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Experimental Study on Performance Characteristics of Single Cylinder Four Stroke Diesel Engine Using Blends of Diesel & Palm Oil Methyl Ester as an Alternate Fuel

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Abstract

Petroleum based fuels play a vital role in rapid depletion of conventional energy sources along with increasing demand and also major contributors of air pollutants. Major portion of today's energy demand in India is being met with fossil fuels. Hence it is high time that alternate fuels for engines should be derived from indigenous sources. As India is an agricultural country, there is a wide scope for the production of vegetable oils (both edible and non-edible) from different oil seeds.

The present work focused only on vegetable oils as fuel for engines, as the edible oils are in great demand and far too expensive. Experiments are carried out in a more popular petter type single cylinder, water cooled engine. Major problems associated with vegetable oils are higher viscosities, lower heating values, raise in stoichiometric fuel air ratio and thermal cracking. The focused is mainly on the utilization of Palm oil methyl ester and their blend with diesel in diesel engine. The neat oil blends with diesel were heated before entering into combustion chamber. The heating value depends on the increase in percentage of neat oils in mixture to reduce the viscosity of the fuel. The performance parameters of the test engine Viz. Brake thermal efficiency is decreased, Brake specific fuel consumption and Exhaust gas temperature are increased for all neat oils compared to diesel. From the experimentation, it is observed that 25% of neat oil mixed with 75% of diesel is the best suited blend, without heating and without any modification of the engine.

Keywords: alternate fuels, diesel engine, palm oil, performance parameters.

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1. Introduction

India is one of the fastest developing countries with a stable economic growth, which multiplies the demand for transportation in many folds. Fuel consumption is directly proportionate to this demand. India depends mainly on imported fuels due to lack of fossil fuel reserves and it has a great impact on economy. India has to look for an alternative to sustain the growth rate. Bio-diesel is a promising alternative for our Diesel needs. With vast vegetation and land availability, certainly bio-diesel is a viable source of fuel for Indian conditions. Recent studies and research have made it possible to extract bio-diesel at economical costs and quantities. The blend of Biodiesel with fossil diesel has many benefits like reduction in emissions, increase in efficiency of engine, higher Cetane rating, lower engine wear, low fuel consumption, reduction in oil consumption etc. It can be seen that the efficiency of the engine increases by the utilization of Bio-diesel. This will have a great impact on Indian economy.

History of vegetable oils:
India is importing crude petroleum & petroleum products from Gulf countries. Indian scientists searched for an alternate to diesel fuel to preserve global environment and to withstand economical crisis. So, vegetable oils from plants both edible, crude non-edible and Methyl esters (Bio-diesels) are used as alternate source for Diesel oil. Bio-diesel was found as the best alternate fuel, technically and environmentally acceptable, economically competitive and easily available. In the view of future energy crisis, the author has chosen Methyl esters of Palm oil for investigation in diesel engine. In this the author has focused on Methyl esters of Palm oil & its blends with diesel have been tested as alternate fuel for C.I. Engine.
The important physical and chemical properties of the above said oil and their blends are determined. The effect of blending this oil with diesel was studied. Effect of temperature on viscosity has been studied. Then the suitability of vegetable oils as alternate fuel is identified through the evaluation based on the performance parameters. These results are compared to those of diesel.

2.1 PROPERTIES OF VEGETABLE OILS USED IN TEST ENGINE

Palm oil has pleasant odour and taste. It is stable and resistant to rancidity. The colour of palm oil varies from yellow to deep orange. Inter esterification of palm oil produces two fractions. Palm oil obtained at low melting point called “Olein” and the oil obtained at high melting point called “Stearin”. Oil palm fruits are oval-shaped sessile drupes. Palm oil contains some triglyceride species, which are completely saturated. The iodine value of palm oil is lower (44-58) when compared to other vegetable oils because of high proportion of saturated fatty acids. Palm oil is solid at ambient temperature and fluid in tropical and subtropical climates with certain fractions held in crystalline form. It is used in manufacturing plastics, fibers and soaps. It is available in Asia, Africa, Indonesia, Nigeria and Malaysia.

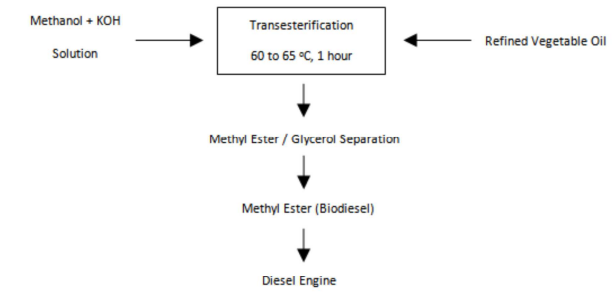
Property of oils	Neat Diesel (B00)	B25	B50	B75	Methyl Ester of Palm Oil (B100)
Density(gm/cc)at 40^0C	830	842	851	858	876
Viscosity(cst)	2.7	3.2	3.91	4.78	5.71
Flash point(0C)	64	NA	NA	NA	174
Fire point(0C)	69	NA	NA	NA	179
Calorific values(KJ/Kg)	42500	41480	40100	39200	38500
Cetane number	51	NA	NA	NA	51

2.2 TRANSESTERIFICATION PROCESS

The transesterification process will be adopted for the preparation of ethyl ester or methyl ester of vegetable oil. In the preparation of ethyl ester (biodiesel), five distinct stages will be involved.

