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A NEW GENERATION ENERGY EFFICIENT RESIDENTIAL HOUSE IN AUSTRALIA

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ABSTRACT

The residential housing sector is one of the largest energy consumers in the developed world and subsequently the larger greenhouse gas emitter. The overall impact of residential housing energy and materials consumption on global warming potential, ozone depletion, acidification, and ground-level ozone creation potential is significant. A new energy efficient residential house is proposed in this study that designs and builds all aspects of the home with the goal of maximizing energy efficiency while ensuring good indoor air quality and occupant comfort. The whole building concept encompasses the climate, the specific home site, the foundation, walls, roof, the use of windows and doors and natural lighting, the heating and cooling systems, appliances, lighting and rain water storage. By integrating all of these components, the proposed home can be built for the same or lower cost than a conventional home and can offer significant savings in energy use.

Key words: *Energy efficient house, sustainable building, rain water, solar thermal power*

1. INTRODUCTION

Today, conservation of energy and reduction of greenhouse gas emission are the primary goal of mankind. A significant portion of total energy consumption and greenhouse gas emission is coming from building construction and dwelling. Residential and commercial buildings account for 7.9% and 4.3% of Australia's total energy use respectively [1]. A recent Australian government study reported that the energy consumption by the residential housing sector in 2008 is 402 PJ compared to 299 PJ in 1990. The report also says the energy consumption in 2020 will be almost 467 PJ, i.e., an increase of 56% over period of 1990 to 2020. The number of residential households will be around 10 million in 2020 compared to 6 million in 1990. Modern residential houses being more energy efficient (most houses comply with five or more star energy rating) require more energy as the floor area of today's house has increased significantly. For example, the average floor area per household was 114 square meter in 1990 compared to 168 square meter in 2020, i.e., an increase of 32% over the period of 1990-2020 [7]. The larger floor area not only increases the construction cost (approximately A$1,200 per square meter) but also consumes more energy increasing the energy bills (heating, cooling and lighting for extra spaces) resulting in significant rise of greenhouse gas emission. At present, the heating and cooling, and hot water systems require most of the energy, consumed by the residential building envelop (see Figure 1).

Currently most conventional residential houses are assessed for their energy consumption efficiency by using computer based energy rating method. Widely accepted method is CSIRO's Nationwide House Energy Rating Scheme (NatHERS) [5]. It simulates the potential energy efficiency of a house on a scale of zero to ten stars. More stars theoretically equates to less likelihood that household occupants will need cooling or heating to maintain comfort. This star rating system was incorporated with the Building Code of Australia. NatHERS only consider energy for heating and cooling. It does not predict environmental impact

However, some other computer based tools such EcoHomes™, UK based Research Establishments Environmental Assessment Method (BREEAM), Australia based Building Sustainability Index (BASIX) and National Building Environmental Rating System (NABERS)- go beyond energy and consider elements such as water, waste, material use, health and wellbeing, and overall environmental impact [2, 3, 6]. Unfortunately, most of these software based tools does not account for 60 to 70% of total household energy for the conventional residential houses and their greenhouse gas emissions. Often the field (experimental) data is significantly different from the predicted data found by using these tools [9]. Some sustainability rating tools are frequently used for subjective weightings with some assumptions to bring together many different aspects of environmental sustainability [9]. One such tool is the 'Energy Rating Scoresheet' that estimates building envelope contributions to heating and cooling loads and associated energy consumption [8, 9, 10].

It is no doubt that a sustainable, energy efficient construction, building and dwelling can significantly lower the fossil fuel energy dependency and the greenhouse gas emission. Currently over 140,000 new residential houses are built in Australia each year (demand is significantly more, see Tables 1 & 2. Most of these houses are conventional constructions generally made of concrete footing, brick veneer walls with timber structures and timber roofs with colorbond or tiles. An alternative construction proposed here mainly comprises concrete footing, external walls with render, polystyrene foam, re-enforced concrete and plaster board eliminating the timber structure (frame) altogether. The external wall structure of the proposed house as well as conventional house is shown in Figure 2 & Figure 4 respectively. Additionally, the interior walls will be free standing and made of compressed wheat/rice straws or hay without using any chemicals for bonding. The walls made of straws are fireproof, biodegradable, soundproof and environmentally friendly. The proposed residential house construction and other energy saving devices/methods during construction and dwelling phases are shown in Figure 3. However, no study on sustainability, energy consumption rating, internal air quality, heat and mass transfer, and acoustic properties has been reported or is available in the public domain.

Table 1: Housing Investment Forecast (in million A$) & Housing Demand in Australia [7]

Year	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Total	Housing demand
2007	16,033	14,605	16,666	3,983	8,376	1,221	538	940	62,362	190,500
2008	15,927	15,447	16,588	4,149	9,033	1,287	534	937	62,510	193,700
2009	15,539	15,160	16,346	4,210	8,067	1,237	550	924	61,013	197,000
2010	16,274	15,633	16,964	4,255	7,795	1,272	568	931	63,446	200,300
2011	17,628	16,968	18,152	4,510	8,418	1,300	602	960	67,410	203,700

Table 2: States Housing Demands for 2008/2009 in Australia [7]

States	House under construction	Total demands	Shortages	
NSW	29,140	47,800	18,660	(39%)
VIC	42,380	47,040	4,660	(10%)
QLD	43,700	48,600	4,900	(10%)
SA	11,270	11,000	-270	(-2.5%)
WA	21,200	28,175	6,975	(25%)
TAS, NT ACT	6,500	7,885	1,385	(18%)

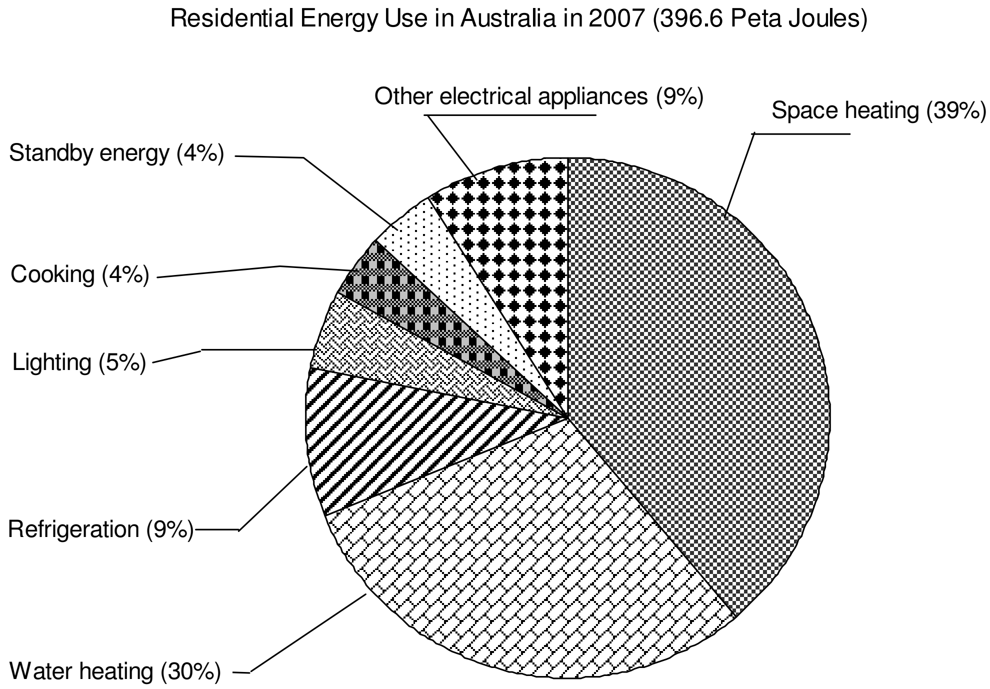

Figure1: Residential household energy use in Australia in 2007 (396.6 Peta Joules), adapted from [7, 10]

2. CONVENTIONAL HOUSE CONSTRUCTION SYSTEMS

A conventional residential house in Australia now a days is generally made of concrete slab and/or footings for foundation, external walls (external 110 mm brick veneer, 50 mm air cavity, thin sisalation foil, approximately 90 mm timber structure filled with insulation batts and 10 mm plaster board), internal walls which is generally comprised approximately 90 mm timber structure and 10 mm plasterboard on both sides), timber roof structure with tiles or colorbond. A schematic of conventional residential external wall construction is shown in Figure 2. This construction method was introduced in residential house building of Australia in early 1960s and still a dominant construction method in Australia and elsewhere. This construction method was relatively energy efficient compared to construction methods prior to 1950s and becomes less energy efficient over the time compared to modern construction materials and methodologies. The materials acquisition, construction and dwelling phases of this conventional residential house are responsible for significant greenhouse has emission and carbon foot print. Figure 3 shows potential sources of environmental impact and greenhouse gas emission at all levels except end of life stage.

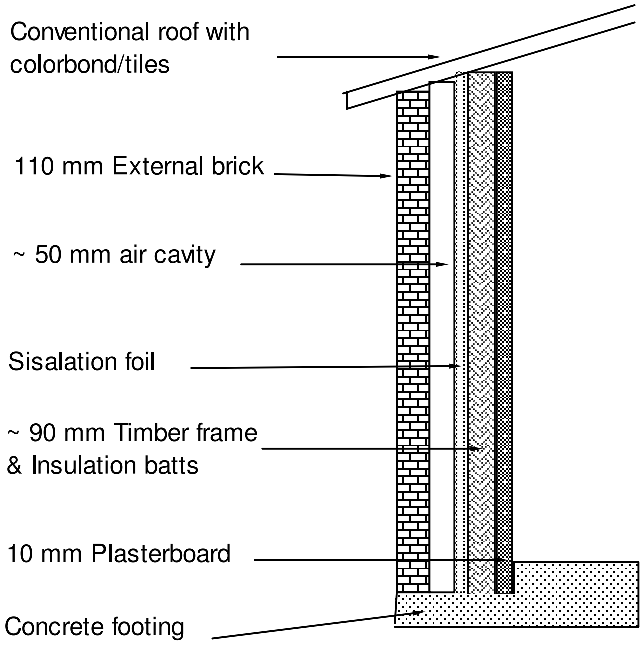

Figure 2: External Wall of a Conventional Residential House

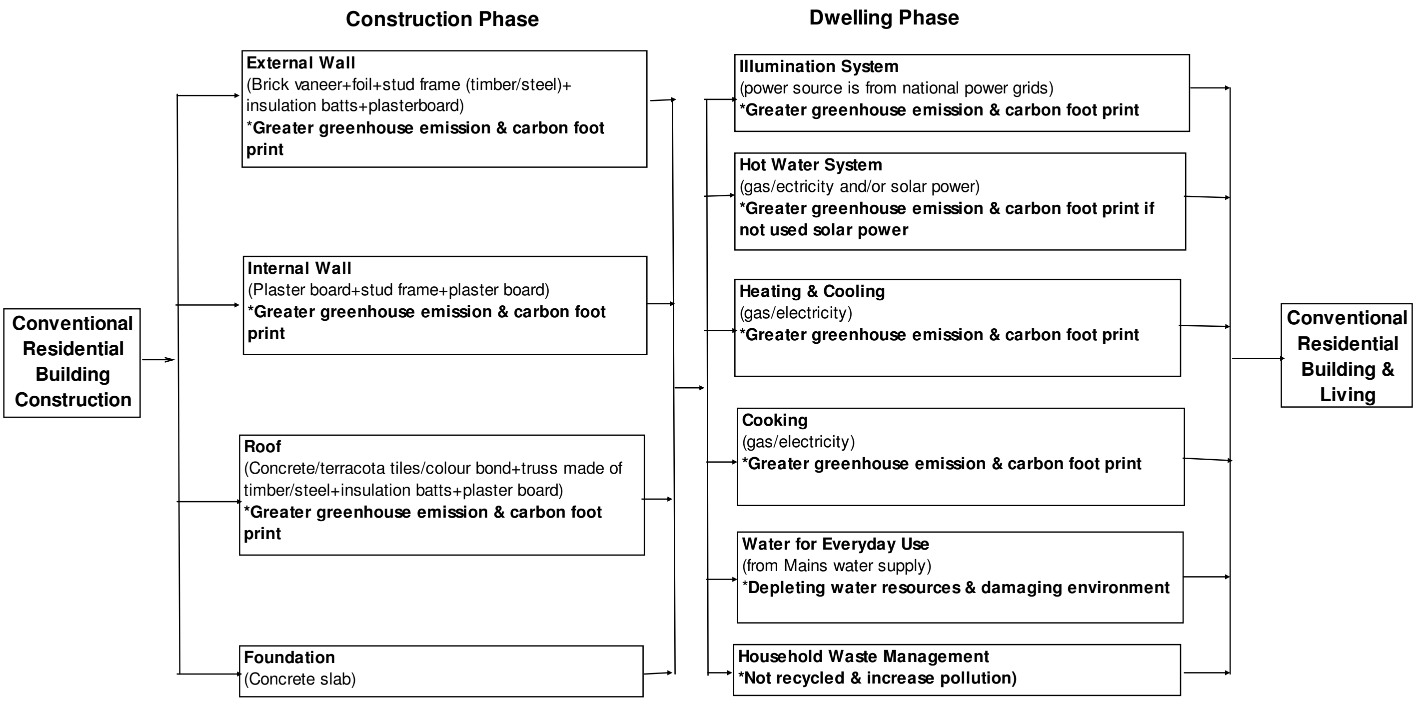

Figure 3: Schematic of Conventional Residential House Construction Systems and Dwelling

3. A SUSTAINABLE HOUSE CONSTRUCTION SYSTEMS

An alternative residential house construction method, significantly different from conventional, is believed to be more energy efficient, fully recyclable, biodegradable, cost effective and environmentally friendly compared to conventional residential house. The alternative house is sustainable and primary consists of concrete foundation like conventional house, external walls (5 mm render outside, 50 mm polystyrene, 120 mm reinforced concrete, 50 mm polystyrene and 10 mm plaster board from inside), internal walls free standing and made of compressed rice/wheat straws (see Figure 4). The internal wall panel (compressed rice/wheat straws) is completely recyclable, biodegradable and free from any chemical bonding elements. Additionally, it is fire resistant and sound proof. The materials acquisition, construction and dwelling phases of this proposed energy efficient residential house will reduce greenhouse gas emission and carbon foot print. It will also allow making the dwelling phase more energy efficient and sustainable living. Figure 5 shows potential reduction of environmental impact and greenhouse gas emission at all levels except end of life stage.

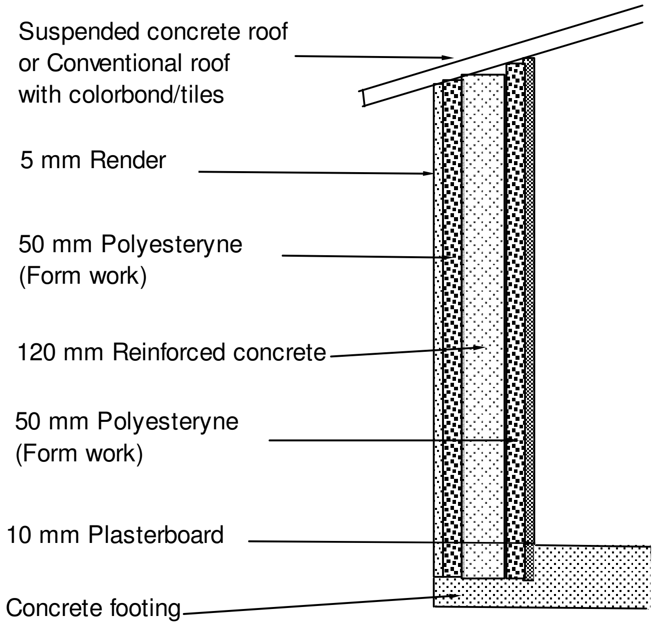

Figure 4: External Wall of a Sustainable Residential House

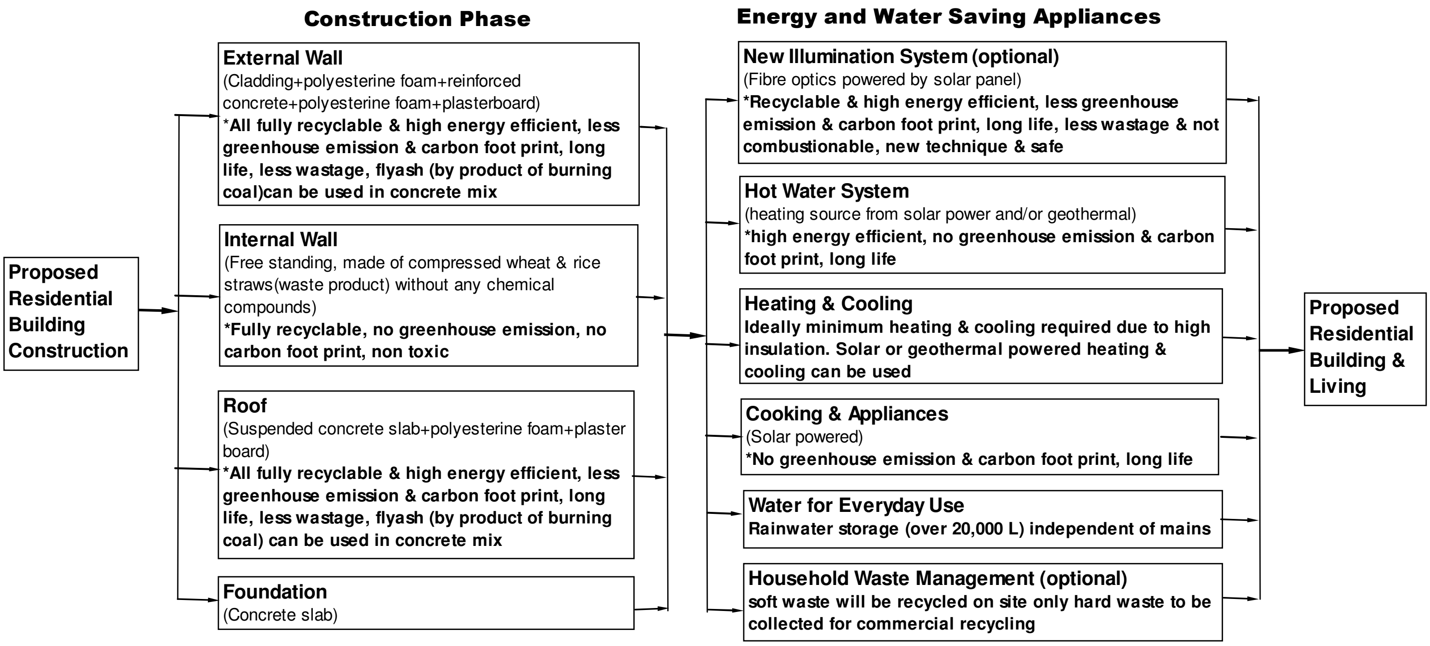

Figure 5: Schematic of Sustainable Residential House Construction Systems and Dwelling

3.1 Integrated Solar Hot Water

At present, approximately 30% of energy consumption for an average household in Australia is attributed to hot water system (see Figure 1). The energy consumption for hot water is significantly higher in southern states of Australia as the region experiences more cold weather compared to northern Australian states. The use of a well designed solar powered hot water system can reduce energy consumption from national grids significantly. In locations where plenty of sunshine is available all year round, a solar thermal hot water system is most effective, economical and environment friendly. Variety of solar thermal hot water systems is commercially available. These systems are mainly: thermosiphon, direct circulation, indirect circulation and air water solar thermal systems. Most of these systems use different types of solar heating element (collector) including batch solar collectors, flat-plate solar collectors, evacuated tube solar collectors and transpired solar collectors. A typical solar hot water system with flat plate solar collector is shown in Figure 6. The proposed energy efficient residential house will include an efficient solar hot water system based on commercially available components. Climatic conditions, orientation, solar access and loads – all will be considered in the detailed study of solar thermal hot water systems. Optimal locations (on wall or roof) and provisions for easy maintenance and repair (cleaning collectors' surfaces, checking leaks etc) will also be considered.

