 2004) indicated that the supply chain management is critical since firms always confront the competition on their supply chain efficiency. This article discusses the trend in supply chain management by examining Web technologies that transform and streamline the supply chain management.

3. Problems of supply chain and application of IT:

As the development of the industry is continuously evolves, several trends are becoming apparent. Businesses in touch with these trends and prepared to address them, will likely be better positioned to succeed.

3.1. Risk management of Supply chain

In the field of production the supply chain is a very crucial sector for the better combinations among the different stages of production and provides the better feedback of the customer demands. For this reason the matter of risk management of supply chain are eagerly considered by the companies. The risks are too high. Information technology and the techleaders build collaborative, agile supply chains, capable of rapid yet cost-effective adaptation. They achieve this agility through practices that include: a variable vs. fixed supply chain network; collaboration and risk sharing across supply chain partners; extended supply chain information visibility and sharing; sense-and-respond mechanisms for spotting anomalies and changes; segmented supply chain management risk mechanisms tied to value at risk; orchestrated supply chains, with partners aligned on key value dimensions. The more mature a company's supply chain and risk management processes are, the better the company fares when disruption occurs, the experiment shows that: 44percent of companies with mature processes are directly suffered at a 3 percent or more decline in their revenue, compared to 57percent with immature processes.

3.2. Bullwhip Effect and the application of IT

Bullwhip effect in the field of supply chain creates a great problem. It generally occurs for the lacking of information between the different stages of the supply chain. Consumers demand in the market will to be influenced by the entering of the new products or by the satisfactions of using the current products and the value of the incumbent competitor products and so on. This type of fluctuation of demands of the customers greatly affected not only the proper satisfaction or the supply of the products but also to the production of the product or services. This type of problem occurs for the lack of information among the different stages of supply chain which creates the bullwhip effect. In this regard if the proper information systems will to be adopted by using the flexible information systems and technology the better conformity between the information of different stages of supply chain and provide the organizations to avoiding the bullwhip effect. In this regard they use different types of supply chain software like SAP, ERP, MRP software etc.

3.3. Transaction processing

Transaction processing of IT use for increasing the efficiency of repetitive information exchanges between supply chain partners. In this type of IT use the exchanged information is typically related to such tasks as order processing, billing, delivery verification, generating and sending dispatch advices, and producing order quotes. The second type of IT use, supply chain planning and collaboration, represents the use of IT for sharing planning-related information such as demand forecasts and other demand information, inventory information, and production capacity information, with the intention of increasing the effectiveness of the supply chain.

3.4. Data collection

The data about the customer demand and about the production is one of the major concern in the field of supply chain management. For maintaining good and balanced relation between the customer demand and production proper data and the better collection of these data should be confirmed by the production or service organizations. Because proper and updated data provides better flexibility and helps to boosts up the eminence and service ability of the organizations. On the other hand lack of proper data collection is so much deleterious for the organization in order to maintain harmony of the organization. In this respect the information technology provides a support to maintain or collection of proper data among all the stages of the supply chain management by using different types of data assortment software (JDA software, DOYELI etc.) and using computer and different varieties of information technological system.

3.5. Data analysis and information sharing

The success of the organization and also the service ability not only depends on the data collection but also proper analysis of the collecting data and also the proper information sharing. Because the proper data analysis helps the organization to understand the fluctuation s of their customer demand, their production rate, their service condition, their current market situation and so on. In this regard information of these analyzed data should be shared among different stages of the supply chain management. Because it helps the company to rescheduling or scheduling their production plan, aggregate planning, better forecasting, resource scheduling and better flexibility among different stages of supply chain management. The modern information technology plays an important role in this purpose. Such as using the MATLAB software the FUZZY LOGIC is more appropriate for analyzing and calculating most critical and more amount of data within a short time and helps to maintain the record of this analyzed data.

3.6 Scheduling and planning problem for effective supply chain management:

Scheduling and planning is one of the most valuable parts in the supply chain management system. Better planning and scheduling system helps the organization to control their supply policy in the more sophisticated way and also helps to reduce to the chance of risk occurring event and helps to up to date their information. The better scheduling and planning technique help the company for the better utilization of their scare resources and also helps the company to lessen the extra manpower and transportation cost.

We survey a local company in order to utilize how the information technology plays an important role in the field of better planning and scheduling in order to effective supply chain management.

The name of the company is “Brothers Beverage Company Limited”. They have total 68 sub point in Khulna city where they supply their beverage items.

Table1. Sub point category, their numbers and company routing policy in a month

Sub point category	Number of sub point	Company policy

High Value	8	Monthly travel 5 times
Medium value	41	Monthly travel 4 times
Low value	18	Monthly travel 2 times
Total	68	Total travel 199 times in a month

In this routing policy in each month the company use 5 rickshaw van and 4 mini pickup and they were 10 workers for delivery the products in different shops. Including all the fixed cost(office rent, employee salaries, furniture etc.) and also the transportation cost the total expenses of the company is approximately 1 corer 20 lakhs monthly. It seems too much expensive for the company. The routing policy of the company is not sophisticated. The table shows that the company emphasizes mostly the high value sub points. In this respect we found that the medium value and the low value sub point is not get so much routine observation than the high value sub points. The survey find out that there is a distinguish and for the lacking of proper synchronizing causes great expenses each month for the company. This problem can be solved by using better information technology and adopting the updated technological facilities and also by using different types of information software. For collecting the order from the retailer shop easily and quickly and up-to-date the data time to time we suggested to use a server based ordering system instead of classical system. This helps the company to gather their demand from the retailer shop quickly and reduce the time to record them by the classical manner and helps the company to response of their customer more quickly than the current system. The "DOYELY" is one of the most effective software in this purpose which is server based software and helps to collect the data in a more sophisticated way.
For better synchronization between the different sub points we use the "ARC GIS" software. This software helps to better synchronizing between different sub points and create an optimum route by synchronizing closest sub points on each individual route. This software is generated 11 routes by combining 68 sub points. It helps to emphasize the sub points of all categories almost equally (to cover all routes 5 times in a month) which helps the better distribution and increasing the sales. The "OPTRAK" is more sophisticated tool. This creates an optimum travel schedule of the vehicles on the basis of the data and the optimum route plan which is generated by Arc Gis software. These optimum vehicles routing schedule helps the company to reduce the total number of vehicles. And it shows that only 3 Rickshaw van and 3 mini Pickup are able to covering all the optimum routes equally in a month instead of 5 rickshaw van and 4 mini pickup. So it is able to reduce 2 Rickshaw van and 1 mini Pickup. This optimum routing schedule of the vehicles not only helps to increase the serviceability but also help to reduce the total routing in each month as well as the transportation cost and also the manpower.
The following table giving the overall comparison between the existing and optimal network.

Table 2. Comparison between Existing & Optimal Distribution Network Analysis

Criteria	Existing	Optimal	Difference
Manpower	10 Delivery Man	6 Delivery Man	4 Reduced
Vehicle	5 Rickshaw van+4 mini Pickup	3 Rickshaw van+3 mini Pickup	2 Rickshaw van and 1 mini Pickup Reduced
Transportation cost	2,40000	1,51000	89000 Taka Reduced
Other fixed cost	372000	320000	52000 Taka

Total Cost Reduced= 89000+52,000= 1, 41,000 taka Per Month. This practical example shows that the information technology and the modern technologies are plays an important role in the field of supply chain management for better planning and scheduling and helps to improves its service ability as well as sustainability in the competitive market place and helps to extended the network and reduce the chance of risk.

Table 3. The following table shows the fields of supply chain management where the IT is frequently use.

Supply Chain Problem	IT Solution
Linear sequence of processing is too slow.	Parallel processing, using workflow software.
Waiting times between chain segments are excessive	Identify reason (using decision support software) and expedite communication and collaboration (intranets, groupware)
Existence of non-value-added activities.	Value analysis (SCM software) , simulation software
Slow delivery of paper documents.	Electronic documents and communication system (e.g., EDI, e-mail).
Repeat process activities due to wrong shipments, poor quality, etc.	Electronic verifications (software agents), automation, eliminating human errors, electronic control systems.
Learn about delays after they occur, or learn too late.	Tracking systems, anticipate delays, trend analysis, early detection (intelligent systems).
Excessive administrative controls such as approvals (Signatures). Approvers are in different locations.	Parallel approvals (workflow), electronic approval system, and analysis of need.
Lack of information, or too slow flow.	Internet/intranet, software agents for monitoring and alert, barcodes, direct flow from POS terminals.
Lack of synchronization of moving materials.	Workflow and tracking systems, synchronization by software agents.
Poor coordination, cooperation, and communication.	Groupware products, constant monitoring, alerts, collaboration tools.
Delays in shipments from warehouses.	Use robots in warehouses, use warehouse management software.
Redundancies in the supply chain. Too many purchasing orders, too much handling and packaging.	Information sharing via the Web, creating teams of collaborative partners supported by IT.
Scheduling problems, manufacturing lack of control.	Intelligent agents for B2B modeling.

4. Conclusions

The outcomes of this analytical study contribute support to the interrelationships between supply chain and the use of IT. So the contribution was also essential to found to the expected influence of the use of IT for supply chain management. The main focus was to use of IT for supply chain planning and collaboration, conversely, discuss about some further possibilities and findings and more through research and findings. Also now a days the information technology has greatly influenced the supply chain management by adopting E-commerce. By using information technology (IT) the will be more systematic and more electric mode of control over the supply chain and thus more complex and critical procedure will see the light of success.

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Study on the effects of back rest roller height of warp yarn breakages with asymmetric sheds.

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Abstract

Maintaining fabric quality and conformity of the fabric parameters as per buyer's requirement are very challenging job in the weaving industries. During weaving, there are various factors that affect weaving performance leading poor quality of the fabric as well as nonconformance in the constructional parameters. Warp breakage during weaving is an important aspect that can deteriorate fabric quality. Improper backrest height is an important weaving parameter that affects warp breakage leading to loss of fabric quality. The work reported here in this paper demonstrates this aspect of weaving process e.g. study on the effect of back rest roller height on the warp breakages for using finer yarns while asymmetric sheds. In this regard fabrics were woven using 40^s ,50^s and 60^s yarns (both warp and weft) at several back rest height position (0 to +10cm) and warp breakages was studied. To produce the fabrics Picanol OptiMax rapier loom was used with asymmetric cam shedding mechanism. The results show that the back rest height has significant effect on the warp breakages during weaving. Least breakages were found when the back rest roller was at 6cm to 10cm positions upper from the reference line. The results are then represented in tabulated and graphical forms with the analysis.

Key-words: Weaving, warp yarn, breakage, back rest roller, asymmetric shed

"1. Introduction"

Woven fabrics are the ancient and most aristocratic mean of weaving. The woven fabrics are produced the machine called "loom". Loom has different setting areas which are needed to be changed when the fabric designs and constructions are changed.

On a weaving loom, warp yarn are divided into two half to make up a shed. This division makes up a specific geometry of divided warp yarns, called "Shed Geometry". Shed Geometry plays vital role in controlling warp yarns & tension, elongation and friction between them resultantly this helps in controlling weft density of fabric by controlling pick penetration, warp and weft yarn breakages and loom stoppages, hence machine Efficiency. Components that may part of the shed geometry of may contribute to it are: frame height, frame depth, cloth support (front rest) height, back rest (and deflecting roller) height and depth, virtual shed dividing line, dropper box adjustment and droppers movement, top shed line, bottom shed line, front shed, rare/back shed.

Most of the high speed modern looms are operated with cam shedding motion- either symmetric or asymmetric. But the later one is preferred because of the higher scope of design variety. In our country, almost all the looms are running with asymmetric cam systems. The most disadvantageous feature of the asymmetric cam system is the higher tension in the top warp shed. This higher tension occur higher breakages. While dealing with finer yarns and plain weave in such asymmetric cam motions, the setting in the warp shed geometry is needed to be changed so that minimum warp breakages occur. The easiest mean of changing the warp shed geometry is to change the position of the back rest roller.

The main purpose of this work is to show the optimized setting of the backrest roller to minimize the warp breakage thus stable weaving.

“2. Literature Cited”

The vertical and horizontal position of the back rest influences the shed geometry. As known, the raised back rest gives better spreading of warp ends on the face of the fabric. If the back rest is horizontally away from the heald, the tension per unit length of the warp ends is reduced. That is why for silk and filament weaving the back rests are away from the healds as compared to their positions for cotton weaving.

• BTRA studies [1] have shown the scope for improving productivity and quality by varying the vertical and horizontal positions of the back rest. For non-automat looms weaving plain cotton fabric, the back rest is given an oscillating movement by means of a cam on crank shaft through a lever to ease the warp threads during shedding. The effect of loom parameters on properties of fabrics has been studied by a number of research workers. Joshi [2] has made the following observations unless otherwise stated while weaving a plain cotton fabric with 32 epc, 33 ppc, 2/60 Ne warp and 2/60 Ne weft on Northrop Vicker Stafford Loom.He found the following observations:

• Raising the back rest to 25 - 50 mm above the normal height reduces the warp crimp, increasing the welt crimp. Lowering of the back rest below the normal height increases the warp crimp decreasing the weft crimp ,Positioning of back rest does not have any effect on breaking strength of fabric, The fabric elongation at break, both warp and weft is affected by a change in the back rest position. Similar observations have been made by Salem and Natarajan [3].

• Lyer [4] has found that the back rest position has greater influence on thread crimps than shed timing. According to Agarwal [5] both earlier shedding and raised back rest give higher limit of weft packing density however, the former is more effective than the later, when used alone. Joshi, Salam and Natarajan have observed that the warp way fabric strength is not effected by change in shed timings.

During the process of weaving , the warp yarn is subjected to a complex action consisting of extension, abrasion and bending [6,7,8]. Maximum abrasion takes place in the heald eyes whilst the deflection of the yarn and its movement in a plane at right angles to the plane of the heald eye intensify the abrading action. Lord [9] found that early shedding gives a low warp tension but the amount of abrasion is maximum. The race board rubs the threads on the bottom shed line and the shuttle abrades the warp yarns in the longitudinal and transverse direction. Wear of the warp yarn by abrasion increases with the increase in warp and weft density of the cloth.

The mechanical condition of loom parts which directly come in contact with the warp and settings of loom motions and mechanisms have a great influences on the warp breakages. Some important factors as recommended by BTRA [10]are as follows: depth of the shed & shed timing: More depth of shed than necessary and too early shed timing lead to a high number of warp breaks.

Effect of cam asymmetry on fabric formation was further explained by Stubli [11],a famous shedding cam manufacturer. Some of their results are mentioned below-

Symmetrical cam
Ft = Fb

Asymmetrical cam
AL 20 Ft = 1,17 x Fb
AL 40 Ft = 1,3 x Fb

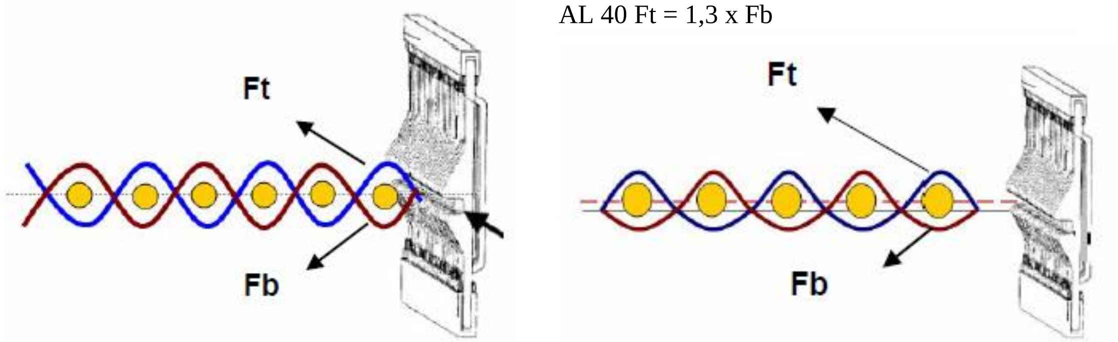

Figure 1: Distribution of warp tension for both symmetrical and asymmetrical sheds

“3. Methodology”

To conduct this work, fabrics were prepared fabric with same yarn density but yarn count was different. The fabric parameters are shown as tabulated below:

Fabric parameters:
The fabric particulars are tabulated below.

Table 1: Fabric parameters used in the experiment

Sl No	EPI	PPI	Warp Count (Ne)	Weft Count (Ne)	Fabric Width (inch)	Weave Type
1	100	90	40	40	36	1/1
2	100	90	50	50	36	1/1
3	100	90	60	60	36	1/1

Yarn parameters:
The yarns have the following criterion which are shown in a tabulated form.

Table 2: Yarn parameters used to produce the fabrics

Specification	40 Ne	50 Ne	60 Ne
Actual count	40.56	50.44	60.61
CV%	0.66	.69	0.77
IPI	74	86	97
CSP	2975	2910	2842
E%	8.93	8.67	8.77
TPI	26.56	29.69	32.53
Fiber MIC Value	4.4	4.4	4.4
Fiber Staple Length(mm)	30	30	30
Type	Comb	Comb	Comb

The warping was done by Karl Mayer High Speed warping machine. Sizing was done by Karl Mayer Slasher sizing machine which is originated from Germany. The size take-up percentage was 11% to all of the warp yarns and to weave the fabric Picanol Optimax which is one of the latest weaving machine was used.

"4. Results & Analysis"

Table 3: Breakage of different yarns when shed angle is 26°

Sl No.	Back Rest Position	Shed angle in °	Time	Yarn count	Breakage number	Yarn count	Breakage number	Yarn count	Breakage number
1	0	26	1 hr	40 Ne	11	50 Ne	14	60 Ne	17
2	1				8		11		14
3	2				6		10		9
4	3				5		7		8
5	4				3		4		5
6	5				3		4		5
7	6				1		4		3
8	7				0		3		3
9	8				0		3		4
10	9				1		4		4
11	10				2		4		4

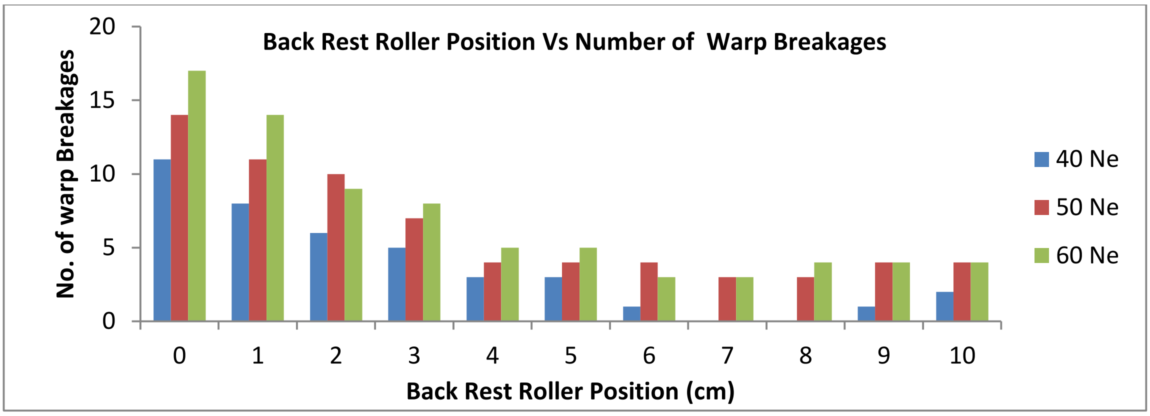

Figure 2: Graphical representation of warp breakages when shed angle is 26°

Table 4: Breakage of different yarns when shed angle is 28°

Sl No.	Back Rest Position (cm)	Shed angle in °	Time	Yarn count	Breakage number	Yarn count	Breakage number	Yarn count	Breakage number
1	0				12		14		18
2	1				10		11		14
3	2				9		11		9
4	3				6		7		7
5	4				5		5		6
6	5	28	1 hr	40 Ne	5	50 Ne	5	60 Ne	4
7	6				3		4		4
8	7				1		4		4
9	8				0		3		3
10	9				0		4		3
11	10				2		4		4

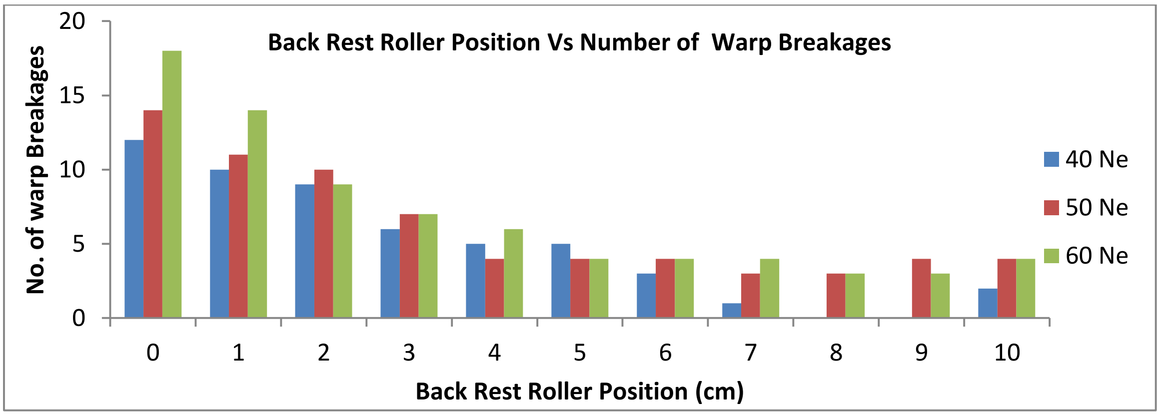

Figure 3: Graphical representation of warp breakages when shed angle is 28°

Graph 1,2,3 is showing the comparative breakage status of 40 Ne,50Ne,60,Ne warp yarn at shed angle 26° and 28° respectively. From the graph it is clear that when the shed angle is 28° the warp breakages are more. This may be due to the greater stroke length of the heald frames for 28° shed angle. From these graphs it is clear that minimum warp breakages were found at the back rest roller position 7cm,8cm,9cm above the centre line (8cm & 9cm for 40ne & 60ne yarns respectively whereas 7cm & 8cm for 50ne yarns). To explain this phenomena, amathamatical model calculation was done result of which is shown as table below.

Table 5: Percentages of warp strain for different sheds.

Shed Type	Strain on Top Shed	Strain on Bottom Shed
Symmetric Shed	0.725%	0.725%
Asymmetric Shed with back rest roller position at 0	1.81%	0.11%
Asymmetric Shed with back rest roller position at +5	1.52%	0.339%

From the table 5.8, 5.9 and graph 5.11, 5.12 it is clear that as the yarn is becoming more finer the number of warp breakages are more. This may be due to the yarn strength.40 Ne yarn has more strength than to 50 Ne and 50 Ne has greater than 60 Ne warps. So the warp yarn with 40 Ne yarn count have least breakages and 60 Ne having the maximum.

"5. Conclusion"

In this work it was tried to show the effect of the position of back rest roller on warp breakage while using the asymmetric cams. From this work it was found that position of the back rest roller has significant effect on the warp breakages. While the back rest roller was at the bottom position i.e at 0 line the shed was strongly asymmetric and strain on the top shed was maximum. So the number of warp breakage was also maximum. With the back rest roller moving upwards the effect of shed asymmetry reduces so as the warp breakage. So it can be recommended that while using asymmetric cams, the back rest roller should be in higher position i.e. back rest height should be greater so that the yarns in the top shed have least tension so as least warp breakage.

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Optimal procurement strategy for uncertain demand situation and imperfect quality by genetic algorithm

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Abstract

This paper determines an optimal procurement strategy as the demand over a finite planning horizon is known. This study considers the scenario of supply chain with multiple products and multiple suppliers, all of which have limited capacity. It is assumed that the received items from suppliers are not of perfect quality. Items of imperfect quality, not necessarily defective, could be used in another inventory situation. Imperfect items are sold as a single batch, prior to receiving the next shipment, at a discounted price. Some critical parameters for determining optimal procurement strategies like maximum storage space for the buyer, standard deviation of demand during lead time the corresponding product dependent compensation cost are also considered here. The whole mathematical model is structured and represented as linear programming model and was solved by an efficient meta-heuristic algorithm (Genetic Algorithm). Some computational studies were also carried on to prove its acceptance in the real world.

Keywords: Supply Chain Management, Inventory control, Genetic algorithm, Integer linear programming, optimal procurement strategy, Supplier selection.

1. Introduction

For a multi-objective optimization problem, a complete optimal solution seldom exists, and a Pareto-optimal solution is usually used. A number of methods, such as the weighting method, assigning priorities to the objectives and setting aspiration levels for the objectives are used to derive a compromised solution. In general, an inventory model involves ''fuzziness" since shortage constraint and demands are not always known exactly. Furthermore a DM often has vague goals such as ''This profit and ROII objective functions should be larger than or equal to a certain value." For such cases, fuzzy set theory and fuzzy mathematical programming methods should be used [16]. Again some researcher proposed an interactive fuzzy method for multi-objective non-convex programming problems using genetic algorithms.

Classical inventory models generally deal with a single-item. But in real world situations, a single-item inventory seldom occurs and multi-item inventory is common. In a multi-item inventory system, the companies or the retailers are required to maximize/minimize two or more objectives simultaneously over a given set of decision variables. This leads to the idea of a multi-objective mathematical programming problem. Toroslu and Arslanoglu [14] researched a genetic algorithm for the personnel assignment problem with multiple objectives. While modeling an inventory problem, inventory costs, purchasing and selling prices in the objectives and constraints are defined to be confirmed. However, it is seldom so in the real-life. For example, holding cost for an item is supposed to be dependent on the amount put in the storage. Similarly, set-up cost also depends upon the total quantity to be produced in a scheduling period.

During the last two decades, many researchers have given considerable attention to the area of inventory of deteriorating/defective/perishable items, since the life time of an item is not infinite while it is in storage and/or all units can't be produced exactly as per the prescribed specifications. Recently, Goyal and Giri [7] have presented a review article on the recent trends in modeling with deteriorating items listing all important publications in this area. The application of control theory in production inventory control analysis is now-a-days gradually increasing due to its dynamic behavior. Many research papers [Bounkel et al. [4] Kleber et al. [9] etc.] have been published in this regard. Later many researchers utilized optimal control theory to obtain optimal production policy for production inventory systems where items are deteriorating at a constant rate. Optimal control problems usually deal with both objective function and the constraints. The objective function is the cost function that needs to be minimized with respect to time, fuel, energy, etc. The constraints are usually the system dynamics, the limits of the system states and the control effort.

