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PERFORMANCE ANALYSIS OF DI DIESEL ENGINE USING DIESEL WITH CASTOR SEED OIL BLENDS

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ABSTRACT: *The aim of the present investigation is to study the performance characteristics of single cylinder four stroke direct injection diesel engine using Castor seed oil as an alternate fuel. Here castor seed oil is used in the form of blends at various proportions with diesel. High viscosity is one important difference between castor seed oil and commercial diesel fuel. A single cylinder, four stroke, constant speed, water cooled, direct injection diesel engine is going to be used for the experiment. In general, viscosity of neat vegetable oil is high, which can be reduced through blending with diesel and heating them. The performance characteristics of engine are determined using Castor oil blends with diesel. These results are compared to those of pure diesel. The performance of the engine will be measured using electrical dynamometer and the emissions such as CO_2, CO, HC& NO_x will be measured using exhaust gas analyzer. After acquiring the experimental data they will be analyzed for various parameters such as thermal efficiency, brake specific fuel consumptions (BSFC). The engine is expected to run with reduced emission levels with acceptable engine performance. It is concluded that castor non-edible oil can be used as an alternate to diesel, which is of low cost. This usage of neat Castor oil has a great impact in reducing the dependency of India on oil imports.*

Keywords - *Castor oil, alternate fuel, non edible oils, performance characteristics.*

I. INTRODUCTION

The consumption of diesel fuels in India was 28.30million tones which was 43.2% of the consumption of petroleum products. This requirement was met by importing crude petroleum as well as petroleum products. The import bill on these items was 17,838 crores. With the expected growth rate of diesel consumption of more than 14% per annum, shrinking crude oil reserves and limited refining capacity, India will be heavily dependent on imports of crude petroleum and petroleum products.

From the standpoint of preserving the global environment and to sustain from the large imports of crude petroleum & petroleum products from Gulf countries, alternate diesel fuel is the need of the hour.

The idea of using vegetable oils as a fuel for diesel engines is not a new one. Rudolph Diesel used peanut oil to fuel in his engine at Paris Exposition of 1900.However, despite the technical feasibility, vegetable oil as fuel could not get acceptance, as they were more expensive than petroleum fuels. Later the various factors as stated earlier, created renewed interest of researchers in vegetable oil as substitute fuel for diesel engines. In recent years systematic efforts have been made by several researchers to use vegetable oils such as sunflower, safflower, peanut oil, soybean oil, rapeseed oil, rice bran oil, Jatropha, pongamia, coconut oil etc. and their derivatives, in the place of diesel in C.I. engines and proved useful as alternate fuel. As many of them are edible, their usage may create shortage of oil seeds for daily food, which necessitates identification of new kinds of non-edible vegetable oil. The recent upward trend in oil prices due to uncertainties in supply of petroleum products scarcity and ultimately depletion has a great impact on Indian economy and the Nation has to look for alternatives to sustain the growth rate. The Castor seed cultivation in India is abundantly done and the availability of Castor seeds is also high. The oil obtained by crushing these seeds can be used as an alternate fuel and they are also non edible. The emission characteristics and engine performance are expected to be acceptable .Also due to the high availability of Castor seed oil the impact of fossil fuel on Indian economy can be minimized. If mass production of oil is done, it will favor the agricultural sector of our country.

From above stated factors it is evident that identification and testing of new non edible oils on diesel engine is of great importance. In the present investigation Castor oil, non-edible vegetable oil is selected for the test and its suitability as an alternate fuel is examined. This is accomplished by blending of Castor oil with diesel in 5/95%, 10/90%, 15/85%, 20/80% on volume basis; further these blends are heated to reduce viscosity equal to that of diesel. Then the following investigations are carried out:

- The effect of blending Castor oil with diesel on viscosity.
- The effect of temperature on viscosity of various Castor oil and diesel blends and the temperature at which the viscosity of blends equal to that of diesel at 300C.
- The performance and emission characteristics of diesel engine using various blends and compare the results with that of diesel.