1) Heating of oil.
2) Preparation of alkaline mixture.
3) Adding of alkaline alcohol to oil and stirring the mixture.
4) Settling of separation of glycerol.
5) Washing of methyl ester with water.

The biodiesel can be obtained by transesterification of vegetable oil using either ethanol or methanol as the Trans-esterifiction agent. Transesterification reaction is a stage of converting oil or fat into methyl ester or ethyl esters of fatty acids which constitutes to biodiesel. Biodiesel (methyl esters) is obtained though the reaction of triglycerides of vegetable oils with an active intermediary formed by reaction of an alcohol with a catalyst. The general reaction for obtaining biodiesel though transesterification.



$$\begin{array}{lcl} CH_2COOR_1 & & CH_2OH \quad R_1COOR \\ | & & | \quad\quad | \\ CHCOOR_2 + 3ROH & \xrightarrow[\text{(NaOH)}]{\text{Catalyst}} & CHOH + R_1COOR \\ | & & | \quad\quad | \\ CH_2COOR_3 & & CH_2OH \quad R_1COOR \\ \text{Triglyceride} \quad \text{Alcohol} & & \text{Glycerin} \quad \text{Biodiesel} \end{array}$$

Transesterification reaction

Figure 1. Procedure of manufacturing biodiesel through transesterification with vegetable oil

The reaction requires heat and a strong catalyst (alkalis, acids, or enzymes) to achieve complete conversion of the vegetable oil into the separated esters and glycerin. Generally potassium hydroxide (KOH) and sodium hydroxide (NaOH) are used as alkaline catalysts with methanol (CH_3OH) for production of biodiesel. The alcohol & catalyst is charged into a closed reaction vessel and the vegetable oil is added. The reaction is heated to the boiling temperature of the alcohol (normally 50-60 deg C) and is refluxed for a certain length of time under agitation. When agitation is stopped (after 60minutes) the reaction mixture separated into an upper layer of methyl ester and lower layer of glycerol diluted with un reacted methanol. Once the reaction is complete, two major products are produced: Glycerin and biodiesel (methyl ester). The quantity of glycerin varies according varies according to the vegetable oil used, the process used, and the amount of the excess alcohol that is used in the reaction. The fatty ester produced in the upper layer is neutralized and vacuum distilled for the removal of excess methanol. The methyl ester produced from the reaction is then washed with hot water and separated out by centrifugation

2.2 EXPERIMENTAL WORK

The Engine chosen to carry out experimentation is a single cylinder, four stroke, vertical, water cooled, direct injection diesel engine.

Single Cylinder Diesel Engine Test Rig With Rope Brake Dynamometer. The J.P.T.I.' unit consist of a 4-stroke diesel engine coupled to a rope brake dynamometer. A water cooled brake drum along with spring balances is provided. A Rope brake arrangement is provided to load the engine.

SPECIFICATION:-

J.P. Techno Instru. Make A Single Cylinder Four Stroke Diesel Engine

Engine Power: 3.75kW 1500rpm 5hp	Max speed: 1500rpm	
Cylinder Bore: 84.5mm	Stroke Length: 110mm	
Displacement: 660cc	Compression Ratio: 17.5:1	
Speed: Constant speed type	Cooling: Water cooling type	Type of start: Crank shaft type starting

1) Diesel engine of 5 H. P. capacity ,1500 R. P. M. 4-stroke vertical, single cylinder engine.
2) Loading device - Rope brake consisting of a brake drum of size suitable diameter & rope brake arrangement with rope ,hand wheel, spring balances.
3) Fuel measuring arrangement-Consisting of a fuel tank, mounted on a strong iron stand, measurement of a fuel consumption by a burette & 3- way cock. Connecting tube, a stop watch.
4) Cooling water arrangement:- Cooling pipes, thermocouples, measuring flask to determine the discharge of cooling water & heat carried away by cooling water.
5) Exhaust gas temperature (digital temp. indicator)
6) Air intake measurement :- Air tank reservoir of size 0.5 m. x 0.5 m. x 0.5 m. with orifice plate, differential manometer, connecting hose.

The engine has a rope brake dynamometer to measure its output. The experiments are conducted for variable loads like 0, 25%, 50%, 75% 7 full load conditions at rated speed. The blends of diesel and methyl ester of palm oil are prepared with different proportions like 25% methyl ester of palm oil + 75% diesel and termed it as B25 (Biodiesel 25), similar to B25; B50, B75 and B100 (neat palm oil) are prepared and used in experimentation. The palm oil and their blends with diesel are heated externally to a required temperature as stated earlier before injecting into the test

cylinder. All the observations recorded were replicated thrice to get a reasonable value. The performance parameters such as Brake Thermal Efficiency (ηB.Th.), Brake Specific Fuel Consumption (bsfc), Exhaust Gas Temperature (EGT). These performance parameters of oils are compared to those of pure diesel.