The traditional economic order quantity (EOQ) models cannot be applied to solve these types of production problems. Wang et al. [13] discussed an economic production plan under chaotic demands to minimize overall cost. There have been numerous publications on EOQ models with fixed cost per unit. Recently, however, several papers relaxed the assumption of the fixed cost per unit for the EOQ models. Supplier selection problem has gained great attention in the business management literature and Under the business environment of global sourcing, core-competence outsourcing strategy, supply base reduction, strategic buyer–supplier relationship, cross functional purchasing program, Internet and e-commerce and so forth, the supplier selection decision is becoming ever important and complicated decision.

Basnet and Leung [2] presented a model for optimal procurement lot-sizing with supplier selection. Multi-period models also offer the opportunity to change suppliers for a product from one period to the next. Many supplier selection models are single period models. Benson [3] by introducing capacities for the suppliers, considered a supply chain with multiple suppliers, all of which have limited capacity and determined an optimal procurement strategy for this multi-period horizon. Rezaei & Davoodi [11] provided a deterministic multi-item inventory model with supplier selection and imperfect quality. O. Jadidi et al [10] propose models the problem of supplier selection as a multi-objective optimization problem (MOOP) where minimization of price, rejects and lead-time are considered as three objectives.

In this paper, a multi-item inventory model is discussed having demand uncertainty/lumpiness as well as imperfect quality items. The demand uncertainty is expressed in terms of the demand variation in the lead time which eventually causes the cost of compensation for the organization concerned. Later, a way for determining optimal procuring quantities from supplier along with the selection of suppliers in a particular period is formulated as an integer programming model. Then the model is solved with Genetic Algorithm.

2. Problem formulation

The model which is considered here consists of multiple products and multiple suppliers having capacity limitation (fig.1). It is assumed that the products or materials that would be purchased from the supplier are all not of perfect quality. That means some of them may be of imperfect quality, not necessarily defective and would be used in another inventory situation. These imperfect quality products will be sold as single batch at a discounted price prior to receiving the next shipment. In fig.1, it is shown that each of the suppliers is providing each of the products. After receiving the products, screening takes place to sort out the imperfect quality items. Then production is carried out and demand is fulfilled with the inventories of currently produced ones along with the inventories from the previous period. Imperfect quality items are also sold prior to the next shipment. Eventually, the unsold products remain in the inventory for use in next period. The demand over a finite planning horizon is considered to be known and what needs to be determined is the optimal procurement strategy for this multi period horizon. A supplier-dependent transaction cost applies for each period in which an order is placed on a supplier. A product-dependent holding cost per period applies for each product in the inventory that is carried across a period in the planning horizon. A product-dependent compensation cost applies for each type of product due to the variation of demand during lead time.

Also a maximum storage space for the buyer in each period is considered. In order to maximize the total profit, the decision maker, the buyer, needs to decide what products to order, in what quantities, with which suppliers, and in which periods (x_{ijt}). Since multiple products, multiple suppliers, multiple periods are considered; solving such a large optimal problem using conventional methods is quite impossible. In order to obtain a population of solutions a GA approach is proposed to solve the problem.

Assumptions & notations

Some assumptions & notations are adopted to develop the model-

O_j	Transaction cost for supplier j does not depend on the variety and quantity of products involved
H_i	Holding cost of product i per period is product-dependent
D_{it}	Demand of product i in period t is known over a planning horizon
P_{ij}	Each lot of product i received from supplier j contains an average percentage of defective items
b_{ij}	Purchasing price of product i from supplier j
S_{gi}	Good-quality items i have a selling price per unit
S_{di}	Discounted price of defective items i are sold as a single batch
v_i	screening cost of product I,
W	Available total storage space
w_i	Product i needs a storage space
σ_L	Standard deviation of demand during lead time
C_i	Corresponding compensation cost for this variation is considered to be of product i

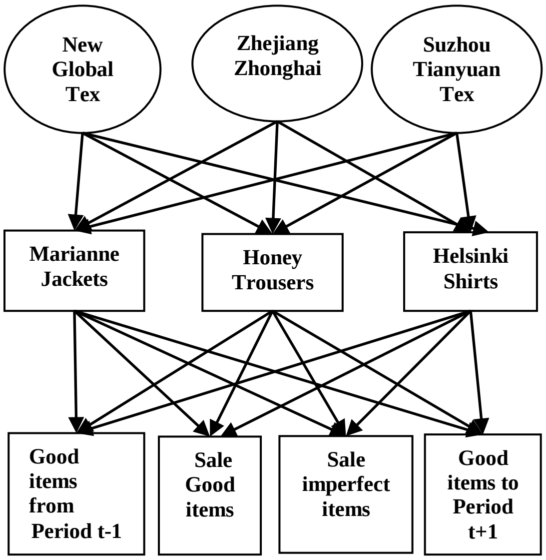

Fig. 1: Behavior of the model in period t

The assumptions are

- 100% screening process of the lot is conducted.
- Items received, are not of perfect quality, not necessarily defective, kept in stock and sold prior to the next period as a single batch.
- Each supplier has a limited capacity.
- All requirements must be fulfilled in the period in which they occur: shortage or backordering is not allowed.
- Also $S_{gi}>S_{di}$

Now, the revenue & cost terms of the model can be stated as below-

Total revenue (TR) = revenue of selling good quality products + revenue of selling imperfect quality products.

$$TR = \sum_i\sum_j\sum_t X_{ijt}(1-P_{ij})S_{gi} + \sum_i\sum_j\sum_t X_{ijt}P_{ij}S_{di} \qquad (1)$$

Total cost (TC) = purchase cost of products + transaction cost for the suppliers + screening costs of the products + holding cost for remaining inventory in each period + compensation cost

$$TC= \sum_i\sum_j\sum_t X_{ijt}b_{ij} + \sum_j\sum_t O_jY_{jt} + \sum_i\sum_j\sum_t X_{ijt}V_i +$$

$$\sum_i\sum_t H_i(\sum_{k=1}^{t}\sum X_{ijt}(1-P_{ij}) - \sum_{k=1}^{t} D_{ik} + \sum_i\sum_j\sum_t X_{ijt}\sigma_L C_i \qquad (2)$$

So, Profit, (π) = TR – TC

$$= \sum_i\sum_j\sum_t X_{ijt}(1-P_{ij})S_{gi} + \sum_i\sum_j\sum_t X_{ijt}P_{ij}S_{di} - \{ \sum_i\sum_j\sum_t X_{ijt}b_{ij} + \sum_j\sum_t O_jY_{jt} +$$

$$\sum_i\sum_j\sum_t X_{ijt}V_i + \sum_i\sum_t H_i(\sum_{k=1}^{t}\sum X_{ijt}(1-P_{ij}) - \sum_{k=1}^{t} D_{ik}) + \sum_i\sum_j\sum_t X_{ijt}\sigma_L C_i \} \qquad (3)$$

The problem is to find the number of product i ordered from supplier j in period t so as to maximize the total profit function subject to restrictions and boundary conditions.

Objective function:

$$Max(\pi)=Max[\sum_i\sum_j\sum_t X_{ijt}(1-P_{ij})S_{gi} + \sum_i\sum_j\sum_t X_{ijt}P_{ij}S_{di} - \{ \sum_i\sum_j\sum_t X_{ijt}b_{ij} + \sum_j\sum_t O_jY_{jt} + \sum_i\sum_j\sum_t X_{ijt}V_i$$

$$+ \sum_i\sum_t H_i(\sum_{k=1}^{t}\sum X_{ijt}(1-P_{ij}) - \sum_{k=1}^{t} D_{ik}) + \sum_i\sum_j\sum_t X_{ijt}\sigma_L C_i \}] \qquad (4)$$

Subject to:

$$\sum_{k=1}^{t}\sum X_{ijk}(1-P_{ij})-\sum_{k=1}^{t} D_{ik\backslash} \geq 0 \text{ for all i, t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\sum_{k=1}^{t} D_{ik\backslash} Y_{jt} - X_{ijt}(1-P_{ij}) \geq 0 \text{ for all i, j, t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\sum_{i} w_i \sum_{k=1}^{t}\sum_{j} X_{ijk}(1-P_{ij})-\sum_{k=1}^{t} D_{ik} \leq W \text{ for all t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$0 \leq X_{ijt}$ for all i, j, t………………………………………………………………..(8)

The constraints (5) indicate that all requirements must be fulfilled in the period in which they occur and shortage or backordering is not allowed. The constraints (6) represents that each Suppliers have limited capacities. The constraint (7) represents that the available total storage space is limited.

3. Results and discussions

To solve the model and to observe how profit is maximized, data are collected from one of the reputed garment industries in Bangladesh namely Talisman Ltd. which is a sub-company of FCI group and it's a UK-based company. Garments of different styles are usually produced by Talisman Ltd. each year. But considering all the styles will make the maximization problem more cumbersome and also the collection of such a huge data is quite arduous. Thus three particular styles namely Marianne jackets, Honey trousers and Helsinki shirts are taken into consideration. These products are supplied from each of the three suppliers i.e. **New Global Tex, Zhejiang Zhonghai Printing & Dyeing Co. Ltd. and Suzhou Tianyuan.**

In this paper, result is actually representing what products to order, in what quantities, with which suppliers and in which periods. That means the result is associated with the variables X_{ijt} and Y_{jt}. Thus for the two variables a nearly optimal outcome is reached such that it maximizes the profit. The MATLAB R2012a is used with genetic algorithm being the solver to solve the maximization problem. The options and codes that are used for running the problem are mentioned in appendix along with the other used & required details.

Table 1: Demand in pieces of three products over four periods

Products	Planning horizon (periods in four quarters of a year)			
	1st	2nd	3rd	4th
Marianne jackets	330	1594	357	1461
Honey trousers	320	1977	1886	426
Helsinki shirts	405	1925	2712	653

For that, the required data include demand, purchase price, transaction cost, average percentage of defective items, selling price of both the good & defective items, holding cost, screening cost, compensation cost for a variation in demand during lead time and warehouse space. Data of three products i.e. jackets, trousers, shirts are collected over a planning horizon of four periods. In this paper, data for only fabrics are considered since it incurs 95 % of the total cost. Demand in pieces of three products over four periods (Table 1).

Table 2: S_{gi}, S_{di}, C_i, H_i, V_i, σ_L, w_i for three products

parameter ↓	Products		
	1	2	3
S_{gi}	$ 16.15	$ 12.5	$ 10
S_{di}	$ 9.5	$ 6.8	$ 5.75
C_i	$ 0.80	$ 0.30	$ 0.10
H_i	$ 2.75	$ 2	$ 2.5
V_i	$ 0.20	$ .15	$ .18
σ_L	5 pcs	5 pcs	5 pcs
w_i	28.14 m^2	16 m^2	20.6 m^2

There are three suppliers and their prices and transaction cost and average percentage of the defective items are shown in Tables 2 and 3, respectively. In Table 4, selling price of good product i (S_{gi}), selling price of defective product i(S_{di}), storage space of product i (W_i), holding cost of product i per period (H_i) and screening cost of product i(v_i) are shown.

Table 3: Average percentage of defective items for three suppliers

Products	Average percentage of defective items		
	1	2	3
Marianne jackets	13	15	16
Honey trousers	12	11	14
Helsinki shirts	14	13	10

Total storage space, W = 3521.03 m^2

In this section the numerical example of the above model is solved by using a Real Parameter Genetic Algorithm. So, after running the problem in MATLAB software, the magnitudes of the variables X_{ijt} & Y_{jt} are obtained. The nearly optimal values of ordering frequency (X_{ijt}) of the three products i.e. jackets (Table 4), trousers (Table 5) & shirts (Table6) from each of the three suppliers at each quarter of a year is summarized. As the model has been formulated with vague parameters, the decision maker may choose that solution which suits him best with respect to resources. At the same time the standard deviation of lead time demand and the percentage of defective item supplied by supplier is considered.

Table 4: Ordering quantities for Marianne jackets

Jackets (i=1)		**Periods (t)**			
		1	2	3	4
Suppliers (j)	1	9688	55	9	55
	2	13	151	29	20
	3	9935	181	8	23

Table 5: Ordering quantities for Honey trousers

Trousers (i=2)		**Periods (t)**			
		1	2	3	4
Suppliers (j)	1	27	108	100	70
	2	323	1576	25	9597
	3	21	6498	337	9930

Table 6: Ordering quantities for Helsinki shirts

Shirts (i=3)		**Periods (t)**			
		1	2	3	4
Suppliers (j)	1	93	10001	139	9516
	2	122	9848	50	8169
	3	145	171	9963	24

Here uncertainty is incorporate to the analysis by the standard deviation of demand during lead time i.e. σ_L. For 5% standard deviation of demand during lead time i.e. σ_L the corresponding result is obtained the genetic algorithm. Since the suppliers have limited capacities, thus the quantities that the supplier can provide are also restrained. Depending on that restriction, the decision of which supplier is selected (Y_{jt}) in which quarter of a year that summarized in (Table 7). Also imperfect quality and compensation cost incorporated to the model to find the actual scenario of inventory control system.

In the table, the binary values represent yes/no decisions. 1 for yes and 0 for no i.e. 1 means to select the supplier where 0 indicates those suppliers that should not be selected for particular period of a year. Thus order should be received from supplier 1 in periods 2 and 4, from supplier 2 in periods 1 and 3, from supplier 3 in periods 1 and 2. The objective function value for the concerned problem is **282518.85,** which actually indicates the magnitude of annual profit of the concerned company. Thus the profit is determined to be $ 282518.85.

Table 7: Decision for the selection of suppliers

Periods → supplier ↓	1	2	3	4
1	0	1	0	1
2	1	0	1	0
3	1	1	0	0

For sensitivity analysis, the main parameter to be considered in this paper is the standard deviation of demand during lead time i.e. σ_L which is the indicator of uncertain demand. So, by both increasing and decreasing the values of σ_L will show how it has affected the result. For increased value of σ_L (σ_L=10 pcs) it is seen that the ordering quantities of each product has changed a lot. Not only that but also the supplier selection situation has also changed. The profit has decreased tremendously. For decreased value of σ_L (σ_L=1 pcs) it is seen that the ordering quantities of each product remain the same so do the supplier selection situation. The profit here has increased approximately by 42%. So, comparing the profit indicates that a little larger value of σ_L can cause a great loss to the concerned organization while keeping it as lower as possible can enlarge the profit.

4. Conclusions

A multiple-production-inventory model with multiple suppliers is considered in this paper. The current paper aims at providing a basis of planning and controlling the inventory in supply chain and unifying the selection of supplier for multi-products, period, and suppliers Backlogging compensation is one of the major considerations of this paper. They also face a great problem to decide appropriate suppliers from multiple suppliers what products to order, in what quantities, and in which periods. But it can be possible for the decision maker (DM) to apply this process to come to an overall verdict with fewer hurdles. Genetic Algorithm is used to solve the problem but Fuzzy Logic solver or other heuristic approaches can also be used to solve the problem. This study considers fabric cost of three products. So in future one may also consider accessories cost for as high number of products as possible.

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Analysis of the effects of shed crossing timing angle on the pick density of woven fabrics.

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Abstract

It is always difficult to weave cloths specially with finer yarns controlled by asymmetric cam motion. During weaving, there are various factors that affect weaving performance leading poor quality of the fabric as well as nonconformance in the constructional parameters. Consistency in uniform pick spacing is an essential requirement for good quality woven fabrics. There are many factors that can hamper this consistency and timing of the shed crossing angle was found to affect the consistency in picks spacing. The paper reported here demonstrates this aspect of weaving process e.g. the effect of timing of shed crossing angle on the consistency in pick spacing. In this regard fabrics were woven using 40^s ,50^s and 60^s yarns (both warp and weft) as well as shed crossing timing was also changed to different angles. To produce the fabrics Picanol OptiMax rapier loom was used with asymmetric cam shedding mechanism. It was found that the shed crossing angle timing affect the consistency in pick spacing to a significant extent. The optimum pick density was found when the timing was 298° or 300° with minimum CV%. The results are shown as both in tabulated and graphical forms.

Key-words: Woven fabric, pick density, sheds crossing, loom timing, asymmetric cams.

"1. Introduction"

Woven fabrics are the ancient and most aristocratic mean of weaving. The woven fabrics are produced the machine called "loom". Loom has different setting areas which are needed to be changed when the fabric designs and constructions are changed. Most of the high speed modern looms are operated with cam shedding motion- either symmetric or asymmetric. But the later one is preferred because of the higher scope of design variety. Problem with asymmetric cams is the variation in the pick density. This occurs due to the changes in the shed crossing timing angle. So an optimized timing angle is to be set up to find out the best pick density. Shed crossing angle is the angular measurement of loom shafts when the top and bottom sheds are crossing each other. Every loom has an standard range of angle of this crossing time. When this crossing is done either earlier or later the standard timing angle it results pick space variation. Generally early shed results higher pick density and late shedding causes less pick density. But with early shedding it causes bumping which is harmful for both the machine and cloth. So an optimized setting is needed to find out maximum pick density with no harm. The main purpose of this work is to find out the optimized shed crossing angle to find out the best pick density of the fabric.

Early Shedding

The weft carrier enters and leaves the shed at around 110^0 and 240^0 respectively. The shed is leveled (closed) at 270^0. Then it starts to open as the two healds starts to move in opposite directions. The shed is fully open at 30^0. Two healds are at two extreme positions at this moment (One heald is at its topmost position and another is at its bottommost position). From 30^0 to 150^0, the healds are stationary. Therefore, the shed is fully open and at dwell during this period. After 150^0, the healds start to move in opposite direction as compared to the movement they had between 30^0 and 150^0. This means that the heald which was at its topmost position starts to descend and vice versa. The shed is again leveled at 270^0.

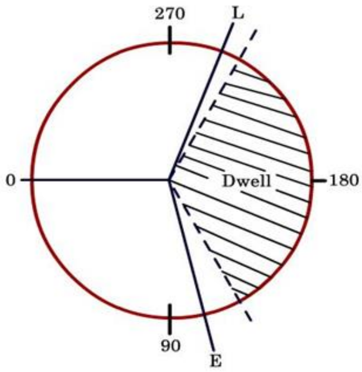

Figure 1: Early Shedding

It is understood that when the rapier enters the shed (110), more than half of the dwell period is over. When the weft carrier leaves the shed (240), the shed is about to close. Therefore, there is high probability that the rapier will abrade the warp sheet which is not desirable especially for the delicate warp yarns. However, this type of timing is advantageous for weaving heavy cotton cloth. Because during beat up (0), the shed is fully crossed. Therefore, the newly inserted pick will be trapped by the crossed warp yarns. As a result, the pick will not be able to move away from the cloth fell ever after the reed recedes. This facilitates attaining higher picks per inch which is required for heavy fabric.

Late Shedding

The problem of abrasion between warp sheets and weft carrier can be minimized by adopting late shedding. In this case, the timing of shedding is delayed is such a way that it is almost coinciding with the timing of carrier flight. The shed is leveled (closed) at 0^0. Then it starts to open as the two healds move in opposite directions. The shed is fully open at 120^0. From 120 0 to 240 0, the healds are stationary. Therefore, the shed is fully open and at dwell during this period. The timing of weft carrier flight almost coincides with the dwell time. After 240^0, the healds start to move in opposite direction and the shed is again leveled at 0 $0/360^0$.

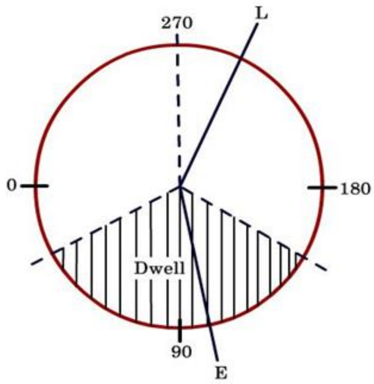

Figure 2: Late Shedding

The beat up occurs when the shed is leveled and healds are yet to cross each other. Therefore, this timing is not favorable for weaving heavy fabrics. However, this kind of timing is favorable for weaving delicate warp yarns and the possibility of abrasion with the carrier is very low.

"2. Literature Cited"

Early shed timing has a significant effect on fabric properties, whereas late shed timing has limited effects. When shed timing is changed from normal to early Joshi [11] found that the warp crimp decreases and weft crimp increases, but the fabric thickness decreases. Lyer [13] has found that the back rest position has greater influence on thread crimps than shed timing. According to Agarwal [14] both earlier shedding and raised back rest give higher limit of weft packing density however, the former is more effective than the later, when used alone. Joshi, Salam and Natarajan have observed that the warp way fabric strength is not effected by change in shed timings. Lord [18] found that early shedding gives a low warp tension but the amount of abrasion is maximum.

"3. Methodology"

To conduct this work, fabrics were prepared fabric with same yarn density but yarn count was different. The fabric parameters are shown as tabulated below:

Fabric parameters:

The fabric particulars are tabulated below.

Table 1: Fabric parameters used in the experiment

Sl No	EPI	PPI	Warp Count (Ne)	Weft Count (Ne)	Fabric Width (inch)	Weave Type
1	100	90	40	40	36	1/1
2	100	90	50	50	36	1/1
3	100	90	60	60	36	1/1

Yarn parameters:

The yarns have the following criterion which are shown in a tabulated form.

Table 2: Yarn parameters used to produce the fabrics

Specification	40 Ne	50 Ne	60 Ne
Actual count	40.56	50.44	60.61
CV%	0.66	.69	0.77
IPI	74	86	97
CSP	2975	2910	2842
E%	8.93	8.67	8.77
TPI	26.56	29.69	32.53
Fiber MIC Value	4.4	4.4	4.4
Fiber Staple Length(mm)	30	30	30
Type	Comb	Comb	Comb

The warping was done by Karl Mayer High Speed warping machine. Sizing was done by Karl Mayer Slasher sizing machine which is originated from Germany. The size take-up percentage was 11% to all of the warp yarns and to weave the fabric Picanol Optimax which is one of the latest weaving machine was used.

Data Collection:

The pick density was measured by looking glass and needle by physical observation manually following ASTM standard.

"4. Results & Analysis"

Table 3: Showing comparison of pick density and its CV% on different timing of shed crossing when warp yarn count is 40 Ne, 50 Ne and 60 Ne.

Sl no	Shed crossing timing in ^{o}	Averages for pick density in inch			CV% of Pick density		
		40 Ne	50 Ne	60 Ne	40 Ne	50 Ne	60 Ne
1	290	90.6	90.2	90.4	0.020051	0.026469	0.022939
2	292	89.6	90	89.6	0.016926	0.017568	0.020274
3	294	90.4	90.4	89.6	0.012613	0.01851	0.020274
4	296	88.4	88.4	88.4	0.006196	0.012898	0.010118
5	298	88	87.8	88.2	0.0	0.005094	0.00507
6	300	88	87.2	88	0.0	0.005129	0
7	302	88.2	86.2	87.4	0.00507	0.009706	0.006267
8	304	86.2	86.2	86.4	0.005188	0.005188	0.010352
9	306	85.8	85.8	86.2	0.005212	0.005212	0.005188
10	308	86	86.2	86.2	0.0	0.005188	0.005188
11	310	85.4	85.4	84.4	0.006414	0.006414	0.013509

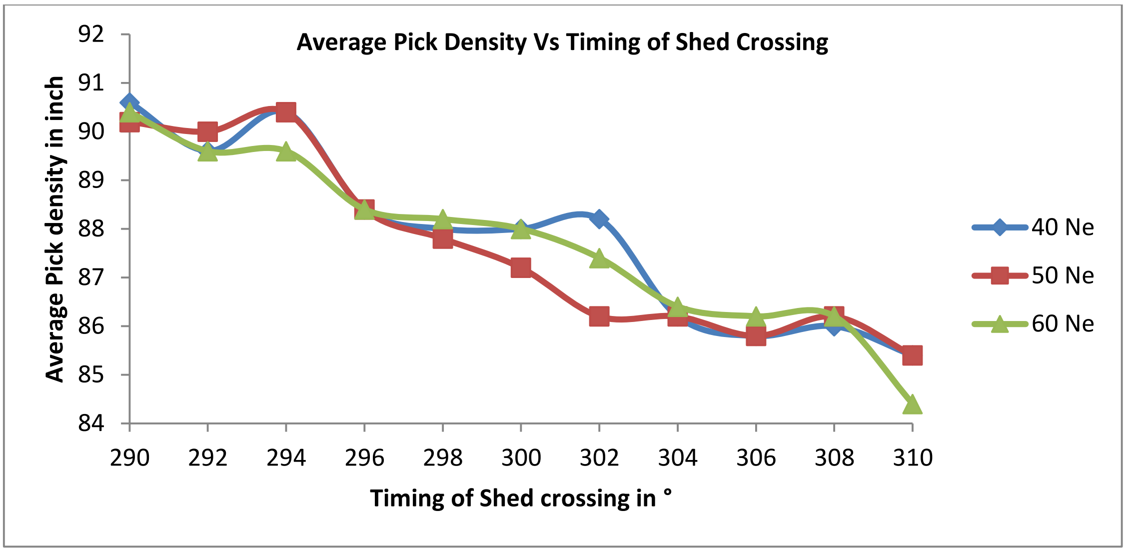

Figure 3: Showing the variation in the average pick density in inch for different count of warp yarn with the variable timing of shed crossing.