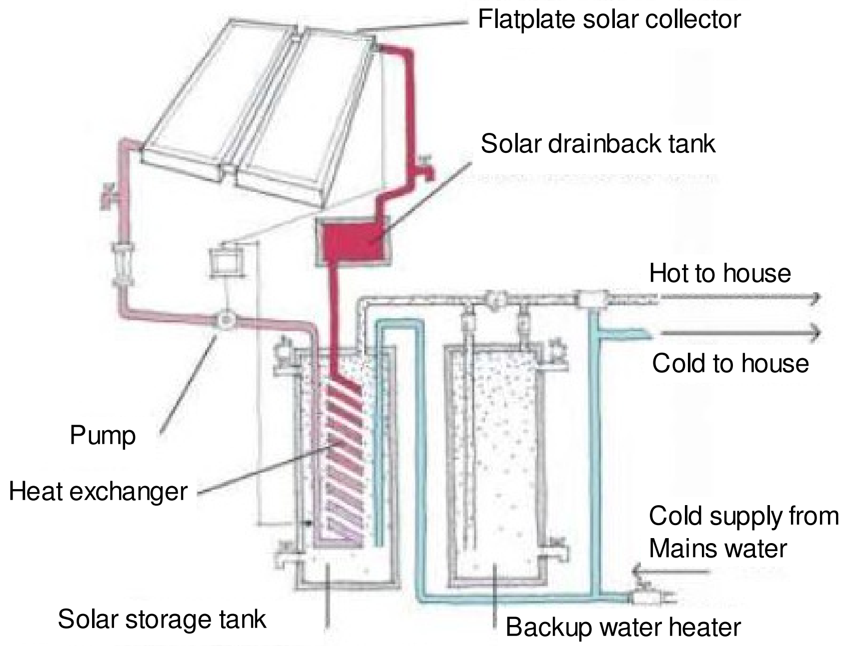

Figure 6: A typical solar powered hot water system for residential household use [11]

3.2 Integrated Rain Water Storage and Utilisation System

Fresh water is a critical and strategic resource in Australia and elsewhere. At present, there is acute shortage of fresh water in all major states and cities in Australia. The water shortage has highlighted the need for greater re-use and recycling of waste/storm-water resources. However, in order to re-use water, including stormwater, treated sewage effluent, treated industrial discharge and 'grey' (household) wastewater, a well planned, strong will and technological approaches are needed. In Australia, currently 97% of the city runoff and 91% of effluent water is unproductive, thus, developing methods to recycle and re-use the stormwater and effluent water/wastewater has become an important and urgent issue. One of the simplest and cost effective methods is to store and manage rain water for residential households. It will significantly reduce dependency on mains water supply as almost all states and territories in Australia have been facing severe shortage of fresh water supply due to draught, global warming and el Niño effect. Severe restrictions on water use have been enforced in all major cities in Australia. Renewable and sustainable rain water use will not only assist the households to reduce water bills but also save Australia's unique and delicate ecosystem and biodiversity.

The proposed energy efficient house will have integrated water storage facilities for everyday use including drinking, cooking, laundry, bathroom washing and gardening. The rain water storage systems will be incorporated with the house design with a negligible or no extra cost. Emphasis will be given to concrete rainwater tank design for collecting and storing the rainwater for everyday use including drinking. An optimal location for that preferably under garage floor will be explored. The size of the tank will be designed according to local rain fall data, rainwater collection roof area, household water needs and site space limitation. A user friendly maintenance procedure for avoiding harmful microbial organisms (bacteria, viruses and protozoa) and chemical contaminations will be developed for ensuring the safe uses of water for drinking. Special filter system will be implemented with the rain water tank management. The design will allow connecting with the mains water supply if rainwater storage runs out of water due to draught or insufficient rain. A cost effective water recycle system will also be explored.

4. GENERAL DISCUSSION

Currently, the conventional residential houses in Australia must be built with compliance to at least five star energy rating. Some Australian states, especially Victoria requires all new residential houses from July 2008 to comply with six star energy rating, which is highly ambitious and costly for the builders using traditional construction materials and building practices. Conventional residential buildings are energy intensive both in construction stage as well as dwelling stage. Renewable and environmentally sustainable materials are not widely used due to lack of knowledge and research. Most Australian building industries do not have research capabilities to evaluate energy efficiency of the construction materials, develop new construction methodology and performance monitoring of display or dwelling houses. Compared to other industrial sectors, the housing industry is reluctant to embrace new technology, new construction methods and advanced materials as they are not sure how these will affect the overall energy rating, environmental impact and performance of the house. Often it is difficult to convince regulatory authorities of the advantages of new construction methods and materials and long term performance as no comprehensive research data is available in public domain. The effects of climatic conditions on various parameters such as heating and cooling, structural longevity, internal air quality were not well studied for typical house series that can be built with minimum modifications in all climatic zones in Australia. Renewable energy sources are not widely used apart from solar hot water system for conventional residential houses. Additionally, most conventional residential households are dependant on mains water supply. Currently, most conventional houses have virtually no rain water utilisation systems integrated with the house construction for household use. Current construction process and methodology are time consuming, labour intensive and costly. The proposed construction method will allow addressing most of the above mentioned concerns. The development of a new generation of energy efficient and environmentally friendly residential houses that will require significantly less fossil fuel energy and less or no water from mains. Advanced and fully recyclable materials will be used to develop the external and internal walls of the new generation houses, which will reduce the energy needs from the grids.

5. CONCLUDING REMARKS AND FUTURE WORK

The proposed residential house construction method has immense potential to comply with higher energy rating compared to conventional construction method. However, a comprehensive study using various energy rating simulations tools and in situ monitoring of a prototype residential house is required.

A comprehensive life cycle assessment of construction materials as well as their environmental impact needs to be carried out in comparison with conventional construction materials.

Embedded energy at all four stages: materials, construction, dwelling and end of life of the proposed residential construction and conventional construction should be evaluated in order to find usefulness of the proposed method.

Rain water storage systems along with mains water supply as back up will be extremely useful. In case of less rain than predicted or draught, main water supply will provide the water needs.

The household power needs must be met using rooftop solar panels and energy efficient appliances. A fibre optic interior illumination system can be evaluated and explored. The fibre optic illumination system is believed to be energy efficient and safe compared to conventional wiring system in the residential houses.

Currently, a large research project in conjunction with three Australian universities (RMIT University, Central Queensland University and the University of South Australia) is underway to study comprehensively the energy ratings, in situ energy evaluation, climatic adaptation and interior air quality and thermal comfort of the proposed residential house construction.

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BIODIESEL FROM NON-EDIBLE RENEWABLE KARAMJA SEED OIL AND ITS EFFECT ON DI DIESEL ENGINE COMBUSTION

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Abstract

The use of biodiesel is rapidly expanding around the world, making it imperative to fully understand the impacts of biodiesel on the diesel engine combustion process and pollutant formation. With fuel prices soaring, people are looking for cheaper, renewable sources of fuel for their vehicles. Biodiesel fuel is used in diesel engines and is made from domestically available, renewable organic resources, such as vegetable oils and animal fats. This study investigates the preparation of biodiesel from non-edible renewable karamja (Pongamia Pinnata) seed oil. In the first part of this paper biodiesel is prepared from karamja seed oil by transesterification method. The food versus fuel conflict will not arise if karamja seed oil is used for biodiesel production because of its non-edibility in nature. A maximum of 96% biodiesel is produced for 0.45 % sodium hydroxide and 20% methanol at a reaction temperature of 55°C. In the second part, the fuel is characterized for its chemical properties and experiment has been conducted with neat diesel and biodiesel blends in a four stroke single cylinder direct injection diesel engine. The result showed that CO, PM and engine noise decreased and on the other hand, fuel consumption and NOx emission increased slightly by using biodiesel.

Keywords: Alternative fuel; Karamja seed oil; Biodiesel; Diesel engine combustion.

1. Introduction

At present the world is highly dependent on petroleum fuels for generating power, vehicle movement, agriculture and domestic useable machinery operations and for running different industries. Thus the demand of the petroleum fuel increases simultaneously. However the reserve of the petroleum fuel is limited. As a result, attention has gone to the search of renewable source of fuel which can meet the demand. In this context karamja seed oil can play a vital role as a substitute diesel fuel. karamja seed plant can be cultivated most economically in the barren land. The climate and soil condition of south Asia is also suitable for the production of this plant. Biodiesel is chemically known as “the mono alkyl fatty acid ester. It is renewable in nature and derived from vegetable oils or animal fats [1]. Vegetable oils may be an alternative renewable source of diesel fuel known as “biodiesel” which can be produced in locally in any country. Various renewable energy sources can be used for production of biodiesel, such as sunflower oil [2], rapeseed oil [3], palm oil [4] etc. Vegetable oils have higher viscosity, low volatility and cold flow properties that cause injector cocking, piston ring sticking, fuel pumping problem and deposit on engine. These problems limit the direct use of vegetable oil in engine in place of conventional diesel. However, the limitations can be greatly minimized by converting the vegetable oil into ester through esterification which is named as biodiesel. Biodiesel also causes significant reduction of brake thermal efficiency, higher specific fuel consumption and excessive NOx formation. By using biodiesel blend with conventional diesel, this problem can be greatly minimized.

2. Materials and methods

2.1 Transesterification process

Transesterification is the process of using an alcohol in presence of a catalyst such as sodium or potassium hydroxide, to break the molecule of the raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as a byproduct [5]. The process has been widely used to reduce the high viscosity of triglycerides. The basic reaction is one of transesterification in which the triglyceride molecule reacts with alcohol and form three ester molecules and one glycerol molecule. NaOH is used as catalyst as it is a rapid former of biodiesel. The methyl ester is separated from the glycerol by the gravity separation method. Methanol is removed by water washing system from the product to increase the flash point and the cetane number[6]. Finally different parameters for optimization of biodiesel production are investigated and it is found that the optimum combination for production of biodiesel from karamja seed oil is 0.45% NaOH, 20% methanol and a reaction temperature of 55°C.

2.2 Test procedure

A four-stroke single cylinder naturally aspirated stationary DI diesel engine is used. All experimental data are taken after 30 minutes of engine start after which the exhaust line temperature is no further increased i.e. constant and there is almost no fluctuation of emissions. This condition of the engine is chosen because of the consistent data at this condition. Tests are carried out at the warmed up condition of the engine at different engine loadings and at 600-1250 rpm. Loads are measured by electric dynamometer. The Maximum efficiency is obtained at 850 rpm with a load of 49N. Each time corresponding data of exhaust emissions and fuel consumption are measured and noted for the diesel and biodiesel blends. The volumetric blending ratio of biodiesel to diesel fuel is set at 10% to 30%. The diesel fuel used in this study is No. 2 diesel fuel with a lower calorific value of 43000 kJ/kg and cetane number of 50. A flue gas analyzer (IMR 1400) is used to measure carbon monoxide (CO) and NOx of exhaust gases. PM is measured by filter cloth method. Two-stage filtration is used to better separate the PM from exhaust. Two filters are weighed before setting these to the exhaust. Then these are set to the exhaust and the full flow of exhaust is passed through the filters. Again the filters are weighed with PM loading. The difference between the readings before and after their use indicates the PM in the exhaust at that condition. No significant increase in backpressure is developed during PM collection.

3. Results and discussions

3.1. Comparison of different parameters among diesel, biodiesel and Karamja oil

Table-1 illustrates the comparison of different parameters among diesel, biodiesel and Karamja oil. The cetane index of biodiesel is higher than the diesel which indicates a better combustion of biodiesel than diesel. The density, viscosity and higher heating value are found closer to diesel which indicates the importance of this fuel. The only disadvantageous properties that is found is the flash point, which is higher than the diesel; however, similar with other biodiesel.

Table 1. Comparison of different parameters of diesel, biodiesel and karamja oil

No.	Properties	Neat diesel	Karamja oil	Neat Biodiesel
1	Density (gm/cc)	0.86	0.945	0.87
2	Viscosity (c.st) @ 23ºC	4.98	8.10	6.22
3	Higher heating value (kJ/kg)	44579	*	38500
4	Cetane index	47	*	50
5	Flash point (ºC)	74	*	153

3.2. Effect of engine speed on efficiency

Figure 1 shows the variation of brake thermal efficiency with engine speed. It is seen that the brake thermal efficiency of engine increases with increasing engine speed at a constant load of 49N. With the further increase of the engine speed, the efficiency decreases. This is due to the fact that, initially with the increase of engine speed, the torque produced by the engine increases, hence the efficiency also increases. However at higher rpm (>850), more fuel is injected into the engine cylinder per cycle and due to higher speed, all the fuel can not burnt properly at short time, thus the efficiency reduces.

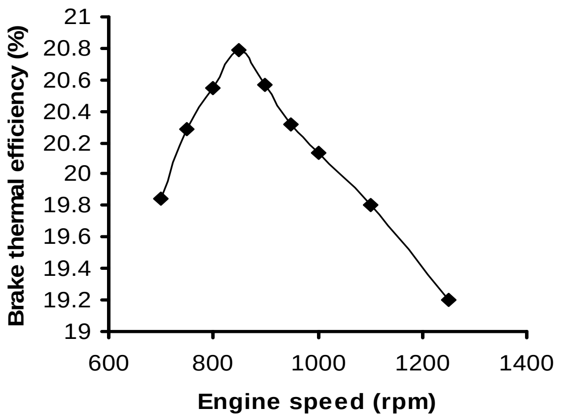

Fig. 1. Effect of engine speed on brake thermal efficiency. (Load 49N)

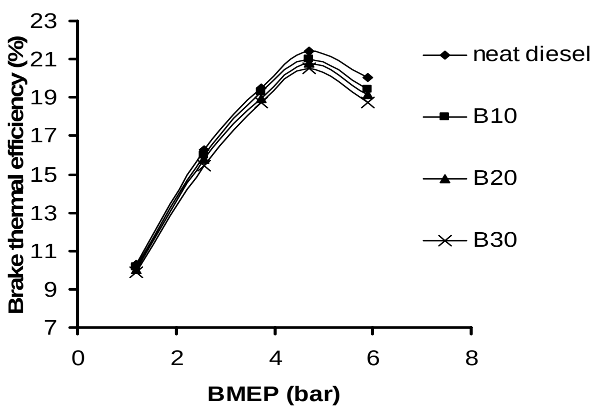

Fig. 2. Effect of BMEP on brake thermal efficiency. (Engine speed 850 rpm)

3.3. Effect of BMEP on efficiency

Figure 2 illustrates the variation of brake thermal efficiency with BMEP. It shows that the efficiency of engine increases with the increase of engine BMEP. Further increase of the BMEP causes the decrease of efficiency. Biodiesel blends have a lower efficiency than the neat diesel. For poor volatility, higher viscosity and higher density with biodiesel the fuel consumption increases and the efficiency decreases.

3.4. Effect of CO emission with engine BMEP

Figure 3 illustrates the variation of CO emission with engine BMEP. The CO emission for biodiesel is found to be lower than that of neat diesel fuel as biodiesel supplies an extra 10 to 15 % of oxygen. Due to the presence of extra oxygen, additional oxidation reaction takes place between oxygen and CO, this oxidation reaction lowers the CO emission producing extra CO_2 by complete combustion.

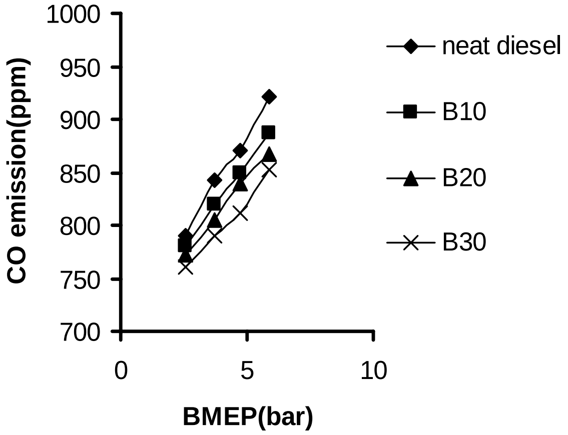

Fig. 3. Variation of CO emission with engine BMEP. (Engine speed 850 rpm)

3.5. Effect of BMEP on NOx emission

Figure 4 shows the variation of NOx emission with BMEP. It is seen that for biodiesel blends, the NOx emission is always higher than that for neat diesel fuel. Nitrogen is

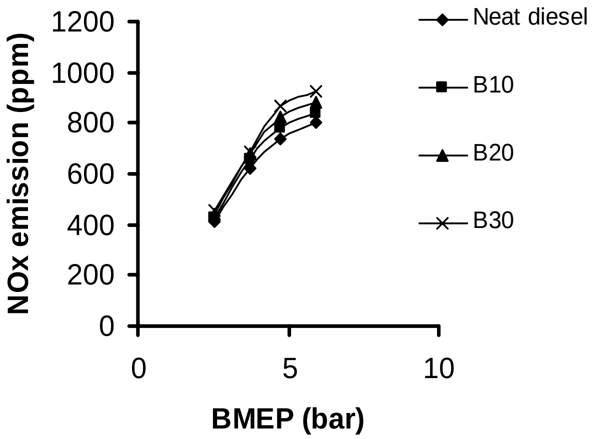

Fig. 4. Variation of NOx emission with BMEP. (Engine speed 850 rpm)

an inert gas upto a certain temperature level of 1100°C. At higher temperature above this level, nitrogen reacts with oxygen and form NOx. Since biodiesel contain excess amount of oxygen; this additional oxygen is responsible for extra NOx emission than that for the neat diesel.

3.6 Effect of BMEP on Particulate matter (PM)

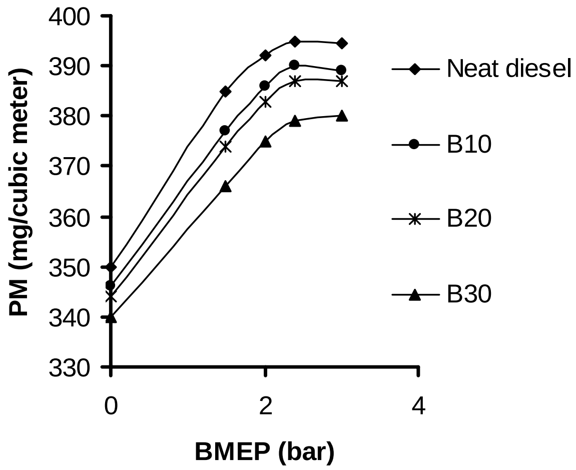

Fig. 5.Variation of PM with BMEP. (Engine speed 850 rpm)

Figure 5 illustrates the variation of PM with engine BMEP. Biodiesel contains more oxygen than diesel and it leads the proper combustion within the engine. This is why PM emission of engine is decreased by using biodiesel blends. At higher load PM emission is decreased. This might be due to the failure of agglomeration (a group of things put together in particular order and arrangement) of carbonaceous particulates in the engine as a result of the increase in temperature due to higher load.

