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Experimental Investigation on Performance of Direct Injection Diesel Engine Fuelled with Jatropha Methyl Ester, Waste Plastic Oil and Diesel Oil

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Abstract: *Research work on performance analysis of diesel engine, blended with Waste plastic oil (WPO), Jatropha methyl ester (JME) and diesel fuel is presented in this paper. For this experiment we used four stroke, single cylinder, water cooled , direct injection (DI) diesel engine. Four different blends of varying WPO , JME and diesel from 10% to 50% at steps of 10% on a volume basis, were considered for the investigation. Performance parameters are evaluated at different blend ratios and are compared with those of diesel. 20% blend with equal ratio of WPO and JME in diesel shows nearly same results as compared to diesel.*

Keywords: *Waste plastic oil (WPO), Jatropha methyl ester (JME), Diesel.*

1. INTRODUCTION

Increasing industrialization has lead to a significant rise in demand of petroleum products. As these are the nonrenewable resources, it is difficult to predict availability of these resources in future, resulting in uncertainty in its supply because fossil fuel reserves are depleting at a faster rate, causing continuous increase in price of petroleum products all over the world. The high price of petroleum products is a big concern for Indian economy. India imports on an average 80% of total demand of crude oil. It is one of the main reasons of GDP expense. Therefore an alternative cheaper fuel is required to fulfil the needs of men and at the same time it will save more foreign exchange. Many researchers worked on alternate fuels like vegetable oil, biodiesel (transesterified vegetable oil), alcohol, natural gas, biogas and pyrolysis oil. Some of the vegetable oils are Sunflower, Soybean, Jatropha, Cottonseed, Canola and Peanut oils. Biodiesel fuels are considered a potential replacement for diesel, and have a number of advantages, such as higher cetane number and lower emissions of carbon dioxide. They are also renewable, biodegradable, non-toxic, environmentally friendly, and carbon neutral. From jatropha seeds jatropha oil is extracted which have similar properties as diesel but some properties such as kinematic viscosity, solidifying point, flash point and ignition point is very high in jatropha oil. Which is improved by transesterification process, by this process, Jatropha oil is converted into biodiesel. Alternative source of fuel also lies in plastic. In India 56 lakh tonnes of plastics are generated each year and only 60% of it is recycled. Safe method of disposing the waste plastic has not yet been implemented, and dumping of waste plastic underground is hazardous to the environment. But we can use it as an alternative source of fuel for gasoline and diesel. This will save the environment from hazardous effect as well as to boosting the Indian economy. Properties of WPO is somewhat similar to that of jatropha biodiesel. Many researchers worked on JME and WPO, they found that both fuels can be used in diesel engine without any modification. Their study reveals that by using JME and WPO in diesel engine, there is significant reduction in CO and HC.

NOMENCLATURE

B10	5% WPO + 5% JME + 90% Diesel
B20	10% WPO+ 10% JME + 80% Diesel
B30	15% WPO + 15% JME + 70% Diesel
B40	20% WPO + 20% JME + 60% Diesel
B50	25% WPO + 25% JME + 50% Diesel
CO	Carbon monoxide
HC	Hydrocarbon

1.1 Jatropha methyl ester

Among the non edible seeds produced in India, Jatropha is the most preferred because of its high oil content and biodiesel yield, Its Oil content is around 40%. Direct use of vegetable

oil is not applicable to most of diesel engines as the high viscosity would prevent atomization and might damage the engine, So to decrease the viscosity and to make it useable in diesel engine, there is a process called transesterification. It is the process of reacting triglyceride of fatty acids (vegetable oil) with alcohol in the presence of a catalyst to produce glycerol and fatty acid esters. These fatty esters are known as biodiesel. Transesterification is the most common method for biodiesel production due to its simplicity, thus this method has been widely used to convert vegetable oil into biodiesel.