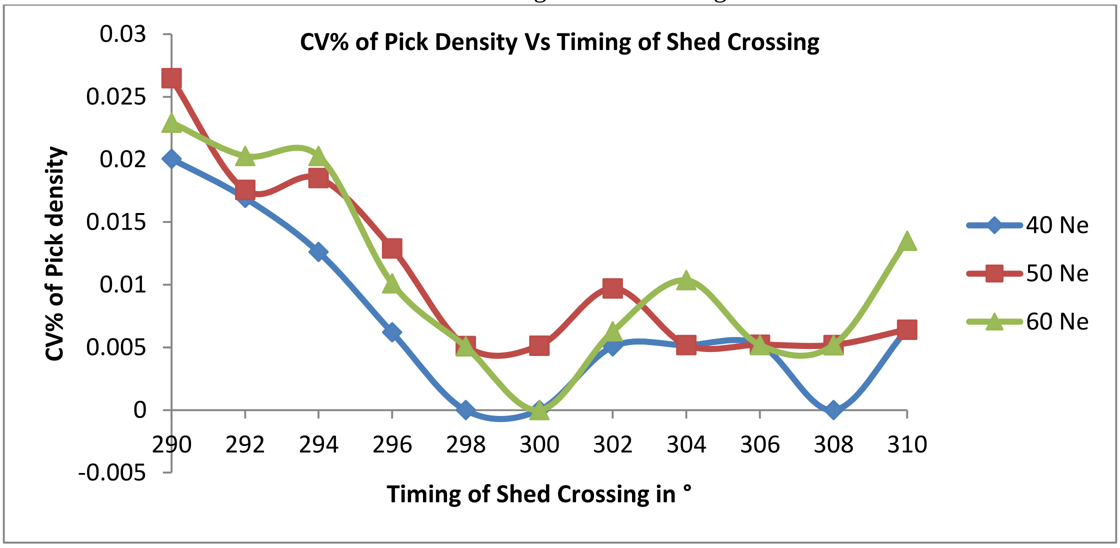

Figure 4: Showing the CV% pick density for different count of warp yarn with the variable timing of shed crossing.

Analysis

From the table 5.12 it can be stated that, earlier timing of shed crossing gives much higher pick density than to the later timing. But both earlier and late timing has higher CV%. The optimum pick density found with minimum variation at timing 298° to 300°.
It can also be noted that, shed crossing timing does not necessarily have any influence on the pick density for different count of yarn but have some on the variation of the density. More finer the yarn more the variation on the pick density.[Graph 5.18 & 5.19]

“5. Conclusion”

It was assumed that the shed timing has great influence on pick density and going with this work the assumption was found true. For earlier shed crossing the pick density was found much higher than the late shedding. At crossing angle 290° the pick density was found the highest and at 310° it was found lowest. But with earlier shed crossing the CV% of pick density was also very much high. This variation of the pick density was also found at the late shedding at an significant mark. The CV% of pick density was lowest when the shed crossing angle was 298°-300°.At this crossing angle range the pick density was 88 which is very much acceptable. It was also found that yarn count variation has almost no effect on pick density. So it can be recommended that for getting an optimum pick density the shed crossing angle should be kept on the range of 298°- 300°.

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A Comparative Analysis of Heuristics for Optimizing the Makespan in Flow Shop Scheduling

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Abstract

*Scheduling is the allocation of launch and finish time to each particular order. Therefore scheduling can bring about a revolutionary change in productivity in shop floor by providing a calendar for processing a set of jobs. The single machine scheduling problem consists of **n** jobs with the same single operation on each of the jobs, while the flow shop scheduling problem consists of **n** jobs with **m** operations on each of the jobs. The main objective of this investigation is to find out the optimal makespan for a 5 jobs and 5 machines flow shop scheduling problem. Then the makespan that have been determined by Palmer's heuristic, CDS heuristic (Campbell Dudek Smith), Insertion algorithm (Nawaz Enscore Ham) and Gupta's algorithm are compared and which is better technique among these four techniques also have been shown in this paper. From the comparative analysis, it has been found that Insertion algorithm (NEH) up to 4 machines problem provides better results as compared to Palmer's heuristic, CDS heuristic, Insertion algorithm and Gupta's algorithm. Gant chart is provided for confirming the effectiveness of heuristics. The practice of these four techniques makes it conceivable to generate a schedule that minimizes the makespan.*

Keywords: Flow Shop Scheduling, Palmer's Heuristic, CDS heuristic, Insertion algorithm, Gupta's Heuristic, Makespan, Comparison of Makespan.

1. Introduction and Literature Review

Flow Shop Scheduling is one kind of decision making procedure and its intention is to optimize the allocation of resources over time to perform a collection of tasks. In a production process system a job is operated by a series of machines. In the case of multiple job operation, jobs must go through each machine in a sequence or a series so that a machine can operate every job effectively. But problems arise when scheduling and sequencing of these jobs, if the amount of Job and Machine is quit high. The order of processing of the required jobs with different processing times over different machines is included by a typical permutation flow shop scheduling problem [8].

A variety of objectives to be minimized for flow shop scheduling are total job completion time, total Flow time, Makespan, Tardiness based objectives etc. The flow shop scheduling was first introduced by Johnson in which a given set of machines are used to process a set of n jobs with an identical order [1]. Different heuristics and Meta heuristics are developed to solve the complex type of flow shop scheduling problems. The most well-known methods are Palmer Heuristics [4], Campbell Dudek Heuristics [5], Insertion algorithm (NEH) [6] and Gupta's Heuristic algorithm [7] for solving flow shop problems having machine greater than 3.

Literature shows that most of the heuristics developed over the last half century for minimizing makespan in flow shop scheduling. A K Sahu (2009) compared RA, Gupta's, CDS and Palmer's Heuristics in Flow Shop Scheduling on 8 jobs & 3 machines, 10 jobs & 8 machines & 10 jobs & 10 machines. He determined that RA heuristic performs well when compared to other heuristics. Malik A. & A. K. Dhingra (2013) had made a Comparative Analysis of Heuristics for Makespan Minimizing in Flow Shop Scheduling [13]. They concluded that NEH heuristic shows the minimum value of makespan when compared to other heuristics.

2. Problem Statement

The minimization of the makespan by four different heuristics and selection of the best heuristics that gives the optimal makespan of a flow shop scheduling problem is our main objective in this study. As the primary data of a flow shop is not available, a secondary data of a flow shop industry is used in this paper [9]. By using this secondary data, the minimum makespan and optimum job sequence have computed for four Heuristics. The makespan of these four methods are compared and the minimum (optimal) makespan is selected for this flow shop scheduling problem. This flow shop problem has the processing times for 5 jobs and 5 machines which are tabulated below;

Table 1: Processing times for 5 jobs and 5 machines in a flow shop [9]

⇩ ⇨	Processing time				
Job	Machine-1 (M1)	Machine-2 (M2)	Machine-3 (M3)	Machine-4 (M4)	Machine-5 (M5)
Job-1(J1)	5	9	8	10	1
Job-2(J2)	9	3	10	1	8
Job-3(J3)	9	4	5	8	6
Job-4(J4)	4	8	8	7	2
Job-5(J5)	3	5	6	3	7

3. Methodology

In order to minimize the makespan and to obtain the optimum job sequence palmers heuristics, CDS algorithm, Insertion algorithm and Gupta's heuristic algorithm are used in this paper. These methods consist of a series of steps which are given below;

3.1 Palmer Heuristics

To minimize the makespan in static flow shop, palmer has developed a heuristic which is known as the Palmer Heuristics. This algorithm sometimes gives optimal solution (Makespan) but not guarantee to give optimal solution for all the time. Palmer has developed a concept of slope to compute the optimum makespan and job sequence in flow shop. Based on this slope (A_j), this heuristic can evaluate only one optimal sequence of job. Palmer heuristics comprises two following steps [4, 3];

***Step1*:** If the number of job is n and machine is m, then the slope A_j for j^{th} job is computed as follows;

$$\mathbf{Aj} = \sum_{i=1}^{m} \{\mathbf{m} - (\mathbf{2i} - \mathbf{1})\}\mathbf{Pij} \qquad (1)$$

Where, P_{ij} denotes the processing time of the job.

Step 2: Jobs are arranged in the sequence according to their descending (decreasing) order of slope $\mathbf{A_j}$ value.

Table 2: Determination of job's slope

Job ⇩	M1	M2	M3	M4	M5	**Slope A_j**
J1	5	9	8	10	1	*-14*
J2	9	3	10	1	8	*-8*
J3	9	4	5	8	6	*-4*
J4	4	8	8	7	2	*-10*
J5	3	5	6	3	7	*+10*
m-(2i-1)	-4	-2	0	+2	+4	

Arranging slope values in decreasing order; the job sequence **J5-J3 -J2-J4-J1** is obtained.

Table 3: Makespan calculation of Palmer's heuristic for job sequence **J5-J3 -J2-J4-J1**

Job ⇩	M1	M2	M3	M4	M5	*Makespan*
J5	3	8	14	17	24	
J3	12	16	21	29	35	
J2	21	24	34	35	43	*61*
J4	25	33	42	49	51	
J1	30	42	50	60	61	

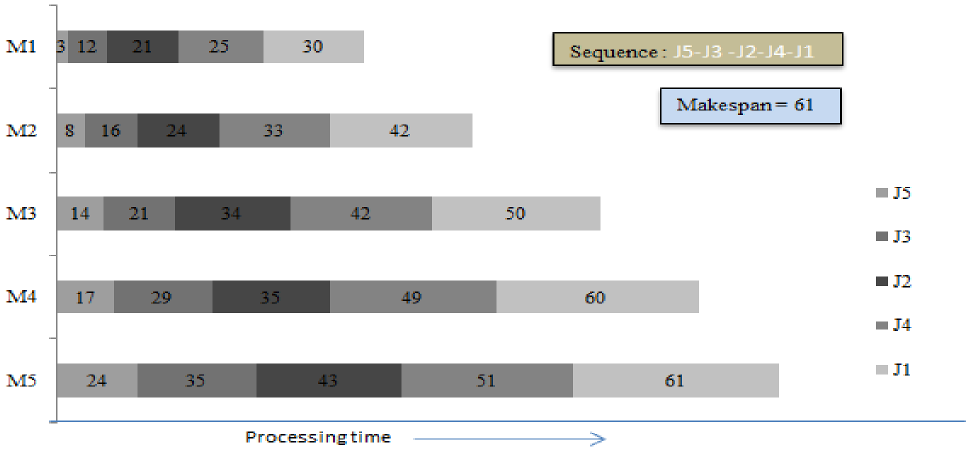

Figure 1: Gantt chart for sequence **J5-J3 -J2-J4-J1** (Palmer's Heuristic)

3.2 CDS Algorithm

An unostentatious heuristic algorithm was proposed by Campbell et al based on extension of Johnson's rule which is known as the Campbell, Dudek, and Smith (CDS) heuristic [5]. This method constructs (m-1) different sequences of jobs in which each sequence assembles to the engagement of Johnson's rule on a new 2-machines problem [10]. After computing the sequences, the best sequence is picked. This heuristic is better than the Palmer heuristics because it can evaluate (m-1) sequences. CDS heuristic comprises following steps;

***Step 1*:** Taking machine M1 & M5 and using Johnson's rule, sequence **J5-J2-J3-J4-J1** is obtained;

Table 4: Makespan calculation of M1 & M2 for job sequence **J5-J2-J3-J4-J1**

Job⇩	M1	M2	M3	M4	M5	*Makespan*
J5	3	8	14	17	24	*61*
J2	12	15	25	26	34	
J3	21	25	30	38	44	
J4	25	33	41	48	50	
J1	30	42	50	60	61	

***Step 2*:** Taking M1+M2 and M4+M5, the following sequence is obtained that is shown in Table 5;

Table 5: Makespan calculation for M1+M2 & M4+M5

Sequence	Makespan
J5-J3-J1-J4-J2	61
J5-J3-J1-J2-J4	61

***Step 3*:** Taking M1+M2+M3 and M3+M4+M5, the following sequence is obtained that is shown in Table 6;

Table 6: Makespan calculation for M1+M2+M3 & M3+M4+M5

Sequence	Makespan
J5-J3-J2-J1-J4	62
J5-J3-J1-J2-J4	61

Among the two sequences, J5-J3-J1-J2-J4 sequence is selected because of minimum makespan 61.

***Step 4*:** Taking M1+M2+M3+M4 and M2+M3+M4+M5, the sequence **J5-J1-J4-J3-J2** is obtained and the makespan is calculated which is shown in Table 7 below;

Table 7: Makespan calculation for M1+M2+M3+M4 and M2+M3+M4+M5

Job⇩	M1	M2	M3	M4	M5	*Makespan*
J5	3	8	14	17	24	*64*
J1	8	17	25	35	36	
J4	12	25	33	42	44	
J3	21	29	38	50	56	
J2	30	33	48	51	64	

***Step 5*:** From the step 1, step 2, step 3and step 4; job sequences **J5-J2-J3-J4-J1, J5-J3-J1-J2-J4, J5-J3-J1-J4-J2** are selected for optimum makespan 61.

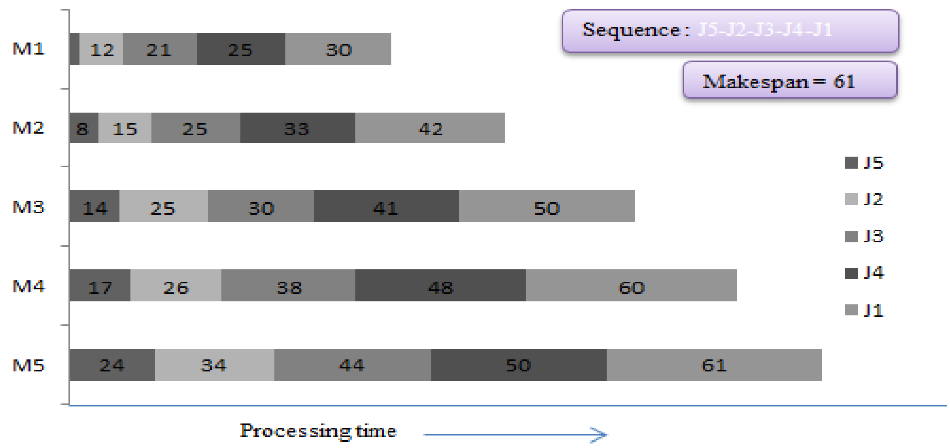

Figure 2: Gantt chart for sequence **J5-J2-J3-J4-J1** (CDS Heuristics)

3.3 Insertion (NEH) Algorithm

Newaz, Enscor and Ham (NEH) algorithm concept creates job sequence in iterative manner [6]. It evaluates n-sequences and results better than Palmer and CDS heuristics. It comprises following steps [6];

***Step 1*:** The total work content (**T_j**) for each job is calculated using expression;

$$\mathbf{Tj} = \sum_{i=1}^{m} \mathbf{Pij} \qquad (2)$$

***Step 2*:** The jobs are arranged in a work content list according to decreasing values of **T_j.**
***Step 3*:** First two jobs are selected from the list and from two partial sequences by inter changing the place of two jobs. The value of partial sequences is computed. Of the two sequences, the sequence having larger value of Makespan is discarded. The lower value of Makespan is called as incumbent sequence.
***Step 4*:** The next job is picked and put in incumbent sequence. The value of Makespan of all sequences is calculated.
***Step 5*:** If there is no job left in work content list to be added to Incumbent sequence then STOP otherwise go to step 4.

Table 8: Makespan and job sequence for Insertion algorithm

Sequence	Makespan	Optimal Makespan & Sequence
J5-J4-J3-J1-J2	58	Optimal
J4-J5-J3-J1-J2	58	Optimal
J4-J3-J5-J1-J2	58	Optimal
J4-J3-J1-J5-J2	63	Not optimal
J4-J3-J1-J2-J5	61	Not optimal

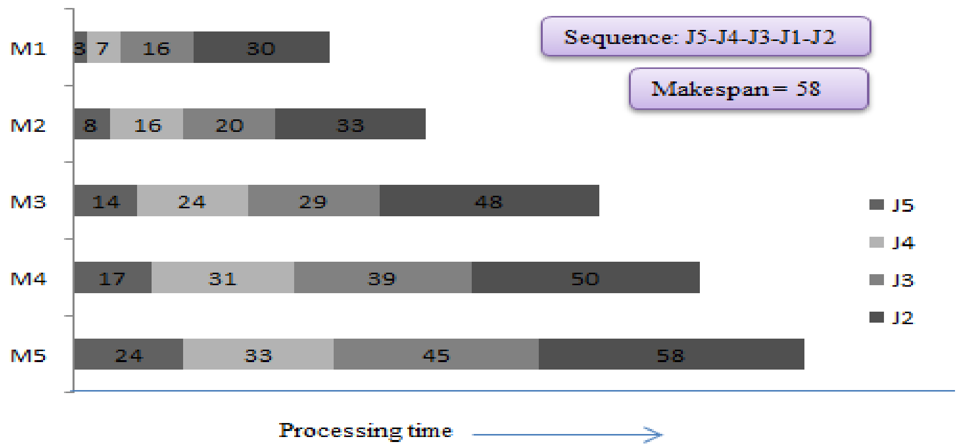

Figure 3: Gantt chart for sequence **J5-J4 –J3-J1-J2** (Insertion Algorithm)

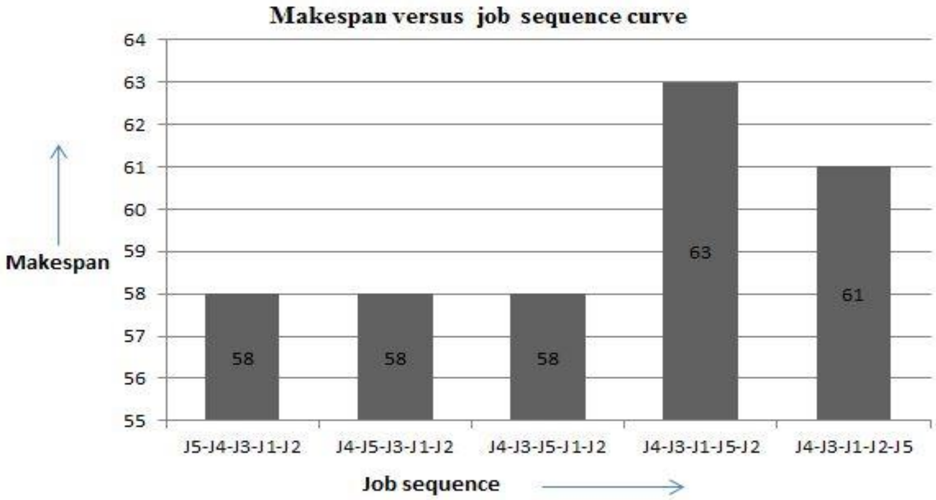

Figure 4: Makespan versus job sequence curve for Insertion (NEH) Algorithm

3.4 Gupta's Heuristic Algorithm

Gupta developed a heuristic to achieve a nearly minimum makespan in which all the jobs are allocated into two groups by comparing the dispensation times of the first machine and the last machine in each job [7]. For each group, the sum of processing times of any two adjoining job are calculated and the minimum processing time is quested, and then the jobs are arranged according to the ascending order of summed processing times [2, 7].

Step 1**:** Form the group of jobs **U** less time is taken on the first machine than on the last machine.
Step 2**:** Form the group of jobs **V** less time is taken on the last machine than on the first machine.
Step 3**:** For each job Ji in **U**, the minimum of (tkj + t(k+1)j) is calculated for k = 1 to m-1.
Step 4: For each job Jj in **V**, the minimum of (tkj + t(k+1)j) is calculated for k = 1 to m-1.
Step 5**:** The jobs in **U** in ascending order of πi's are sorted; if two or more jobs have the same value of πi then the jobs are sorted in an arbitrary order.
Step 6**:** The jobs in **V** in descending order of πj's are sorted; if two or more jobs have the same value of πj then the jobs are sorted in an arbitrary order.
Step 7**:** The jobs on the machines in the sorted order of **U** are scheduled, then in the sorted order of **V** [2].

Table 9: Makespan and job sequence for Gupta's Heuristic Algorithm

Sequence	Makespan	Optimal Makespan & Sequence
J2-J3-J4-J5-J1	63	Not Optimal
J3-J2-J4-J5-J1	64	Not Optimal
J4-J2-J3-J5-J1	60	Optimal
J5-J2-J3-J4-J1	61	Not optimal

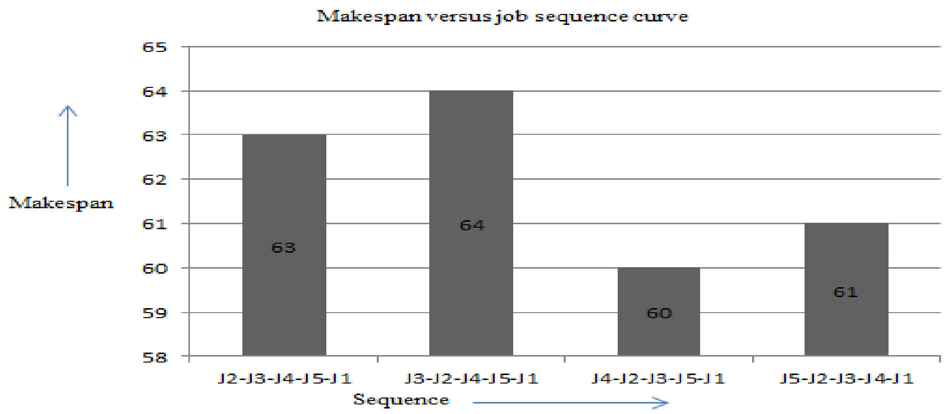

Figure 5: Makespan versus job sequence curve for Gupta's Heuristic

4. Results

Table 10: Makespan Comparison of Palmer Heuristics, CDS Heuristics, Insertion Algorithm and Gupta's Heuristics

Method No.	Method Name	Optimal sequence	Optimal Makespan
1	Palmer's Heuristic	J5-J3 -J2-J4-J1	61
2	CDS Heuristics	J5-J2-J3-J4-J1; J5-J3-J1-J2-J4; J5-J3-J1-J4-J2	61
3	Insertion (NEH) Algorithm	**J5-J4-J3-J1-J2; J4-J5-J3-J1-J2; J4-J3-J5-J1-J2**	**58**
4	Gupta's Heuristic	J4-J2-J3-J5-J1	60

The Makespan of the Palmer Heuristics, CDS Heuristics, Insertion Algorithm and Gupta's Heuristic are compared. From the comparison table 10, it is clear that Insertion Algorithm (NEH) results the best optimal Makespan (58) and gives the best optimal job sequence. So to achieve best optimal makespan, job sequences **J5-J4-J3-J1-J2; J4-J5-J3-J1-J2; J4-J3-J5-J1-J2** can be employed in the flow shop.

5. Conclusion and Summary

Scheduling plays an important role in several flow shop industries. Without proper scheduling productivity decreases that may reduce the profit of the organization and cause an increased price of the product. This paper mainly shows how the makespan are minimized by using the Palmer's Heuristic, CDS Heuristic, Insertion Algorithm and Gupta's heuristic of a 5 job and 5 machine flow shop problem and their differences. Finally, this analysis proves that the Insertion (NEH) algorithm is the best among these four heuristics because it results most optimum makespan 58 for the given problem. In future, this work can help the flow shop industries and researches to identify the effective and efficient heuristic techniques for resolving the flow shop scheduling problems. By elaborating the size of the problems and adding any assumptions this analysis can be extended. If the hybrid methods of these heuristics are developed in future, larger type of flow shop scheduling problem can be mitigated.

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Present Scenario and Possible Scope of Film Industry: a Case Study on Bangladeshi Film (Dhallywood)

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Abstract

The present condition of the Bangladeshi film industry is not as good as compared to other countries' film industry like Hollywood, Bollywood, Chinese, etc. This industry is plunging day by day as though it reflects not only one country's people, their customs, society, etc., just like a window of a society but also a huge amount of profit can be earned through it. If it can be improved anyway the country of that film industry can be easily highlighted all over the world and can bring the benefit in multi-dimensional way. This research is conducted to identify the ins and outs of Bangladeshi film industry namely Dhallywood in order to bring out the possible scopes that can be improved for making film more attractive and interesting along with getting financial benefit. A customer survey of different ages is taken to know about their attitude towards the contemporary commercial Bangladeshi cinema, environment of cinema hall, etc. According to their opinions and suggestions regarding to this subject, a comprehensive analysis is conducted by adopting Quality Function Deployment (QFD) and Fuzzy TOSPIS group decision making techniques. Finally a list of scopes with their priority is mentioned.

Keywords: Film, Dhallywood, Survey, QFD, Fuzzy TOPSIS

1. Introduction

Cinema of a country is nothing but a reflection of the culture, customs, society and all other things having the nation of its own. Therefore it can portray the pros and cons of a society and it can also introduce the nation to the world as doing different big film industries such as Hollywood, Bollywood etc. The first Bangladesh based full length film is Mukh O Mukhosh produced in 1956 after the release of Pather Pachali by Satyajit Roy. In 1957, Bangladesh Film Development Corporation (BFDC) was established and Suryo Dighal Bari was the first internationally recognized film. Before it, Bangla cinema means the production of Kolkata. But now the scenario is different, Bangladesh is producing huge number of films in a year. Among them very few number of films are successful and one or two film is world standard. Therefore it has been demanded that there are some actors, actresses, directors and others who have sufficient potentialities to gift the world standard films. If the problems of the Bangladeshi Film industry (namely Dhallywood) can be found out and possible to solve, then it will be the most profitable sector of the government and one day it will lead with the world famous film industries such as Hollywood and Bollywood [1].

The successive comparison among the different film industries such as Hollywood, Bollywood, Kolkata, Korean, Telegu, and Dhallywood in the year of 2013 with respect to the gross income for the top five movies in the box office are as follows:

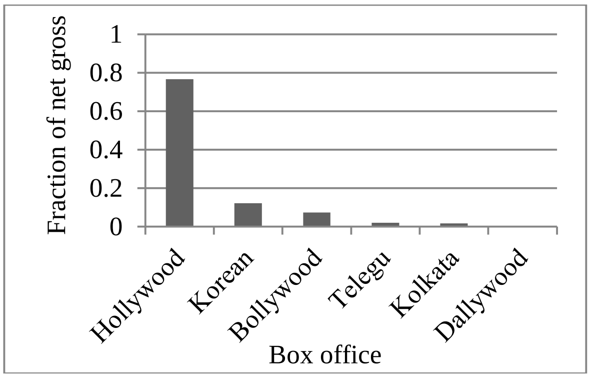


Fig. 1. Fraction of net gross

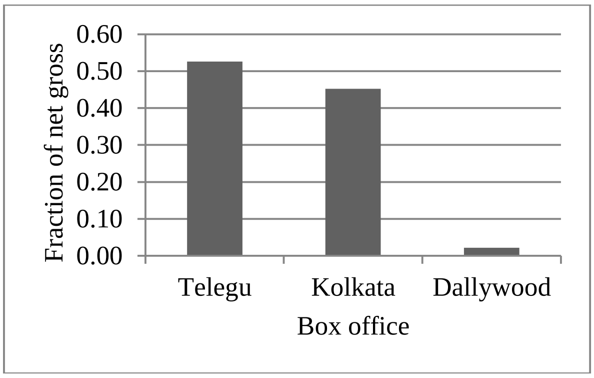


Fig. 2. Fraction of the net gross

In the fig. 1 there is no sign of the fraction of net gross of Dallywood with respect to other big film industries in the world. Excluding the first three, the Fig.1 is redrawn as follows. In fig.2 the bar of the Dallywood is appeared as though it is little hope. If the problems of the Bangladeshi film industry can be identified by any means and these problems can be overcome then it will be world standard film industry. This study will accommodate different views of different people from different classes of society having a variety of age range. According to their views the existing laggings of our film industry will be identified. Possible ways of improvement according to the requirements of people to make a higher standard films will be recommendated. Suitable tasks are to be performed and to be prioritize to wipe out the existing laggings.