II. CHARACTERIZATION OF CASTOR OIL

Properties of Castor oil

Castor oil is non-volatile fatty oil taken from beans of the plants. It ranges in color from colorless to greenish. It has two derivatives such as blown castor and hydrogenated oil. Castor oil used in textiles, paints, varnishes, plastics, cosmetics, fibers, hair oils and drying oils. It is also used for traditional and medical treatment purposes. Table 1 shows the comparison of properties of castor oil with diesel.

Table 1: Comparison of properties of castor oil with diesel oil

SL.No	Fuel property	Diesel	Castor Seed Oil
1.	Density @30^{o} C	840kg /m^{3}	956 kg /m^{3}
2.	Flash point in	57^{o} C	252^{o}C
3.	Kinematic viscosity at 30^{o} C	5 cst.	78 cst
4.	Fire Point in	65^{0}C	264^{0}C
5.	Calorific value	42000 kJ/kg	36000 kJ/kg

III. Experimental Test Rig Instrumentation

A single cylinder, 4-stroke, water cooled, diesel engine coupled with electrical dynamometer as shown in figure 1 was used for the present work. The specification of engine & dynamometer are given in table 3.1 & 3.2. The measuring instruments used in this project are listed in table 3.3. The suction side of the test engine is attached with anti-pulsating drum to measure air inflow quantity. The inlet temperature of air is measured with inlet air thermometer. The exhaust side of the engine consisting of series of devices such as Exhaust Gas Thermometer (EGT), gas analyzer probe and smoke meter probe. A combustion analyzer is also attached with the test rig to study the combustion behavior of engine. The set-up also consists of fuel flow measuring device to measure the fuel consumption of the engine. The output side of the engine consists of an electrical dynamometer and followed by a loading rheostat. The output is measured in terms of watts using digital wattmeter mounted in the panel. An 8 bit Data Acquisition system (DAS) is also connected with test rig to acquire the combustion pressure and crank angle, pressure –volume, MFB and HRR data for a stipulated number of cycles.

Fig .1 .Experimental Setup

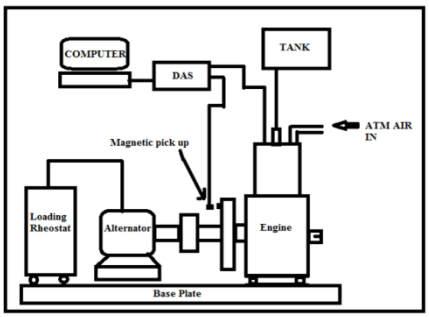

Table 2: Engine specification

Make	Kirloskar AV 1 model
Type of Engine	Vertical,4-Stroke cycle, single acting, High speed , DI, diesel engine.
Number of Cylinder	One
Speed	1500rpm
Maximum power output	5Hp(=3.7 kW)
Bore	80mm
Stroke	110mm
Cubic Capacity	0.553 litres
Normal compression ratio	16.5:1
Fuel timing by spill	23 Deg. BTDC
Lubrication	Forced Full Pressure lubrication
Type of cooling	Water cooled
BMEP at1500 rpm	5.42 bar

Variable load tests are conducted for 0.2, 1, 2, 3, 4, 5.2 KW at a constant rated speed of 1500 rpm, 200bar injector opening pressure. The Linseed oil and its blends with diesel are heated externally as stated earlier before injecting into the test cylinder. The engine was sufficiently warmed up and stabilizes before taking all readings. All the observations are replicated thrice to get a reasonable value. The performance characteristics of the is evaluated in terms of Brake Thermal Efficiency (ηth), Brake Specific Fuel Consumption (BSFC) and exhaust gas temperature (E.T) and the emission characteristics in terms of CO, UHC, NO and smoke opacity. These performance and emission characteristics are compared with the results of baseline diesel.

IV. Results and discussion

Experimental investigations are carried out on a single cylinder DI diesel engine to examine the suitability of castor oil as an alternate fuel. Firstly, the effect of dilution with diesel and heating of blends on viscosity were studied. Then the performance and the emission characteristics of blends are evaluated and compared with diesel and optimum blend is determined. Further for the confirming its validity the results are compared with that of neat cotton seed and neat rice bran oil available in the literature for similar work.