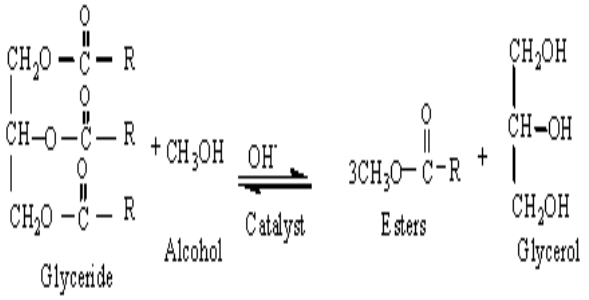

Fig. 1

Transesterification, also called alcoholysis, is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis. Methanol is most commonly used for the purpose since it is the cheapest alcohol available. Ethanol and higher alcohols such as isopropanol, butanol etc. can also be used for the esterification. If we are using methanol as alcohol, then we get jatropha methyl ester and by ethanol, we get jatropha ethyl ester. Various properties of JME is shown in table 1.

Table 1

Properties	Diesel	JME	WPO
Density(Kg/m^3)	830	880	835
Kinematic viscosity(cSt)	3.5	5.65	2.52
Calorific value(KJ/Kg)	46500	38450	44300
Flash point(^{o}c)	50	160	42
Cetane no.	55	50-55	51

1.2 Waste plastic oil

WPO is produced by Pyrolysis process. It is the process of thermal degradation of waste in an oxygen-free environment in which the oxygen content is low for gasification to take place. Pyrolysis liquefaction is a non-combustion heat treatment that chemically decomposes waste material by applying heat directly or indirectly to the waste material. It is an endothermic reaction which requires an input of energy that is mainly applied indirectly through the walls of the reactor in which the waste material is fed into. Pyrolysis liquefaction occurs under pressure and at operating temperatures above 430^{o}c. Pyrolysis oil, Charcoal and gases are produced. The pyrolysis process for plastic takes the long chain polymer molecules and breaks or cracks them into shorter chains through heat and pressure. Essentially the process is if goes under the natural process of the earth to break down carbon into oil which takes million of years in nature. The pyrolysis process does this with intense heat in a closed system in a short amount of time. Conditions for producing pyrolysis oil are more likely to include virtually no oxygen. Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, like wood, cloth, and paper, and also of some kinds of plastic. Anhydrous pyrolysis can also be used to produce liquid fuel similar to diesel from plastic waste. Properties of WPO is shown in table 1.

2 EXPERIMENTAL SETUP

The experimental setup consists of a diesel engine with dynamometer. The engine used in the experiment is a constant speed Kirloskar engine, four stroke, single cylinder, direct injection vertical diesel engine. The engine is water cooled. The load applied on the engine is by means of electric loading device. The engine is mounted on concrete bed with suitable connections for water cooling and lubrication. The outlet temperature of water from engine is maintained at 50^{o}C by adjusting the flow of the coolant. Experiments were initially started with diesel fuel and after the warm up condition is achieved, it was switched to WPO and then JMEWPO. The schematic arrangement of experimental setup is shown in figure 2.

Engine specifications are given in table 2

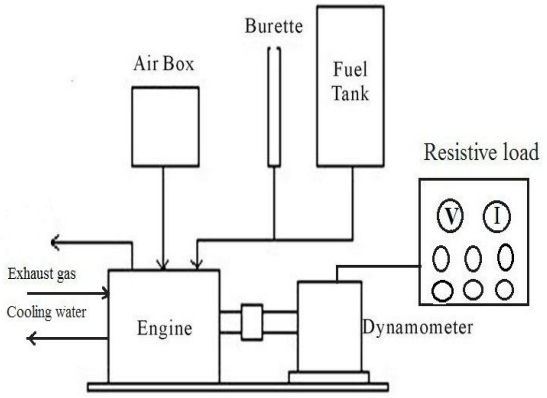

Figure 2

Table 2

Model/ Manfacturer	Kirloskar
Brake power(hp)	5
Rated speed(rpm)	1500
Compression ratio	18

Type of cooling	Water cooled
Injection type	Direct injection
Stroke length(mm)	110
Bore(mm)	80

3. RESULT AND DISCUSSIONS

The comparison of performance paramerers of DI engine using waste plastic oil and jatropha methyl ester and diesel are charted.