3.7. Effect of engine speed on bsfc

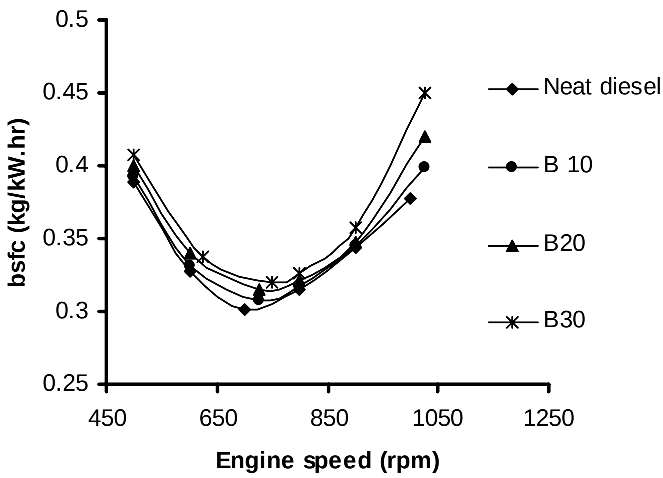

Fig. 6 . Effect of engine speed on bsfc. (Load 49N)

From figure-6 it is seen that the bsfc decreases with engine speed due to increase of the torque. However, after a certain engine speed the torque as well as power reduces and the bsfc increases. The bsfc for biodiesel blend is higher than the neat diesel due to lower power developed than the neat diesel. The average bsfc increase for B10 2.2%, 4.7% for B20 and 8.1% for B30 than diesel.

4. Conclusions

The following conclusions can be drawn from the investigation.

(i) Karamja seed is crushed for oil and a weight percentage of 22% oil is obtained by crushing of karamja seed.

(ii) Biodiesel is produced by transesterification process using methanol and NaOH from karamja seed oil.

(iii) A maximum of 96% ester (biodiesel) is obtained at a temperature of 55°C.

(iv)The properties of karamja seed biodiesel is determined and compared with those of conventional diesel fuel. The properties of biodiesel are very much closer to those of conventional diesel fuel. Thus, karamja seed oil may be considered as an important candidate of potential source of alternative fuel, for which further investigation is required.

(v) The addition of biodiesel in the blend causes an increase in NOx emissions, fuel consumption and a decrease in CO and PM as compared to the reference diesel fuel.

5. Nomenclature

CO	carbon monoxide
NOx	nitrogen oxide
CO_2	carbon dioxide
PM	particulate matter
DI	direct injection
bsfc	brake specific fuel consumption
NaOH	sodium hydroxide

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ESTIMATION OF WIND ENERGY POTENTIAL IN COASTAL AREAS OF BANGLADESH BY USING WEIBULL DISTRIBUTION

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ABSTRACT

Wind as a source of energy can hold good prospect for an underdeveloped country like Bangladesh. Bangladesh has fairly wind energy potential; exploitation of the wind energy is still in the crawling level. Modeling of wind speed variation is an essential requirement in the estimation of the wind energy potential for a typical site. The measured wind data are processed as hourly and monthly basis. Weibull probability density functions of the locations are calculated in the light of observed data and Weibull shape parameter and scale parameter are also calculated by three methods. A relative comparison is made between these methods by determining root mean square error (RMSE), correlation coefficient and coefficient of efficiency (COE). Finally, most fruitful site is selected for the utilization of wind energy potential from the studied locations.

Key words: *Wind energy, Weibull distribution, Wind power, Coastal area, Weibull parameter.*

1. INTRODUCTION

Bangladesh is situated in the latitude between 20°34' - 26°38'N and longitude between 88°01-92°4E. The country has a 724 km long coastal line along the Bay of Bengal. There are many islands in the Bay, which belongs to Bangladesh. The strong south /south-westerly monsoon wind coming from the Indian Ocean, after traveling a long distance over the water surface, enters into the coastal areas of Bangladesh. This wind blows over Bangladesh from March to September with a monthly average speed 3 m/s to 6 m/s. [1]. The wind speed is enhanced when it enters the V- shaped coastal region of the country. According to preliminary studies, (from meteorological department, BCAS, LGED, and BUET) winds are available in Bangladesh mainly during the monsoon and around one to two months before and after the monsoon (7 months, March to September). During the months starting from late October to February wind speed remains either calm or too low. The peak wind speeds occurs during the months of June and July [2]. There are many islands along the Bay of Bengal where the wind speed is quite high. Hence, these sites hold good prospect of extracting wind energy. The most important parameter of the wind energy is the wind speed. In statistical modeling of the wind speed variation, much consideration has been given to the Weibull two-parameter (shape parameter k and scale parameter c) function because it has been found to fit a wide collection of wind data [3].

2. WIND DATA:

In the present study, the objective is to statistically analyze of wind characteristics in some coastal region of Bangladesh and make a comparison between various methods to determine Weibull parameter. Wind data of some coastal areas in Bangladesh such as Kutubdia, Kuakata, Mongla, Sandwip and Teknaf from March to September, 2003 have been considered [4]. The wind data measured at ten minutes interval and then further processed to hourly time series.

3. METHODOLOGY:

Knowledge of the wind speed distribution is a very important factor to evaluate the wind potential in the windy areas. If the wind speed distribution in any windy site is known, the power potential and the economic feasibility belonging to the site can be easily obtained. To analyze wind characteristics, the simplest and most practical method for the procedure is to use a distribution function. Among various methods, the most common is the Weibull functions.

The Weibull distribution is characterized by two parameters: the shape parameter k (dimensionless) and the scale parameter c (m/s.) The cumulative distribution function (Weibull function) [5] is given by,

$$F(v) = 1 - e^{-(\frac{v}{c})^k} \quad (1)$$

And the Weibull density (probability density) function by [5],

$$f(v) = \frac{dF(v)}{dv} = (\frac{k}{c})(\frac{v}{c})^{k-1} \times e^{-(\frac{v}{c})^k} \quad (2)$$

There are several methods to calculate the Weibull parameter k and c such as, Weibull paper method, Standard deviation method, Energy pattern factor method etc

3.1 Weibull Paper Method:

In this method at first percentage of cumulative distribution have been calculated and these are plotted for corresponding wind speed. Then a straight line is drawn in such a way that it can cover maximum point and from this line an intersection with c estimation line gives the corresponding value of c for the desired location [5]. The value of k is found by measuring the slope of the line just drawn. It is found that the angle is equal to 74° with the horizontal, so k = tan74°. To facilitate the angle measurement, a simple geometrical operation can be performed; draw a second line through the previous point, and a perpendicular to the Weibull line. The intersection of this second line with the linear k-axis on top of the paper gives the desired k-value [5].

3.2 Standard-Deviation Analysis Method:

By determining the mean wind speed v_{mean} and standard deviation σ of wind data k and c can be obtained [5] by solving the following equation

$$\bar{v} = c \times \Gamma\left(1 + \frac{1}{k}\right) \quad (3)$$

The standard deviation of the distribution [5] is calculated with the equation,

$$\sigma^2 = \frac{\sum (V_n)^2 - \frac{\left(\sum V_n\right)^2}{N}}{N - 1} \quad (4)$$

The corresponding k value [5] can be found as the relative standard deviation of a Weibull distribution is **which** a function of Weibull shape factor, k.

3.3 Energy Pattern Factor Analysis:

The energy pattern factor K_E is defined by **Lysen**[5] as,

$$K_E = \frac{\text{Total amount of power available in the wind}}{\text{Power calculated by cubing the mean wind speed}}$$

The energy pattern factor [5] of a given set of N hourly data V_n can be determined with the following equation,

$$K_E = \frac{\frac{1}{N}\sum_{n=1}^{N}(V_n)^3}{\left(\frac{1}{N}\sum_{n=1}^{N}V_n\right)^3} \quad (5)$$

Using the previous expression the Weibull shape parameter k is easily found out as the energy pattern factor of a Weibull wind speed distribution is a function of the Weibull shape factor, k [5]..

4. ESTIMATION OF WIND POWER DENSITY:

The available power in the wind flowing at mean speed v_m through a wind rotor blade with sweep area A at any given site can be estimated as follows [3]:

$$P(v) = \frac{1}{2}\rho A v_m^{\ 3} \tag{6}$$

And the wind power density (wind power per unit area) based on the Weibull probability density function can be calculated as [3]:

$$p(v) = \frac{P(v)}{A} = \frac{1}{2}\rho c^3\left(1+\frac{3}{k}\right) \tag{7}$$

Where is *P(v)* the wind power (W), *p(v)* is the wind power density (W/m^2), ρ is the air density at the site = 1.21(kg/m^3), *A* is the swept area of the rotor blades (m^2), v_m is the mean wind speed at that location (m/s).

5. PREDICTION PERFORMANCE OF THE WEIBULL DISTRIBUTION MODEL:

For the analysis of wind speed data, the root mean square error (RMSE) and determination coefficient (R^2) [6] are used for statistically evaluating the performance of the Weibull probability density functions. These parameters [7] are calculated based on the following equations:

$$R^2 = \frac{\sum_{i=1}^{N}(y_i - z)^2 - \sum_{i=1}^{N}(x_i - z)^2}{\sum (y_i - z)^2} \tag{8}$$

$$RMSE = [\frac{1}{N}\sum_{i=1}^{N}(y_i - x_i)^2]^{1/2} \tag{9}$$

$$COE = \frac{\sum_{i=1}^{N}(y_i - x_i)^2}{\sum_{i=1}^{N}(y_i - z)^2} \tag{10}$$

Where, y_i is the i^{th} actual data, x_i is the i^{th} predicted data with the Weibull distribution, z is the mean of actual data and *N* is the number of observations.

6. RESULTS AND DISCUSSION:

Table 1, shows the mean wind speed for each Coastal region and it is found that among the entire region, Kutubdia has the maximum mean wind speed of 5.17 m/s and that of Sandwip is 5.12 m/s. As can be seen in Fig. 1, the mean wind speed varies from 2.6 m/s to 12 m/s. However, the maximum wind speed is obtained from the month of May to August.

Table 1: Mean speed for different locations

Location	Teknaf	Kutubdia	Sandwip	Kuakata	Mongla
Mean Speed (m/s)	3.22	5.17	5.12	3.58	3.44
Ranges (monthly)	2.4~4.71	2.95~12.02	2.3~8.3	2.03~5.26	2.4~4.74

Although the wind speed is maximum at Kutubdia but the wind speed at Sandwip is more stable, because the wind speed varies roughly in Kutubdia. So, Sandwip is more prospective for wind power extraction considering wind turbine overall performance.

6.1 Weibull Density Functions:

Weibull/Probability density functions are usually used to determine the wind speed distribution of a windy site in a period of time, which is also the relative frequency of wind speeds for that site. The comparison between calculated and observed Weibull density function for each location is presented in Fig 2. From this figure, it is found that the Weibull density function that are calculated by using three methods namely, Weibull paper method, energy pattern factor method and standard deviation method are fairly match with each other except for Kutubdia and Sandwip. This may be due to higher peak of wind speed existing in these locations and also due to wind speed fluctuation. Other locations have relatively lower wind speeds with minimum wind speed fluctuations.

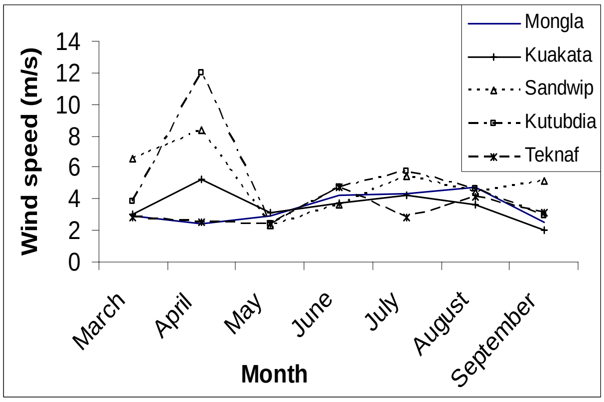


Fig. 1: Monthly wind speed variation

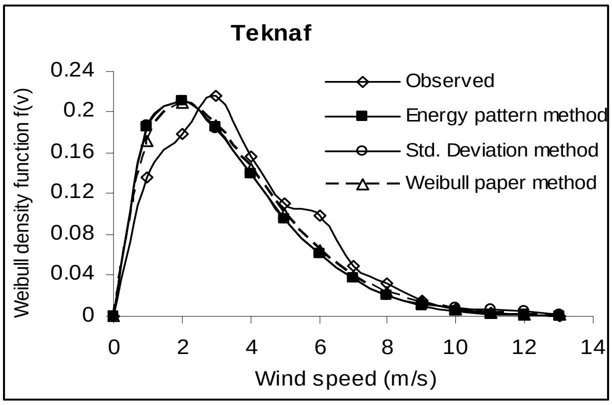


Fig. 2(a): Weibull density function f (v) for different locations.

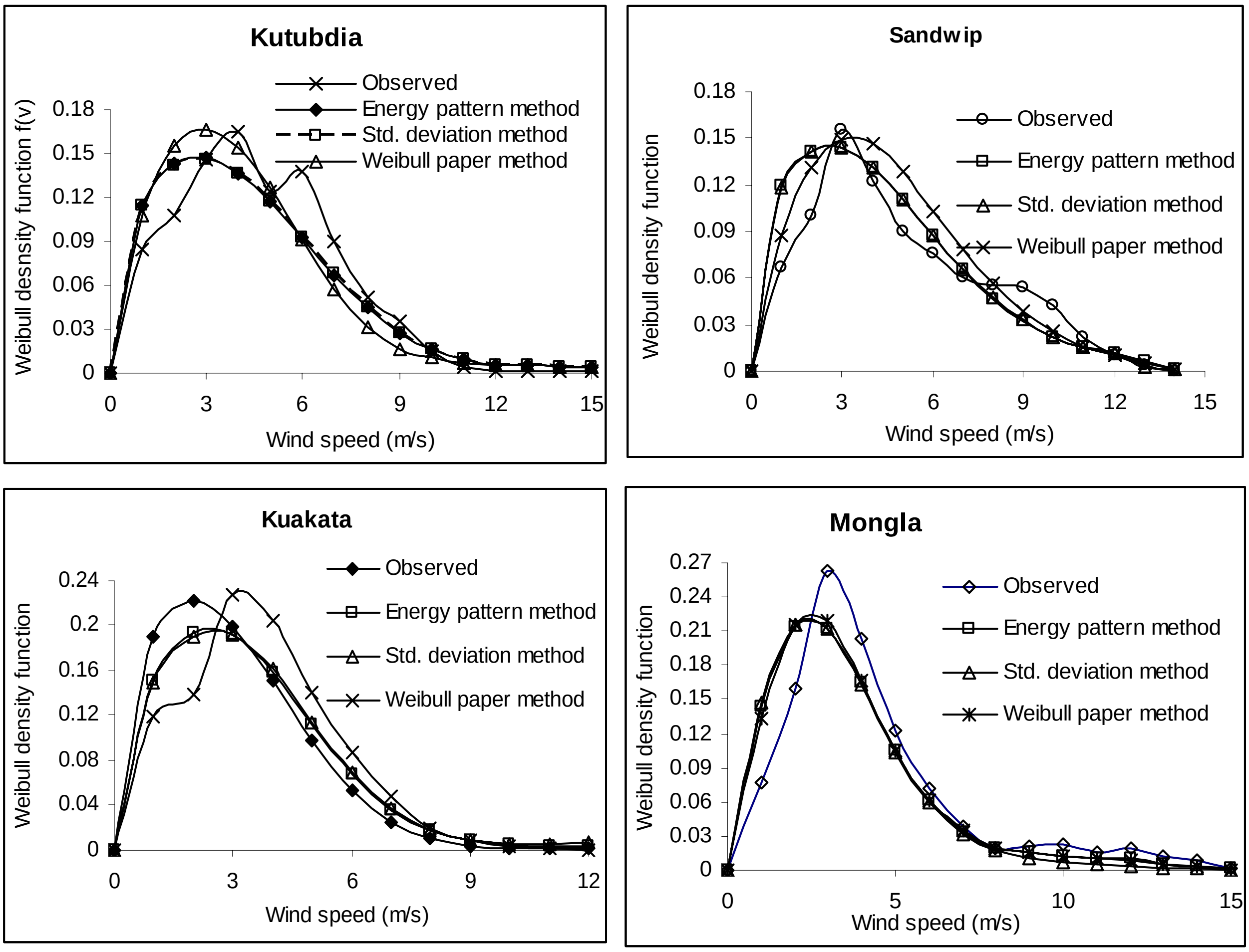
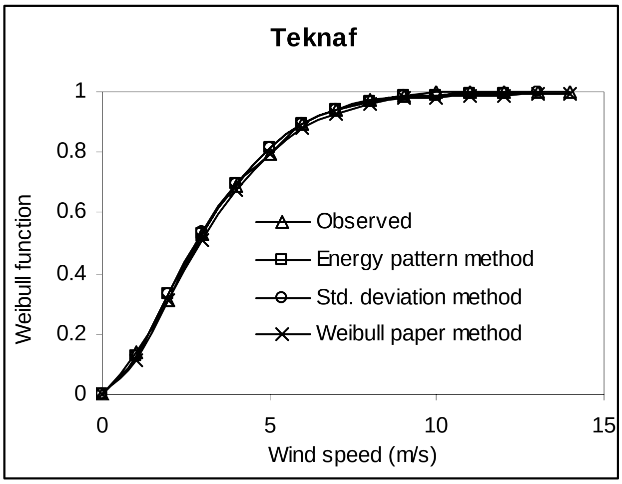
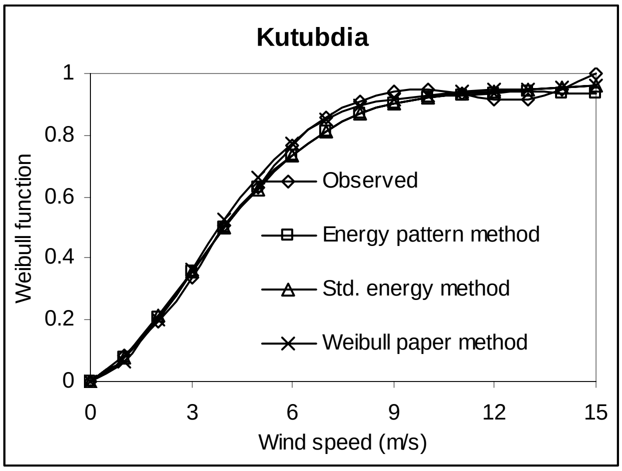


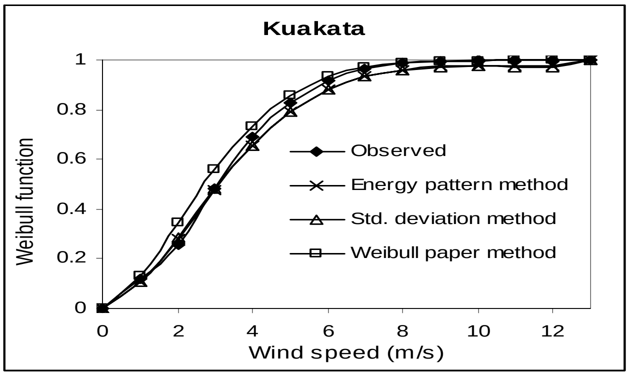
Fig. 2(b): Weibull density function f (v) for different locations.