2. Research methodology

A questionnaire consisting of 34 questions is distributed among 150 people and their opinions are taken. The age of those people is ranging from 18 to 50 years.According to their viewpoint the existing problems, probable solutions and their expectations are indicated. Interview and some propositions are collected of a renowned Bangladeshi Film director. The principal factor which is a crying need for the improvement of our films is determined by using QFD tool. Other factors are also sort out by applying the same process. Fuzzy TOPSIS is also used for determining what technical specification is getting first priority to solve and finally a comparison between QFD and Fuzzy TOPSIS are made.

3. Data collection and analysis

Quality function deployment

QFD is a way to assure the design quality while the product is still in the design stage [2]. QFD consists of two components which are deployed into the design process: quality and function. The “quality deployment" component brings the costumer’s voice into the design process. The "function deployment" component links different organizational functions and units into to the design-to-manufacturing transition via the formation of design teams [3].

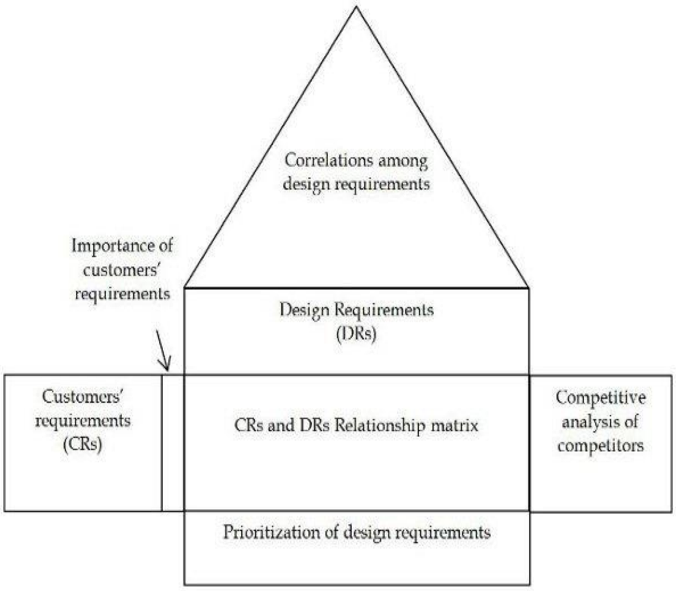


Fig. 3. Description of the house of quality (HOQ)

The following steps are taken to implement the QFD in the film industry domain.

Step 1: List the customer requirement (WHATs): QFD starts with list of customer requirements. 150 voices of customers in the age of 18 to 50 are collected and the key customer requirements are listed into the QFD diagram shown its location in fig. 3.

Step 2: List the corporate language (HOWs): it is then required to breakdown general customer requirements into more specific technical requirements which here is called corporate language by probing what is needed.

Step 3: Develop a relation matrix between WHATs and HOWs: it is very important to develop relationship between customer requirements and the corporate languages. It should be taken extra care because each customer requirement may relate with more than one corporate language. It is completed by breakdown the relation into three categories such as strong, medium, and low.

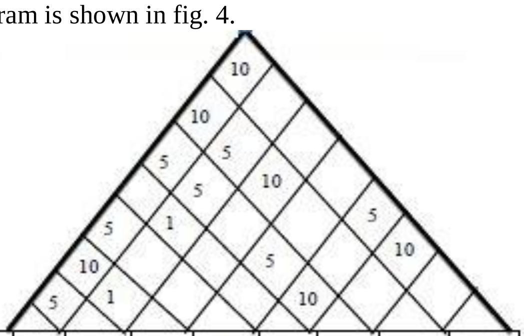
Step 4: Develop an interrelationship matrix between HOWs: A comprehensive relationship is represented at the roof of the house of quality in between the corporate languages. Blank block represents no relationship.

Step 5: Customer rating of the competition: understanding the customers' rating to the competitors and how they rating our film provide the tremendous advantages for the improvement of the target. At most right of the house of quality diagram represents it.

Step 6: Develop prioritized customer requirements: the prioritized customer requirements consists of we today, target value and improvement ratio.

Step7: Prioritization of design requirement: the QFD team identifies technical descriptors that are most needed to fulfill customers' requirements and need to further improvement.

The final house of quality diagram is shown in fig. 4.



Corporate Language → / Customer's demand ↓	Relative importantance out of 10	% Importance	Handsome budget	Expert directors	Technical support & filming device	Young talents & newcomers	Modified sensor board	Good story	Trained technician & stuffs	Qualified screenplay writers	Bollywood (10)	Kolkata (10)	We today (10)	Target values (10)	Improvement ratio
Reflect real culture	10	10.9	5	10	1	1	5	10	5	10	10	10	1	5	5.0
Realistic theme	10	10.9	1	10	1	1	5	10	1	10	5	5	1	5	5.0
Good quality film	10	10.9	5	10	5	5	10	5	10	5	10	10	1	5	5.0
Digital print	9	9.8	10	1	10		1	5	1	5	10	10	5	10	2.0
Avoid copying	8	8.7		5		1	1	10		10	5	5	1	5	5.0
Good location	7	7.6	10	1				1	5	1	10	10	1	5	5.0
Good camerawork	7	7.6	5	10	1	1		5	10	1	10	10	1	5	5.0
Creativity	7	7.6	5	10	1	5	5	10		10	10	10	5	10	2.0
Active sensor board	7	7.6					10	5			10	10	5	10	2.o
Not aiming specific people	6	6.5	1	10		1	5	5		10	10	10	5	10	2.0
Independency upon hero/heroine	6	6.5	5	5		10		1		5	10	5	1	10	10.0
Smart title	5	5.4		5		1	1	1		5	10	5	1	5	5.0
Importance			**408**	**664**	**188**	**207**	**388**	**503**	**298**	**624**					
Bollywood (10)			10	10	10	10	10	10	10	10					
Kolkata (10)			10	10	10	10	10	10	10	10					
We today (10)			5	1	1	5	1	1	5	5					
Target value (10)			10	5	10	10	5	10	10	10					
Improvement ratio			2.0	5.0	10.0	2.0	5.0	10.0	2.0	2.0					

10=strong relation

5=medium relation

1= low relation

Fig. 4. The house of quality diagram

Fuzzy TOPSIS

Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) is widely used approach to evaluate potential alternatives against the selected criteria [4]. Fuzzy TOPSIS has been applied to facility location problems by researchers in [5-9]. The following steps are generally followed for this approach.

Step 1: Define the customer requirements those they want to see in the Bangladeshi film. It is defined in the WHATs part of HOQ.

Step 2: define the customer requirements into the engineering term denoted as corporate language in this study. Corporate language is presented in the HOWs part of the HOQ.

Step 3: Build relationship between the customer requirements and the corporate language and finally select the potential corporate language for incorporating into the Bangladeshi film as priority basis Fuzzy TOPSIS is adopted. According to [4], the following steps required for the completion of Fuzzy TOPSIS:

Assignment of ratings to the customer requirements and the corporate language: Let consider the customer requirements weight are denoted by $w_i = \{w_1, w_2, \ldots, w_i\}$. The performance ratings of each decision maker $D_k = \{D_1, D_2, \ldots, D_k\}$ for each corporate language $A_j = \{A_1, A_2, \ldots, A_j\}$ with respect to customer requirements $C_m = \{C_1, C_2, \ldots, C_m\}$ are denoted by $R_k = x_{ijk}$ with membership function $\mu_{Rk}(x)$.

Assignment of ratings to the customer requirements and the corporate language: If the fuzzy rating and the importance weight of the k[th] decision maker are $x_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and weight $w_{ijk} = \{w_{ij1}, w_{ij2}, w_{ij3}\}$, then the aggregated fuzzy ratings of alternatives with respect to each criterion are given by $x_{ij} = (a_{ijk}, b_{ij}, c_{ij})$ where,

$$a_{ij} = {}^{\min}_{k}\{a_{ijk}\} \quad ; \quad b_{ij} = \frac{1}{k}\sum_{1}^{k} b_{ijk} \quad ; \quad c_{ij} = {}^{\max}_{k}\{c_{ijk}\}$$

The aggregated fuzzy weights of each criteria are calculated as $w_j = (w_{j1}, w_{j2}, w_{j3})$, where,

$$w_{j1} = {}^{\min}_{k}\{w_{jk1}\} \quad ; \quad w_{j2} = \frac{1}{k}\sum_{1}^{k} w_{jk2} \quad ; \quad w_{j3} = {}^{\max}_{k}\{c_{jk3}\}$$

Compute the fuzzy decision matrix: the fuzzy decision matrix and the criteria are constructed as follows:

$$D = \begin{matrix} & C_1 & C_2 & & C_n \\ A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ A_3 & \cdots & \cdots & \cdots & \cdots \\ A_4 & x_{m1} & x_{m2} & \cdots & x_{mn} \end{matrix}$$

$$W = (w_{1,} w_2 \ldots, w_n)$$

Normalized the fuzzy decision matrix: The normalized fuzzy decision matrix R is given by $R = [r_{ij}]m * n$ where i= 1,2…,m and j= 1,2…,n;

$$r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{ and } c_j^* = {}^{max}_{i} c_{ij} \quad \text{(benefit criteria)}$$

$$r_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \text{ and } a_j^- = {}^{\min}_{i} a_{ij} \quad \text{(cost criteria)}$$

Compute the weighted normalized matrix: it is the multiplication of the weight of evaluation criteria and the normalized fuzzy decision matrix as follows: $V = [v_{ij}]m * n\text{where } v_{ij} = r_{ij}(.)w_j$

Compute the fuzzy Ideal solution (FPIS) and Negative Ideal Solution (FNIS): it is computed as follows:

$$A^* = (v_1^*, v_2^*, \ldots, v_n^*), \text{ where } v_j^* = {}^{\max}_{i}\{v_{ij3}\}, \ i=1,2,...,m; \ j=1,2,\ldots,n$$

$$A^- = (v_1^*, v_2^*, \ldots, v_n^*), \text{ where } v_j^- = {}^{\min}_{i}\{v_{ij1}\}, \ i=1,2\ldots,m; \ j=1,2,\ldots,n$$

Compute the distance of each alternative from FPIS and FNIS: it is computed as follows:

$$d_i^* = \sum_{j=1}^{n} d_v(v_{ij}, v_j^*) \ ; \ d_i^- = \sum_{j=1}^{n} d_v(v_{ij}, v_j^-)$$

Where, j= 1,2,…,n, d_v is the distance measure between two fuzzy number (a, b).

Compute the closeness coefficient (CC_i) of each alternative: it represents the distance to FPIS and FNIS simultaneous. It is calculated as follows:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*} \text{ , where i=1,2,\ldots,m}$$

Rank the corporate language (alternatives): select the alternative with the highest closeness coefficient for final implementation. The best alternative is the closest to the FPIS and farthest from FNIS.

Table 1. Customer requirements and corporate languages

Customer Requirements(C)	Definition	Corporate Language (Alternative A)
Reflect real culture (C_1)	the more the better	Handsome Budget (A_1)
Realistic Theme (C_2)	the more the better	Expert directors (A_2)
Good quality film (C_3)	the more the better	Technical support & filming devices (A_3)
Digital print (C_4)	the more the better	Young talents and new comers (A_4)
Copying (C_5)	the less the better	Modified sensor board (A_5)
Good location (C_6)	the more the better	Good story (A_6)
Good camera work (C_7)	the more the better	Trained technician and stuffs (A_7)
Creativity (C_8)	the more the better	Qualified screen play writers (A_8)
Active sensor board (C_9)	the more the better	
Film for only targeted people (C_{10})	the less the better	
Independency to hero or heroine (C_{11})	the more the better	
Smart title (C_{12})	the more the better	

Table 2. Linguistic terms for customer requirements rating as well as corporate language rating

For customer requirements rating		For corporate language rating	
Linguistic term	Membership function	Linguistic term	Membership function
Very Low	(1,1,3)	Very Poor	(1,1,3)
Low	(1,3,5)	Poor	(1,3,5)
Medium	(3,5,7)	Fair	(3,5,7)
High	(5,7,9)	Good	(5,7,9)
Very High	(7,9,9)	Very Good	(7,9,9)

Table 3. Linguistic Assessment of the criterion

Criteria	Decision Maker			
	D1	D2	D3	D4
Reflect real culture (C_1)	VH	VH	H	VH
Realistic Theme (C_2)	VH	H	VH	VH
Good quality film (C_3)	VH	H	H	VH
Digital print (C_4)	VH	H	M	H
Copying (C_5)	H	H	M	VH
Good location (C_6)	H	M	M	VH
Good camera work (C_7)	VH	VH	H	VH
Creativity (C_8)	M	H	H	M
Active sensor board (C_9)	M	M	M	H
Film for only targeted people (C_{10})	M	M	M	M
Independency to hero or heroine (C_{11})	M	M	L	M
Smart title (C_{12})	M	M	H	M

Table 4. Linguistic assessment of the corporate languages based on customer requirements

		Decision Maker (D)															
C	A	D_1	D_2	D_3	D_4	C	A	D_1	D_2	D_3	D_4	C	A	D_1	D_2	D_3	D_4
C_1	A_1	F	G	G	F	C_5	A_1	VP	VP	VP	VP	C_9	A_1	VP	VP	VP	VP
	A_2	VG	VG	VG	G		A_2	F	G	F	F		A_2	VP	VP	VP	VP
	A_3	VP	VP	P	P		A_3	VP	VP	VP	VP		A_3	VP	VP	VP	VP
	A_4	VP	P	P	VP		A_4	VP	P	P	VP		A_4	VP	VP	VP	VP
	A_5	F	F	F	G		A_5	VP	VP	VP	VP		A_5	VG	G	G	VG
	A_6	VG	VG	G	VG		A_6	VG	VG	VG	G		A_6	F	G	G	F
	A_7	F	G	F	F		A_7	VP	VP	VP	VP		A_7	VP	VP	VP	VP
	A_8	VG	G	VG	VG		A_8	VG	VG	VG	G		A_8	VP	VP	VP	VP
C_2	A_1	VP	VP	VP	P	C_6	A_1	VG	VG	VG	G	C_{10}	A_1	VP	P	P	VP
	A_2	VG	VG	VG	G		A_2	VP	VP	VP	P		A_2	VG	G	G	VG
	A_3	VP	P	VP	VP		A_3	VP	VP	VP	VP		A_3	VP	VP	VP	VP
	A_4	VP	VP	VP	VP		A_4	VP	VP	VP	VP		A_4	VP	P	P	VP
	A_5	F	F	G	G		A_5	VP	VP	VP	VP		A_5	F	F	F	F
	A_6	VG	G	G	G		A_6	VP	P	VP	P		A_6	F	G	G	G
	A_7	VP	VP	VP	P		A_7	F	F	F	F		A_7	VP	VP	VP	VP
	A_8	VG	VG	VG	VG		A_8	VP	P	P	P		A_8	VG	G	G	VG
C_3	A_1	F	F	F	G	C_7	A_1	F	G	F	G	C_{11}	A_1	F	F	F	F
	A_2	VG	G	VG	VG		A_2	VG	G	G	G		A_2	F	G	F	G
	A_3	F	G	G	G		A_3	VP	P	P	VP		A_3	VP	VP	VP	VP
	A_4	F	G	F	G		A_4	VP	VP	VP	P		A_4	VG	G	VG	VG
	A_5	VG	G	G	G		A_5	VP	VP	VP	VP		A_5	VP	VP	VP	VP
	A_6	F	G	F	G		A_6	F	F	F	F		A_6	VP	VP	VP	VP
	A_7	VG	G	G	VG		A_7	VG	VG	G	G		A_7	VP	VP	VP	VP
	A_8	F	F	F	F		A_8	VP	P	P	P		A_8	F	G	F	G
C_4	A_1	VG	G	G	VG	C_8	A_1	F	F	F	F	C_{12}	A_1	VP	VP	VP	VP
	A_2	VP	G	G	F		A_2	VG	VG	VG	G		A_2	F	G	F	F
	A_3	VG	G	VG	VG		A_3	VP	VP	P	P		A_3	VP	VP	VP	VP
	A_4	VP	VP	VP	VP		A_4	F	VG	G	G		A_4	VP	VP	VP	VP
	A_5	VP	P	P	P		A_5	F	F	F	F		A_5	VP	P	P	P
	A_6	F	F	F	G		A_6	VG	G	G	VG		A_6	VP	VP	VP	P
	A_7	VP	VP	VP	VP		A_7	VP	VP	VP	VP		A_7	VP	VP	VP	VP
	A_8	F	G	G	F		A_8	VG	G	G	G		A_8	F	G	F	G

Table 5. Closeness coefficient (CC) of alternatives

	A1	A2	A3	A4	A5	A6	A7	A8
d+	65.516	64.032	74.455	76.661	69.712	67.113	70.388	67.397
d-	51.963	52.543	38.800	37.302	43.904	47.716	42.842	46.778
CC_i	0.442	0.451	0.343	0.327	0.386	0.416	0.378	0.410
Rank	2	1	7	8	5	3	6	4

4. Results and Findings

The importance of the corporate languages those are strongly related to the customer requirements is obtained from the house of quality diagram. According to the rank, if those can be incorporated into the Bangladeshi film then it will be world standard and can keep pace with the market leader film industries. Another analysis is also adopted called Fuzzy TOPSIS that also ranks the corporate language on the basis of customer requirements. The results of both methods are summarized as follows:

Quality Function Deployment	Fuzzy TOPSIS
A2>A8>A6>A1>A5>A7>A3	A2>A1>A6>A8>A5>A7>A3>A4

5. Conclusion and Recommendation

Bangladeshi films have lot of opportunities to achieve the world standard. Because it has lot of talents and creative faces who are able to direct the international level film. It has been already proved. But numbers of such level film are directed and produced very few. Therefore, Bangladesh Film Development Corporation with the help of Bangladesh government should take steps for patronizing the expert film directors and should welcome the young talents in the domain. Most of the people of Bangladesh want to go to cinema hall for expending their leisure period with family watching cinema. But nowadays it is very difficult to go into cinema hall with family due to unsecured environment and absence of art, culture, qualified story etc in the cinema. If these can be improved the arrival rate of audience of the viewers will increase tremendously. Therefore the Bangladeshi commercial films will not flop. In the mean time the new producers dare not to invest in this sector. Both Educated and uneducated film viewers always want to watch clean, morally sound, cultured films according to statistics. Actually none want to watch vulgar, unsocial, or illogical film. The film which is good quality is liked to all. From few decades past to present, the parents whatever they are upper class or lower class do not feel free to allow their children to go into cinema hall for entertainment. Even they do not like Bangladeshi cinema to be watched of their children at home. If the aforesaid problems along with modified sensor board; trained technician and stuffs; qualified screen play writers can be improved it will not take no longer time to become world standard film to lead with the big film industries.

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Minimizing Make span for Flow Shop Scheduling using Matrix Manipulation and Heuristic methods under processing uncertainty

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Abstract

Scheduling has to consider operations sequences, machine load and availability of machines. Its aim is to optimize the objectives with the allocation of resources to tasks within the given time periods. A typical flow shop scheduling problem involves the determination of the order of processing of jobs with different processing times over different machines. In reality, any inaccuracy in scheduling can cause long lead-time, production cost increase, and lateness. This inaccuracy may occur due the inaccurate information, uncertainties in demand and uncertainties production facilities. In this paper, matrix manipulation method with MATLAB is proposed to solve flow shop scheduling problem of n jobs on m machines under uncertain processing time. The problems have been considered for comparative analysis with Palmer's heuristic, CDS heuristic & NEH heuristic. The preliminary result indicates that the proposed code is very efficient and time saving in comparison with other methods to find out the minimum makes span through an optimal sequence for flow shop scheduling problem of n jobs on m machines.

Keywords: Scheduling, Flow shop, Uncertainty, Make span, MATLAB, Heuristic.

1. Introduction

Scheduling plays an important role in most manufacturing and service systems. Scheduling is a decision making practice that is used on a regular basis in many manufacturing and services industries. Its aim is to optimize one or more objectives with the allocation of machines to tasks over given time periods. Flow shop Scheduling is used to determine the optimal sequence of n jobs to be processed on m machines in the same order. In this paper, the problem considered in which processing times of jobs are uncertain. The uncertain parameters are represented by triangular fuzzy number. We have used Liou and Wang [1] approach for ranking fuzzy numbers to precisely determine the total integral value of triangular fuzzy number with respect to the degree of achievement. In this paper an attempt was made to apply matrix manipulation method in MATLAB for finding out the best optimal result for the flow shop scheduling problem without performing any manual calculation at very minimum effort compared to other heuristic methods.

2. Literature Review

Most research works for minimizing make span in flow shop scheduling have been being done over the last half centuries. From then many methods have developed. One of them was Johnson [2] who proposed an algorithm to solve general flow shop problem for two machines and n jobs to find out the optimum sequence. After that Johnson's algorithm was extended for three machines and n jobs. Palmer [3] proposed an algorithm which is a slope indexing method to solve n jobs and m machines for finding optimal sequence. Campbell et al. [4] proposed an algorithm which was an extension of Johnson's algorithm for solving flow shop scheduling problems to find optimal sequence with minimum make span. Gupta [5] developed an algorithm which was similar to Palmer's algorithm in which the slope index was defined in a different way by considering some interesting facts of Johnson's algorithm for three machines. Dannenbring [6] developed a 'Rapid Access' procedure which combined the advantages of Palmer's and CDS algorithm to provide a better solution in which it solves only one artificial problem using Johnson's algorithm instead of solving m-1 artificial two machine problems. Nawaz et al. (NEH) [7] proposed an algorithm which is based on the assumption of assigning the highest priority of job with higher total processing time on all machines. It is a constructive algorithm in which sequences are built by adding a new job at each step and finding the optimal solution. Rajendran [8] proposed a method for solving flow shop scheduling problem with multiple objectives of optimizing make span, total flow time and idle time for machines in which the first sequence was taken from CDS algorithm. Tejpal & Jayant

[9] proposed a method which is an extension of Palmer's heuristic for the flow shop scheduling problem. Tang and Zhao [10] developed a model for scheduling a single semi continuous batching machine for scheduling jobs on the machine to minimize make span. Eren and Guner [11] developed a bi-criteria flow shop scheduling problem with a learning effect in a two-machine flow shop for finding a sequence that minimizes a weighted sum of total completion time and make span. Fuzzy sets are often used to describe the processing time when the processing time is uncertain. A number of fuzzy approaches to flow shop scheduling problems have been established. The job sequencing with fuzzy processing time was addressed by MacCahon and Lee [12]. Hong and Chuang [13] proposed a new triangular fuzzy Johnson algorithm. Seyed Reza Hejari [14] etc introduced an improved version of Mc Cahon and Lee algorithm. Yager [15], Shukla and Chen [16], Marin and Roberto [17] have contributed remarkably in the field of flow shop scheduling problems. Ishibuchi and Lee [18] formulated the fuzzy flow shop scheduling problem with fuzzy processing time.

3. Treatment of the fuzzy variables

This work assumes that the decision maker (DM) has already adopted the pattern of triangular possibility distribution to represent the crashing cost, variable indirect costs per unit time and Available total budget in the original fuzzy linear programming problem. In the process of defuzzification, this work applies Liou and Wang (1992) approach for ranking fuzzy method to convert fuzzy number into a crisp number.

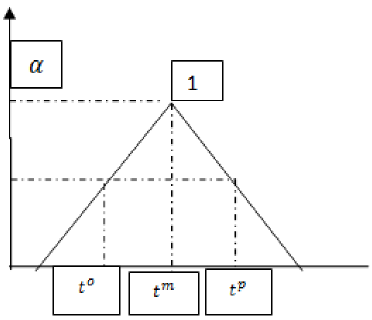

Figure: Membership function of t^{α}

If the minimum acceptable membership level α, then corresponding auxiliary crisp of triangular fuzzy number $t = [t^o, t^m, t^p]$ is:

$t^{\alpha} = \frac{1}{2}\{\alpha t^o + t^m + (1-\alpha)t^p\}$…………(1)

The primary advantages of the triangular fuzzy number are the simplicity and flexibility of the fuzzy arithmetic operations. For instance, Figure 1 shows the distribution of the triangular fuzzy number of t. In practical situations, the triangular distribution of t may: (1) the most pessimistic value (t^p) that has a very low likelihood of belonging to the set of available values (possibility degree 0 if normalized); (2) the most likely value (t^m) that definitely belongs to the set of available values (membership degree = 1 if normalized); and (3) the most optimistic value (t^o) that has a very low likelihood of belonging to the set of available values (membership degree = 0 if normalized).

4. Data collection & case description

We have collected data of 4 Jobs, 10 Machines flow shop problem with processing times in second described by triangular fuzzy numbers as given in table 1. The given data is collected from RFL Plastics Ltd, 105 Pragati Sarani, Middle Badda, Dhaka 1212, which is a leading manufacturing company in Bangladesh. They produce Premium/Elegant/Fancy Towel Hanger (J1), Premium Tissue Holder (J2), Premium/Fancy Soap case(J3), Elegant Corner Rack (J4) and for making these they need six machines namely Sealing (M2), lock setting (M3), Body setting (M4), Royal Plug packing (M5) and Finished Good Packing machines (M6).They produce these products as J1-J2-J3-J4 sequence to M1-M2-M3-M4-M5-M6 order machine sequence.