- Load Vs brake thermal efficiency
- Load Vs Bsfc
- Load Vs Exhaust gas temperature

3.1 Load Vs Brake thermal efficiency

Variation of Brake thermal efficiency with various load conditions is shown in fig 3. The brake thermal efficiency for diesel is 29.24% at full load. For blends, B10, B20, B30, B40 and B50, it is 29.1%, 29.21%, 26.8%, 24.3% and 23.68 respectively at full load. Data shows that B20 values are very close to that of Diesel.

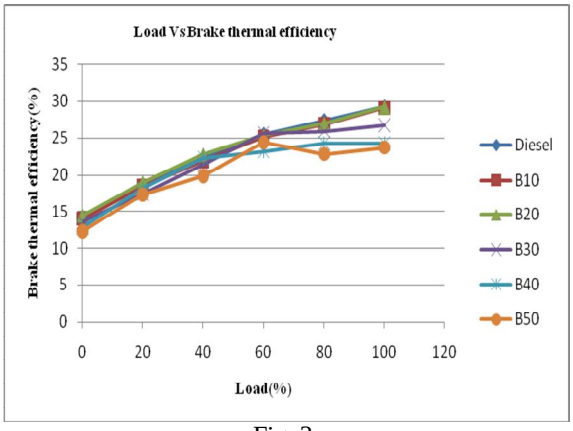

Fig. 3

3.1 Load Vs Bsfc

Variation of Brake specific fuel consumption with various load conditions is shown in Fig 4. Bsfc values for diesel, B10, B20, B30, B40 and B50 are 0.29, 0.32, 0.3, 0.35, 0.38, 0.45 respectively at full load. Data shows that B20 values are very close to that of Diesel.

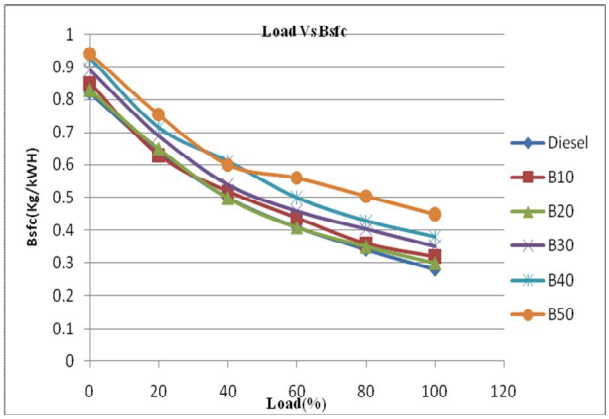

Fig. 4

3.1 Load Vs Exhaust gas temperature

Variation of exhaust gas temperature with various load conditions as shown in Fig 5. As load increases temperature also increases. Temperature value for diesel, B10, B20, B30, B40 and B50 are 290, 298, 311, 328, 348 and 362^0c respectively at full load.

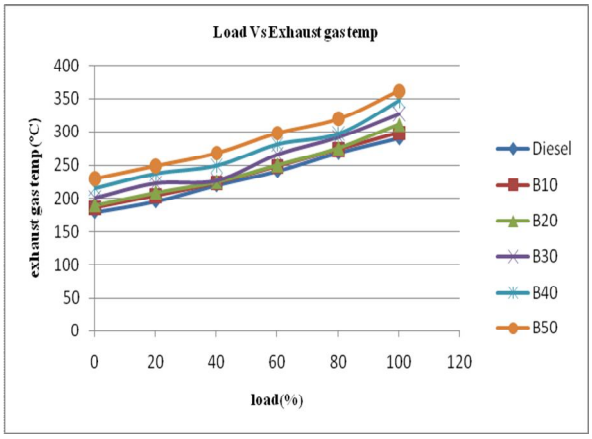

Fig. 5

4. CONCLUSION

In this study, experiments were conducted using WPO, JME and Diesel blends. It is concluded from the results that B20 gives optimum results, as compared to other blends. At full load, Brake thermal efficiency of B20 is 29.21 and that of diesel is 29.24, which is almost same. Brake thermal efficiency decreases as blend rato is increased after 20%. Bsfc decreases with increase in load and increases with increase in blend ratio of JME and WPO.

It is concluded that JME and WPO blends are good alternative fuels for diesel engine.

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