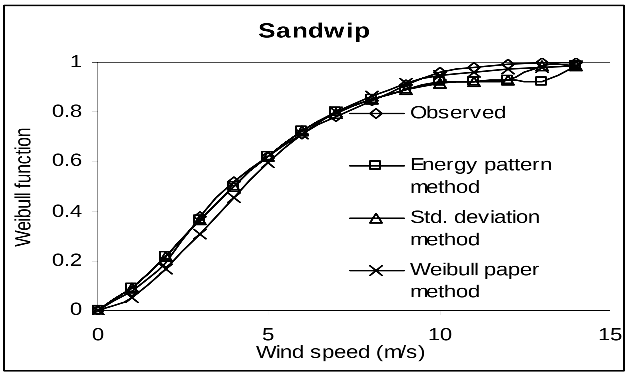
6.2 Weibull Functions:

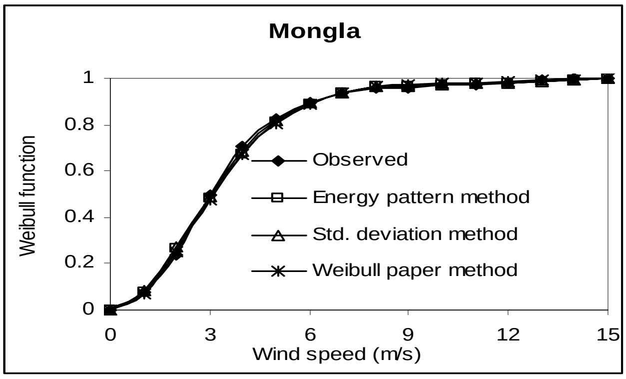
Weibull Function is the integration of Weibull Density Function. It is the cumulative of relative frequency of each velocity interval. The comparison between calculated (by using three methods) and observed Weibull function for each location is presented in Fig 3. From these figures, it is found that the observed and calculated data of Weibull function fairly match with each other.











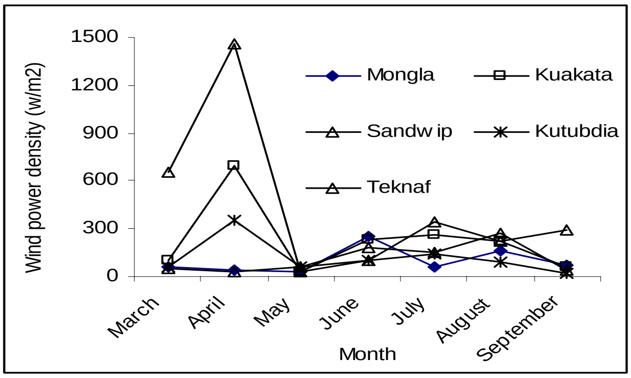


Fig. 3: Weibull function for different locations. Fig. 4: Wind power density for different locations

6.3 Wind power density:

It is an important parameter to find out the available power to use from any specific location. Higher wind power density indicates more potential about wind energy utilization. At the same time, it indicates the class of load that can keep peace with the specific location. Fig. 4 presents the wind power density for the selected coastal region of Bangladesh.

CONCLUSION:

In this study, assessments of wind characteristic for Coastal region of Bangladesh were made. The following conclusion can be drawn from the present analysis:

a) The mean wind speed (v_{mean}) for each location remains 2.5 to 5.17 m/s and highest two mean wind speed are found in Kutubdia (5.17m/s) and in Sandwip of 5.12 m/s respectively.
b) Although in the current study the wind speed is higher in Kutubdia but the wind speed is not so stable throughout the study period. In comparison with it, Sandwip has relatively stable wind speed. So, considering all these, Sandwip can be considered as more potential energy site. The

maximum wind power is obtained from Kutubdia which is 697.89 W/m^2 and that at Sandwip is 697.89 W/m^2.

c) The Weibull probability distribution scale parameters (c) are consistently higher in values and variability than the shape parameters (k) of monthly distributions.

d) The coefficient of determination between the measured wind speed data and the Weibull distribution function ranges between 0.475 to 0.792. The Weibull distribution function can be used with acceptable accuracy for prediction of wind energy output required for preliminary design and assessment of wind power plants.

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SYNTHESIS OF BIODIESEL FROM OILS OF JATROPHA, KARANJA AND PUTRANJIVA TO UTILIZE IN RICARDO ENGINE AND ITS PERFORMANCE & EMISSION MEASUREMENT

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Abstract
The production of biodiesel from three non-edible oils of putranjiva (Putranjiva roxburghii, a new source), karanja (Pongamia glabra) and jatropha (Jatropha carcus) by base catalyst method and their use in Ricardo variable compression diesel engine has been compared to evaluate better one for future purpose. The comparison of fuel properties, performance and emission characteristics of three biodiesels has been carried out in Ricardo Variable Compression Engine and evaluated for the best one for diesel engine application. Biodiesel of karanja (100% fatty acid methyl ester) gives best efficiency than putranjiva and jatropha but in case of blends jatropha gives best efficiency than others. Jatropha oil shows maximum reduction in emission and fuel economy than others. Exhaust gas temperature of biodiesel of jatropha is higher than karanja and putranjiva. Considering the results of fuel properties, performance and emissions, jatropha appears to be best as alternative fuel than putranjiva and karanja.

Key Words: *Comparison, Renewable energy, Transesterification, Performance & Emission*

1. Introduction

Increasing the consumption and price hike of petroleum fuel day to day is really problems for developing countries those are dependent on foreign suppliers and pay huge amount of import bill. During the last decade, the use of alternative fuel in diesel engines has received renewed attention. The uncertainty of petroleum-based fuel availability has created a need for alternative fuels [1]. Hence research on biodiesel as an alternative of diesel is in progress. Biodiesel is renewable fuel, it has simple technology of production, low handling hazards, emits low pollutants, and can be used in engine without substantial modifications [2]. The main source of biodiesel i.e. oil producing plant, can grow easily in wide range of geographic locations and flexible climatic conditions. Among the edible and nonedible vegetable oils, the nonedible oils such as jatropha, karanja, putranjiva etc are economical as biodiesel for its less consumption in domestic purposes. It is widely agreed that biodiesel decreases the emissions of hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM) and sulphur dioxide (SO_2). It is also said to be carbon neutral as it contributes no net carbon dioxide to the atmosphere [3]. Other countries have seriously considered the massive use of bioenergy in the future. China [4], Germany [5], Austria [6] and Sweden [7] have set goals of utilizing 10–15% of their internal primary energy supply through bioenergy up to the year 2020, where Vietnam has set a target of using bioenergy i.e. 37.8% of the total energy consumption [8].

Different researchers have tried to produce biodiesel from vegetable oils either by enzyme, acid or alkali [9]. Knothe et al [10] reported about 97.7% conversion to product in transesterification reaction within 18 minutes by using 1% KOH catalyst at 69^0C. Freedman et al [11] studied the transesterification reaction of sunflower and soybean oils at different temperature and different molar ratio. He got the conversion from 90 to 98%.

Literature shows already that many researches are done on non-edible vegetable oils such as jatropha, mahua, karanja, neem, etc. and edible vegetable oils separately to study the performance and emission characteristics of these in diesel engine. Jatropha, karanja and putranjiva plants are abundantly available in tropical and subtropical regions such as India, Bangladesh. The seeds from these plants go waste annually which can be utilize for biodiesel production and hence may solve partly fuel crisis problem. The present conventional fuel crisis has inspired the authors to compare the performance and emission characteristics of Ricardo variable compression diesel engine using transesterified oils of karanja, jatropha and putranjiva and select the best one for the use in diesel engine.

2. Materials and Methods

2.1. Materials

Oils of putranjiva, karanja and jatropha were obtained by mechanical pressing of seeds that were collected from Arabari forest (Midnapur, West Bengal, India). Methanol and Na_2SO_4 were purchased from Merck Limited (Mumbai, India). Wood chips were collected from local carpenter shop to prepare charred sawdust [12] for filtration of crude vegetable oils.

2.2. Fuel properties measurement

The physical and chemical properties of pure karanja, jatropha and putranjiva oils were measured and compared with diesel oil (table 1). The calorific value was measured by Bomb Calorimeter (Petroleum Instruments India Pvt. Ltd.) according to ASTM D-4809. The viscosity was measured by Redwood Viscometer (Petroleum Instruments India Pvt. Ltd.). The flash point and fire point were determined by Pensky-Martens apparatus closed-cup method (ASTM D-93). The pour point was measured according to ASTM D-97. Carbon residue was measured by Conradson Method (ASTM D-189). The cetane number was determined according to ASTM D-4737.

2.3. Transesterification of three vegetable oils

Transesterification of three vegetable oils was done by base catalyst. In transesterification process the oil was taken in a three necked round bottom flask and heated with stirring for 10 minutes continuously by Remi Stirrer at a temperature 100^0C to remove excess moisture. The weight ratio of oil:methanol was taken as 1:3. Sodium methoxide as base catalyst (1.5% of oil and methanol) was mixed well with methanol. The base-methanol mixture was added slowly with oil in the round bottom flask that was fitted with thermometer and condenser. The reaction mixture was stirred vigorously with heating for two hours at 67^0C. Then the mixture was cooled by ice water. Two layers formed, the upper layer was product layer and the lower layer was glycerol layer. The upper layer was taken in a separating flask and washed three times by distilled water to remove catalyst and methanol. The washed oil was stirred with anhydrous sodium sulphate and kept for three hours at room temperature for dehydration. The dehydrated oil was taken for properties, performance and emission measurement.

2.4. Measurement of Performance and Emissions

To measure emissions, automotive exhaust monitor of model PEA205 and smoke meter of model OMS103 has been used (Indus Scientific Pvt. Ltd, India). The Ricardo Variable Compression Diesel Engine has been used to run at different loads (0–2.7 kW) with constant injection timings (45^0 CA bTDC), constant speed of 1200 rpm, and at constant compression ratio of 20:1. The important specifications of the engine are as follows:

Number of cylinder	: Single
Make	: Ricardo & Co. Engineers Ltd., Shoreham, England
Type	: Four stroke
Bore	: 76 mm
Stroke	: 111mm
Speed	: 1000 to 3000 rev/min
Range of compression ratio	: 4.5:1 to 20:1
Range of timing	: 30^0 to 45^0 CA bTDC

3. Results and Discussion

3.1. Comparison of fuel Properties

The fuel properties of three transesterified vegetable oils and diesel are shown in Table 1. The kinematic viscosities of biodiesel of karanja, jatropha and putranjiva at 40^0C are more than diesel fuel. Pour point of biodiesel is not favorable in cold weather.

Table 1: Fuel properties of three biodiesels and diesel fuel.

Properties	Biodiesel (100% FAME)			Diesel
	Putranjiva	Karanja	Jatropha	
Viscosity in cSt (at 40°C)	5.81	5.81	5.42	5.03
Cetane Number	40.2	35.6	41.0	46.3
Calorific Value (kJ / kg)	39254	38119	39065	42707
Pour Point (°C)	2	5	2	-12
Specific Gravity at 25^0C	0.883	0.899	0.878	0.834
Flash Point (°C)	152	190	171	78
Fire Point (°C)	155	192	175	85
Carbon residue (%)	0.10	1.20	0.15	0.10

The flash point is better than diesel fuel for the engine application. The calorific value and cetane number of the three biodiesel are less than diesel fuel but are comparable with other biodiesels as reported by Rakopoulos et. al. [13]. In comparison of three vegetable oils jatropha shows better results in specific gravity, viscosity, cetane number, and pour point where as putranjiva is found better in calorific value, flash point and carbon residue. The difference in properties for different vegetable oils is due to variation of fatty acid composition and other associated compounds such as colouring matters, odorant compounds, etc.

3.2. Comparison of the Effect of Loads on the Performance of Biodiesels

The performances of three transesterified vegetable oils and diesel are shown in Fig. 1-2. It is observed that biodiesels of jatropha, karanja and putranjiva show higher in brake specific fuel consumption (BSFC) and lower in brake thermal efficiency (η_{bt}) than diesel fuel. Transesterified karanja oil (100%) has shown better efficiency than putranjiva and jatropha where as jatropha has shown better in BSFC. The differences in performance of different biodiesels are due to variation in combustion characteristics, specific gravity, cetane number and calorific value.

The blends of biodiesels and diesel show different results. Blend of jatropha biodiesel shows better performance (Table 2) than others. With increasing the percentage of blend the BSFC is increased and efficiency is decreased which is also reported by Raheman et al [14].

3.3. Comparison of the Effect of Loads on the Emission of Biodiesels

It is observed that with increasing loads, NOx emission is increased (Fig. 3). The NOx of biodiesel increases slightly with load where as diesel fuel shows a steady increase throughout the load. With increasing load, fuel consumption rate increase and hence more heat release during burning. NOx emission increases with increasing temperature of combustion chamber. Biodiesel has low calorific value than neat diesel and therefore the rate of increase of NOx is low with load than diesel fuel. With increasing the percentage of biodiesel in blends (Table 2), NOx emissions decrease that is due to decrease of the calorific value of blends and hence less exhaust gas temperature. Jatropha blends show lowest NOx emission than others. Hydrocarbon emission of biodiesel (Fig. 4) is lower than diesel that is due to better combustion of biodiesel. Higher percentage of biodiesel in blends gives less hydrocarbon emission. Smoke, CO and particulates (Fig. 5-7) of three biodiesel are lower than diesel fuel that indicate good impact on the environment and living beings. Higher concentration of biodiesel in blends (table 2) show lower CO emission because of higher ignition temperature of biodiesel than diesel give better combustion of blends and hence less exhaust emissions.

3.4. Exhaust Gas Temperature

The exhaust gas temperatures of different biodiesel at various loads are compared with that of diesel fuel (Fig. 8). The exhaust gas temperatures of 100 % biodiesel and its blends show always lower than that of diesel fuel. The exhaust gas temperature of blends decreases with increasing amount of biodiesel (table 2). This is due to less calorific value of biodiesel than diesel fuel. The exhaust gas temperature of 100% biodiesel of putranjiva shows higher than 100% biodiesel from karanja and jatropha. Blends of karanja (Table 2) show higher exhaust gas temperature than jatropha and putranjiva. This is due to difference in calorific value of oils and variation in combustion of blends.

4. Conclusion

Biodiesel from karanja oil, jatropha oil and putranjiva oil, pure or blended with diesel fuel, have shown very satisfactory results as alternative fuel for diesel engines. Out of the three biodiesels, jatropha is promising to yield good performance and low emissions at each load in all respects. Comparing the emission characteristics such as CO, NO_x, HC, smoke and particulates of three biodiesels, jatropha is very promising. Considering the above-mentioned points, it can be concluded that the diesel engine can run very satisfactorily using 100% of biodiesel at 45^0 bTDC timing, and at 20 compression ratio. Any diesel engine can be operated with 100% biodiesel as a prime mover without any modification of engine.

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Table2: Performance & emissions of blends of biodiesels and diesel fuel at 2.04 kW.

Biodiesel	Percentage in blends	BSFC (g/kWh)	η_{bt} (%)	HC (ppm)	CO (%)	NOx (ppm)	Smoke (Hu)	Particulate (mg/m^3)	Exhaust temp (^0C)
Putranjiva	10	268	31.7	111	0.037	118	8.1	17.8	210
	30	314	27.5	102	0.034	108	7.3	17.1	206
	50	332	26.5	89	0.032	91	6.7	14.4	201
	70	345	25.9	78	0.031	83	5.9	12.5	197
Karanja	10	311	27.4	116	0.023	99	6.4	18.9	222
	30	320	27.2	104	0.018	86	4.9	18.3	207
	50	325	27.4	95	0.017	78	4.2	17.6	202
	70	328	27.8	84	0.014	72	4.0	17.1	186
Jatropha	10	282	30.2	105	0.019	76	4.4	15.4	170
	30	286	30.3	93	0.017	71	4.1	14.8	167
	50	295	29.9	87	0.014	59	3.8	14.0	166
	70	302	29.68	71	0.011	56	3.2	12.6	162
Diesel	100	272	30.9	120	0.058	80	10.5	22.7	234

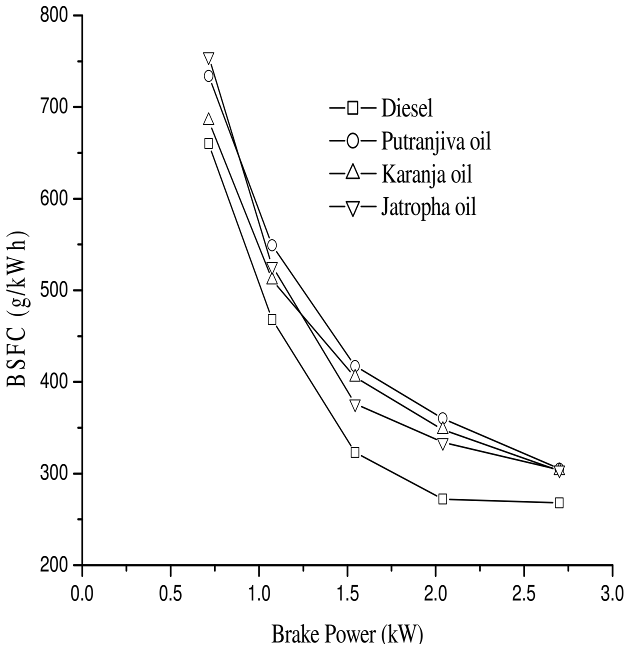

Fig. 1. Brake specific fuel consumption vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

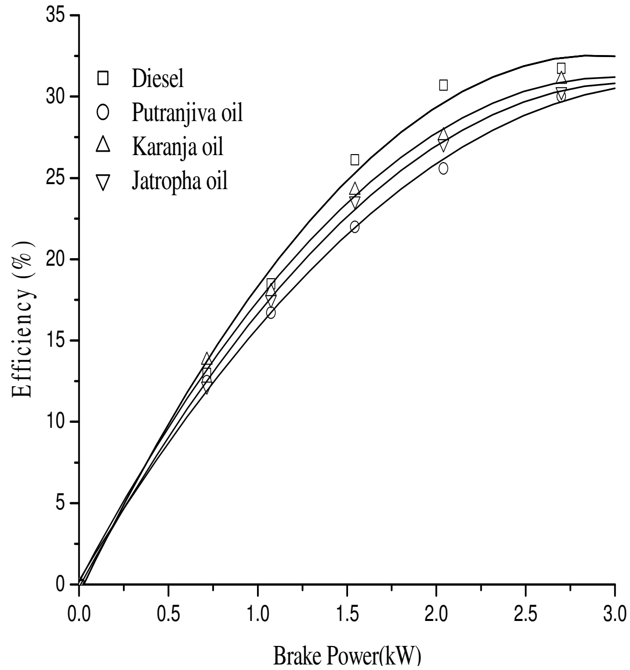

Fig. 2. Brake thermal efficiency at various brake power of diesel fuel, 100% biodiesel of jatropha, karanja and.