Performance characteristics

Fig.2 shows the variation of brake thermal efficiency of diesel, 5%C, 10%C, 15% C, 20% C. are shown in above figure. From the figure, it is observed that 5%C blend offers comparatively higher brake thermal efficiency than other blends. This trends prevails all over the load range except at full load operation. This is attributed to improved volatility, better spray performance, rapid gasification and higher heat content of the blend. As 5%C possesses lower viscosity, it offers approximately half of the viscosity Castor seed oil. So heavier molecular structure of the castor seed oil is cracked sooner and produces lighter fraction rapidly. This yields complete combustion without leaving cocked greasy substances inside the cylinder. As a result, the blend performs better than other blends.

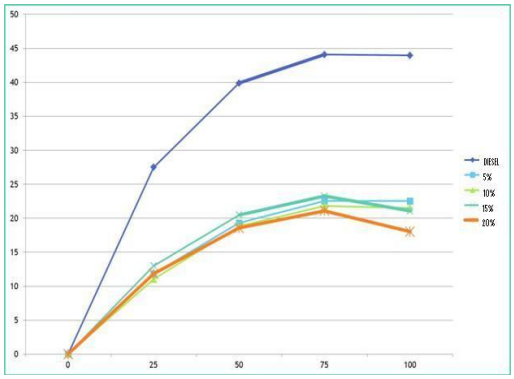

Fig.2. Variation of brake thermal efficiency with brake power for castor oil and its blends

Fig 3 shows the variation of specific fuel consumption of diesel and various blends of CSO are presented in the above figure. From the observation, it is seen that lower energy consumption is observed for 5%C blend and highest SFC is observed in 100%C blend, compared to other fuels. The reason for lower specific fuel consumption of 5%C blend is due to improved heat content, improved reactivity and rapid gasification.

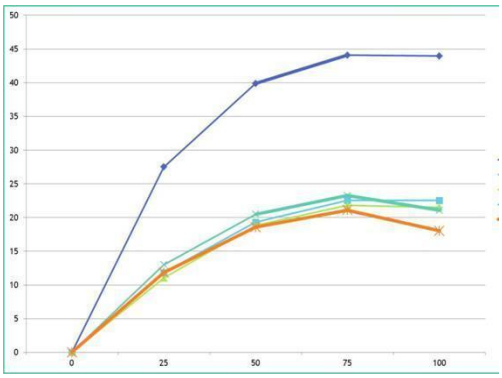

Fig .3.Comparison of SFC of Diesel and various Blends of CSO

Fig 4 shows the variation of exhaust gas temperature of Diesel and various CSO blends are shown in figure above. The figure indicates higher exhaust gas temperature in 100%C than those of other blends and lower exhaust gas temperature occurs in 5%C.The reason for lower exhaust temperature of 5%R is due to lower viscosity, improved volatility, improved spray and shorter burn duration.

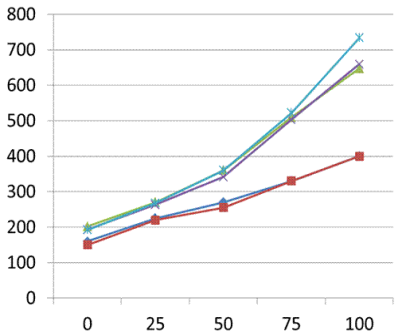

Fig. 4. Comparison of EGT of Diesel and various CSO blends

V. CONCLUSION

- The properties like density, viscosity, flash point and fire point of castor oil is higher and calorificValue is 0.936 times that of diesel.

- Dilution of castor oil reduces the viscosity considerably. The blend containing 5% of diesel has viscosity close to viscosity of diesel at 30^0C and does not requireany heating prior to injection into combustion chamber.
- The performance characteristics of 5%blend of castor is better than that of all other blends and it is well comparable with diesel.
- Performance of the castor oil is validated as results are well comparable with the results of cotton seed oil and rice bran oils.

Hence from above conclusions it may be stated that blends up to 5% without preheating and up to 20% with preheating can be substituted as fuel for diesel engine without any modifications in the engine.

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