Table 1: Fuzzy processing times

JOB	M1	M2	M3	M4	M5	M6
J1	(21.5,22,23)	(23,24,25.5)			(15.5,16,17.5)	(15,16,16.5)
J2		(23.5,24,25)	(24,25,26.5)	(27,28,29.25)	(34.20,35,36.75)	
J3	(9.6,10,11.1)		(11.2,12,12.9)		(14.3,15,16.2)	(11.35,12,12.9)
J4		(20.95,22,23.5)		(31.2,32,33.4)	(20.95,22,23.5)	(20.4,21,22.10)

In that company all the jobs need to have same operation for meeting customer demand as product. So as the position of machines can always be fixed. And that is why this is flow shop scheduling and will be fruitful to our selected methodologies. By this way, they usually face high time to the get the final products. Here we find the problem and take challenge to reduce the total completion time. In the process of defuzzification, this work applies Liou and Wang (1992) approach for ranking fuzzy method to convert fuzzy number into a crisp number. If the minimum acceptable membership level $\alpha = 0.5$, then corresponding auxiliary crisp of triangular fuzzy number using equation (1) is given in the table 2 and table 3.

Table 2: Crisp value of Fuzzy processing times when $\alpha = 0.5$

JOB	M1	M2	M3	M4	M5	M6
J1	22.125	24.125	0	0	16.25	15.875
J2	0	24.125	25.125	28.0625	35.2375	0
J3	10.175	0	12.025	0	15.125	12.0625
J4	0	22.025	0	32.15	22.1125	21.125

Table 3: Crisp value of Fuzzy processing times when $\alpha = 0.6$

JOB	M1	M2	M3	M4	M5	M6
J1	22.2	24.25	0	0	16.35	15.95
J2	0	24.2	25.25	28.175	35.365	0
J3	10.25	0	12.11	0	15.22	12.14
J4	0	22.16	0	32.26	22.24	21.21

5. The solving approaches and procedures

The matrix manipulation method using MATLAB, Palmer's heuristic, CDS heuristic and NEH algorithm are used and compared for finding out the optimal result for the collected flow shop problem. Palmer's heuristic have the calculation of slop of the completion times of each job respected to the machines and with decreasing order of it makespan is being determined. It has limitation of much number products and machines production scheduling problem. CDS heuristic and NEH algorithm are good compared to Palmer's heuristic because of in there the makespan are to calculate for more than one job sequence. And in MATLAB manipulation, the makespan for the jobs of every possible job sequences. Since the problem is of flow shop production scheduling, the heuristic algorithms and our proposed MATLAB coding are assembled here to find out optimal makespan.

Matrix Manipulation in MATLAB

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. A MATLAB code has been developed using matrix manipulation method to find out the optimal result for the given problem. In our MATLAB code, permutation system has been used where every possible permutation of the jobs is being included as well their makespans and it will also find out what the minimum completion time is and also its job sequence. With increasing but a certain risk factor α, it has been seen that the completion time is also increased. That's why the company gets more chances to cope up with uncertain time and to get their final product within lead time. The outputs derived from the code are given below.

Table 4: Final result for matrix manipulation in MATLAB

Type of Processing Times	OUTPUT
Processing times when **α**=0.5	Optimal Time=158.80s, Optimal Sequence= J4-J1-J3-J2
Processing times when **α**=0.6	Optimal Time=159.44s, Optimal Sequence= J4-J1-J3-J2

Palmer's Heuristic

In flow shop scheduling, Palmer proposed a heuristic to minimize the make-span measure. He mainly proposed a slope index S_j for each job. The formula for the slope index S_j is shown below.

$$S_j = (m-1)\, t_{j.m} + (m-3)\, t_{j.m-1} + (m-5)\, t_{j.m-2} + \ldots - (m-3)\, t_{j.2} - (m-1)\, t_{j.1}$$

Where m is the total number of machines.

Procedure:

Step 1.Compute slope for each job.

Step 2.Arrange the jobs as per the decreasing order of slope.

When **α**=0.5 then the company gets more time than previous one and for considering the value of risk factor a little bit uncertainty of time can be minimized easily. And for 0.5 value of the risk factor Palmer's heuristic give the J4-J3-J2-J1 job sequence. This job sequence shows total job completion time 166.7 seconds which is less than traditional completion time of the company.

Table 5: Solution of Palmer's heuristic with J4-J3-J2-J1 when **α**=0.5

Job	M1	M2	M3	M4	M5	M6
J4	0	22.025	22.025	54.175	76.2875	97.4125
J3	10.175	22.025	34.05	54.175	91.4125	109.475
J2	10.175	46.15	71.275	99.375	134.575	134.575
J1	32.3	70.275	71.275	99.375	150.825	166.7

And in second case, for 0.6 value of the risk factor, Palmer's heuristic gives a higher completion time than **α**=0.5 with job sequence J4-J3-J2-J1 and the total completion time is 167.45 seconds. In this sense, the company gets good opportunity to cope up with uncertain processing times of each job.

Table 6: Solution of Palmer's heuristic with J4-J3-J2-J1 when **α**=0.6

Job	M1	M2	M3	M4	M5	M6
J4	0	22.16	22.16	54.42	76.66	97.87
J3	10.25	22.16	34.27	54.42	91.88	110.01
J2	10.25	46.36	71.61	99.785	135.15	135.15
J1	32.45	70.61	71.61	99.785	151.5	167.45

CDS Heuristic

CDS heuristics is basically an extension of the Johnson's algorithm. The main objectives of the heuristic are the minimization of make-span for n jobs and m machines in a deterministic flow shop scheduling problem. The CDS heuristic forms in a simple manner a set of an m-1 artificial 2-machine sub problem for the original m machine problem by adding the processing times in such a manner that combines M1, M2,...,Mm-1 to pseudo machine 1 and M2, M3,... M_m to pseudo machine 2. Finally, by using the Johnson's 2-machines algorithm each of the 2-machine sub-problems is then solved. The best of the sequence is selected as the solution to the original m-machine problem. For the given flow shop problem as stated in table 1 of size 6×4 using this heuristic the following sequences and make span has been established.

Table 7: Solution of CDS heuristic with J4-J3-J2-J1 when **α**=0.5

Job	M1	M2	M3	M4	M5	M6
J4	0	22.025	22.025	54.175	76.2875	97.4125
J3	10.175	32.15	44.175	54.175	91.4125	109.475
J1	20.3	56.275	56.275	56.275	107.6625	125.35
J2	20.23	80.4	105.525	133.5875	168.825	168.825

When **α**=0.5 applying CDS heuristic it is observed that the sequence J4-J3-J1-J2 will have minimum make span and the total completion time is 168.825 seconds. The makespan from CDS heuristic is higher than Palmer's heuristic with same uncertain processing times of the jobs. For this the result given by the CDS heuristic is obsolete by the Palmer's heuristic. The minimized makespan given by this heuristic is as follows.

Table 8: Solution of CDS heuristic with J4-J3-J2-J1 when **α**=0.6

Job	M1	M2	M3	M4	M5	M6
J4	0	22.16	22.16	54.42	76.66	97.87
J3	10.25	32.41	44.52	54.42	91.88	110.01
J1	32.45	56.7	56.7	56.7	108.23	125.96
J2	32.45	80.9	106.15	134.325	169.69	169.69

Again when the value of the risk factor is being increased, the makspan by the CDS heuristic also be increased for the uncertain processing time of the jobs. When **α**=0.6, then the total completion time is 169.69 seconds which is shown in the above mentioned tableau.

NEH Heuristic

Step 1: Find the total work content for each job using Expression $T_j = \sum_{i=1}^{m} P_{ij}$

Step 2: Arrange the jobs in a work content list according to decreasing values of T_j

Step 3: Select first two jobs from the list and from two partial sequences by inter changing the place of two jobs. Compute C_{max} the value of partial sequences. Of the two sequences, discard the sequence having larger value of C_{max}, Call the lower value of C_{max} as incumbent sequence.

Step 4: Pick the next job and put in incumbent sequence. Calculate value of C_{max} of all sequences

Step 5: If there is no job left in work content list to be added to Incumbent sequence, Stop go to step 4.

Sequence analysis by NEH Heuristic:

1st Case: For processing times when **α**=0.5

Step 1: Taking J2 & J4

Sequences: J2-J4 &J4-J2 and makespan 155.7875 & 134.375 respectively

Step 2: Choosing J4-J2 & taking J1

Sequences: J4-J2-J1 & J4-J1-J2 & J1-J4-J2 and makespan 166.7, 158.925 & 180.95

Step 3: Choosing J4-J1-J2 & taking J3

Sequences: J4-J1-J2-J3 & J4-J1-J3-J2 & J4-J3-J1-J2 & J3-J4-J1-J2 and makespan 186.1125, 158.8, 168.975 & 168.975 seconds.

Table 9: Solution of NEH heuristic with J4-J1-J3-J2 when **α**=0.5

JOB	M1	M2	M3	M4	M5	M6
J4	0	22.025	22.025	54.15	76.2875	97.4125
J1	22.125	46.25	46.25	54.15	92.5375	113.2875
J3	32.3	46.25	58.275	58.275	107.6625	125.35
J2	32.3	70.375	95.5	123.5625	158.8	158.8

2nd Case: For processing times when **α**=0.6

Step 1: Taking J2 & J4

Sequences: J2-J4 &J4-J2 and makespan 156.44 & 135.15 respectively

Step 2: Choosing J4-J2 & taking J1

Sequences:J4-J2-J1 & J4-J1-J2 & J1-J4-J2 and makespan 167.45, 159.4 & 181.6

Step 3: Choosing J4-J1-J2 & taking J3

Sequences: J4-J1-J2-J3 & J4-J1-J3-J2 & J4-J3-J1-J2 & J3-J4-J1-J2 and makespan 186.76, 159.4, 169.9 & 169.9 seconds.

Table 10: Solution of NEH heuristic with J4-J1-J3-J2 when **α**=0.6

JOB	M1	M2	M3	M4	M5	M6
J4	0	22.16	22.16	54.42	76.66	97.87
J1	22.2	46.45	46.45	54.42	93.01	113.82
J3	32.45	46.45	58.56	58.56	108.23	125.96
J2	32.45	70.65	95.9	124.075	159.44	159.44

6. Result Analysis

We have applied four optimization tool to determine the optimal make span where Palmer's and CDS heuristic has given a very high completion time to get the final product though these are better than traditional scheduling of the industry. And finally we have gotten the same but better, comparing to Palmer's and CDS heuristic,

Table 11: Comparison among Matrix Manipulation in MATLAB, Palmer, CDS and NEH Heuristics

No. of observation	Technique	Optimal sequence	Make span (When α=0.5)	Make span (When α=0.6)
01	Matrix Manipulation in MATLAB	J4-J1-J3-J2	158.8	159.4
02	Palmer's Heuristic	J2-J3-J1-J4	166.7	167.45
03	CDS Heuristic	J4-J2-J2-J1	168.825	169.69
04	NEH Heuristic	J4-J1-J3-J2	158.8	159.44

results for matrix manipulation in MATLAB and NEH algorithm whereas NEH algorithm takes much time to find out the makespan. By applying any of them we can get our optimum make span though.

7. Conclusion

In this paper it has been proposed that matrix manipulation method in MATLAB to solve flow shop scheduling problems for minimizing make span. The problem up to 4 jobs and 6 machines under uncertain processing times have been considered for comparative analysis among our proposed matrix manipulation method in MATLAB and Palmer's heuristic, CDS heuristic & NEH heuristic. From the analysis, it has been found that our used matrix manipulation method in MATLAB and NEH heuristic show the minimum value of make span time when compared to other heuristics. But NEH and other heuristics take long time for the calculation and it will be very difficult to solve if the size of the problem is very large. In this regard our proposed matrix manipulation method in MATLAB is able to solve any problem of any size such as n jobs and m machines without any manual calculation and gives the output at a very short time. Moreover if you wish to see the completion time required for any of the sequences of very large size problem then our proposed system will help you must and very firstly. But it is not at all possible in NEH or other heuristic because of they do not find all the job sequences and their respective make span. In our MATLAB coding, you will just have to put the processing times for every jobs for corresponding machines .The work can be extended by making a comparison of the effectiveness of the coding for the proposed matrix manipulation method with other coding.

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An evaluation of failure modes and effect analysis for a battery manufacturing industry

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Abstract

Failure mode and effects analysis (FMEA) is one of the well-known analysis methods where the potential failure modes usually are known and the task is to analyze their effects on system behavior. This thesis paper aim to identifies and eliminate current and potential problems from assembly lines in a battery industry. Feasibility test using control chart aim to find out the error and process performance. This thesis provides work sheets for problems identification and guide lines for recommending corrective actions. This thesis paper also analyzes Risk Priority Number (RPN). The different types of information are very difficult to incorporate into the FMEA by the traditional risk priority number (RPN) model. In this thesis paper we present an FMEA using the evidential reasoning (ER) approach, a newly developed methodology for multiple attribute decision analysis. The proposed FMEA is then illustrated with an application to a fishing vessel. As is illustrated by the numerical example, the proposed FMEA can well capture FMEA team members' diversity opinions and prioritize failure modes under different types of uncertainties.

Keywords: Failure mode and effects analysis, evidential reasoning (ER) approach, risk priority number.

1. Introduction

In the present era, there has been tremendous pressure on manufacturing and service organizations to remain competitive and provide timely delivery of quality products. The managers and engineers have been forced to optimize the performance of all systems involved in their organizations. The deterioration and failure of these systems might incur high costs due to production losses and delays, unplanned intervention on the system and safety hazards. In order to avoid such situations, an appropriate maintenance policy strategy is necessary in order to repair or replace the deteriorated system before failure. Deciding on the best policy is not an easy matter, as the maintenance program must combine technical requirements with the management strategy. A good quality program must define maintenance strategies for different facilities. The failure mode of every component must be studied in order to assess the best maintenance solution, in accordance with its failure pattern, impact and cost on the whole system. The management of large number of tangible and intangible attributes that must be taken into account represents the complexity of the problem. Several techniques have been discussed in the literature for planning maintenance activities of industrial plants. The most commonly used technique to evaluate the maintenance significance of the items failure modes and categorizing these in several groups of risk is based on using Failure Mode Effect and Analysis FMEA. This methodology has been proposed in different possible variants, in terms of relevant criteria considered and/or risk priority number formulation. Using this approach, the selection of a maintenance policy is performed through the analysis of the obtained priority risk number. The FMEA discipline was originally developed in the United States Military. The generic nature of the method assisted the rapid broadening off MEA to different application areas and various practices fundamentally using the same analysis method were created. The rest of this paper is organized as follows; section 2 represents literature review, section 3 represents problem statement & methodology, Section 4 represents data collection and result analysis. Section five represents the discussion and conclusion and finally references are mentioned after the conclusion portion.

2. Literature Review

Procedures for conducting FMEA were described in US Armed Forces Military Procedures document MIL-P-1629(1949); revised in 1980 as MIL-STD-1629A). During the 1970s, use of FMEA and related techniques spread to other industries. The automotive industry began to use FMEA by the mid-1970s.Although initially developed by the military, FMEA methodology is now extensively used in a variety of industries including semiconductor processing, battery industry, food service, plastics, software, and healthcare. There is relatively little information published on the use of FMEA for battery manufacturing systems. Documenting and analyzing potential risks proactively are essential for improved patient safety. Accomplishing this goal requires an effective method to identify risks and an easily understood approach to manage risks [3]. In situ simulation occurs in a patient unit at the microsystem level and involves inter disciplinary teams and organizational processes. Unlike simulations that occur in a laboratory setting, in situ simulation is a strategy that takes place on a patient care unit [5]. The authors [9] proposed a method to combine multiple failure modes into a single one, which opens the possibility for us to analyze a system considering multiple failure modes at the same time. Unfortunately, although they proposed such method, the detailed procedure such as which multiple failures need to be combined was not given. This paper aims to develop a new FMEA method that enables us to combine multiple failure modes into single one, considering importance of failures and assessing their impact on system reliability. FMEA is a tool for identifying, analyzing and prioritizing failures. It is a design technique which systematically identifies and investigates potential system weakness. It consists of a methodology for examining all the ways in which a system failure can occur, potential effects of failure on system performance and safety, and all seriousness of these [12]. effects A safety system used to monitor a nuclear power plant may have a logic error that allows a failure to dampen an overloaded reactor to go undetected. Risk prioritization produces a ranked ordering of risk items that are identified and analyzed. [4] Collected and analyzed a number of key risk factor and their impact on the system. An error in a spacecraft program for controlling re-entry angle could cause skip-out and loss of mission. The authors [8] proposed that this study was carried out considering the specific processes implemented at CNAO, therefore, the detailed definition of failure modes and the assignment of RPN scores, strongly depend on the specific process under investigation and on the current strategies/solutions locally applied. However, the process and fault trees here delineated can be easily adapted by other users to their local scenario or, at least, be useful as a starting reference point, thus minimizing the workload impact of the FMEA analysis on the involved team. P. C. [11] proposed a method for FMEA generation for a generic application using minimum information during the conceptual design stage. Prototype software has been created for the proposed method. It has been evaluated using case studies from the design and manufacture of two way radios. The evaluation revealed the feasibility of the proposal, as well as some weaknesses that need further improvement. Generally, the capability of the method to generate FMEA report with minimum information is demonstrated. According to BS 5760 FMEA is a method of reliability analysis intended to identify failures, which have consequences affecting the functioning of a system within the limits of a given application, thus enabling priorities for action to be set. In the paper [1] draw attention a new technique based on modified FMECA along with TOPSIS is proposed to determine the Maintenance Criticality Index (MCI) and to over- come the limits of the conventional RPN, as cited above. This technique permits to take into consideration the several possible aspects concerning the maintenance selection problem (failure chances, detect-ability, etc.).

3. Problem statement

In case of process improvement, at first one should know about the process whether the existing process is capable or not. Incapable process produces large number of defective items. In these case manufacturers should justify the process capabilities. In Rahimafrooz Globatt Ltd. the production of defective items in different stages of assembles line is well enough. But the failure in Open circuit voltage is serious. If this failure is occurred there is no way to rework except scrap. So this paper concentrates on the reasons of OCV failures and develops worksheet for individual reasons of failure. RPN is also important for ranking of seriousness of those failures. The objectives of this thesis work are (i) Find out the failure rate. (ii) Find out the failure reason. (iii) Proposed corrective action.

3.1 Methodology

- Statistical data collection methods for checking the quality percentage of errors and determining Process Capacity Ratio (PCR) of the process. Production process flow and Standard operation procedure is reviewed. We collect data from production engineer and Quality Assurance department of Rahimafrooz Globatt Limited.
- Identify potential design and process related failure modes. Ideally, the process is changed to remove potential problems in the early stages of development.
- Find the effects of the failure modes for each failure on system operation.
- Find the root causes of the failure modes. Barkai (1999) stated that an FMEA is designed to find the sources of the failures of a system.

- Identify, implement, and document the recommended actions. Pries noted that FMEA documents should be under formal document control. Kennedy stated that the recommended actions are to address failure modes with rankings that are considered unacceptable.

4. Data Collection and Results analysis

4.1 Control Chart: X bar R chart

From a day's a production, a sample of 4 batteries is selected randomly from the production line and their voltage are recorded. The average voltage of this sample are computed and recorder in a table. We collected this data in 20 days in the month of December. Thus, X bar and R values of 20 samples are recorded in the table.

Table 4.1: Voltages of battery in volt from four observations

SL	Voltages of battery for four observations				$\bar{X}$	R
	i	ii	iii	iv		
1	12.63	12.55	12.59	12.60	12.59	0.08
2	12.63	12.66	12.67	12.64	12.65	0.04
3	12.69	12.65	12.63	12.58	12.64	0.11
4	12.58	12.54	12.67	12.69	12.62	0.15
5	12.70	12.64	12.69	12.60	12.66	0.10
6	12.63	12.66	12.67	12.64	12.65	0.04
7	12.55	12.56	12.60	12.56	12.57	0.05
8	12.69	12.64	12.65	12.69	12.67	0.05
9	12.69	12.62	12.63	12.58	12.63	0.11
10	12.67	12.60	12.73	12.60	12.65	0.13
11	12.70	12.64	12.69	12.63	12.67	0.07
12	12.68	12.61	12.63	12.69	12.65	0.08
13	12.62	12.69	12.69	12.62	12.66	0.07
14	12.68	12.63	12.60	12.69	12.65	0.09
15	12.59	12.57	12.68	12.69	12.63	0.12
16	12.73	12.78	11.50	12.51	12.38	1.28
17	12.65	12.68	12.70	12.63	12.67	0.07
18	12.51	12.65	12.68	12.69	12.63	0.18
19	12.63	12.66	12.67	12.58	12.64	0.09
20	12.60	12.66	12.56	12.65	12.62	0.10
Average					12.63	0.151

4.1.1 R Chart development:

First, the R chart is developed.

$$\bar{R} = \frac{\sum_{i=1}^{m} R_i}{m} = \frac{3.02}{20} = 0.151$$

For samples of size n=4, from appendix: D_3=0&D_4=2.282

We know, the control limits Range (R) chart are found

$UCL_R = \bar{R} D_4$ = (0.151) * (2.282) = 0.343 $CL_R = \bar{R}$ = 0.151 LCL_R = (0.151) * (0) = 0

Hence, the R chart is constructed as below.

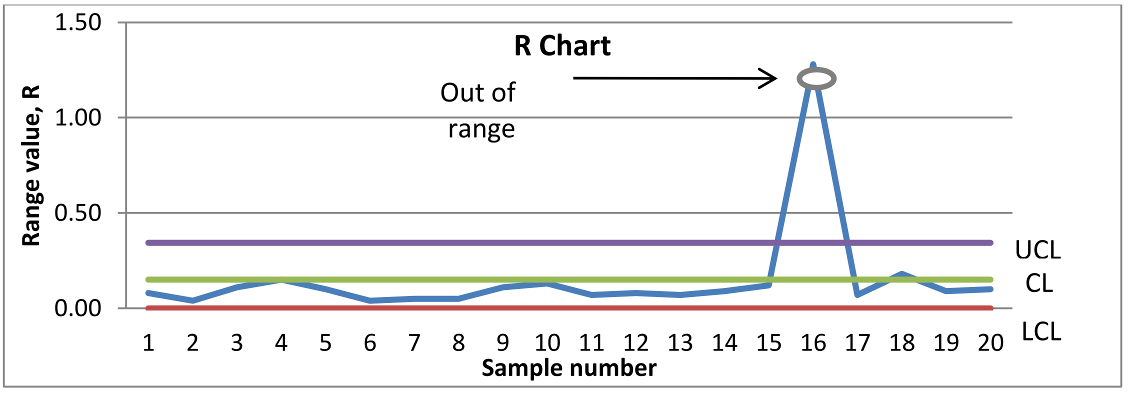


Fig 1: the R chart

We observed that one of the sample values go outside of the limits. They are not pretty random around the mean as well. Thus, the range chart can be considered as "out of control".

4.1.2 $\overline{X}$ Chart development

The $\overline{X}$ chart is constructed below

$\overline{\overline{X}} = \frac{\sum_{i=1}^{20}\overline{X}}{20} = \frac{\sum_{i=1}^{20}252.5}{20}$ =12.625

For samples size n=4 then form appendix Table D, A_2=0.729

$UCL_X = \overline{\overline{X}} + A_2\overline{R}$ = 12.625+ (0.729)*(0.151) = 12.735 $CL_X = \overline{R}$ = 12.625

$LCL_X = \overline{\overline{X}} - A_2\overline{R}$ = 12.625- (0.729)*(0.151) = 12.516

Sample standard deviation:

$\widehat{\sigma} = \frac{\overline{R}}{d_2} = \frac{0.151}{2.059}$ =0.073

Suppose that the stated speciation limits are: 12.50 V and 10.78 V, the centre line or the mean of the process has been found equal to 12.625.

Probability of the Voltages greater than the USL and less than LSL

P(X>USL) =1 - $\varphi\left[\frac{12.78-12.625}{.073}\right]$ =1 – φ (2.123) = 1-0.9831 = 0.0168= 1.68% & P(X<LSL) = 4.34%

Process Capability Ratio (PCR) is

PCR =$\frac{USL-LSL}{6\sigma} = \frac{12.78-12.50}{6*0.073}$ =0.639 < 1

This shows that the PCR value is less than 1, which indicates that a large number of products are nonconforming.

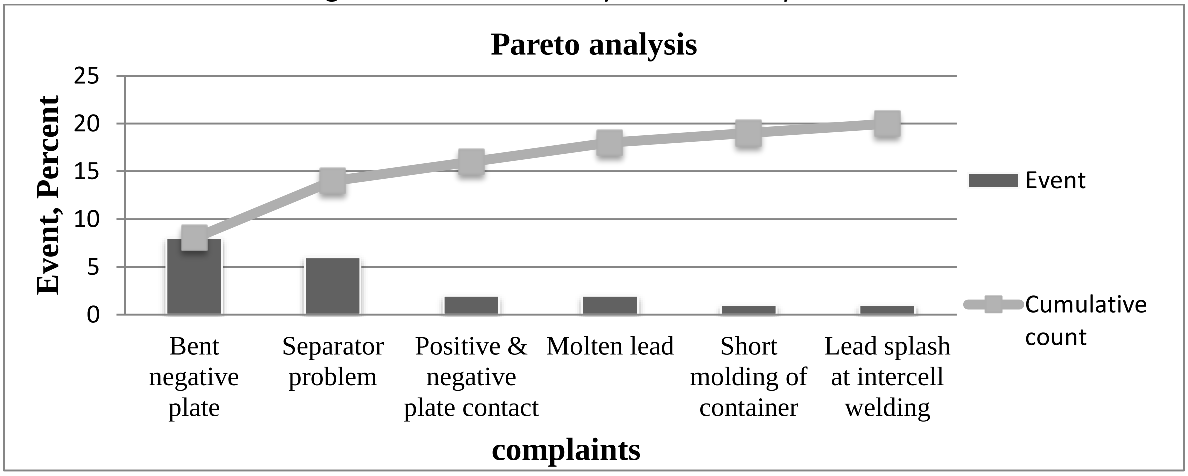
4.2 Pareto analysis for OCV failure

Table 4.2.1: Cumulative sum for various complaints

S. No.	Complaints	Event	Cumulative count	Percentage
1	Bent negative plate	8	8	40
2	Separator problem	6	14	30
3	Positive & negative plate contact	2	16	10
4	Molten lead	2	18	10
5	Short molding of container	1	19	5
6	Lead splash at inter cell welding	1	20	5
	Total	20		100

4.2.2 Graphical view:

Fig 4.2.2.1: Pareto analysis for battery defect



4.3 Worksheet for failure

Sub system name: OCV test, Model year: 2013

P=probability of occurrence, S=seriousness of failure

D=likelihood the defect will reach the customer, RPN= risk priority number

4.3.1 FMEA worksheet for OCV failure:

Table 4. 3.1: Function of OCV tester

SL	Part Name	Function	Failure Mode	Mechanism & cause of failure	Effect of Failure	Current controller	RPN	Recommended corrective action	Action taken
1	OCV tester	Check the open circuit voltage	Low output voltage	Less charging time & parameter Inter cell	The battery is scraped	Refill acid level then charging properly	40	Replace the wire check the charging	Wire changed Regularly inspect

4.3.1.1 FMEA worksheet for Negative plate bending:

Table 4. 3.1.1: Function of Negative plate bending

SL	Part Name	Function	Failure Mode	Mechanism & cause of failure	Effect of Failure	Current controller	RPN	Recommended corrective action	Action taken
1	Negative plate bending	Drop 2.1 voltage	Low output voltage	Thin grid than specification Low pasting	The battery is scraped	N/A	42	Maintain specific thickness Carefully insert cell	Improve grid casting m/c performance Train up labor

4.4 Potential failure cause with RPN for 20 defects Battery

For different potential failure the value of probability severity and detection are given bellow.