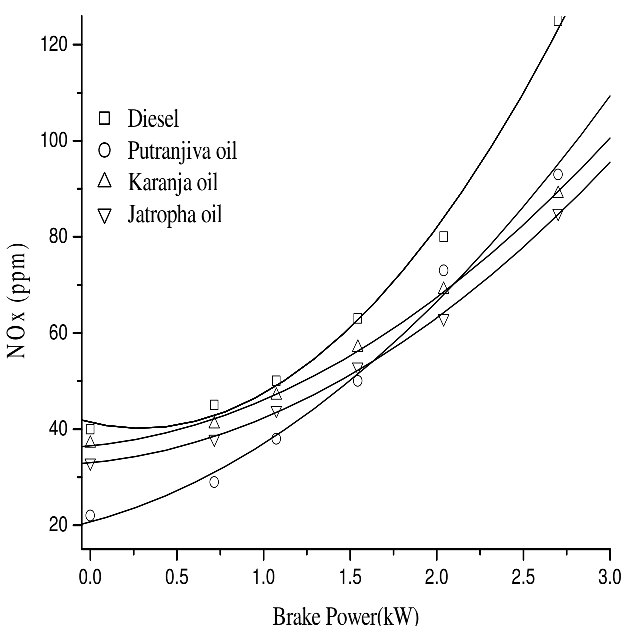

Fig. 3. Nitrogen oxide vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

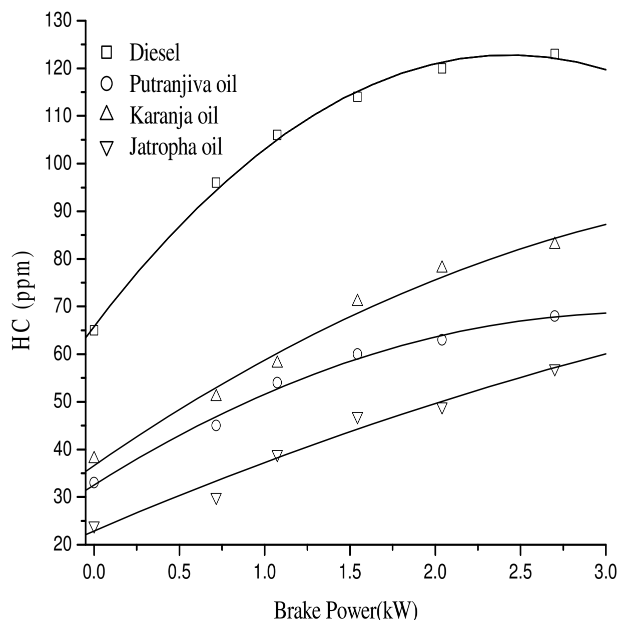

Fig. 4. Unburned hydrocarbon vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

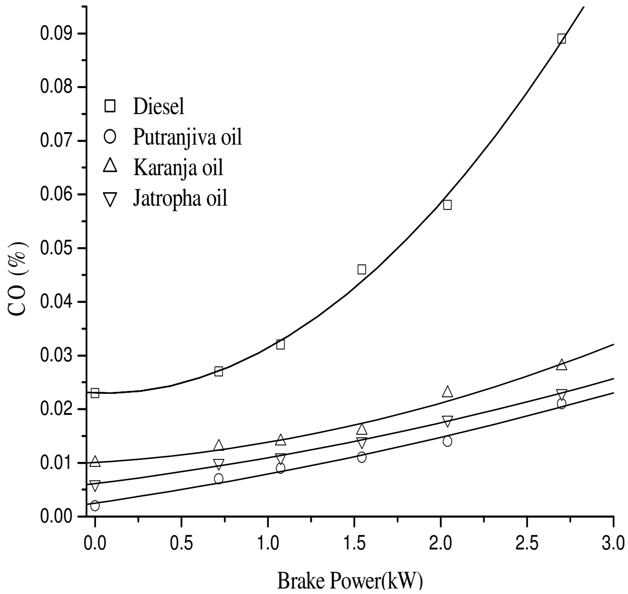

Fig. 5. Carbon monoxide vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

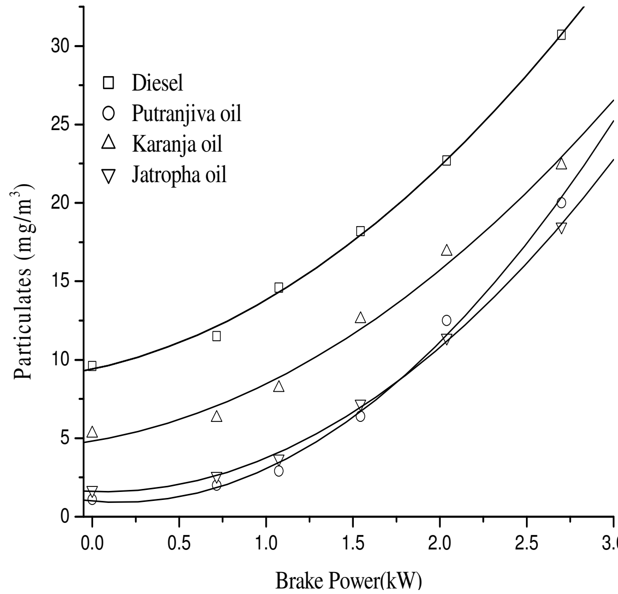

Fig. 6. Particulates vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

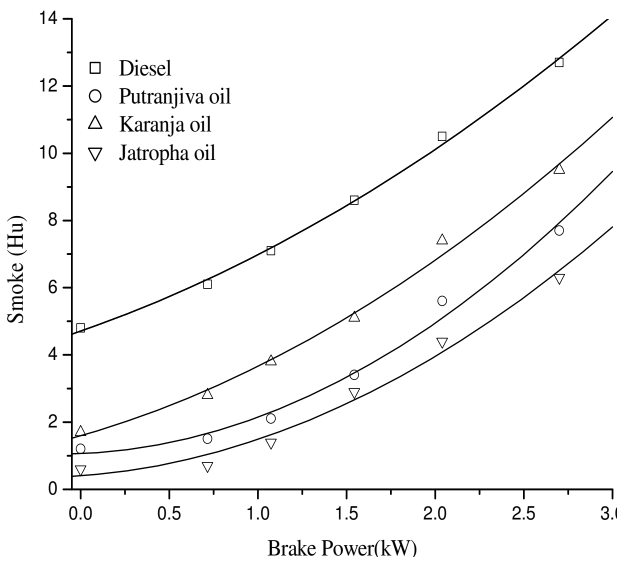

Fig. 7. Smoke vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

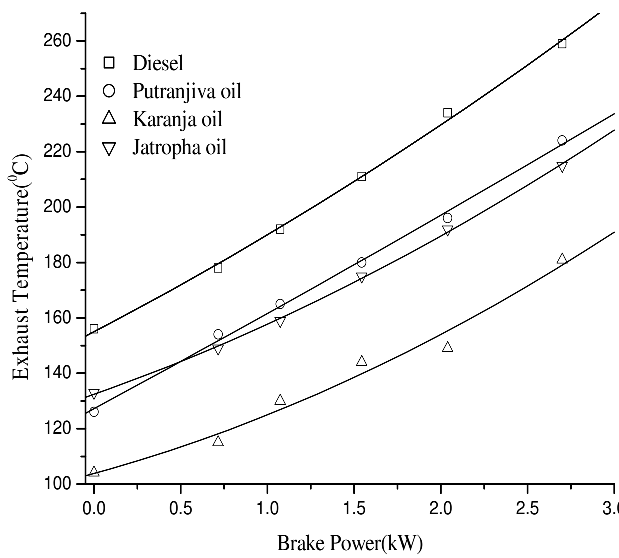

Fig. 8. Exhaust gas temperature vs. brake power of diesel fuel, 100% biodiesel of jatropha, karanja and putranjiva.

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FIRST GENERATION BIODIESEL PRODUCTION FROM NON EDIBLE VEGETABLE OIL AND ITS EFFECT ON DIESEL EMISSIONS

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ABSTRACT

This paper reports on biodiesel production and discusses experimental results from a laboratory performance study using biodiesel blends in a diesel engine. The biodiesel used is based on a non edible neem oil and using transesterification process a maximum of 94% biodiesel has been produced with methanol at a molar ratio of 6:1. The engine experimental results show that exhaust emissions including carbon monoxide (CO) particulate matter (PM) and smoke emissions have been reduced for all biodiesel blends. However, a slight increase in oxides of nitrogen (NOx) emission has been experienced for biodiesel blends. With 50% biodiesel blend (B50) it has been found that CO, smoke and PM have been reduced by 31%, 34% and 30% respectively compared with those of neat diesel fuel. On the otherhand, B50 has resulted in a 10% increase in NOx emission. The carbon deposit on the injector nozzle has been found lower with all biodiesel blends.

Key words: *Neem oil, biodiesel, diesel engine and exhaust emissions.*

1. INTRODUCTION

Biodiesel is an alternative to the conventional diesel fuel and produced from renewable resources such as animal fats, waste cooking oils, yellow grease and all kinds of edible and non edible vegetable oils. Biodiesel may be produced in several ways (1), but the most common technique is transesterification. In this process, glycerides in the fat or oil are reacted with an alcohol in the presence of a catalyst to produce esters and glycerin. Specifically, the oil and fat are most often reacted with methanol or ethanol in the presence of a catalyst like sodium hydroxide or potassium hydroxide to form methyl or ethyl esters and glycerin. In the sense that different feedstocks have diverse fat and oil (2), this process may require various amounts of alcohols and catalyst to generate esters as well as byproducts (e.g. glycerin) with a range of quality attributes. Biodiesel is a fuel that can be blended easily with fossil diesel fuel and offers several advantages over diesel fuel. Biodiesel reduces sulfur emissions, enhances lubricity and has engine cleaning properties (3).Previous studies(4-5) have investigated the effect of biodiesel on engine performance. It has been found that biodiesel reduced regulated emissions including CO, total unburnt hydrocarbon (THC), and PM except NOx. Knothe et al (6) investigated diesel emissions with biodiesel introducing exhaust gas recirculation (EGR). They found that PM, THC and CO emissions were reduced with biodiesel compared with neat diesel. Their results also showed that NO*x* emissions were slightly increased with commercial biodiesel and technical grade methyl oleate, while methyl laurate and methyl palmitate as well as dodecane and hexadecane led to a slight decrease of NO_x emissions compared to the neat diesel fuel.

The purposes of this work are as follows:
1. To produce laboratory test quantity of biodiesel (methyl ester) from non-edible neem oil
2. To determine the fuel properties of the biodiesel fuel
3. To compare the performances of a diesel engine using neat diesel fuel and biodiesel blends.

2. PROCEDURE FOR BIODIESEL PRODUCTION BY TRANSESTERIFICATION PROCESS

To produce a test quantity of biodiesel neem oil was first filtered to remove impurities the oil. Lye catalyst, sodium hydroxide (NaOH) was added in methanol and shaked well so that the NaOH is completely dissolved in alcohol. The alcohol-catalyst mixture was then charged in a blender, where neem oil was added. The whole mixture was stirred well. The blend was then heated to a temperature from 50 to 70 ^{0}C. Reaction time was varied from 2 to 24 hours. Samples of the mixture were extracted at one hour interval and the total glycerin level of the ester fraction was measured. The same procedure was repeated with ethyl alcohol (C_2H_5OH) and potassium hydroxide (KOH) as catalyst as well.

2.1 Washing of biodiesel

Biodiesel was washed to remove the products like soap, catalyst and other impurities. After separating the unwashed biodiesel and glycerin, water was added to biodiesel and stirred well. During stirring a white cloudy substance was formed at the bottom of the tank. This cloudy liquid was separated carefully and heated the unwashed biodiesel to 100 ^{0}C to drive off the remaining amount of water.

3. EXPERIMENTAL SETUP AND PROCEDURE OF EXPERIMENTATION

The engine used in the experiments was a single cylinder, water-cooled, naturally aspirated (NA), 4-stroke, DI diesel engine. The specifications of the engine are shown in Table 1. The experiments were conducted with conventional diesel fuel and biodiesel. The properties of fuels are shown in Table 2. The engine speed was measured directly from the digital tachometer attached with the dynamometer. The outlet temperatures of cooling water and exhaust gas were measured using thermocouples (Ni-Cr), which has been attached to the corresponding passages. The dynamic fuel injection timing was set at 13º BTDC (before top dead center). The exhausts emissions were measured with a portable digital gas analyzer (IMR 1400). The engine speed was kept constant to 1250 rpm. The engine experiments were carried out at medium load condition (0.45 MPa). An inclined water tube manometer, connected to the air box (drum), was used to measure the air pressure. Fuel consumption was measured by a burette attached to the engine setup. A stop watch was used to measure the fuel consumption time for every 10 cm^3 fuel. Each data reading was taken three times and the mean of the three is taken for final reading.

4. RESULTS AND DISCUSSION

4.1 Effect of Temperature on Biodiesel Production with Methanol and Ethanol

Figure 1 shows the effect of temperature on biodiesel production using methanol and ethanol as alcohols. For methanol, the molar ratio was optimized at 6:1, while for ethanol the molar ratio

Table 1 Specification of tested engine

ITEMS	SPECIFICATION
Model	S 195
Type	Single cylinder
Aspiration	Naturally aspirated
Bore × stroke (mm)	95 × 115
Rated output	9.8 kW / 2000 rpm
Compression ratio	20
Type of cooling	Water evaporative
Injection pressure	13.5 MPa
Number of holes	01

Table 2 Properties of tested fuels

Test property	Neat Diesel	B100
Viscosity at 40°C (cP)	6.8	8.8
Density at 25°C (g/cc)	0.82	0.84
Heating value (MJ/kg)	44.5	40.1
Cetane number	49.0	51.0
Carbon mass (wt%)	86.8	76.7
Hydrogen (wt%)	13.1	12.1
Oxygen (wt%)	0.00	11.15
Sulfur (wt%)	0.042	<0.004
Distillation (90%) °C	344	357
Total glycerin (%)	-	0.26
Free glycerin (%)	-	0.02
Acid value mg/g	-	0.76

was optimized at 10:1. The optimization was mainly based on maximum biodiesel production. Using methanol the maximum biodiesel yield was observed at 6.5 hours reaction time, while for ethanol it was about 8 hours. For both alcohols, NaOH was used as catalyst and its percentage was kept constant to 0.7%. It can be seen from the Figure that with the increase in reaction temperature, biodiesel yield is increasing. A maximum of 94% biodiesel yield was observed with methanol at a reacttion temperature of 60°C, while for ethanol 88% biodiesel yield was observed at 75°C. Biodiesel yield is decreasing at higher temperatures. This is associated with the vaporization of methanol and ethanol because the boiling points of methanol and ethanol are 64 and 76°C respectively. Compared with ethanol, methanol gives higher biodiesel yield, because there is higher percentage of hydrogen in ethanol than that of methanol, thus the formation of water with ethanol is higher. The higher amount of water with ethanol produced more wax.

4.2 Effect of Temperature on Biodiesel Production with NaOH and KOH

Figure 2 depicts the biodiesel production at different temperatures with two different catalysts NaOH and KOH. Methanol was used as alcohol instead of ethanol. As optimized earlier for maximum biodiesel yield, the molar ratio of methanol and oil was kept at 6:1 and the percentage of NaOH was kept at 0.7% while it was kept constant at 1.0% for KOH. From the figure it is found that biodiesel yield is lower when KOH is used as catalyst. This is associated with better phase separation when NaOH is used. As a result less amount of biodiesel was found when KOH was used. Purity of the catalyst also affects the biodiesel yield. The purity of NaOH is higher than that of KOH. Purity caused lower quantity of biodiesel production with KOH.

4.3 Emissions with Neat Diesel Fuel and Diesel Biodiesel Blends

Figure 3 depicts the variations of CO emission with neat diesel fuel and biodiesel blends. Engine CO emissions are reduced with increasing biodiesel percentage in the diesel fuel. It is well known that the engine CO emission steadily increases with decrease of air fuel ratios. Low volatility of biodiesel inhibits lean mixture formation in the combustion chamber. Also oxygen content in the biodiesel molecule suppresses local fuel air rich regions. It is seen from the figure that with B50 blend, engine CO emission is reduced by 31% compared to the CO emission with neat diesel fuel.

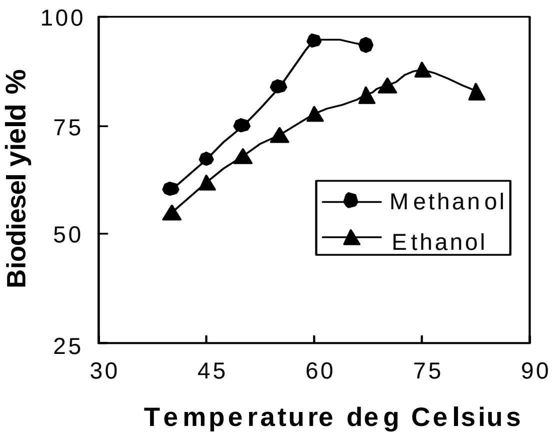


Fig 1. Biodiesel yield with methanol and ethanol (molar ratio of methanol to oil=6:1, NaOH= 0.7%, reaction time 6.5 hrs, molar ratio of ethanol to oil = 10:1, NaOH = 0.7%, reaction time 8 hrs)

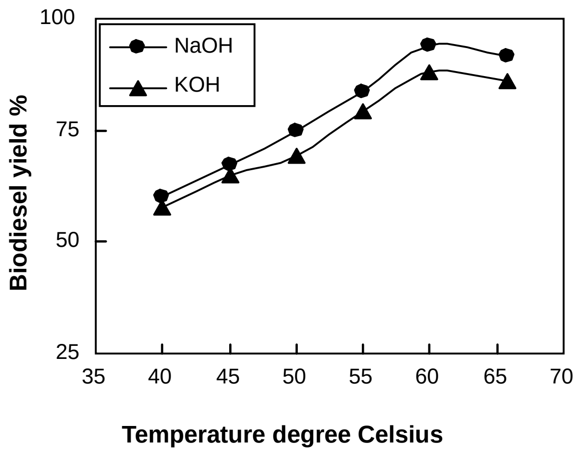


Fig 2. Biodiesel yield with NaOH and KOH with methanol (molar ratio of methanol to oil=6:1, NaOH=0.7%, reaction time 6.5 hrs, KOH=1.0%, reaction time 6 hrs)

Figure 4 shows the smoke emission with neat diesel fuel and biodiesel blends. Smoke number is closely related to the PM emission. Lower smoke emission means lower PM emission and vise versa. It is clearly seen from the figure that smoke emissions with all biodiesel blends are reduced compared to the smoke emission with neat diesel fuel. The smoke emission is reduced by approximately 34% with B50 blend. The reason for lower smoke emission from all biodiesel blends is due to the presence of oxygen in the molecular structure of biodiesel, which results in improved combustion and less PM formation.

Figure 5 illustrates PM emission with 100% diesel fuel and biodiesel blends. It can be seen from the figure that the PM emission is decreased with the increase in biodiesel percentages. The reduction in PM emission with biodiesel blends is mainly due to better combustion as the biodiesel blends contain extra oxygen, burning soot particle more efficiently in the combustion chamber. A maximum of 30% PM emission reduction is achieved with B50 blend.