3. RESULTS & DISCUSSION

The experimental investigations are carried out using the above said oils and their blends on the test engine. The detailed analyses of these results are as discussed below.

Fig. 1 shows the variation of Brake Thermal efficiency with Brake power output for Methyl Ester of Palm oil and its blends with Diesel in the test engine. For 25% blend of Palm Stearin slightly lower Brake thermal efficiency compared to diesel. Neat palm stearin oil has lower Brake thermal efficiency at all loads.

Fig. 2 shows the variation of Brake specific fuel consumption with Brake power output for Palm Stearin oil and its blends with Diesel in the test engine. Neat Palm Stearin oil has higher bsfc compared to diesel. 25% blend of Palm Stearin oil has lower bsfc compared to all other blends.

Fig. 3 shows the variation of Exhaust Gas temperature with Brake power output for Palm oil and its blends with diesel in the test engine. 25% blend of Palm stearin has lower EGT compared to all other blends for all loads.

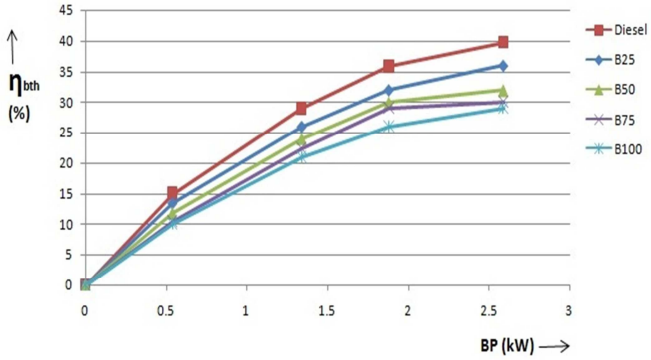


Fig. 1 Break Power (BP) Vs Break Thermal Efficiency (η_{bth})

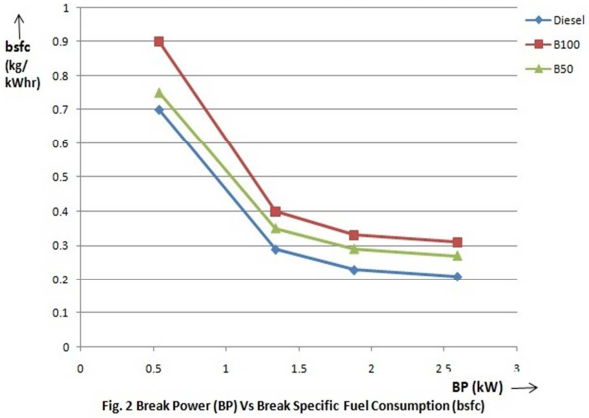


Fig. 2 Break Power (BP) Vs Break Specific Fuel Consumption (bsfc)

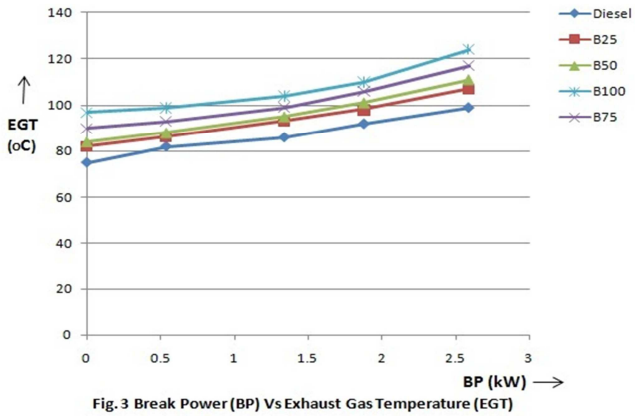


Fig. 3 Break Power (BP) Vs Exhaust Gas Temperature (EGT)

4. CONCLUSION

Performance parameters of engine such as Brake thermal efficiency, Volumetric efficiency are decreased, Brake Considering the need for alternate fuels, the experimental investigations are carried out in the present work in order to run the existing diesel engines with non-edible vegetable oils. specific fuel consumption and Exhaust gas temperature are increased for all neat oils and their blends compared to those of diesel. This is because of high viscosity coupled with lower heating value of the fuels. Physical and chemical properties of the above mentioned oil blends were determined. The performance parameters of chosen neat oil and their blends were evaluated. These results are compared to those of diesel.

5. SUMMARY OF RESEARCH

1. The physical and chemical properties of chosen non edible palm oil and their blends with diesel are determined and analyzed.
2. The analysis for performance characteristics such as brake thermal efficiency, brake specific fuel consumption, exhaust gas temperature, volumetric efficiency of chosen oil and their blends with diesel are done through graphs.
3. The performance characteristics of five chosen oils are compared to the other non-edible oils already available in the literature for validation.
4. The suitability of oils as alternate fuel in C.I. Engines is checked through validation process.

6. FUTURE ISSUES

Investigations are to be carried out on different blends of esters with diesel to determine better performing blends. Investigations have to be carried out on combustion characteristics. Investigations are to be carried out on emission characteristics by using multi cylinder engine.

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7. DISCLOSURE STATEMENT

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