Table 4.4.1: Calculation of Risk Priority

Failure no.	Potential failure cause	Frequency	Probability (p)	Severity (S)	Detection (D)	RPN
1	Bent negative plate	8	7	3	2	42
2	Separator problem	6	6	3	3	36
3	Positive & negative plate contact	2	4	5	2	40
4	Molten lead	2	4	2	2	16
5	Short molding of container	1	3	5	2	30
6	Lead splash at inter cell welding	1	3	4	1	12

From the Table 4.4.1 it can be concluded that failure (1and 3) i.e. Bent negative plate and Positive & negative plate contact failures are of high risk, is catastrophic failure. The failures (2 and 5) i.e. Separator problem and Short molding of container failure, are classified as critical. The failures (4 and 6) i.e. Molten lead and Lead splash at inter cell welding failure are categorized as marginal failures. According to Table 4.4.1 Bent Negative plate failures and Positive & negative plate must be inspected when the failure occurs again and again.

5 Discussions and Conclusion

5.1 Discussion

By calculation the process capability Ration (PCR) is 0.639. This shows that the PCR value is less than 1, which indicates that the process is inappropriate. So the process is not good at all. This is due to a few products were taken as a sample. This paper finds out the products nonconforming or failures area to develop a worksheet or document to reduce products failure and smooth assemble line. FMEA worksheet is our main work which is very effective to increase product Quality and Productivity. Most of the machines are software based and automated so the implementation of recommended corrective action is hard enough.

5.2 Conclusion

EMEA is a team-oriented development tool used to analyze and evaluate potential failure modes and their causes in manufacturing process. It prioritizes potential failures according to their risk and drives actions to eliminate or reduce their likelihood of occurrence. FMEA provides a methodology for documenting this analysis for future use and continuous process improvement. It is structured approach to the analysis, definition, estimation and evolution of risks. This study shows that in battery production the process of manufacturing is very important which demonstrate the OCV (Open Circuit Voltage) failures. This paper checks the process capability and prioritizes reasons of failures using pareto analysis. This study tries to develop a FMEA documentation/worksheet for taking future action. This paper also calculated RPN for failure causes. The data was collected only from Rahimafrooz Globatt Ltd. Therefore, many possible future research works can be defined in this context. For example it is better to involve customers and suppliers in the preparation of FMEA. Involvment of customers and suppliers is a recommended part of TQM and FMEA for a battery industries is more cost effective at the earlier stage of design than at later stage when a design is almost at the final one.

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Statistical Process Control (SPC) Tools for Minimizing the Moulding Defects in Spun Pre-stressed Concrete Electric Pole Production

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Abstract

Statistical process control tools are used to monitor production process over time to detect changes and to decrease mistakes for better capture and conversion of customer's needs. The aim of this paper is to identify and minimize various types of defects in spun pre-stressed concrete pole manufacturing. SPC tools like check sheet, histogram, Pareto chart, process flow chart, cause-effect diagram, control chart (p-chart and np-chart) are used and it is found that the thickness uniformity problem is the vital few problem and responsible for 90% of the total results of the problems. Operating characteristics curve is drawn to find out type-I error and type-II error. It is found that the average run length is 319 when the process is in control. Finally, the major causes of nonconformities of the quality problem are specified and possible remedies are proposed.

Keywords: Check Sheet, Histogram, Pareto Chart, Cause-Effect Diagram, Operating Characteristics Curve.

1. Introduction

Statistical process control tools are basic quantitative techniques for total quality management (TQM) and have widely been used to monitor process performance and to detect abnormal situations of the process behavior. The role of statistical process control (SPC) is to make a process stable by reducing process variability [1]. TQM tools are check sheet, Pareto chart, process flow chart, stratification analysis, scatter diagram, histogram, cause-effect diagram and control charts. Enormous steel rod manufacturing companies and some other manufacturing companies are using various methods to optimize their production and process failures. Paul and Azeem [2] used Pareto chart and cause-effect analysis for identifying and analyzing the defects of a pharmaceutical product. Joshi and Kadam [3] have also used Pareto chart and cause-effect analysis in manual casting process to know correct cause and remedial factors in order to increase productivity and to improve customer satisfaction. Sultana, Razive and Azeem [4] used statistical process control tools to increase total output and for identifying major loss times from various machine breakdowns using hourly data system. Mohana Rao et al. [5] used univariate control chart for monitoring hot metal making process in a blast furnace of a steel industry for continuous quality improvement. They also concluded that large number of process parameters combined with lower penetration of manufacturing automation and shortage of skilled workers are the main causes for which foundry industry suffers from poor quality and productivity. Kumar, Mantha and Kumar [6] analyzed the reasons for increasing scrap in manufacturing industries by using quality management tools. Fouad and Mukattash [7] used statistical process control tools in order to identify the major and root causes of quality problem and possible remedies of them. Applying the tools they have found that the steel tensile strength is the vital few problem and account for 72% of the total results of the problems. Raghavendra et al. [8] used statistical process control technique on liners manufacturing industry that improve process capabilities by reducing rejection rate from 6.52% to 4.62%. Cause effect diagrams, design of experiments, if-then rules (expert systems) and artificial neural networks are used to identify, analyze and rectify casting defects by Mane, Sata and Khire [9]. A comparison of the univariate out-of-control signals with the multivariate out-of-control signals was done by El-Din, Rashed and El-Khabeery [10]. They conduct a case study on steel making where average run length was used to analyze performance for charting method. Samanta and Bhattacherjee [11] used Shewart control chart in order to analyze quality characteristics for mining applications. Statistical process control tools may be used in any industry and service center in order to find out the main causes and sub-causes of any problem of the system. In this paper, statistical process control tools are used in spun pre-stressed concrete (SPC) pole manufacturing industry for identifying and minimizing defects and finally some remedies are proposed to increase productivity and customer satisfaction.

2. Methodology

At first, process flow chart is used to examine various processes for the production of SPC electric pole. A check sheet is used to record data of various types of defects for further processing. A histogram is used that represents the frequencies of defects by classes of data that helps to access the current production situation. Then Pareto chart is used to rank the causes from most significant to least significant. To broken down the main causes to sub-causes; cause-effect diagram is used where the causes are broken down into the main categories of man, machine, material, method, management and environment. To monitor the proportion of nonconforming in a sample p-chart is used and np-chart is used to monitor the number of nonconforming units in a sample. Then the operating characteristic (OC) curve has drawn for displaying and investigating probability of accepting the lot with fraction of nonconforming. Finally, recommendations are given based on the findings.

3. Analysis

To examine potential sources of moulding defects of spun pre-stress concrete pole production and to identify steps for improving, process flow chart is done.

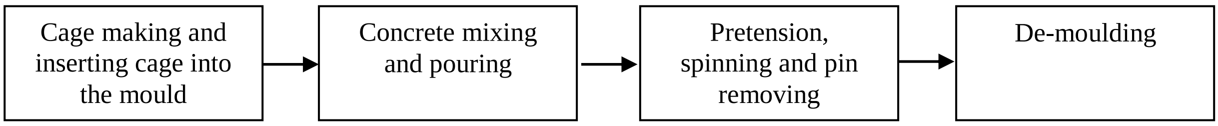

Fig. 1. Process flow chart for spun pre-stressed concrete production

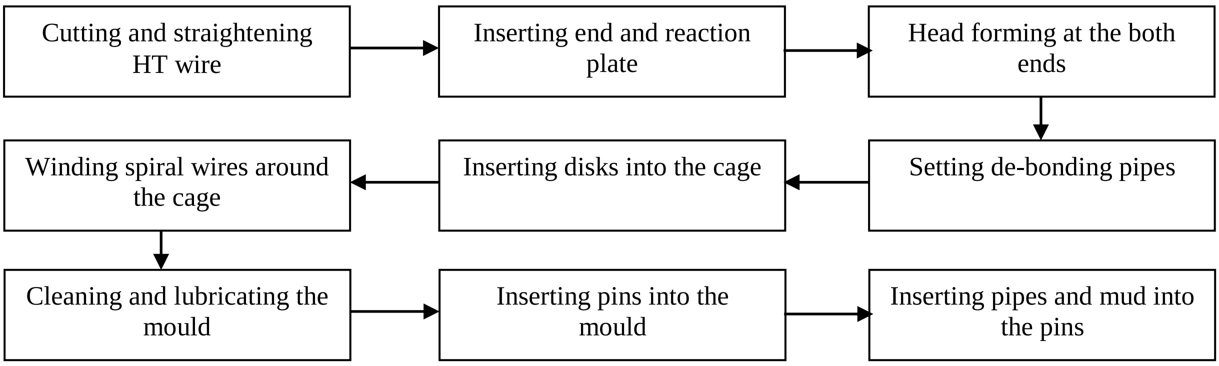

Fig. 2. Process flow chart of cage making and inserting the cage into the mould

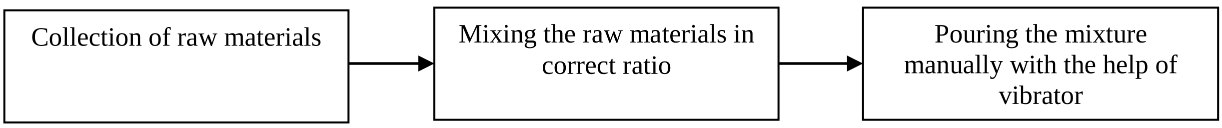

Fig. 3. Process flow chart of concrete mixing and pouring the mixture into the mould

Fig. 4. Process flow chart of pretension, spinning and pin removing

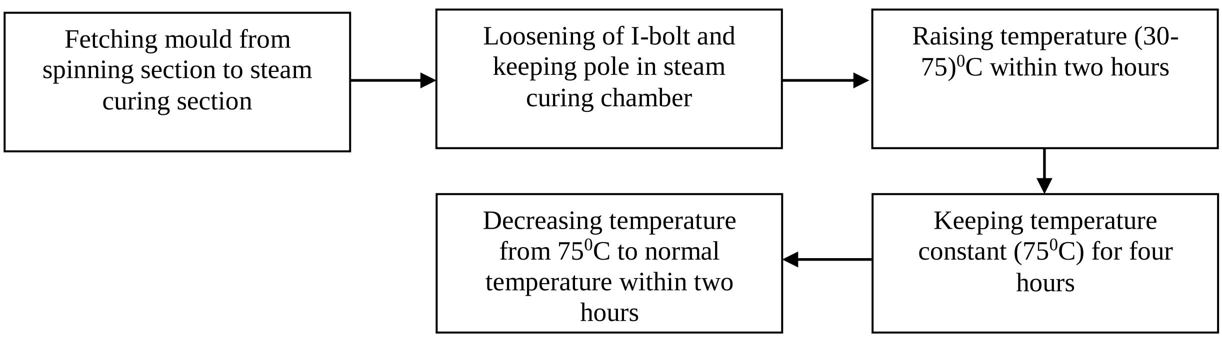

Fig. 5. Process flow chart of de-moulding

After analyzing the process, check sheet is used to collect and organized data of moulding defects. The check sheet, also called a ‘defect concentration diagram’, is a simple tool used to record data for further processing.

Table 1. Check sheet for various defects of spun pre-stressed concrete poll production

Type of defects	Talley	Frequency	Frequency (%)	Cumulative frequency (%)
Thickness problem	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 ll	72	90.00	90.00
Honey comb problem	卌	5	6.25	96.25
Collar distance problem	ll	2	2.50	98.75
Minor crack at the top	l	1	1.25	100
Total		80	100	

Histogram determines the statistical nature of the collected data sets and the frequency distribution shows how often each different value in a set of data occurs. Fig. 6. Shows the histogram of the defects found in moulding of SPC pole production. The Pareto chart ranks the causes from most significant to least significant. It depicts a series of vertical bars lined up in a descending order– from high to low– to reflect frequency, importance or priority. In Pareto chart the number indicated sequentially as: (i) thickness uniformity problem, (ii) honey comb problem, (iii) collar distance problem and (iv) minor crack at the top. It is seen that the thickness uniformity problem is the vital few and responsible for 90% of total defects.

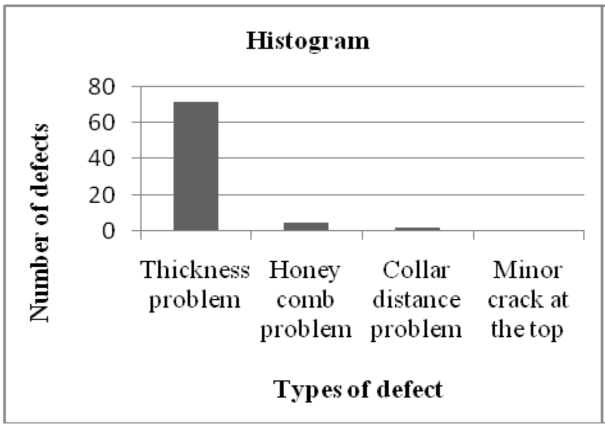

Fig. 6. Histogram for various defects of spun pre-stressed concrete poll production

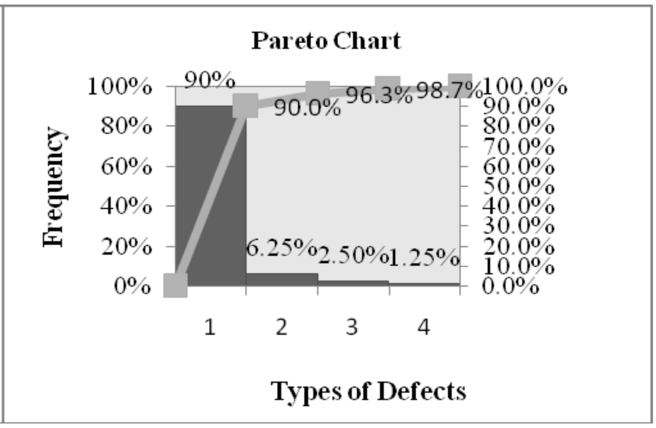

Fig. 7. Pareto chart for various defects of spun pre-stressed concrete poll production

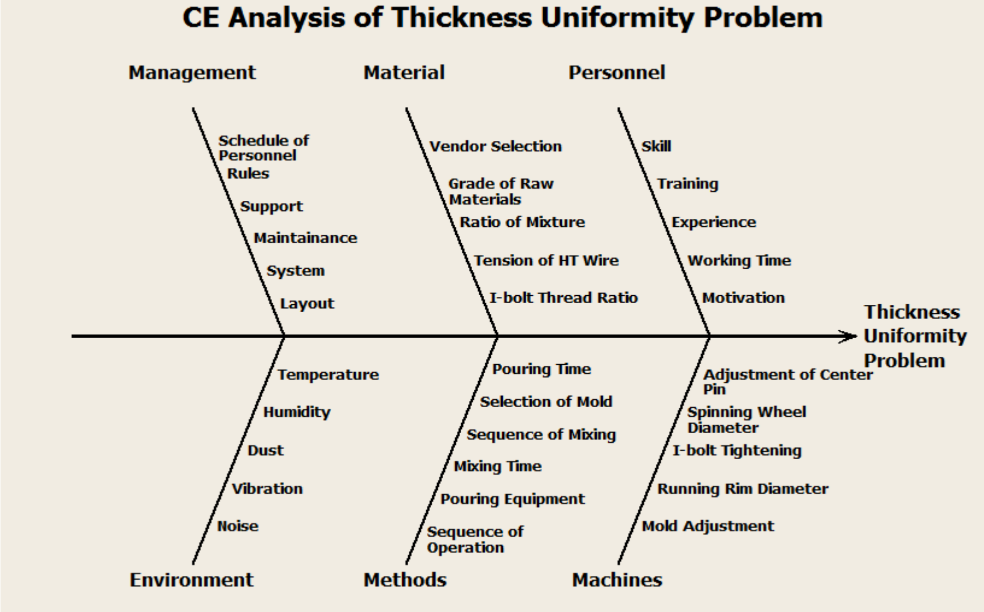

Figure 8: Cause-effect diagram for thickness uniformity problem

Since, the thickness uniformity problem is the major problem; therefore, the cause-effect diagram is used to identify possible causes for thickness uniformity problem by broken down the main causes into sub-causes. It is also known as 'fishbone diagram' which combines brainstorming that helps to consider all possible causes of thickness uniformity problem for spun pre-stressed concrete electric pole production. Control chart have used to monitor quality and to see how the process chances over time.

p-chart for fraction non-conforming of average sample size

d = Non-conforming (defective) poles, n = average sample size =180 and m = number of periods =27

$\bar{p}=\frac{\sum_{i=1}^{m} p_i}{m}$ = 0.0105

Therefore, Control limit,CL = $\bar{p}$ =.0105

Upper control limit, UCL = $\bar{p} + z_{\alpha/2}\sqrt{\{\bar{p}(1-\bar{p})/n\}}$ and Lower control limit, LCL =$\bar{p} - z_{\alpha/2}\sqrt{\{\bar{p}(1-\bar{p})/n\}}$

For 3σ quality, $z_{\alpha/2}$= 3

Here, UCL = 0.0333 and LCL = - 0.0115. As the fraction non-conforming can't be negative. So, LCL = 0

np-chart for fraction non-conforming of average sample size

UCL_{np} = np +3$\sqrt{\{np(1-p)\}}$ = 5.99, CL_{np}= np = 1.89, LCL_{np}= np - 3$\sqrt{\{np(1-p)\}}$ = -2.2.

As the fraction non-conforming can't be negative. ∴ LCL = 0

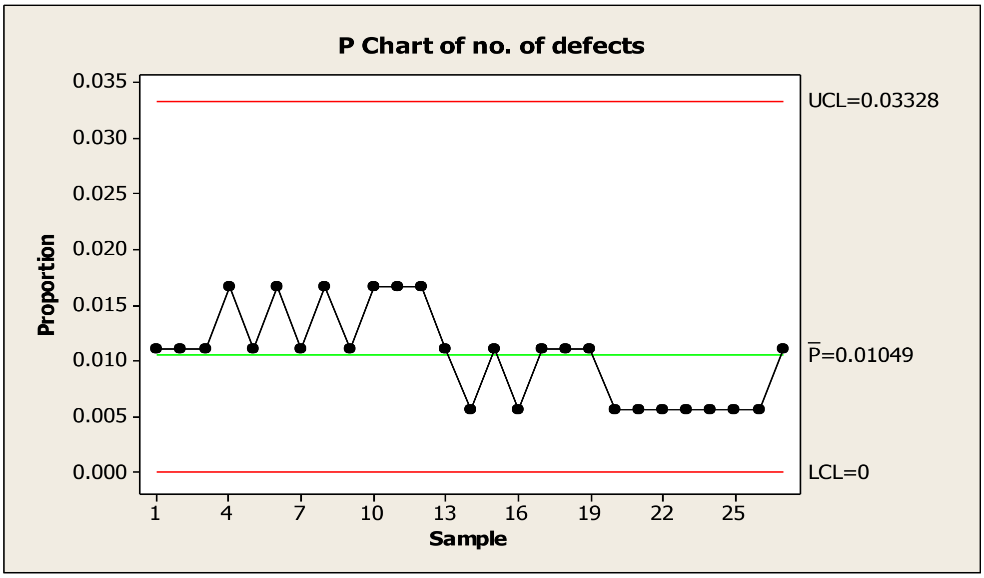

Fig. 9. p-chart for average Sample Size

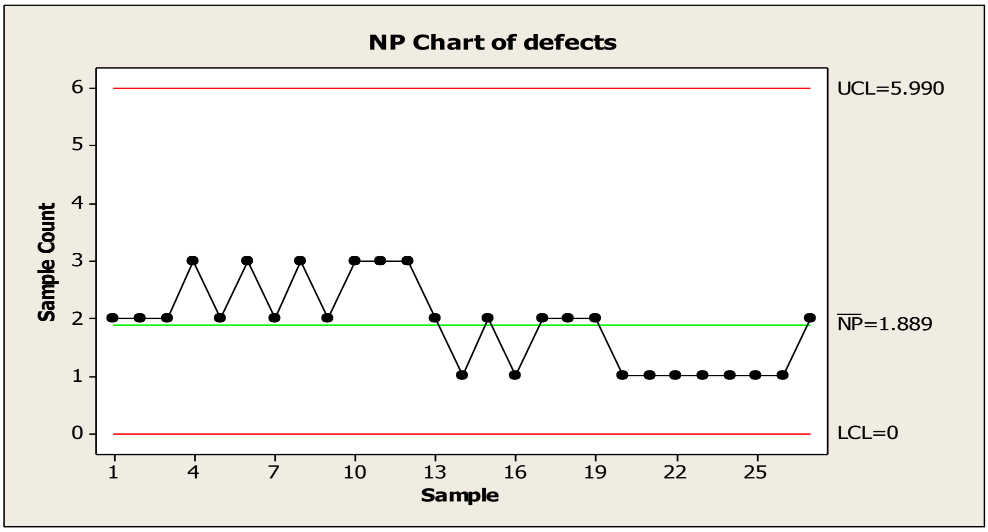

Fig. 10. np-chart for average Sample Size

The control chart shows that the process is in control. Therefore, operating characteristics curve has used to investigate the probability of accepting the lot with fraction of nonconforming.

The Operating Characteristics Function and Average Run Length

Let, α = Type-I error = Producer's risk, and, β = Type-II error = Customer's risk.

$\beta = P(D < n.UCL) - P(D \leq n.LCL)$

Here, UCL = 0.03310, $\bar{p}$ = 0.01044 and LCL = 0.

$\beta = P(D<181*0.03310) - P(D\leq 0*0.3310) = P(D<6) - P(D\leq 0) = 0.996$

$\alpha = 1 - \beta = 1 - 0.996 = 0.004$

If we vary the value of $\bar{p}$,then the value of β also changes which is shown below:

Table 2: Sensitivity analysis of β

$\bar{p}$	P(D<6)	P(D≤ 0)	β=P(D<6)− P(D≤ 0)
0.005	0.999	0	0.999
0.010	0.997	0	0.997
0.01044	0.996	0	0.996
0.015	0.979	0	0.979
0.020	0.927	0	0.927
0.025	0.830	0	0.830
0.030	0.698	0	0.698
0.035	0.552	0	0.552
0.040	0.411	0	0.411
0.045	0.290	0	0.290
0.050	0.195	0	0.195
0.055	0.125	0	0.125
0.060	0.078	0	0.078

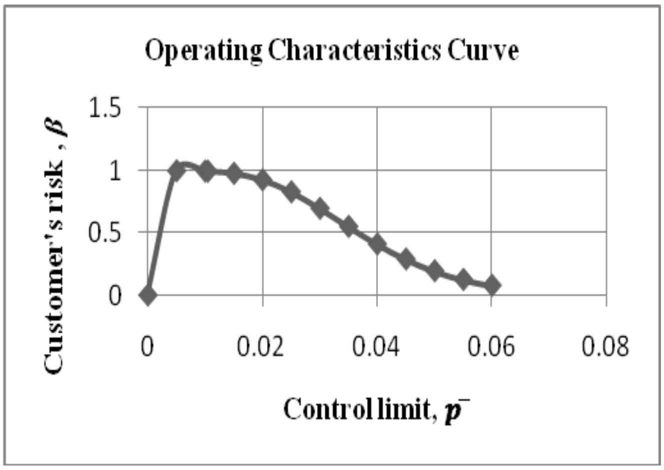

Fig. 11. Operating characteristics curve

ARL = $\frac{1}{\alpha}$, as the process is in control. Thus ARL is 319. This indicates that we have to take the sample size as large as 319 to detect a non-conforming product when process is in control.

4. Discussion and Recommendation

We have recognized that the main cause of quality problem is thickness uniformity problem. So, here are some remedies of this problem:

1. Changing the design or one of the designing parameters of the mould, such that introducing an extra sheet metal section in the joining sections of the mould or changing the edge parts of the mould for leakage control of concrete mixture into the mould during spinning may minimize the defects. This research proposes a new edge design of the mould.

Figure 12: Existing mould

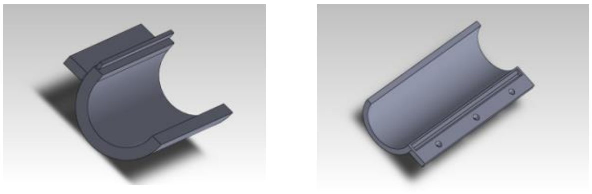

Figure 13: Proposed design mould

2. Check center pins and tightening the bolt before starting the operation of molding.
3. Optimize the r.p.m. of existing spinning machine.
4. Create groups for Fixed Area Network (GFAN) to minimize problems of scheduling and inter-relationship between the quality control team, junior engineers and workers.
5. The diameter of the spinning machine and the mould should check regularly to ensure the peripheral uniformity of both mould and spinner to avoid the mould hammering.
6. Check the wet of the raw materials before stating the production and keep checking the wet after a certain interval as the quality largely depends on the raw materials.
7. Change the metals used for manufacturing the mould. Metals of light weight and of high tensile and compressive strength should be chosen for manufacturing the mould.
8. Improved I-bolts should be attached with the mould for tightening the mould properly. Moreover, existing I-bolts should be re-grinded regularly for effective use of the threads of the bolt.