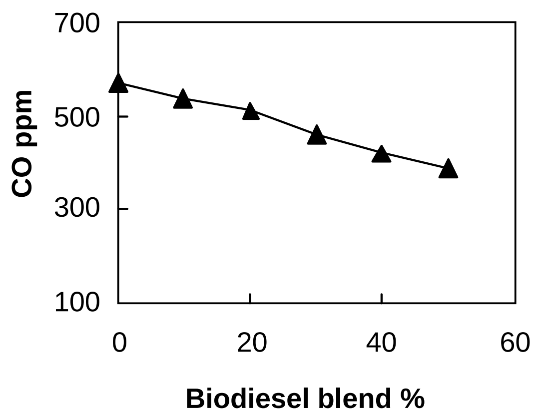


Fig 3. Variation of CO emission with biodiesel blends (BMEP = 0.45 MPa)

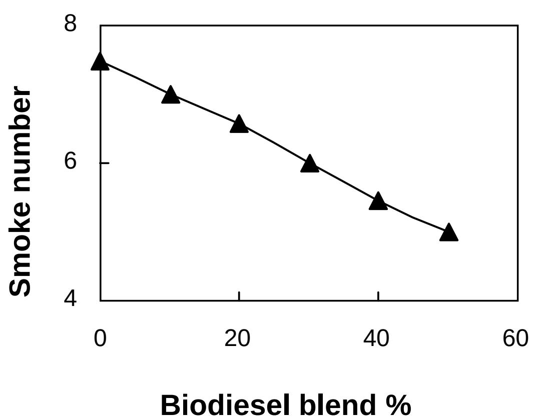


Fig 4. Variation of smoke emission with biodiesel blends (BMEP = 0.45 MPa)

Figure 6 shows the NOx emissions of neat diesel fuel and blends of biodiesel. Naturally NOx emission increases with the increase in engine load. It is well known that nitrogen is an inert gas, but it remains inert up to a certain temperature level, above this level it participates in the chemical reaction producing NOx. During the combustion, the flame temperature inside the engine cylinder rises abive 1000^0C. At this temperature, oxidation of nitrogen takes places in the presence of oxygen inside the cylinder. On the other hand, the formation of nitrogen oxides do not attain chemical equilibrium reaction at the end of the expansion stroke when the burned gases suddenly are cooled. The formation of NOx then freeze the concentration of the formed NOx in the exhaust gas remains unchanged. Figure 6 shows that NOx emission is higher for biodiesel blends than that of neat diesel fuel for the same engine load. Compared with neat diesel fuel, about 10% increase of NOx emission with B50 blend is experienced. This result is almost identical with the result of Canakci et al. (7). The increasing of NOx emission with B50 blend is associated with the oxygen content in the B50 blend. Neat biodiesel contains about 10% to 12% oxygen in its molecule. This additional oxygen is responsible for higher NOx emission. The B50 blend has more double bonds than neat diesel fuel, which may be an additional reason to increase NOx emission.

Figure 7 exhibits the carbon deposit in the injector nozzle tip with neat diesel fuel and different biodiesel blends. For this test, a fresh injector was first weighted. Then the engine was run several hours with neat diesel fuel and biodiesel blends. After that the injector was dismantled from the engine and weighted again. The weight difference is the weight of carbon deposit. It is seen from the figure that all biodiesel blends show lower carbon deposit in the injector nozzle tip. This results may help to explain why smoke emissions are reduced with biodiesel blends.

Figure 8 presents the photographic images of the piston crown. The images were taken with a digital camera. The piston was dismantled from the engine after running the engine for four hours with 100% diesel fuel and biodiesel blends. It is seen from the Figure that carbon deposit is formed at the piston crowns and from the photographs it is a bit difficult to see the difference, however a careful visualization with naked eyes it is clear that the piston crowns are less darker with biodiesel blends.

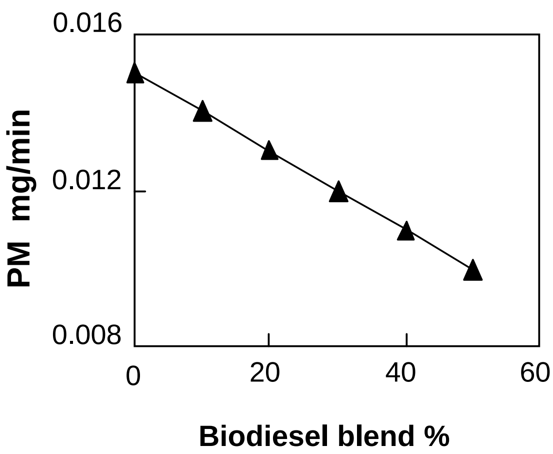


Fig 5. Variation of PM emission with biodiesel blends (BMEP = 0.45 MPa)

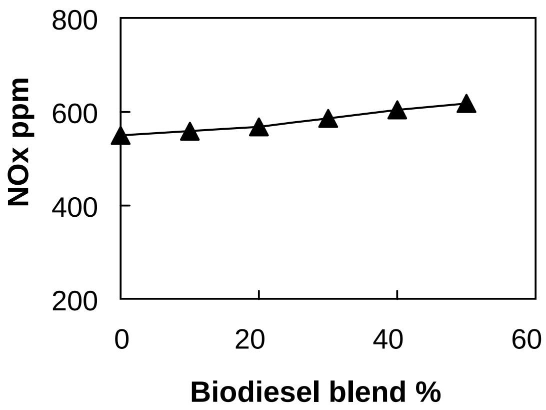


Fig 6. Variation of NOx emission with biodiesel blends (BMEP = 0.45 MPa)

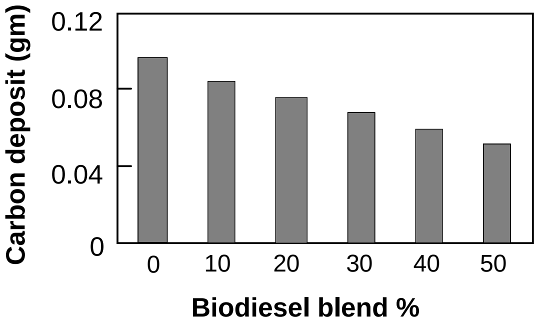
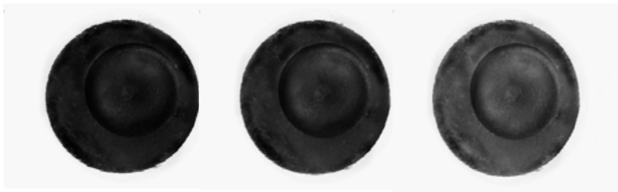


Fig 7. Carbon deposit on injector nozzle tip with biodiesel blends



Neat diesel **B10** **B50**

Fig 8. Photographic images of piston crown with 100% diesel fuel and biodiesel blends

5. CONCLUSIONS

This report investigates parameters for optimization of biodiesel production and performance study of diesel engine with diesel fuel and biodiesel blends. The results of this work can be summarized as follows:

1. The production of biodiesel was done with transesterification process. The methanol and ethanol was used separately to produce biodiesel. A maximum of 94% biodiesel production was found at 20% methanol and 0.7% NaOH.
2. The optimum reaction time for maximum biodiesel production with methanol and NaOH was observed to be 6.5 hours.
3. Almost similar trends were observed for biodiesel production when ethanol was used as alcohol instead of methanol. Like both alcohols, biodiesel production trends are almost identical when KOH was used as catalyst. However, methanol and NaOH gave increased biodiesel production.
4. Biodiesel blends showed less CO, PM, smoke emissions than those of neat diesel fuel. NOx emission with biodiesel blends showed higher values when compared with neat diesel fuel. Compared to the neat diesel fuel, B50 reduced PM, smoke and CO emissions by 30%, 34%, 31% respectively, while 10% increased in the NOx emission was experienced with the same blend. The reason for reducing three emissions (PM, smoke and CO) and inceasing NOx emission with biodiesel blends is due to the presence of oxygen in their molecular structure. Also low aromatics in the BD blends may be an additional reason for reducing these emissions.

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ROLE OF BIOMASS BRIQUETTING IN THE RENEWABLE ENERGY SECTOR AND POVERTY DIMINUTION FOR BANGLADESH

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ABSTRACT

Bangladesh is a developing country whose poverty level decreased from 70% to 40% since 1970 to 2000. Almost 1% per year of the population went down to poverty level due to industrialization and higher agricultural production rate for green revolution and improved irrigation system to all over the country but recently the energy crisis over the world and increasing trend of fossil fuel prices are again amplifying the poverty level. Although biomass resources are abounded in Bangladesh but lack of effective and economical use of these resources, reduce the demand of Bio energy by 28.4%. Biomass briquetting is a process of densification of losses biomass to ensure effective use of loose biomass and at the same time reduce the pressure on poverty by creating 150,000 direct and indirect job opportunities as operators, technicians, seller etc. This technology is also helping indirectly for woman empowerment and ensuring their strong participation in the development of national economy by reduction of 70% to 80% fuel collection time. Although different briquetting system were tested in the laboratory scale and estimated that alternative options may lead to establish this technology into maturate level and reduce production cost from Tk. 2.07 per kg to Tk. 1.75 per kg depending on raw materials cost, operation cost and energy cost. The analysis indicated that biomass briquetting cannot diminution poverty but it accelerates the power of poverty reduction that is much needed for developing countries like Bangladesh.

KEY WORDS: ***Biomass, Briquetting, Renewable Energy***

1. INTRODUCTION

Increase In Bangladesh per capita income was US$ 417 in 2005 for about 135 million people in 147,570 sq km [1]. The people in Bangladesh have to struggle lot for livelihood and food security although the evidence showed that the poverty level declined in national level 40% and rural level 44% in 2000 from 70% to 80% since the year following its independent in 1971 [2]. Among all the influencing factors to decline the poverty level the most important indentified factors are green revolution of agriculture and NGOs activities. Although the urban and rural livelihood and the food consumptions pattern depends on the availability of resources, population pressure and natural calamities but in Bangladesh after introduced high yield agriculture crops by the government and NGOs, the economical condition of the urban and rural people expanded since 1980. World Bank reported in 2000 that in 1997 per capita energy consumption was 197kgoe (kg oil equivalent) in Bangladesh where as 443kgoe for

Asia and 1692 for world therefore Bangladesh recognized as a lowest energy consumption country in the world. It is found that in 2001 about 15% household under national electric network and 3% household under natural gas network [3]. Biomass is mainly agriculture and forest residues that become major source of Energy for about 65% rural livelihood in Bangladesh and near about three fourth population of the whole country depends on this sector for their cooking, crop drying and winter heating. The total contribution of biomass energy in the total national energy consumption is found about 70%. Direct burning of biomass energy is very inefficient and also difficult to transport and storage due to its high bulk density. Biomass Briquetting is a densification process of loose biomass to increase its net calorific value per unit volume, eliminate the problems of transportation, storage, residual disposal and uniform shape and make biomass available for verities of application such as cooking, gasification etc [4-8].

Present survey showed that some district cities of Bangladesh like Gaibanda and Sirajgong although the price of briquette is 60% to 70% more then wood but the tea stalls, restaurants and student housings would like to use briquette for its better combustion characteristic. Therefore government and NGOs participation can help to establish this technology all over the country. Although many Nongovernment organizations (NGOs) are working for poverty diminution and ensure livelihood obligatory but only in early 2000 and after few years Grameen Shakti (GS) was involved under Renewable Energy Technology Asia (RETs in Asia) program to broaden out this technology but any remarkable achievement did not achieve on it. Although this technology introduced in Bangladesh in 1980s and many government institutes conducted research to develop this technology and also encourage for adaptation but still now this technology under threat due to following problems [4, 9–11]

- Rapid Screw wearing during operation.
- High electricity consumption during operation.
- High moisture contain in the raw materials.
- Availability of raw materials
- Smoke formation due to partial burning the surface of the briquette.

Repairing by high strength material electrode such as XHDN 6715 can reduce rapid screw wear and improve life up to 22 hrs, alternative driving option (diesel engine option) may reduce the operational cost up to 20%, drying system can be used to reduce the moisture from raw material and improved quality of products, different raw materials such as rice straw, wheat straw, bagasse and sawdust may be use to ensure the availability of raw materials and smoke sucker can be used to improve the room environment and treat sucked smoke to reduce air pollution but to create a market for developed technology is an important factor for its adaptation in national wide [7, 8, 10]**.** Therefore aim of this paper is to develop an economical analysis to identify its strength as a tool of poverty reduction.

1.1 BIOMASS BRIQUETTING TECHNOLOGY

Biomass briquetting is known as high compaction technology or binder less technology in which biomass residues are compressed under high temperature and pressure. This residues are contain lignin that is a non-crystallized aromatic polymer with no fixed melting point but at 200–300°C, lignin starts to become soft, melted and liquefied. At high pressure lignin will glue cellulose together and solidified and formed briquette [5,12-13]. The piston press and the screw press are common technologies for biomass briquetting for India and Bangladesh to produce briquette from loose biomasses but the flow diagram to produce briquette almost similar for all processes (Fig.1) [10, 13-14].

In the Biomass Briquetting processes the compression take place under 200^0C to 250^0C inside taper die and produce denser and stronger briquettes than those produced by piston presses. It is observed that to produce higher quality briquettes pre-heating is a very suitable option. This process also reduces 15% to 30% power consumption and lowering wear on dies and screws and increased screw life time up to 44 hrs during briquetting. The production rate increased up to 340 to 360 kg/hr [5, 10, 13-17].

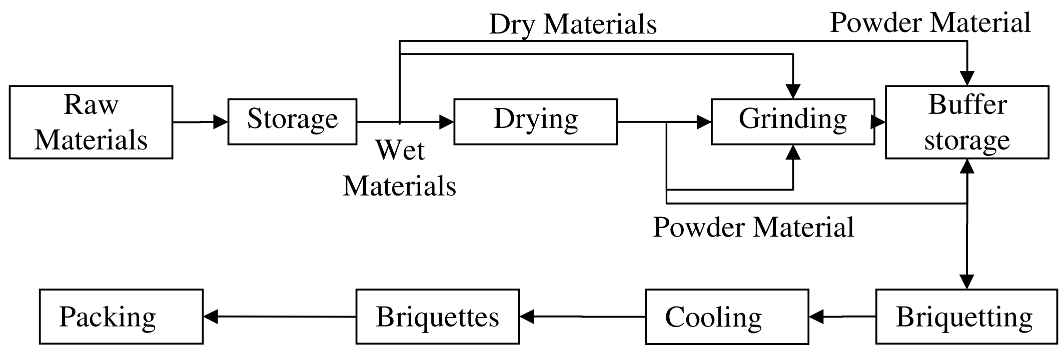

Fig 1: Flow Diagram of Biomass Briquette Production

1.2 BIOMASS AND BIOMASS BRIQUETTING MACHINE IN BANGLADESH

The consumption of Biomass energy is found as dominant over commercial energy and its supply increased by more than 30 % between 1980 to 2000 (Fig 2) but the demand of biomass energy decreased 28.4% from 1980 to 2000 because of its bulk volume, storage facilities and transportation problem, and high moisture content [18].

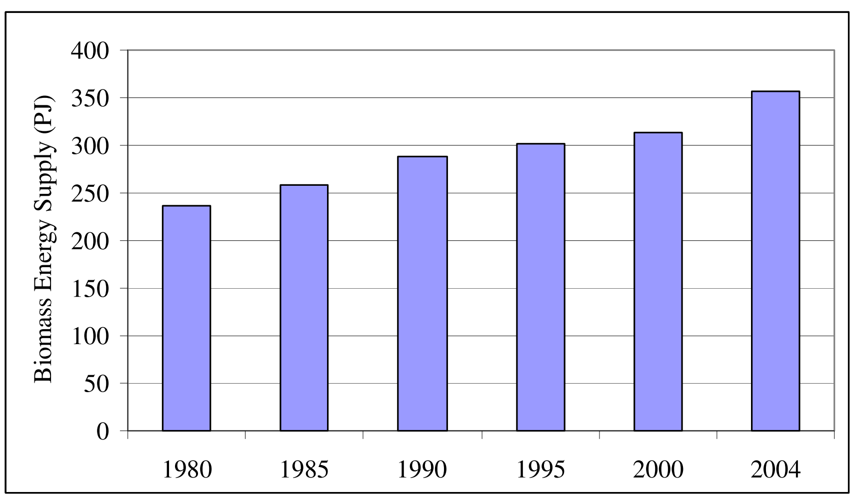

Fig 2: Biomass Energy Supply since 1980 to 2004 [20] (Ahiduzzaman, 2007)

The extensive use of biomass as an alternative source of energy would reduce the dependence on natural gas, LPG and other petroleum products. Bangladesh is an agricultural country, about 15% households have access to electricity, and about 3% have connected with natural gas network to fulfill the demand of energy [19]. Bangladesh has large quantities of agricultural and forestry residues e.g. rice husk, rice straw, saw dust, bagasse, coconut shell, peanut shell, etc. those are the major source of energy for 75% of the total population traditionally used as roofing material, cooking foods, cattle feed, raw materials for paper mills etc (Tab 1).

A small amount of residues are using for energy production but remainder finds no practical use and wasted. Normally the residues have high moisture content, low bulk density and low heat release per unit volume which made this resource use option infeasible.

Tab 1: Estimate of Energy Supply by Traditional fuel [19]

						000' tons of coal equivalent		
Year	**Dung**	**Jute**	**Rice**	**Ba**	**Fuel**	**Twig**	**Others**	**Total**
1980	1530	466	3211	580	360	1076	891	8114
1985	1670	363	3521	581	435	1270	1053	8893
1990	1866	396	4126	653	425	1325	1096	9887
1995	2018	435	4301	602	529	1325	1183	10397
2000	2046	374	4436	572	604	1473	1255	10760

It is also found that in 2006 production of rice husk was 12477.89 million tons, sawdust was 17,760 million tons, rice straw was 11128930.23 million tons and bagasse was 1377.75 million tons as a source of biomass energy that was more than in the previous years (Tab 2).

Tab 2: Production of Biomass Residues since 1980 to 2005

000' M.tones

Year	Rice	Rice Husk	Rice Straw	Sugar Cane	Bagasses
1980	20,821.00	5971.915	5326302.33	6,676.00	1669.00
1985	22,556.00	6469.55	5770139.53	6,878.00	1719.50
1990	26,778.00	7680.512	6850186.05	7,423.00	1855.75
1995	26,399.00	7571.806	6753232.56	7,446.00	1861.50
2000	37,628.00	10792.53	9625767.44	6,910.00	1727.50
2001	36,269.00	10402.74	9278116.28	6,742.00	1685.50
2002	37,593.00	10782.49	9616813.95	6,502.00	1625.50
2003	38,361.00	11002.77	9813279.07	6,838.00	1709.50
2004	36,236.00	10393.27	9269674.42	6,484.00	1621.00
2005	39,796.00	11414.36	10180372.09	6,423.00	1605.75
2006	43,504.00	12477.89	11128930.23	5,511.00	1377.75

Source: FAO and calculation factor from [21]

By using residues it is estimated that more than 18,000 briquetting machines can run with these residues but study showed that presently in Bangladesh about 1,000 machines are operating haphazardly all over the country.

Screw press with heated die biomass briquetting machine is well introduced in Bangladesh to the low capital group business man for small-scale applications. The raw materials for briquetting are parboiled and boiled rice husk, these feed into hopper is conveyed and compressed by screw and produce briquette which outer surface black due to partial burning. The capacity of the briquetting machine has found about 90 kg/hr and driven by a 20-hp or less power (1 horse power or hp = 746 W) electrical motor or higher power diesel engine (Tab 3 and Fig 3). Pre-heater of raw materials and smoke removal system around the die heater is incorporated to the whole system to improve the efficiency and environmental conditions [4, 5, 10-11, 22].

1.3 BIOMASS DEVELOPMENT POLICIES

The development of easy access biomass energy can ensure the energy security and also improve the power of purchasing by a segment people. Therefore, the government of Bangladesh is already adopted a broad policy measures in the National Energy Policy. Most of the people in Bangladesh lives in the rural area and involves in economics activities and agricultural production so the energy need of the rural area are given priority by the government. Mix biomass fuels are playing an important role for the rural energy sector for many years for rural sector of Bangladesh. Therefore in the national energy policy is mainly highlighting [23].

1. Develop renewable energy projects and training facilities for NGOs and private investors.
2. Assessment potential of establishment of renewable energy projects.
3. Increase the affordability of the rural people to access in the renewable energy sector by under reasonable price.
4. Encourage NGO and private sector to investment in the renewable energy sector

Table 3: Different power option to drive Biomass Briquetting Machine

Description	Electrical System		Mechanical System	
	1	2	3	4
Rated Power (KW)	15.0	11.0	20.0	15.0
Rated RPM	1470.0	1450.0	2200.0	2200.0
Actual Power Consumption (KW)	13.3	9.4	9.0	7.5
Efficiency (%)	88.5	85.5	45.0	45.0
Net weight	132.0	112.0	220.0	180.0

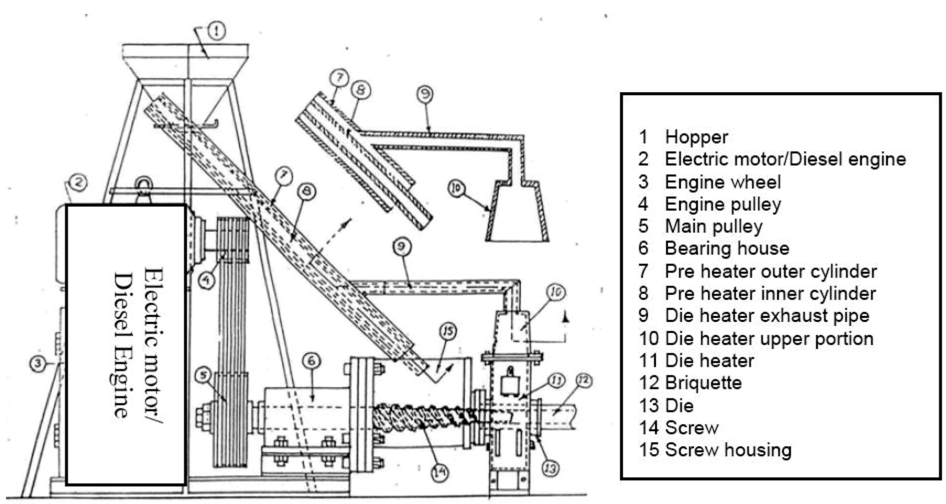

Fig 3 : Improved Biomass Briquetting System (Moral, 2000).

2. ECONOMIC ANALYSIS

The cost of energy was identified as a major barrier to achieve sustainability for biomass briquetting technology. Alternative facilities diesel engine as source of power and briquette burning die heater for heating die were developed and tested. The laboratory test showed that using alternative facilities could help to reduce 50% cost of briquette production. The production cost of Briquette for alternative option was Tk. 1.75/kg. Where as under the previous option it was Tk. 2.07/kg [4-11]. The analysis is based on 10 hours of operation per day and 25 days per month and a number of assumptions: machine life of 10 years, screw life of 222 hours and interest rate of 10%. Tab 4 shows the results of the economic analysis.

Tab 4: Outcome of Economic Analysis of Briquetting system Electric System Diesel System (Moral, 2000).

	Electric System	Diesel System
Total production cost of 90 kg of briquette	186.70	157.50
Sales price of 90 kg briquette (Taka)	225.00	225.00
Net profit (one hour)	38.30	67.50
Net profit per day	383.00	675.00
Net profit per year	114900.00	202500.00
Pay back period	0.64 Years	0.35 Years
Benefit cost ratio	1.2	1.43

On the other hand Biomass Briquetting can create 54,000 direct job opportunities as plant technician, operators and workers and another 100,000 indirect job opportunity as sellers. The emission of pollutant during combustion of Biomass Briquette is less compare to loose biomass therefore it will help us to improve the environment and also help deforestation.

3. BIOMASS ENERGY AND POVERTY ALIVATION

Various factors have been undefined to diminution of poverty since 1970s. The economic growth is clearly one of the factors to achieve this goal. In 1970s were the actual decline in per capita GNP marked about 0.8% a year, the trend per capita rates was increasing order in subsequent years, reached 3.8% a year in 1996-97 [24-26]. The important and most powerful change was Green Revolution in agriculture. Literature showed that in the 1970s and 1980s major gains in agricultural sector that bulldoze our poverty and put into declined trend. The rapid expansion of irrigation by shallow tube-well influences the growth the agriculture production which risen the cropping intensity from 142% in 1970 to 175% in 2000 [19]. Recently the poverty reduction mechanism is under thread due to rapid increase of fossil fuel price because the irrigation depends on the fuel price. Although there is no direct linkage between biomass energy and irrigation but effective and efficient use of biomass can improve the social economic of the rural people. One study showed conducted in Jessor Bangladesh and found that 91.5% energy supply in the household sector from Biomass sector and about 97% women were responsible for cooking, among them 91% of them also involved fuel collection [27]. So effective and efficient use of biomass will help to empower woman to extract more time for others economical activities consequently the socio-economical condition will be changed.

In addition, the investment for single Biomass Briquetting machine is about TK 50000.00 and it create 3 to 4 peoples direct job opportunity and also 5 to 6 peoples indirect job opportunity as briquette seller. Therefore only from 12477.89 and 1377.75 thousand tones of rice husk and Bagasses, more than 18,000 briquetting machines can run successfully that will create more than 54,000 direct job opportunity and 100,000 indirect job opportunity.

4. CONCLUSIONS

The following conclusion can be drawn from the above analysis

1. The production of Biomass Briquette is calculated TK.2.07 per Kg for the existing system and TK.1.75 for the alternative options from which the owner can received benefit Tk. 400.00 to Tk. 675.00 per day after paying the labour charge Tk.150.00 to 200.0 per day.
2. The pay back for the small scale Biomass project will be 5 months to 8 months depending on the operating system, raw material cost and operating cost.
3. The Biomass Briquetting can create 150,000 indirect and direct job market as an operator, technician and seller that will be help for economic development of the country as well as poverty elimination.
4. The raw material of Biomass Briquetting is mainly rice husk, sawdust, bagasses and straw which have got very high bulk density. Therefore, this process will ensure the effective use loose biomass resources as fuel source.
5. The enhancement of the biomass briquetting system not yet matured in Bangladesh although Bangladesh is known as Agricultural base country and produce about 13,000 thousand M. tones of agriculture based waste in each year that is suitable for Biomass briquetting.
6. The effective use of Biomass briquetting in the rural area will help women empowerment and they can take participant in the national development by developing alternative source of income.

It is clearly visualize that Biomass Briquetting can't directly diminish poverty from the society but it may be reduce some pressure and influence to diminish the poverty and consequently develop our national economy.

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ADSORPTIVE SOLAR SPACE COOLING- A CASE STUDY FOR THE CLIMATIC CONDITION OF ORLY, FRANCE

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ABSTRACT

The study investigates the performance of an adsorption chiller driven by solar collector panel with heat storage. A mathematical model describing solar collector, adsorption unit, room conditions and heat storage conditions has been employed to achieve human comport on the climatic conditions for the City Orly, France. It is seen that heat storage is more effective than the direct solar coupling; however, it requires more collectors depending on the size of storage tank. It is found that thermal comfort is achieved for human beings to keep the room temperature below 23 °C during a summer day in Orly. It is also found that 16 collectors (each of 2.415m^2) are required to provide cooling in day and night with heat storage for the base run conditions.

KEY WORDS: *Solar heat, solar collector, air-conditioning, adsorption, heat storage*

1. INTRODUCTION

Nowadays, adsorption refrigeration and air conditioning cycles have drawn considerable attention due to its ability to be driven by low temperature heat source and for the environmental aspects as it uses environment friendly refrigerants. The advantage and development of adsorption cycle is widely studied by Meunier [1]. Extensive studies have been conducted by various researchers for the development of adsorption technology [2-5].

Adsorption technology is very attractive to produce necessary cooling by utilizing low temperature heat source. There are many rural areas in under develop or developing countries where electricity is not available, however, cooling specially ice is essential for those area to preserve some medicines or foods. Adsorption cooling with solar coupling could be the way to fulfill those requirements. From the various study [6-7], it is seen that the solar energy can be used effectively to produce ice as well as to produce effective cooling for air conditioning purpose.

The present study investigates the performance of an adsorption air conditioning system driven by solar heat where CPC solar panel is used. The heat is reserved in a tank and then it used to drive the chiller. Various options have been studied to demonstrate the effect of system parameters on its performance as well as on the room temperature.

2. SYSTEM DESCRIPTION

The basic adsorption cycle consists of two adsorbent beds, one condenser and one evaporator. A panel of CPC solar collectors is used on the roof top of the building to drive the adsorption unit. The heat transfer fluid is heated by the collector and goes to the adsorption chiller to desorb the refrigerant vapor and the goes to heat storage reserve tank. From the

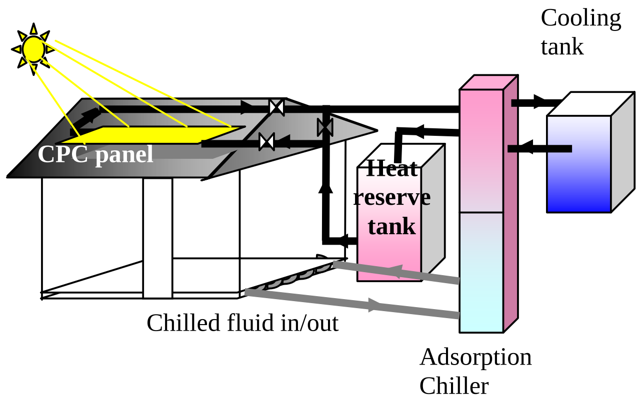

Fig.1 Schematic of solar driven adsorption space cooling

storage tank, the heat transfer fluid goes to the channels of collectors to gain more heat. The principle of basic adsorption cycle is elsewhere available in literature [5]. A schematic of an adsorption air conditioning cycle driven by solar heat is presented in Fig.1.

3. MATHEMATICAL MODELING

3.1 Adsorption Unit

A lumped parameter model is exploited to investigate the performance of the cycle. It is assumed that the temperature, pressure and concentration throughout the adsorbent bed are uniform. With these assumptions the energy balance equation for the adsorbent bed can be expressed as,

$$\frac{d}{dt}\left\{\left(W_M C_{pM} + W_{ac} C_{ac} + W_{ac} q C_{ml}\right) T_{ab}\right\} = Qst \cdot W_{ac}\frac{dq}{dt} + \delta \cdot W_{ac} C_{mv}\frac{dq}{dt}\left(T_{eva} - T_{ab}\right) + \dot{m}_f C_f \left(T_{ab,in} - T_{ab,out}\right) + U_{loss} AS_{ab}\left(T_{am} - T_{ab}\right) \quad (1)$$

$$T_{ab,out} = T_{ab} + (T_{ab,in} - T_{ab}) EXP(-UA_{ab}/\dot{m}_f C_f) \quad (2)$$

Where, δ equals to zero or one depending whether adsorbent bed is working as desorber or adsorber.

The condenser and evaporator energy balance equations are same as those of Clausse et al.[8].

3.2 Solar Unit

The energy balance for the each collector can be expressed as:

$$W_{cp}\frac{dT_{cr}}{dt} = \gamma\left\{\eta_i A_{cr} I + \dot{m}_{f,cr} C_f \left(T_{cr,in} - T_{cr,out}\right)\right\} + (1-\gamma) U_{loss} A_{cr}\left(T_{am} - T_{cr}\right) \quad (3)$$

γ is either 1 or 0 depending on day or night. The collector efficiency is calculated from the equation (4) which is derived from the collector manufacturer data:

$$\eta_{SC} = 0.75 - 2.57\left(\frac{T_{HW} - T_{am}}{I}\right) - 4.67\left(\frac{T_{HW} - T_{am}}{I}\right)^2 \quad (4)$$

The solar irradiance has been evaluated from the following equation:

$$I = I_{max} Sin\left(\frac{\pi(t - t_{sunrise})}{(t_{sunset} - t_{sunrise})}\right) \tag{5}$$

The reserve tank energy balance can be expressed as:

$$\left(W_{tm}C_{tm} + W_{wt}C_{w}\right)\frac{dT_{wt}}{dt} = \dot{m}_{w}C_{w}\left(T_{d,out} - T_{wt}\right) + U_{tloss}AS_{rt}\left(T_{am} - T_{wt}\right) \tag{6}$$

3.3 House Unit

The energy balance equations for room and room floor energy balance are as follows:

$$MC_{room}\frac{dT_{room}}{dt} = UA_{wall}\left(T_{am} - T_{room}\right) + UA_{window}\left(T_{am} - T_{room}\right) + E\dot{V}\left(T_{am} - T_{room}\right) + \dot{Q}_{int} + U_{floor}A_{floor}\left(T_{floor} - T_{room}\right) \tag{7}$$

$$MC_{floor}\frac{dT_{floor}}{dt} = U_{floor}A_{floor}\left(T_{room} - T_{floor}\right) + \dot{m}_{chill}C_{f}\left(T_{floor,in} - T_{floor,out}\right) \tag{8}$$

The ambient temperature is calculated from the correlated equation from the given set of data of ambient temperature. The system performance equations are cited at Clausse et al.[8].

4. RESULTS AND DISCUSSION

The set of differential equations have solved numerically and the input data for beds, collectors and materials property are also same as Clausse et al. [8]. The input data for Reserve tank is presented in Table 1. The climatic data of Orly, a city near Paris, France for a typical day in July has been presented in Fig.2.

Table 1 Input value for the reserve tank

Symbol	Definition	Value
W_{tv}	tank volume	1.3^3 m^3
A_{wt}	outer surface area	$6x1.3^2$ m^2
W_{tm}	metal weight	A_{wt}x0.005x2700 kg
W_{wt}	Weight of water	(W_{tv}x1000-10)kg

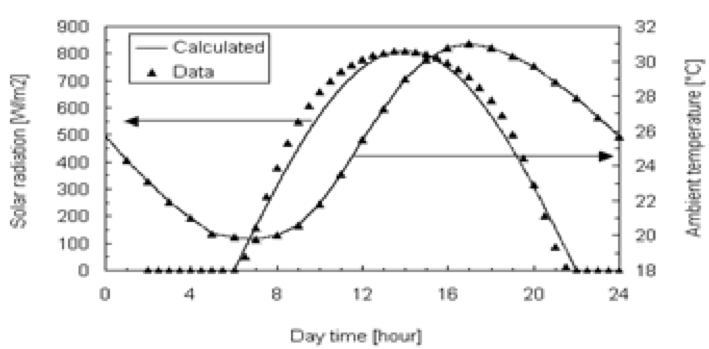

Fig.2. Radiation and ambient temperature in July at Orly, France

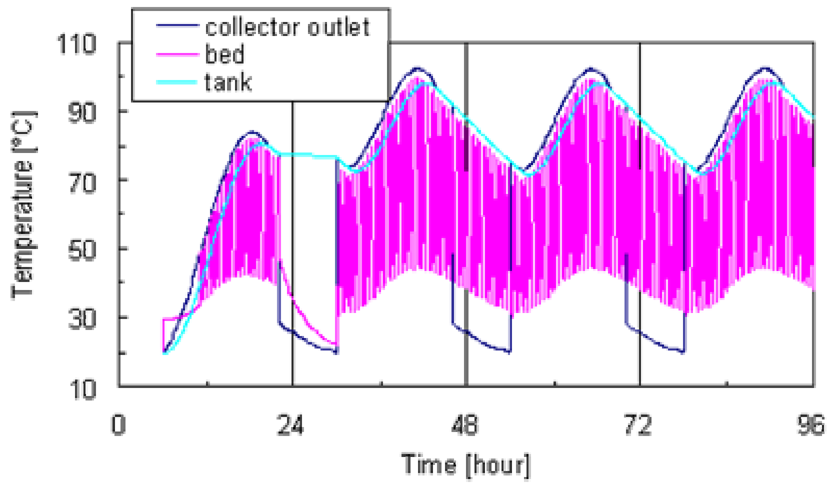

Fig.3 Temperature histories of collector outlet, adsorbent bed and reserve tank.

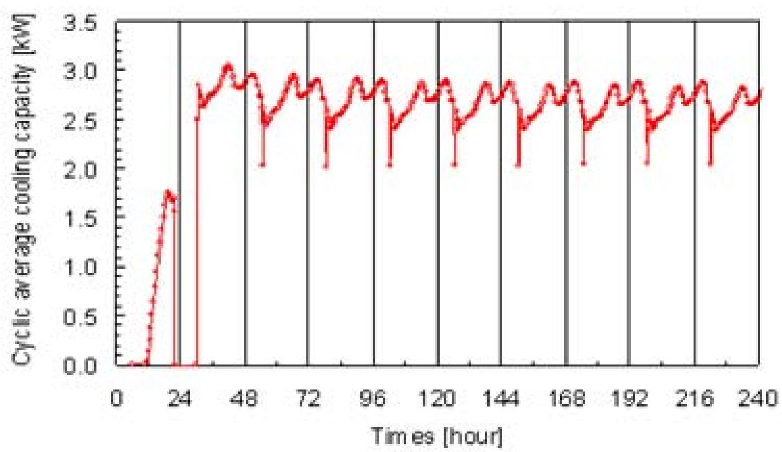

Fig.4 Cyclic average cooling capacity for 10days.

The performances of the chiller driven by solar collectors have also been investigated if the storage heat is used after sunset and the room internal conditions remain fixed during 24 hours. That means no ventilation at night is taken into consideration. The temperature trends of collector outlet, bed and reserve tank have been illustrated in Fig.3. It can be seen that the chiller is unable to run after sunset of the 1st day, however, it runs well after 2nd day. This is due to the initial conditions and the size of tank and collector. As the tank temperature is taken at ambient temperature in beginning day, therefore, the temperature of tank takes time to rise to effective level. It is also seen that the maximum driving temperature goes to 95°C and minimum reach to 70°C. Though the minimum driving heat source temperature is 70°C but the ambient temperature is low that time, therefore, the chiller runs well by this driving heat source temperature and produce effective cooling even after the sunset.

The cyclic average cooling capacity of the system with the above conditions is presented in Fig.4. It can be seen that the cooling capacity in the beginning day is very low comparing to that of other day. The reason is that in the beginning day the driving heat source is very low which explained earlier. The chiller from the 2nd day, however, performs better. Though the value is lower than the case without heat storage (Case studied by Clausse et al [8]), however, the average value in 24 hours is well enough to provide comfortable temperature for 100m^2 house where 1.8kW energy is always emitted internally by users in 24 hours.

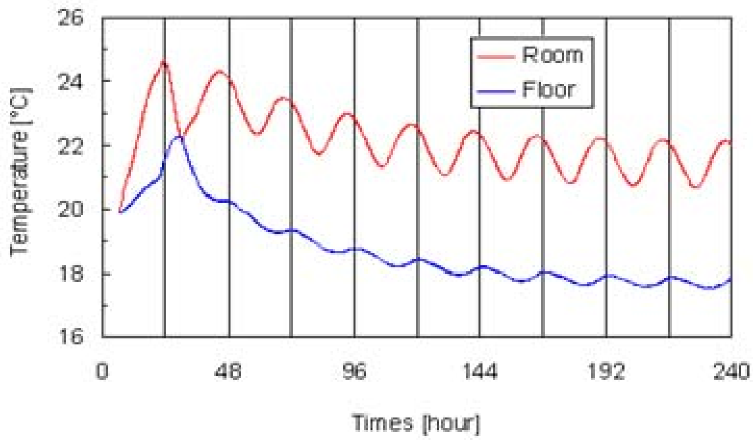

Fig.5 Room temperature histories for 0days.