5. Conclusions

Statistical process control tools detect the major problems for manufacturing spun pre-stress concrete poles. The thickness uniformity problem is the major problem and it should be minimized at first. Operating characteristics curve and calculations of type-I error and type-II error helps to identify customer and consumer risks. The average run length is 319 for this in control process. This research and proposed recommendations is helpful for any spun pre-stressed concrete electric pole production company to minimize the problems and to increase productivity and customer satisfaction.

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CONSTRUCTING A VIRTUAL FACTORY USING 3D STUDIO MAX

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Abstract

The interactive visualization of 3D objects has revolutionized such fields as engineering, medicine, entertainment and education. In fact there are a broad range of applications which are used to give virtual world more realistic detail. It is important to design a layout of any factory before physical construction which gives us the ideas about the machine set up, production process, material handling and inventory management of that factory. To consider design alternatives creation of a 3D virtual factory using 3D modeling software and animation based simulation system can provide a fast, effective method of visualizing and experiencing new designs which can be easily modified. In this paper the construction and visualization of a 3D factory of flanges has been described. 3D Studio Max software has been used for this purpose. The objective of the research paper is to create a 3D factory showing a general layout of a flange factory and providing basic concept on the building techniques of 3D virtual world for the new students and trainee. Conversion process of a 3D studio virtual model to an AutoCAD model and Conversion process of an AutoCAD model, applications of factory planning and advantages of virtual reality have also been described in the paper.

Key words: Factory, Modeling, Software, Visualization and Manufacturing.

1. Introduction

Making virtual environment or virtual reality is modern technology to realize the condition of actual model or any future model. A 3D factory as a well-designed and integrated environment is essential for success applications of new technology. In this paper the construction and visualization of a factory of flanges has been described. It is expected that this method is very much useful for construction of a factory and helps to manage diverse information and re-use 3D models. At the design stage of a production system at a factory, designer can evaluate the feasibility design environment, detect the factory and it can be used for factory management. The development of virtual engineering factory is expected to be valuable by means of a 3-dimentional modeling system and animation based simulation package by taking into account the real data of a factory. A 3D model of a factory has been modeled by using 3D Studio Max software. Participant can navigate through virtual factory and examine the virtual factory from different points. Thus 3D modeling and animation based simulation technique provides a fast, effective method of visualizing and experiencing new designs which can be easily modified. Designer can design and see different types of layout of factory before making final decision to choose the best one. The animations of different machines may also successfully be done.

Virtual reality (VR) started from an unknown science and progressed into a highly exclusive, yet known science. The technology was born from the merging of many disciplines including psychology, cybernetics, computer graphics, database design, electronics, robotics and telepresence. Any representation that emulates reality (i.e. a drawing, a photograph, a movie, an audio recording) is, in a sense, a virtual reality. The term Virtual Reality (VR) is used by different people with many meanings. Virtual Reality (VR) is the computer aided simulation of a 3D model that one can interact with in order to get a better sense of object [2]. Virtual reality can also be defined as a synthetic computer generated (and hence virtual) environment within which a person can navigate and interact with the virtual objects as the person would in the real world (reality) [2].

2. Literature Review

Virtual environments are made up of 3D graphical images that are generated with the intention between the user and the objects in that environment. The term virtual environment (VE) describes a computer-based generation of an intuitive perceivable and experience able scene of a natural or abstract environment [2]. VE application will contribute to enhancing the qualities of human-computer interaction, the importance of which, in view of increasing complex information and communication applications, is constantly rising. Several types of problems can be solved with better visualization support, e.g. issues concerning workshop-layout, production flow, workplace design, etc. Users will get better perspectives if 3D models are used in the planning process instead of traditional 2D models [1]. There are several additional benefits from using detailed visualization in those virtual models. E.g. increase in planning speed, decrease in planning costs, and increase in planning quality are some of the benefits that have been discussed.

Virtual reality originated in 1960's, the person accredited with pioneering the concept of VR is Dr. Ivan Sutherland, who made ground breaking contribution to the computer graphics and immersive interaction at Harvard and University of Utah [3]. He showed that, a person with the aid a light pen could interact with the computer via a display surface. Engineering based applications within all areas of academic, commercial and industrial life are increasing. It is generally acknowledged that most of the growth in the VR industry has been due to the demands for VR in the entertainment sector. In the 1917's, Hollywood started to realize the power of VR in the film industry due to its potential to create extra ordinary visual scenarios. Films such as 'Star Wars', followed by 'Terminator' and 'Jurassic Park' are just some of the films that benefited immensely from VR and computer graphics. Recently Pentagon has conducted a Virtual Nuclear War Game to predict its consequence. 3D digital models can be freely constructed in this virtual environment [4]. From a great deal of digital modeling research in color, material, lighting by Sasada [5], Liu[6] and etc., it can be realize that the simulation is nearly real. This not only enables to receive more feedbacks in the designing process, but also helps non-professionals to fully understand the designing content.

N. Shariatzadeh, G. Sivard, D. Chen I in their paper titled "Software Evaluation Criteria for Rapid Factory Layout Planning Design and Simulation" described the functionalities of software tools which can support the factory layout design process to shorten design time and to identify errors in early stages of design [7]. Tullio Tolio, Marco Sacco, Walter Terkaj, Marcello Urgo in their research paper titled "Virtual Factory: an Integrated Framework for Manufacturing Systems Design and Analysis" addresses the concept of a integrated Factory Design framework providing the capacity of using different and heterogeneous analysis and design tools on the same manufacturing system model in a concurrent and coherent way. This framework is highlighted s a prerequisite condition to tack the co-evolution problem, i.e the integrated management of product, process and production system and their evolution over the time [8]. Sangsu and Sang Do Noh in their study tried to describe the virtual factory implementation strategy (method) of manufacturing companies and the method of diagnosing/evaluating the virtual factory establishment level of a manufacturing company. In addition, a case study of a manufacturing company in Korea was analyzed using the developed diagnosis/evaluation method [9].
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3. Construction of a 3 Dimensional Factory

A factory is integrated infra-structure for digital manufacturing including CAD, 3ds Max and simulation models of machines, equipment, work cells, lines and plants. Fig.1 has shown a general procedure to construct a factory. It takes much time, cost and resources, so effective action plans and objectives are essential. To construct a factory in CAD, 3ds Max and simulation model must be implemented. Both modeling works need considerable time, cost and efforts. So technologies developments for an effective measuring and geometric modeling, a knowledge based CAD, 3ds Max and simulation and reuse models are essential. In addition to this technologies, systematic planning, determinations of detailed scopes and model maintenance are also very important.

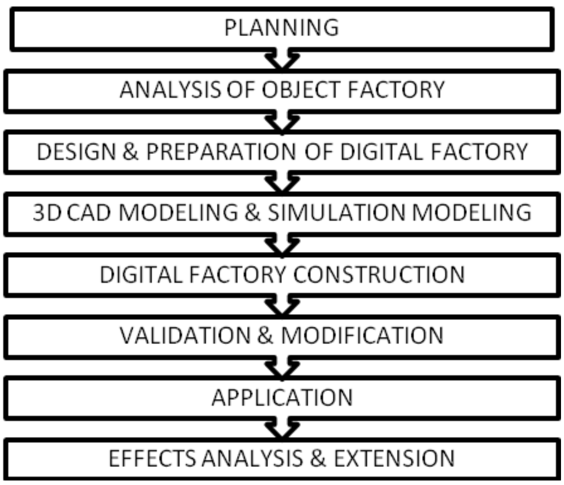

Figure 1: Procedure to construct a 3D factory.

Areas and effects of manufacturing for flange factories are as below:
Environments for 3D engineering design, Design and operation of a factory, Validation and evaluation of products and processes, Line simulations, inspections and quality managements, Visualization of products, processes and resources.

Geometric Modeling

3D geometry modeling CAD system such as AutoCAD is widely used in engineering design. AutoCAD is very suitable as a graphics editor for geometric modeling, especially for 3D geometric modeling. Although AutoCAD is powerful for geometry modeling, it can't be used as the tool for complex system motion verification. AutoCAD do not have the dynamic simulation capabilities. AutoCAD provides some primary 3D objects, such as box, cone, wedge ball etc., which are often used in 3D modeling. In order to create a realistic virtual model of the studio as a 3DS file .Similarly virtual model for modification, the virtual model was imported into AutoCAD as a DXF (Data Interchange Format) file. A DXF file is an ASCH (American Standard Code for Information Interchange) coded file, of an AutoCAD drawing for importing and exporting to and from other software packages [3]. Fig 2 illustrates the process of converting a realistic AutoCAD model into 3D Studio virtual model.

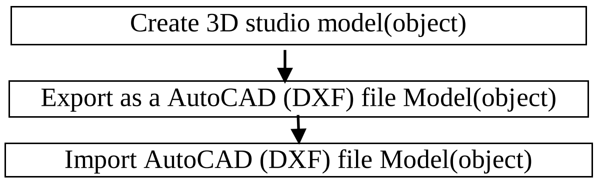

Figure 2(a): Conversion process of a 3D studio virtual model to an AutoCAD model.

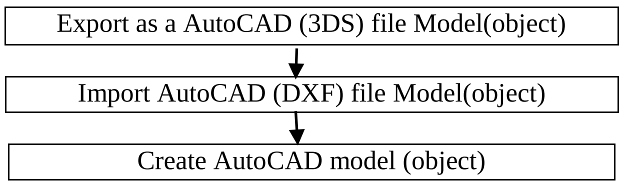

Figure 2(b): Conversion process of an AutoCAD model.

Application of Virtual Engineering Factory Planning

The typical applications of virtual factory planning are:

i. Planning and verification of machine setup.
ii. Determination of production sequence of factory machines.
iii. Analysis of different alternatives of layout of the factory.
iv. Planning and verification of material logistics.
v. Agile planning.

Advantages of Virtual Factory Planning

The typical advantages of virtual factory planning are as follows:

a. More precise planning results compared to conventional tools.
b. Exchange of knowledge among different experts in the planning team.
c. Taking into account various influential factor such as workplace safety, accessibility and production tools.
d. Reduction of planning time and errors.
e. Planning results can be used for the purpose of training and education.
f. Documentation of company know-how.
g. Planning results can be used for the purpose of training and education.

4. Requirements for 3D Factory Modeling

In order to build the virtual factory, which is similar to a real factory, there might be many requirements in modeling the elements of manufacturing system. Among a number of requirements, the authors emphasize that the following three ones are most important to develop a modeling system for virtual factories [10]: **Visualization**: The most important requisite is that a virtual factory should be visualized with reality. With good visualization, one can easily and observes how each system elements work in the manufacturing systems. **Detailed descriptions**: Each elements needs its detailed description, not only for its visualization, but also for calculating a number of its attributes for example when you want to put a work piece into a box, you have to know the shapes and dimensions of the work piece and the box in order to check whether the box can contain the work piece or not. **Flexibility**: The modeling system should present a flexible way of modifying a virtual factory in order to cope with the change of machines, layout and other facilities. Any facility to create computer-generated models of virtual objects and environments that can be interactively explored in 3D and modified and recreated in offers enormous potential for concurrent engineering and for integration of manufacturing activities generally [11]. The designer would be able to quickly visualize the product concept and represent alternative design solution.
The basic requirement for virtual 3D factory facilities planning is, first of all, the availability of all objects in virtual environment. If this requirement is fulfilled simple production facilities planning are possible. The system development was divided into two main parts [12]: **Construction of a virtual environment:** This part provides experience of creating virtual object and placing them in the virtual environment with associated real world. Properties in order to illustrate how models are created. **Use of virtual environment:** This part encourages exploring different attributes of the virtual environment within two broad categories which are factory walk through and visualization of different sections of the factory.

5. Simulation - Using 3D Studio Max

Modeling and editing panel: The cornerstone of 3D Studio MAX is an advanced 3D modeling and animation environment. One can perform 2D drawing, 3D modeling, and spline based animation within the unified workspace. Modeling, editing and animation tools are always available in the command panels and toolbar. **Lights & Camera:** Designer can create light objects using the light category of creating a panel. Ambient light is found in the Environment dialog by choosing Rendering/Environment. The lights can cast shadows, project images, and create volumetric effects for atmospheric lighting. 3D Studio Max also supports real-world camera controls for lens length, field of view, and motion control such as truck, and pan. **Materials:** 3D Studio Max contains a sophisticated Material Editor that floats in its own window above the scene. One can use the Material Editor to create highly realistic materials by defining hierarchies of surface characteristics. **Animation:** The user can begin animating his scene at any time by clicking the animation button. This button can be clicked again to move back and forth between modeling and animation. The users can extensive control over his animation with the 3D Studio Max Track View. This is a window into time where one can edit animation keys, set up parametric animation controllers or display and adjust motion curves for all of your animated effects. **Rendering:** The 3D Studio Max render includes advanced features such as analytical, motion, volumetric, lighting, and environmental effects [11]. A research was done on Design and Development of workshop in 3D environment using 3D studio MAX by Syeda Nusrat Jahan, Muhammad Bayazid Bustami, Ranjan Kumar Das, Dept. of Industrial and production Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh in the year of 2006 [13].
Modeling objects in 3D Studio Max: The latest technology in modeling is utilized in this project by combining 3D Studio Max software and AutoCAD with Supers cape VRT for object drawing. 3D Studio Max is a three-dimensional modeling and animation based package. It has the facilities to add, subtract, combine, and can add material to object, to perform 2D drawing, 3D modeling based animation within the unified workspace. Modeling, editing and animation tools are always available in the command panels and toolbars. The designer can draw 2D and convert it to 3D by using tool bars and can view in front view, top view, and in perspective view. This software helps the designer to change an initial profile of a model, thus updating the previous model and its current drawing. Moreover it helps viewing the model at the same time in different ways. Figure 3 shows the overall factory layout and figure 4 shows the office layout. Figure 5, 6, 7 shows the machines used in the manufacturing of flanges and figure 8 shows the warehouse of the factory.

Fig. 3: Factory area.

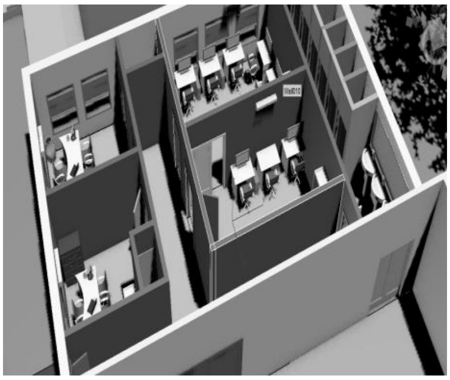

Figure 4: Office layout.

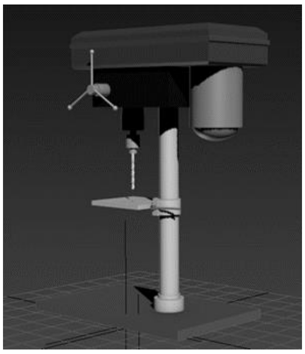

Fig. 5: Drilling Machine.

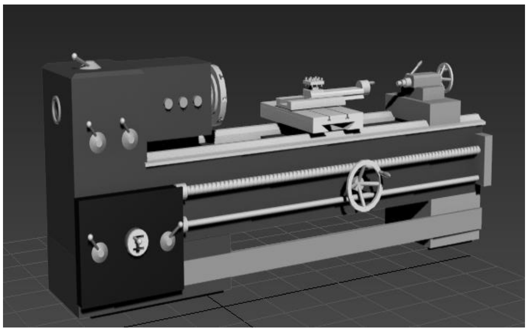

Fig. 6: Engine Lathe machine.

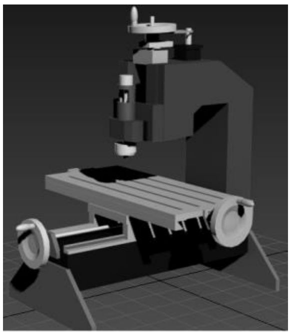

Fig. 7: Milling Machine.

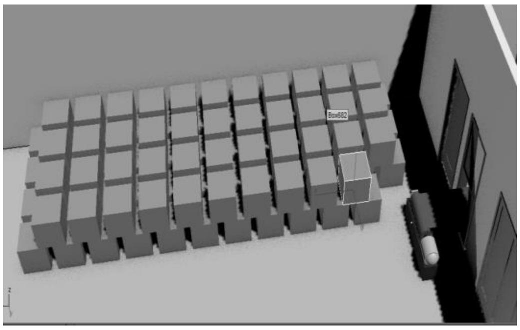

Fig. 8: Factory Warehouse.

6. Conclusion

The initial studies presented in this paper have shown that a realistic virtual model of the factory with high level of details and accuracy. Here a 3D virtual environment and modeling software (3ds Max) is used for effective construction and visualization of flange manufacturing factory. The basic construction method using virtual 3D modeling software has been described here. Also some types of 3D flanges have been cited using 3D Studio Max Software. Presently product are conceptually designed and then modified before making it in real life. So this technology is becoming important in every sector of human needs. This makes important for future designers to design effective 3D factories

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Automatic Whiteboard Cleaner Using Microcontroller Based Rack and Pinion Mechanism

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Abstract

At recent years whiteboard has become a crucial element at almost every educational institute. They are large in size, for that reason it is very time consuming and tedious process to erase the writings from the board with duster manually. It breaks concentration of both lecturers and listeners. Automatic Whiteboard Cleaner can solve these problems. Automatic whiteboard cleaner will reduce the time and also the effort. It takes around 6secs to clear the board smoothly. This paper represents the design and construction of automatic whiteboard cleaner. The system consists of Arduino microcontroller, driver module, dc gear motor, rack and pinion mechanism, sonar sensor, supports, and a cleaner bar to give that an automation figure. When the switch is on, it moves across the full width of the board and its direction is reversed automatically in order to clean the board. So, this "Automatic Whiteboard Cleaner" is a great replacement of "duster" and it can be suggested to use this to reduce the effort of the board user as well as to introduce the classroom with an automation system.

Key words***:*** Automation, whiteboard cleaner, arduino, rack and pinion mechanism, sonar sensor.

1. Introduction

Education is the back bone of a nation. Education comprises of teaching and learning. The resources and materials used in teaching becoming updated along with the teaching and learning techniques. Writing was earlier done on sand, walls, slates made out of wood, chalkboards and in recent times on white boards and electronic boards [1]. Chalk dust scatter causes serious health problems. Because of these reasons white board has been widely implemented into many other sectors of human endeavor besides teaching [2].
Many researches and testing had been done on white board from a long time. Many variations had been done on cleaning of whiteboard surfaces. Remote control motorized cleaners are made in which the dusters are operated with the help of remote control [1]. This type of cleaner moves horizontally by means of motor mechanism and erase the board with the help of dusters attached to it but it could not create sufficient pressure on board . This limitation was solved by using rolling whiteboard surface and fixed dusters [3]. Instead of moving the dusters the whiteboard surface is moved around the rollers. The friction produced between fixed dusters and rolling surface creates sufficient pressure to erase the written data on it but this process is too time consuming to clean the board. This drawback was overcome by using microcontroller and sensors but the longevity of board surface is short because it acts as flat belt [4]. Remote control motorized cleaners makes use of belts which have low wear and tear resistance and with the frequent operation of cleaning process, the belt is likely to cut and hence makes the device or the cleaner less useful [3], [4]. Instead of belt, chain had been used to improve the cleaning procedure but it creates too much noise [5]. Using cord and pulley arrangement the wiper bar connected to the motors can erase writings on the board which creates less noise but it requires four motors and two motor drivers causing too much cost [6]. These limitations have been overcome by the proposed design in this paper. Only one motor and one motor driver with rack and pinion mechanism is used instead of belts and large amount of pressure has provided by rack and pinion mechanism with necessary supports.

2. System components

This system is designed considering the present scenario of white boards. It consists of seven main components. They are dc gear motors, arduino UNO, motor driver, wooden block, duster holders, dusters, rack & pinion mechanism, AC to DC converter and whiteboard surface.

3. Design of system components

The whole system is based upon two individual units. One is the cleaning unit which ensures to erase writings and other is the controlling unit which controls the cleaning system. The cleaning unit consists of the necessary arrangement which enable the cleaner slide over the board and the controlling unit consists of micro-controller which controls the motor, rpm, and the time of rotation.

Design of controlling unit

At controlling unit Arduino Uno is used which is a microcontroller board based on the ATmega328 .It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. One of its most important features is its ease of programmability. Motor Driver of L293D IC model is used which is a monolithic integrated, high voltage, high current, 4-channel driver. Using chip it is possible to use DC motors and power supplies of up to 36 Volts and maximum current of 600mA per channel.

Fig.1. Arduino UNO Microcontroller

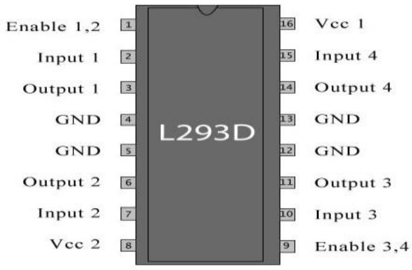

Fig.2. Motor driver

A dc gear motor is used at this project which can be operated within the range of 4V - 24V and has a speed of 100 RPM. The shaft length of motor is 25-30 mm and shaft diameter is 8 mm. This type of gear motors has high torque and produces very less vibration effect so that the pinion can rotate smoothly. AC to DC adapter is used to convert AC supply into DC supply. In this system the converter is used to step down the 240V AC to 18V, 3 amp DC supply. The converter is required for functioning of DC gear motors because these motors work only on dc supply. Sonar Sensor or Ultrasonic Range Sensor (HC-SR04) is used to calculate the distance between the sensor and the reflecting object mounted at brush. Pin connection of both motor driver and arduino UNO has shown at fig. 3.

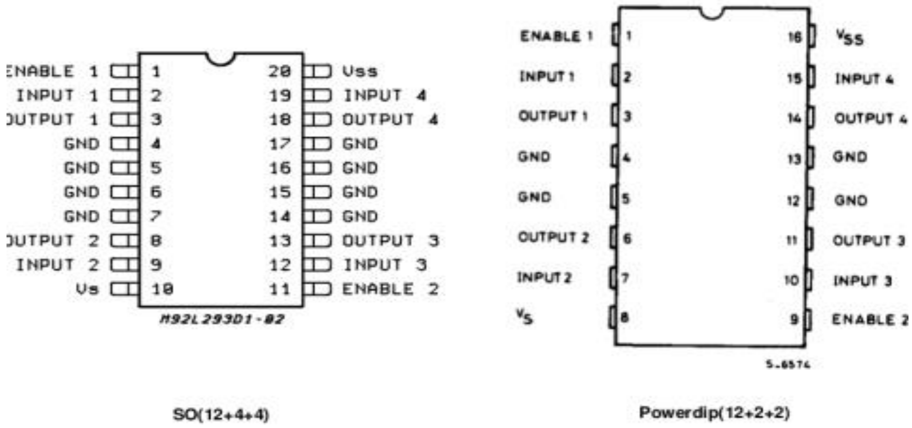

Fig.3. Pin connection of Arduino UNO and Motor Driver

As shown in the figure above, it's possible to drive 2 motors with a single L293D but only 1 motor is used at this project. Table 1 shows how to make the motor turn clockwise and anti-clockwise. For example, if the pins 1 and 7 are in HIGH state, and the pin 2 in the LOW, the motor will rotate clockwise. On the other hand, if the pins 1 and 2 are in HIGH, and the pin 7 in the LOW, the motor will turn to the other way. Signal from sonar sensor will change the state of pin 2 and pin 7.

Table 1. Combination of pin status to make the motor run clockwise and anti-clockwise

Pin 1	Pin 2	Pin 7	Function
High	Low	High	Turn clockwise
High	High	Low	Turn anticlockwise
High	Low	Low	Stop
High	High	High	Stop
Low	Not applicable	Not applicable	Stop

If the distance between the sonar sensor and brush is less than 1 inch then motor will rotate clockwise and if this distance is greater than 1 inch then motor will rotate anticlockwise which is programmed into the microcontroller. The flow chart of motor rotation has shown below.

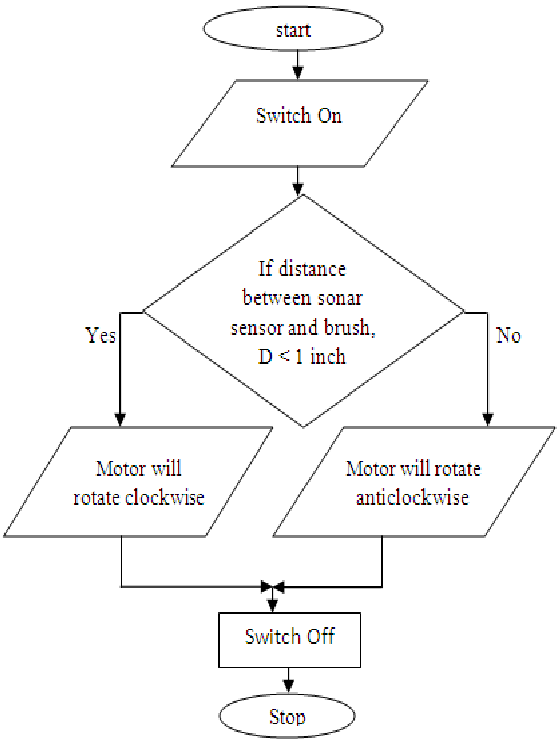

Fig.4. Flow chart of motor rotation

Main circuit diagram of automatic whiteboard cleaner has shown below which comprises of arduino, motor driver, 9v dc gear motor and sonar sensor. 18v dc gear motor has used in the final project instead of 9v dc gear motor.