The room and floor temperature trends when storage heat is used after sunset to continue cooling production by the adsorption chiller are presented in Fig.5. It can be seen that the room and floor temperature take 10 days to reach their cyclic steady state condition. It is also observed that the floor temperature during cyclic steady state is almost constant (fluctuates between 17.6 °C and 17.8 °C) while room temperature fluctuates between 21°C and 22°C which is enough to provide thermal comfort for human during sleeping as reported by Clausse et al. [8]. When no heat storage, extra ventilation and no internal energy in night is used [8] the room temperature goes near to 23 °C, while with heat storage, the system provides better conditions even the same internal conditions are used in night and day. However, it needs 6 more collectors than that the case of Clausse et al.[8].

5. CONCLUSIONS

The study presents an analytical investigation on the performance of an adsorption chiller driven by solar heat collected from CPC panel. The chiller is driven by the storage heat collected from the CPC panel. The following concluding remarks can be drawn from the present study.

- (i) It is seen that heat storage from the CPC panel could be utilize efficiently for space cooling when night time cooling is required.
- (ii) The study also shows that the chiller could be operated effectively in early morning and late afternoon if heat storage system is used instead of direct coupling of CPC panel.
- (iii) If the chiller is run for 24 hours by storage heat, it provides more comfortable room temperature than that provides by the system without using chiller after sunset even the room conditions remain same in 24 hours.
- (iv) It may be noted that 16 collectors (each collector area $2.415 m^2$) in a panel and reserve tank size of $2.197 m^3$ are required to provide effective cooling for a house of $100 m^2$ space area with heat storage system.

Enormous attention and investigation are required to make the system compact and efficient.

NOMENCLATURE

A	area, [m^2]	η	collector efficiency, [-]
AS	outer surface area contact to air, [m^2]		
C	specific heat, [J/kg.K]	Subscript	
E	energy supplied by air flow, [$Wh/m^3.K$]		
		a	adsorption
MC	Heat load, [J/K]	ab	adsorbent bed
$\dot{m}$	mass flow rate, [kg/s]	am	ambient
$\dot{Q}_{int}$	internal energy produced in a room by user, [W]	d	desorption
		f	heat transfer fluid
Q_{st}	adsorption heat, [J/kg]	floor	floor of house
T	temperature, [K]	in	inner/inlet
t	time, [s]	loss	heat loss
U	heat transfer coefficient, [$W/m^2.K$]	m	methanol
UA	thermal conductance, W/K	max	maximum
$\dot{V}$	ventilated air flow, [m^3/s]	ml	methanol liquid phase
W	weight, [kg]	mv	methanol vapor
		out	outer/outlet
Greek letters		p	pipe
		room	room
		t	tube
δ	logical parameter, [-]	wall	wall of room
γ	logical parameter, [-]	window	glass window of room

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An Experimental Investigation on Photovoltaic Power output through Single Axis Automatic Controlled Sun-tracker.

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ABSTRACT:
A single-axis Sun tracker to follow the position of the sun was designed and constructed and an experimental investigation was carried out on photovoltaic power output through the single axis automatic controlled solar tracker. This Solar tracker able to track Solar PV Panel or any concentrator according to the direction of beam propagation of Sun's radiation. The entire tracking system consists of sensor with comparator, control circuits to motor drive with control software, and gearbox with supports and mountings. The tracker can move the concentrator only to East-West Axis. The tracker is operated automatically through a software controlled digital controller. The components used in the tracker are available in everywhere with very little cost and its design simplicity with its maximum solar radiation collecting capability makes it more beneficial. So it can be concluded that, it is a flexible tracking system with least cost and high efficiency for trapping the Sun's incident energy

Key words: Sun-tracker, Solar Radiation, Photovoltaic Power.

1. INTRODUCTION

Any solar system performance depends on how much amount solar radiation it can collect. For collecting maximum amount solar radiation all type solar collector must be directed towards the sun so that all the sun's rays fall normally on the optical system, which can increase the efficiency of the system. Energy collection is maximum for a given system if it is oriented in such a manner that the surface normal at the canter should coincide with solar beam all the time. This will be possible if the system is rotated continuously about the position of the sun i.e. Tracking is done with sun movement. Energy collection will be minimum if no tracking is done. Conventionally, the solar collectors are fixed in position to utilize the sun's incident energy. Since sun is continuously altering its position by virtue of its rotation relative to other planets in the orbit system, the ray's incident on the collectors cannot be in proper direction. This can lead to an insufficient collection system. In order to overcome this problem some systems are developed to trap this energy by continuously changing the orientation of the collector so that direction of propagation of beam radiation is always perpendicular to the collector surface. These systems are known as "Sun tracking system or Sun tracker".

Commercially; single-axis and two axis tracking mechanisms are available. Usually, the single axis tracker follows the Sun's East-West movement, while the two-axis tracker follows also the Sun's changing altitude angle [10-11]. Sun tracking systems have been studied with different applications to improve the efficiency of solar systems by adding the tracking equipment to these systems through various methods[1-10]. A tracking system must be able to follow the sun with a certain degree of accuracy, return the collector to its original position at the end of the day and also track during periods of cloud over. The aim of this work is to design a software controlled single-axis Sun tracker which works efficiently in all weather conditions regardless of the presence of clouds for long period and also to investigate the effect of using single-axis sun tracking systems on the electrical generation of a flat photovoltaic system (FPVS) an experimental study is carried out to evaluate its performance under local climate.

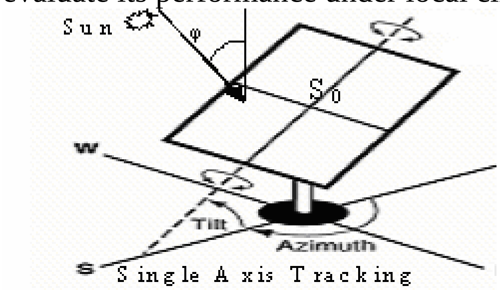


Fig-1: Single-axis Sun-tracker

2. Single-axis Automatic Sun Tracking system design and control

The proposed sun tracking system consists of the following two parts:

(i) The electromechanical movement mechanism

(ii) The system software

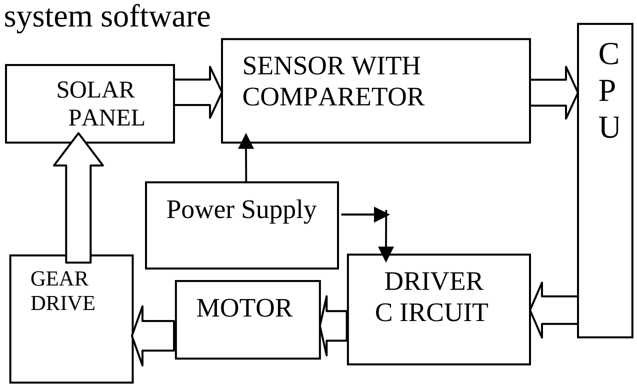


Fig-2: Block diagram of the designed tracking system

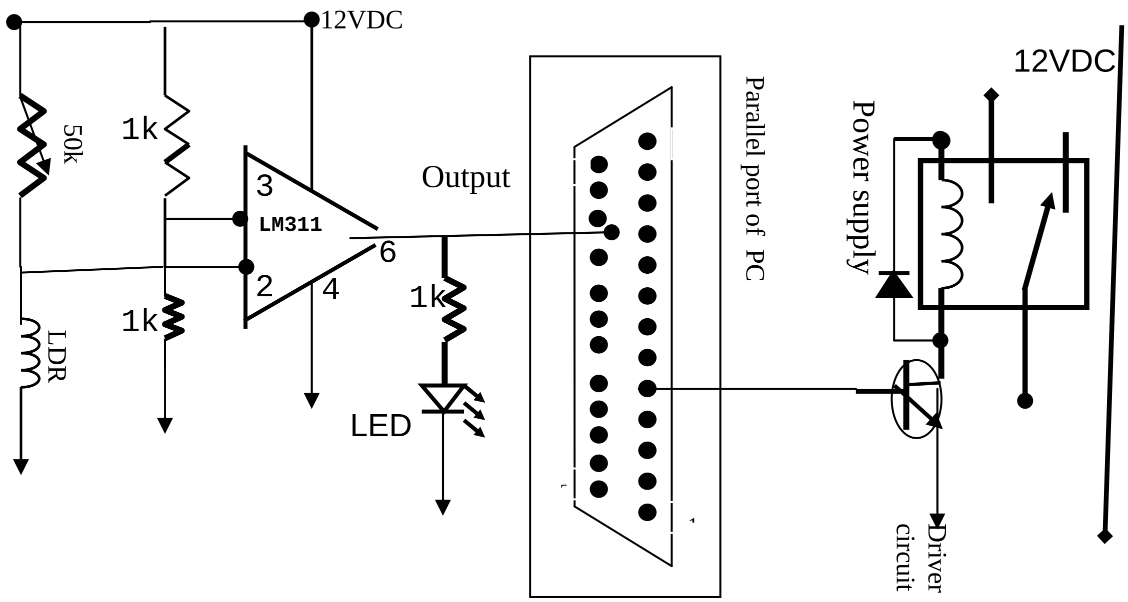


Fig-3: Circuit diagram of the control circuit

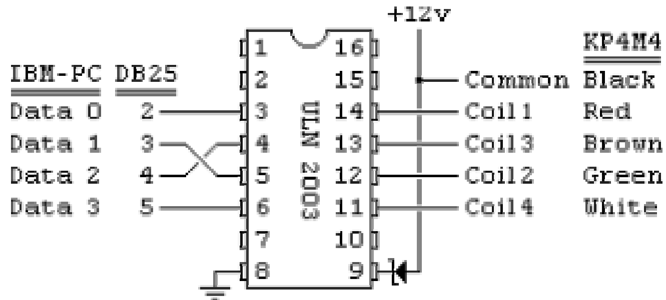


Fig-4: Steeper motor driver ULN2003 IC wiring diagram.

2.1The electromechanical movement mechanism

The entire system is shown in the block diagram (fig-2). The main components of the control circuit are sensor LDR (Light Dependent Resistor) with comparator (LM311 IC) , stepper motor driver (ULN2003 IC with zener diode) , parallel port and software with CPU.There is no any signal conditioner like ADC(analog to digital converter) because comparator can process the LDR output within a desirable range that directly can access the CPU. The electromechanical system consists of one driver with one steeper motor of 0.1° per step: which is used to rotate the panel about E-W tracking axis as shown in fig-1.The sun position sensors, LDR shows a resistance proportional to the radiation beam position inside the sensor. This sensor is intended to keep the radiation beam normal with collector. Here a tube consisting LDR with small opening is used as Sensor. LDR (light dependent resistor) is a sensor whose resistance changes if the light intensity is changed. If LDR is connected with a voltage source, the current will also changes. The change of current will be in accordance with the change of light intensity. Here an Op-AMP (LM311) is used that acts as a comparator to compare the sensor output and set them to a desired range. The comparator (LM311IC) used here change the output value of LDR into voltage and set them to a value that can access the CPU where the control software is run to control the tracking mechanism. The PC based software compare the taken output of the sensor with the reference value for normal position with sun beam and give a track command to the steeper motor driver to rotate the motor that is coupled to tracking axis with gear bearing support mechanism if required .

In the designed tracker the two sensors show same resistance when they are both in perpendicular to the sunbeam. If any unbalance occurred from the perpendicularity results in change in the LDR resistance then the signal comes to the software, which commands the controller to reset the reference resistance that shows the perpendicular position of the concentrator. For resetting the position of the panel from end-of-day position to that for operation early the next day a provision has been kept in the software in this system. In case of seasonal changes of the Sun's position, it is possible only by changing software adjustment to reset position of PV Panel in this system.

2.2 The system Softwar

Control software has been developed to determine the optimum position of the panel during day light .The calculated values taking from the sensor are a function of voltage which is converted to digital form is fed to the PC to control the actuator of the sun tracker. In this research the programming method of control works efficiently in all weather conditions regardless of the presence of clouds.The software for the solar tracker is written in Visual C++. The parallel port has 25 data port where 0-7 is used for signal out named as outport similarly there are some port to take data from outside named as inport .In the program the port address is used and using the port address data is taken and after comparing the data with reference value a signal is out through enabling the outport high or low using the outport address in the program.

2.3. Experimentation:

The designed tracking system has been used software based online tracking method. Two PV modules of the following specifications were used to obtain the surplus energy of the tracking module where one was fixed and other one was in tracking mode. The simplest method to obtain an IV characteristic is to load the module with a variable resistor, and measure the voltage and current through digital multimeter[12]. The measured value of voltage and current is the open circuit voltage and short circuit current of the PV cell. Also there is a digital arrangement with the PV panel that can give the solar irradiation in W/m^2, cell temperature etc and power can be obtained by multiplication of measured voltage and current.

Energy surplus= (Tracker power – Fixed power)/ fixed power * 100%

Table-1: Specification of the solar panel

Company Name	SHOWA solar energy .K,k.Japan
Model No	GL 418-TF
Maximum power	6 watt

4. EXPERIMENTAL RESULTS AND DISCUSSION

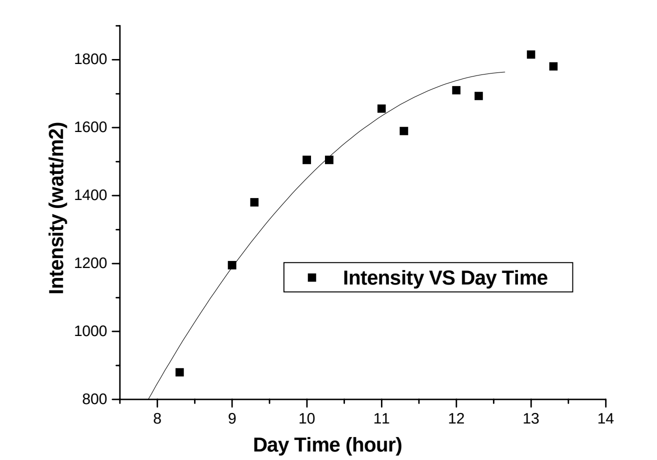


Fig-5: Intensity VS Day time

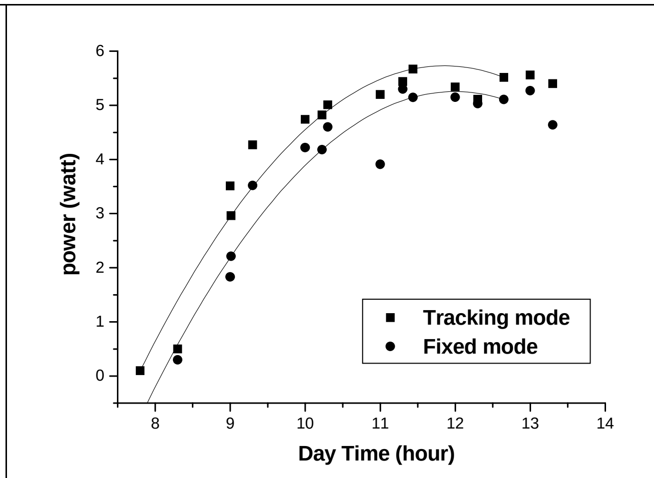
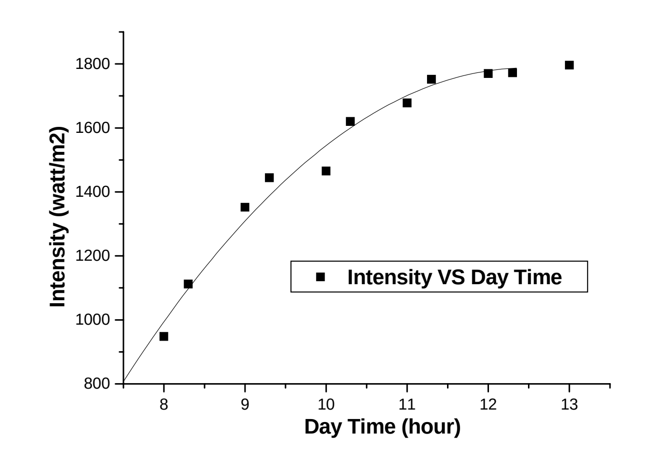


Fig-6: Power VS Day time



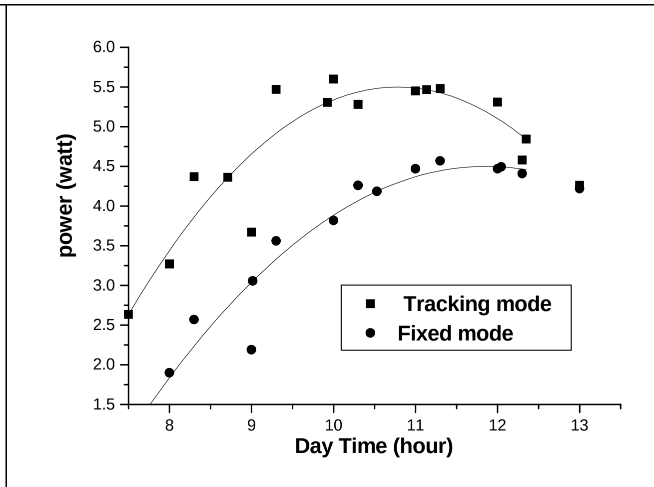


Fig-7: Intensity VS Day time	Fig-8: Power VS Day time

During the experimental study PV output power (fig-6 & fig-8) with solar intensity is measured for both the tracking mode and fixed mode and compared the results. The data is taken several days through the month february2007 and the results which are shown in fig -5 and 6 for dated 08/02/2007 and fig-7 and 8 for dated 22/02/2007.The results indicates that PV output power is more about 23% for single-axis tracking PV panel compared to fixed PV panel. From the analysis of figs 5and 7 it is seen that some fluctuation of solar intensity because the experiment is done in the winter season and so whole the day was not sunny. Also the figs 5 and 7 indicate that solar intensity was not so high to get higher power output

The tracking mechanism is able to track the Sun automatically according to the beam propagation of sun and the system software may be changed in case of seasonal variation if necessary. The power consumption by the system is very low because of low energy consumption devices are used like as COMS digital IC's and other low power consuming solid state electronic components. Moreover the motor (operate by only 12V DC) also consumes a small amount of energy because it rotates only for a fraction of a minute at every interval of time. Tracking system must be cost effective comparing with energy surplus obtained by the application of the system. The designed tracking system is beneficial because the component used in the system is locally available with low cost. The total cost in the control circuit and sensor with comparator system becomes about 500Tk only. The mechanical structure and steeper motor is needed in system as required on the panel size and weight and then cost so like. The tracker able to withstand available wind load and temperature and aims at the sun with greater than+/-1⁄10th degree of accuracy.

5. CONCLUSION

To investigate the PV output power for tracking mode and fixed mode an experimental study is done under local climate. Designed simplicity, Low cost and material availability will make the designed tracking system more effective and acceptable in the market. This tracking system is more compact and easier than any other tracking system with minimum cost. This device does not need auxiliary power and may adjust automatically depending on the direction of the sun. With the designed Sun tracker, it is possible to get substantially more power from each PV panel and this increase in power results in lower cost per watt.

From the result of the performance test of designed system the following conclusion can be drawn.

- The designed solar tracker automatically controlled and follows the sun path preciously;

- The efficiency of the tracking solar panel with respect to fixed panel was 23% at average intensity 1100 W/m^2;
- The use of software outside the mechanical part makes the tracker flexible for future development. The experiments done were implemented during three month. It is necessary to test during other months and The future development of the tracker should include a new case containing the method and all moving parts with electronics circuit, allowing continuous operation under local conditions.

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