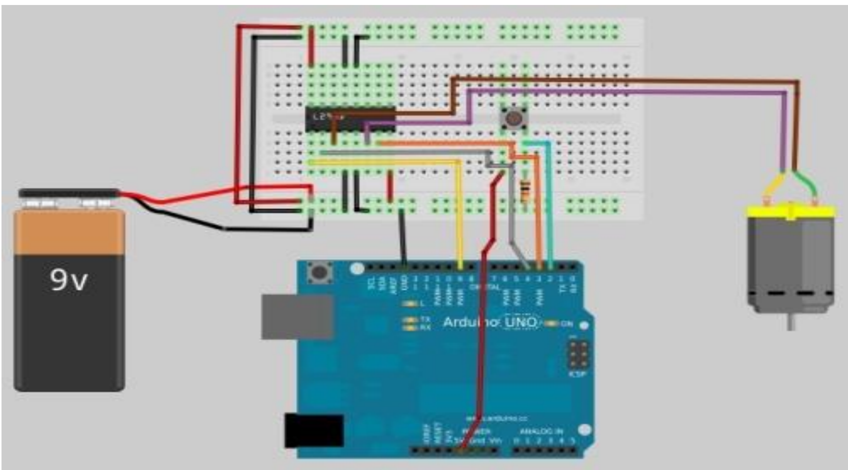

Fig.5. Design of main circuit of Automatic whiteboard cleaner

Design of cleaning unit

Cleaning unit consists of rack and pinion, brush, whiteboard, supportive board etc. Rack and pinion mechanism consists of a circular pinion of a diameter of 1.5 inches and long rectangular rack of a length of 18 inches. The pinion is coupled with the motor that means the pinion rotates with the shaft of the motor. The rotary motion of the motor is transferred to the rack & the rack moves in translatory direction. The brush is an important part for this project. To clean the white board smoothly a brush of better quality has been used. It has attached to the brush holder with the help of glue & the brush holder is attached to the end of the rack with a nut & bolt. Foam has been used as the cleaner. An amonyte sheet of 10 inches × 6 inches size has been used as a white board. The whiteboard is enclosed within two reels. A wooden block is used as a supporting base for the whole system and is made up of plywood. It is of length 50cm, breadth 5cm and height 40cm. It is used to support the whiteboard sheet at the time of writing. The motor and rack & pinion mechanisms are also fitted on wooden block. The reels are fixed with this supportive board by the help of angle plate.

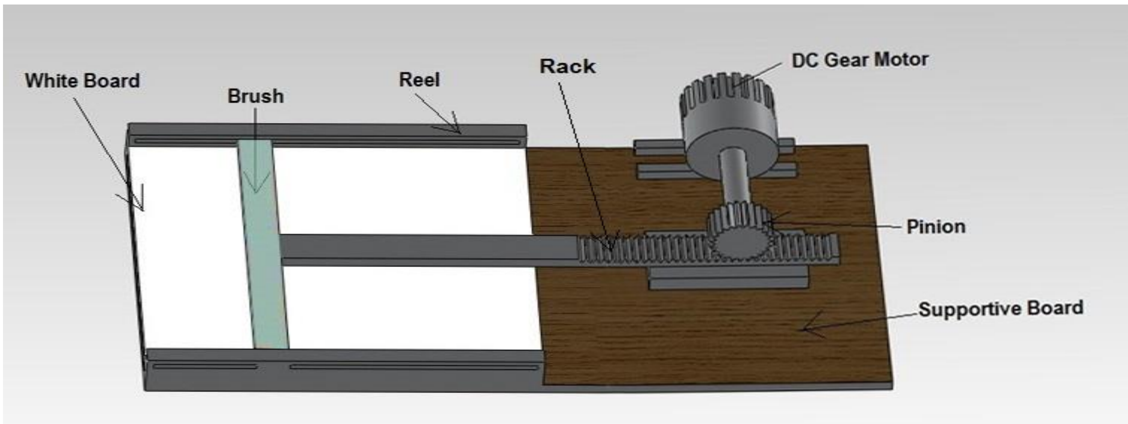

Fig.6. Complete design of an automatic whiteboard cleaner

4. Construction of main structure

The system is assembled by using all the components as mentioned above. The duster holders with the dusters fixed in it are attached on backside of the wooden block. A DC gear motor (18V) is fixed on the upper side of the wooden block with clamp. The pinion is coupled with the motor that means the pinion rotates with the shaft of the motor.

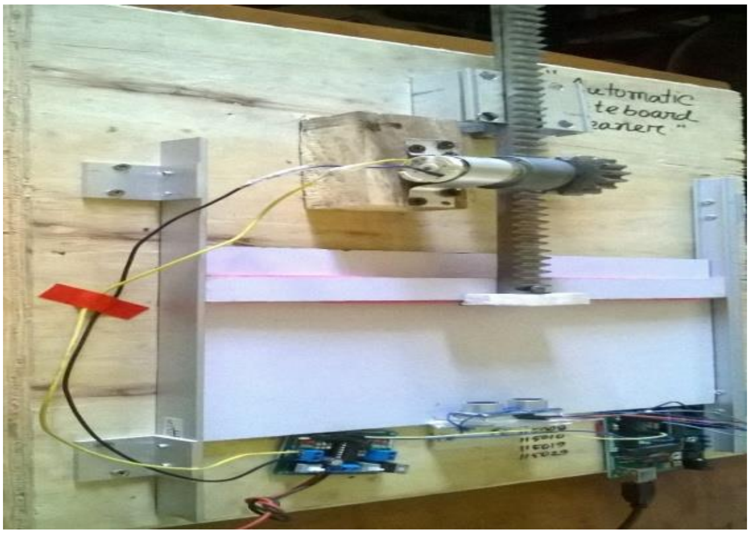

Fig.7. Constructed Automatic whiteboard cleaner

The rotary motion of the motor is transferred to the rack & the rack moves in translatory direction. A brush has been attached to the brush holder with the help of glue & the brush holder is attached to the end of the rack with a nut & bolt. The flexible white board surface is fixed on the wooden block enclosed with reels. The sonar sensor is fixed on the lower portion of whiteboard attached with angle plate.

5. Working procedure

Now, considering the system is in use and the teacher wants to rub the board. When the teacher switch on the supply, current is passed to the 18V adapter and then it passes through Arduino. This ARDUINO provides signal to the driver module at a specific time interval. To drive the motor **a** DRIVER MODULE (L293D) has been used. It receives the signal coming from the ARDUINO & change the polarity of the motor for which the direction of the motor changes. To sense the distance and time specified by ARDUINO, a sonar sensor is used, hence the motor rotates in both clock-wise & anti-clockwise direction. Due to the rotation of the shaft of the motor, the pinion connected to it also rotates which in turn the rack moves in translatory direction along the whiteboard. A brush holder is attached to the end of the rack with a nut & bolt. To clean the white board smoothly a brush of better quality has been used which is attached to the brush holder. The brush moves from the upper portion to the lower portion of the board and get rubbed due to the friction between board surface and brush.

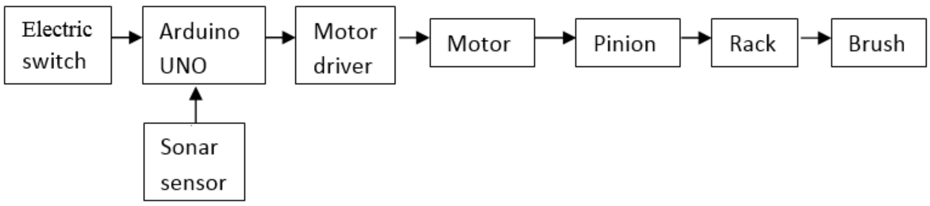

Fig.8. Flow diagram of power transmission of whiteboard cleaner

6. Time analysis

Prototype board of 10 inch wide and 6 inch long has been used in this project. Using manual duster it takes about 25 secs for whole board cleaning. Proposed automatic whiteboard cleaner reduces the time requirement. When switch is on, firstly brush moves downward and then moves upward direction thus completes one full cycle of movement. Proposed automatic brush needs 5 full cycles for cleaning the board completely which takes only 6 secs. Several data had taken to determine the time requirement for completing the wiping process. Table-1 shows the time for ten observations.

Table 2: Time requires for complete cleaning

Trial No n	Downward Motion Time (Sec), D	Upward Motion Time (Sec), U	Total Time of 1 cycle (sec), T	Average Time (sec), A=T/n	Total average time for complete cleaning (Sec), T.A.T= A * no. of cycles
1	0.57	0.59	1.16	1.195	1.195× No of cycles=1.195×5=5.975
2	0.58	0.61	1.19		
3	0.55	0.60	1.15		
4	0.64	0.62	1.26		
5	0.56	0.63	1.19		
6	0.57	0.59	1.16		
7	0.63	0.61	1.24		
8	0.60	0.60	1.20		
9	0.59	0.62	1.21		
10	0.58	0.61	1.19		

7. Result and discussion

It is observed that the time of complete cleaning of the board using this system is average 5.975 sec. On the other hand while using the manual process the time of cleaning is about 25 sec which is about four times of the machine time. So proposed whiteboard cleaner takes less time than other previous models. It creates less noise than other motorized cleaners. Sufficient pressure has been induced during the operation due to the attachment of brush to the side reels of whiteboard which helps to clean the board very effectively and efficiently. Change of brush is very easy and it does not affect any other parts while changing. This system is only applicable to whole board cleaning. Partial cleaning of the board is not possible through this system. Though there is some lagging in to start the motor, but averagely it is optimum.

8. Conclusions

It is concluded that automatic whiteboard cleaner has successfully designed. The system has designed with innovative features which reduces human efforts and makes teaching efficient. This type of whiteboard could be very effectively used in schools, colleges and universities as it increases the interest of the students to study with different technology. The machine has reduced both time and human effort. The construction of automatic whiteboard cleaner consists of arduino microcontroller which is very user friendly in programming. On the other hand to construct the main structure, very simple tool work is needed, and the materials used in this project is cheap and easily available in market. So it is not complicated to construct this machine and it will help to introduce an automation system. The system can be further developed by integrating a bluetooth remote for controlling the switch. Infrared sensors can be used to convert this system to a smart white board. Aesthetic looks of the whiteboard can also be improved.

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Safety Audit in a Milk Industry of Bangladesh

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Abstract

For the safety of the Milk industry and specially Milkvita Bangladesh took the initiative to investigate/identify the areas of improvement on safety through Audit/Observation. The research study includes analyzing the safety awareness and safety condition of a Milkvita Factory resulting in finding non-compliance issues and recommendations for correcting those issues to elevate or upgrade the safety scenario in working and operating the said Milkvita Factory. Parameters are taken in this study are: Equipment based analysis; Job based analysis; Location based analysis; Identifying the presence of resources including PPE(Personal Protective Equipment) etc; Checking on factory premises including factory access, weigh bridge area, roads, lanes and cleanliness related to Health Hazard; Preparing Accident record register in MS Excel; Factory Building design review & recommendation; Electrical Safety assessment & recommendation; Machine Safety assessment & recommendation; Identification and recommendation for occupational health; Evaluation of Fire fighting training & Drill. No secondary data was used. Research results shows that the mean fire risk index (FRI) is 3 on a scale of 5.0, which indicates an alarming condition. Locked exit doors, lack of emergency announcement system and lack of fire drills are the three worst performers among the 24 investigated parameters used in the study. Those parameters require immediate attention from the regulators and stakeholders. It is also observed that a U-shaped relationship between FRI and factory size has been developed. Factories that are members of the industry's trade lobby generally have better fire safety practices than the non-members. FRI for the industry can be very useful to understand the immediate concerns and thus to curb fatalities and injuries from fire accidents in this sector. Given the importance of the Milk industry may be supply quality and hygienic and quality milk to the customers. It is found from the findings that there is lack of training to the entire employee of the Milkvita Company.

Keywords: Safety; Audit, Training; Fire Risk Index and Factory

1. Introduction

Milk production of Bangladesh is gradually increasing day by day due to proper nourishment of milk and milk industry. Milk industry in Bangladesh is increasing. But it is to be mention that Milkvita is one of the largest and pioneer of this sector. Milk is very much essential for the country people to meet up the nutritional requirements. Among all industries Milkvita is one of the industries where safety measures are taken. In factory cases electrical wiring, mechanical measures are taken for the safety of the employee and staffs. It can promote the production line and keep the factory free from hazards. To remove accidental facts it is very much need to improve safety measures. Milkvita has a variety of products such as Pasteurized Liquid Milk ,Flavored Milk ,Butter ,Full Cream Milk Powder, Skimmed Milk Powder, Ice-Creams, Ghee, Sweet Curd , Cream , Lollies ,Rasa Malai (sweet meat) , Condense Milk ,UHT Flavor Milk ,UHT Pasteurized ,Liquid Milk Chocolaté etc. All these products are from health hazards by the unique & systematic tools, engineering and technical helps of our resources personnel. By this way, the Milk industry is a highly competitive industry and cost-saving is highly valued, but, given the lack of a safety culture in the country in general, cost-cutting measures often affect the health and safety of the workers. Clothing is easily flammable and as such fire is one of the most sometimes and damage inducing accidents in these factories in Bangladesh. Cold and fire cause most of the injuries of milk industry, if industry can minimize that by providing suitable environment may get a good result. Cause of on-the-job injuries and fatalities in this sector. Each new incident of fire and related damage adversely affects the reputation of the industry. The Milk industry is a highly competitive industry and cost-saving is highly valued, but, given the lack of a safety culture in the country in general, cost-cutting measures often affect the health and safety of the workers. Clothing is easily flammable and as such fire is one of the most sometimes and damage inducing accidents in these factories in Bangladesh. Cold and fire cause most of the injuries of milk industry, if industry can minimize that by providing suitable environment may get a good result. Cause of on-the-job injuries and fatalities in this sector. Each new incident of fire and related damage adversely affects the reputation of the industry. Despite a number of initiatives to curb fire accidents in the Milk factory, there are still a significant number of fire occurrences in this industry. Unfortunately, there is no comprehensive statistics on the current status of fire provisions and management practices in the Milk industry. Though Milkvita is one of the largest organizations in Bangladesh its safety audit was not done before. This kind of audit can be very much innovative for milk industry, if any milk industry can perform all the safety measure. For this perspective, a safety audit can be done in Milk industry like Bangladesh Milk Producers' Co-operative Union Ltd (BMCUL) for achievement of better performance.

2. Brief History of BMCUL

Dhaka Dairy Plant is a milk processing factory under the organizational trade name MILKVITA and the authoritative of LGRD ministry in Mirpur region, Dhaka. In terms of machineries, it is the largest milk industry of the country. Bangladesh Milk Producers' Co-operative Union Ltd (BMCUL) popularly known by its brand name Milk Vita, was established by the Bangladesh Government in 1973, immediately after the liberation war, based upon the recommendation by UNDP/FAO in the pattern of AMUL, India. The project was set up primarily at the four milk shed areas of the country. It was initiated as a development project of the Government titled "Co-operative Dairy Complex" with the objective of ensuring fair price for the poor, landless and marginal milk producing farmers of the rural Bangladesh and on the other hand to provide the city dwellers with a regular supply of fresh and hygienic milk and milk products at a reasonable price. The total project cost was Tk. 155.61 million comprising of a foreign exchange component of Tk. 61.07 million. Under the starting stage of the project 5 (Five) plants were set up followed by 7 (seven) more plants with self-financing. During the period of its activities, the organization has succeeded in bringing together over 160,000 farmer-members into the fold of 2068 village milk producers' co-operative societies who deliver milk to this organization twice a day, in the morning and in the evening. Thus, around 7, 00,000 farmer family members are being benefited by this organization. Moreover, the activities of Milk Vita have created about 4,000 job opportunities in the urban areas in addition to 1000 at its plant-levels. The co-operatives members get reasonable price of milk produced by their cattle with a guaranteed market. The project infrastructure further could drive away the traditional ghoses, the middle men, who used to exploit the farmers paying low price for their produces from centuries. The co-operative farmers are also given incentive bonus/price difference against their milk supply annually. Through its activities for the last 3 decades, BMPCUL has made a significant impact on the national economy & especially in the milk production sector benefiting the farmers. At the outset of production, Dhaka City was ear-marked as the target market. Gradually the marketing activities have been increased and expansion has been made to big city areas like Chittagong, Comilla, Feni, Rangpur, Brahmanbaria, Sreemangal, Moulvibazar and Sylhet etc. with the expansion of market and diversification of product range as per market demand.

3. OBJECTIVES:

Broad Objective:

In broad sense the safety audit is to make a report that where the factory needs to improve and what to do for a reputed milk industry.

Specific Objective:

In some specific cases following objectives is need to observe for a large milk industry:

- Risk/Hazard Assessment and analysis
    - Equipment based analysis
    - Job based analysis
    - Location based analysis
    - Identifying the presence of resources including PPE (Personal Protective Equipment) etc.
    - Checking on factory premises including factory access, weigh bridge area, roads, lanes and cleanliness related to Health Hazard.
    - Preparing Accident record register in MS Excel
    - Factory Building design review & recommendation
    - Electrical Safety assessment & recommendation
    - Machine Safety assessment & recommendation
    - Identification and recommendation for occupational health
    - Evaluation of Fire fighting training & Drill

4. Methodology

This safety audit can be conducted on Milkvita, Mirpur. Section -7, Milkvita road, Mirpur, Dhaka, Bangladesh. The Data Collection process can be done through primary sources (Face to Face interviews, Department wise Team meeting, and random sampling of the factory staffs) and physical observations of the factory premise and finally all the activity are practice regularly in a large milk industry to produce quality ,hygienic and safety milk and milk products .

5. DATA ANALYSIS AND FINDINGS

5.1 Paraphernalia/Equipment

SL	Non Compliance	Action Plan	Comment/Recommendations
1.	Absent Sprinkler System	Installment of Sprinkler System covering the Pharma, binding and end product storage areas.	Only Firefighting equipment present fire extinguish
2.	Absent Smoke or Heat Detector	Installment of inter-zone smoke detector in all areas including raw material storage specially paint and lubricant storage.	NA
3.	Cold room Equipment	The entire employee use jacket with musk and gum boot to protect them.	World class equipment is available.
4.	Laboratory safety	For the safety of laboratory there is used high quality mask, apron and cap.	Sometimes may be mistakes but it's acceptable.
5.	No high quantity fire prevention instrument present(i.e. Water hydrant or water hose coil)	Installment of water hose for emergency fire fighting. Already there is a water hose of small quantity which is not sufficient for full coverage.	Even though it can be inconvenient for raw materials .It is recommended that at least two point to be installed as front and back point for water output.
6.	Secondary Equipment for chemical fire or chemical hazard which is not sufficient as per standard bench mark.	-Installment of Sand bucket(Minimum requirement) - Already have sufficient storage of Rubber Boot and gloves for chemical handling(As a safety measure)	Acceptable.
5.	About fire alarm	Installment of Fire Alarm for each zone including emergency lights.	NA

5.2. Job based Analysis

SL	Non Compliance	Action Plan	Comment/Recommendations
1.	Availability of Dedicated employee role & responsibility for emergency fire fighting.	Training and assigning dedicated employee for rescue, medical & fire fighting awareness among employees.	Regular Drill can be conducted.
2.	The employee role and responsibility for emergency escape assignment or schedule.	Training and assigning dedicated employee for rescue, medical & fire fighting awareness among employees.	Regular Drill can be conducted.
3.	Not presence of rescue and medical detail among employees in case of emergency.	Training and assigning dedicated employee for rescue, medical & fire fighting awareness among employees.	Regular Drill can be conducted.
4.	About emergency prevention plan	Should implement emergency prevention plan including: • Major work place hazards • Personnel responsible for various emergency procedures • Regular training & Drill on emergency.	Implementation of Health & Safety committee can be formed.
5.	Emergency response procedure	Should implement emergency response plan including: i. Personnel responsible for various emergency procedures. ii. Regular training & drill on emergency procedures.	Application of Emergency response committee can be formed.
6.	Absences of proper First aid training	Conducting regular first aid training and designation of primary responsible for First Aid.	Highly experienced Training Manager (First Aid) can be appointed as contact basis, ASAP.

5.3. Location based Analysis:

Sl	Non Compliance	Action Plan	Comment/Recommendations
1.	Exit: gate are open always	Installation of **“Outward Opening Door”** will be optimum even though the gates are always open while operation goes on.	Three gate with shutters: One front, One back, One middle can be introduced.
2.	Kill paste	Modern equipment are available	NA
3.	Ventilation: there are big ventilation fan for proper air flow.	Need more cool places for quality products.	More or less upto the mark.
4.	Space: Placement of raw and output material.	Lots of modern cold room is present	**NA**
5.	Proper space for planning: Space is used way over the limit of optimal use, resulting congested space because of machineries.	Thinning out the machines and acquiring additional space for more spacious storage place.	It will reduce accident, free up space for emergency pathways and reduce heat.
6.	About separate place for chemicals.	There is a separate chemical place	NA
7.	Building integrity: about approval by concerned authority for building construction for this particular production facility. About occupancy certificate either.	All the programmed is more or less approved from authority.	High quality engineer are available there. .
8.	About environment clearance certificate.	Acquisition of environmental clearance certificate.	Day to day **ETP** monitoring and compliance with DoE.

5.4. PPE and Others:

SL	Non Compliance	Action Plan	Comment/Recommendations
1.	No accident/incident report is maintained, very Few found(only)	Maintenance of chronological accident/incident register	**NA**
2.	Deviation report found but none consistently.	Should maintain as daily routine basis**.**	**NA**
3.	Insufficient of PPE(Personal protective equipment) not maintain up to the Mark	Implementation of regulation on all times usage of Rubber Gloves while handling chemicals and wearing Rubber boots while handling large quantities of it. Even though the sound level is not above tolerance, usage of noise reducing ear plug is preferable. Similarly, usage of metal gloves in cutting machine is advisable.	Employees should be made aware of the necessity of the personal protective equipment through regular training and implemented standard operating procedure (**SOP**).
4.	No sufficient backup light	Installment of More Backup light.	Several charge lights are used as instant back up light, backup generator line comes from outside supplier which supplies power for several lights only (No Generator for machines**).**
5.	No **Safety cell/Committee** or awareness activity	**Formation of safety committee** and conducting regular safety awareness campaign.	Regular training and drills will work greatly in this aspect.

5.5. Electrical Wiring:

Electrical connection, quality & placement of switch boards are barely satisfactory. Each machine has separate line & switch. Most lines are jacketed with plastic pipes and placed above head on the wall. There are some new electrical lines added outside of the jacketed lines which increases the fire risk even though they are bound the jacketed lines with twines or tape. There are no crises-crossing below the roof & no lines on the ground. Only placement of several pedestal revolving fan encroach on unsafe placement.

5.6. Machine Safety:

Machines are mostly safe with regular maintenance. The Heat producing machines has separate exhaust pipe to outside. Additionally some wall mounted revolving fans circulate the excess heat produced while in production. The possibility of work hazard includes cutting machine and various motors running in the press.

Provision of Safety:

- **Identifying the "Areas of Improvement" on Safety through Audit/Observation:**
- Risk/Hazard Assessment & Analysis on
- Equipment based analysis.
- Job based analysis.
- Location based analysis.
- Identifying the presence of the resources including "PPE" (Personal Protective Equipment) etc. & developing a useable PPE Matrix and recommending for immediate arrangement of the equipment to implement the Safety Management Program.
- Factory Premises including Factory Access, Weigh bridge area, roads, lanes & cleanliness related health hazard.
- **Preparing Accident Record Register in MS Excel**: **Must Provide an Excel Sheet and Online Information….**
- Factory Building Design Review & recommendation(subject to availability of the original building architectural layout plan in soft copy in AutoCAD only)
- Electrical "Safety Assessment & Correction" where possible as per recommendation of our Electrical Engineer.
- Machine Safety Assessment & recommendation
- Identification & recommendation for "Occupational Health"
- Working "Uniform/Dress", Safe for work_ awareness campaign among the first line workers.
- Recommendations for "Awareness Campaign Materials".
- Formation of "Safety Cell" (Safety Committee) for self Inspection & carrying out safety events at a regular/scheduled interval.
- Giving Complete Guideline to establish an "Emergency Safety Clinic".
- Formation of "First Aid Team", One day "First Aid Training" by Qualified Medical Professional (On Additional Payment).
- **Fire protection Equipment & PPE :**
- Fire Fighting Training & Drill
- Formation of "Fire Safety Cell (Team)" & Preparing Yearly Fire Safety Drill Schedule(FSDS) :

6. List of Observation Documents

SL	Category	Observation
1.	Documentation	Boiler license
2.	Documentation	Boiler Operator license
3.	Documentation	Fire License
4.	Documentation	HVAC System permission
5.	Documentation	Previous Assessment Report
6.	Fire Protection Construction	Generator Room & Generator control room is not fire rated
7.	Fire Protection Construction	Uncovered light in the stored area
8.	Fire Protection Construction	Fire barriers are provided to separate boiler rooms.
9	Fire Protection Construction	Fire rated separations between Diesel tank and Generator are not found
10.	Electrical Substation establishment	Permission from Power Development Board.
11.	Means of Egress	Some of the Exit signs have no illumination system
12	Means of Egress	Insufficient emergency light
13.	Means of Egress	Day Care location

14.	Fire protection systems	Fire pumps accessibility
15.	Fire protection systems	Fire department connections are not provided
16.	Fire protection systems	Inspection, maintenance and testing records for hose pipe system not found.

7. Conclusion

Milkvita is a branded dairy industry in Bangladesh, no another one as like as Milkvita. The key idea is only a quality and safety products are produced by applying engineering technological assessment and systematic system safety management. As safety precaution equipment it has fire extinguishers, cold room protector which acts as the moderate fire and cold fighting unit. The chemical handling & storage situation is upto the mark. Ventilation scenario is acceptable. Electrical wiring is sufficient in terms of safety protocol with jacketed wiring and separate switch boards for the machines. Usages of space are available and meet up the requirement of milk industry. Moreover the findings and recommendations in section 5 can be introduced in the factory for better performance of the company.

8. Recommendations

Recommendations of safety issues have been mentioned in the section 5 of data analysis and findings. According to observation, the company can try to maintain up to the mark fire safety but one of the major problems there is lack of training to the entire employee. Employees are always doing to break the rules of safety about fire and others. It can be needed proper care from authority.

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