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Performance and Emission Study of Linseed Oil as a Fuel for CI Engine

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***Abstract*—**Increased energy demand and the concern about environment friendly technology, renewable bio-fuels are better alternative to petroleum products. In the present study linseed oil was used as alternative source for diesel engine fuel and the results were compared with baseline data of neat diesel. Performance parameters such as brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC) and emissions parameters such as CO, unburned hydro carbon (UBHC), NO_x, CO_2 and exhaust temperature were compared. BTE of the engine was lower and BSFC was higher when the engine was fueled with Linseed oil compared to diesel fuel. Emission characteristics are better than diesel fuel. NO_x formation by using linseed oil during the experiment was lower than diesel fuel. Linseed oil is non edible oil, so it can be used as an extender of diesel fuel energy source for small and medium energy needs.

***Keywords*—**Bio-fuel, exhaust emission, linseed oil, triglyceride.

I. INTRODUCTION

THE world is moving towards a sustainable energy era with major emphasis on energy efficiency and use of renewable energy sources. Growing concerns on the long-term availability of diesel and its environmental disadvantage have necessitated the search for a renewable alternative to diesel fuel. Bio-fuels can provide a feasible solution to these problems; known liquid bio-fuels are fuels derived from alcohol and vegetable oils. However, modification, handling and transportation, ease of production, and investment cost are some of the important parameters that should be considered before using an alternative fuel in an existing diesel engine. The modification required in the engine design should be very minor to minimize the investment in engine modification [1-4]. Diesel engines are major source of energy for agricultural need. Linseed oil is a better option for small and medium capacity energy needs.

Oil seed crops can provide a fuel grade product using relatively simple extraction and processing technology which could be performed on individual farms. Vegetable oils are promising fuels, particularly for diesel engines. The practicality of vegetable oils as diesel fuels has been sufficiently demonstrated to warrant further investigation of their effectiveness and to develop techniques that will permit their incorporation into agricultural operations, particularly in times of energy shortfall. The present work aims at comparative assessment of performance evaluation exhaust emissions of neat linseed oil with diesel fuel in a single cylinder diesel engine. Due to high viscosity and slight lower calorific value of Linseed oil it can be used with or without blending in diesel.

II. LINSEED OIL AS A POTENTIAL FUEL FOR DIESEL ENGINE

Identification of alternative fuels for use in IC engines has been subjected to studies throughout the globe. Performance tests have shown suitability of variety of alternative fuels such as hydrogen, alcohols, biogas, producer gas and various types of edible and non edible oils. However, in Indian context, the bio-origin fuels like alcohols, vegetable oils, and biogas can contribute significantly towards the problems related to fuel crises. Petroleum based diesel fuels have different chemical structure than vegetable oil. The former contain only carbon and hydrogen atoms which are arranged in normal (straight chain) or branched chain structures as well as aromatic configurations. The normal structure is preferred for better ignition quality. Diesel fuel can contain both saturated and straight or unbranched chain unsaturated hydrocarbons, but the later are not present in large amounts to make oxidation a problem [5-7]. Vegetable oils consist of triglycerides to about 97%; the other 3% distribute among di and mono glycerides and further more 3 fatty acids and the fat accompanying which are mostly removed with refining [8]. Structurally, a triglyceride is a reaction product of one molecule of glycerol with three fatty acid molecules to yield three molecules of water and one molecule of triglyceride [9].

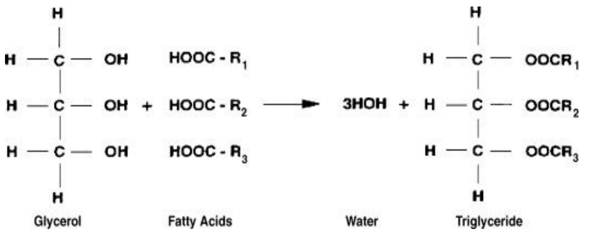

Fig. 1 Chemical structure of vegetable oils

where R_1, R_2 and R_3 are the alkyl groups of different carbon chain lengths (varying between 12-18), and -COO- is an carboxyl group. Vegetable oils have different chemical structure as shown [10].

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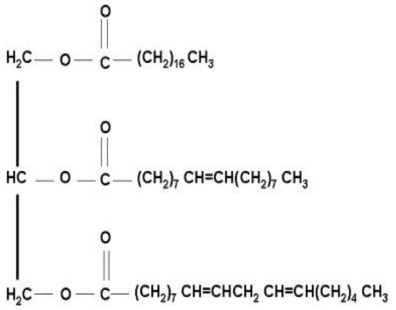

Fig. 2 Structure of a typical triglyceride molecule

The large size of the vegetable oil molecules and the presence of oxygen in the molecules suggest that some fuel properties of the vegetable oils would differ markedly from those of hydrocarbon fuels [8]. Linseed oil consists of primarily of the mixed glycerides of Oleic acid, Linoleic acid and Linolenic acid. The kinematic viscosity of Linseed oils varies in the range of 26-30 mm^2/s at 40ºC. The high viscosity is due to their larger molecular mass and chemical structure. Vegetable oils have high molecular weights of 600-900, which are three or more times higher than that of diesel fuel. The flash point of linseed oil is also very high (about 222ºC). The auto-ignition temperature is about 343ºC. Specific gravity is 0.93 and density 931 kg/m^3. Calorific value is about 40 MJ/kg, comparatively lower than that of diesel fuels (about 45 MJ/kg). This is because the presence of chemically bonded oxygen in vegetable oils lowers the heating value by about 10%. The cetane number is in the range of 32-40, while the iodine value ranges from 0-200, depending on unsaturation. The cloud and pour point of vegetable oils is higher than that of diesel fuel [11-14].

III. EXPERIMENTAL SETUP

A Kirloskar make, single cylinder, constant speed, air cooled, direct injection, CAF 8 model diesel engine was selected for the present research work, which is primarily used for agricultural activities and household electricity generations. It is a single cylinder, naturally aspirated, four stroke, vertical, air-cooled engine. It has a provision of loading electrically since it is coupled with single phase alternator through flexible coupling. The engine can be hand started using decompression lever and is provided with centrifugal speed governor. The lubrication system used in this engine is of wet sump type, and oil is delivered to the crankshaft and the big end by means of a pump mounted on the front cover of the engine and driven from the crankshaft. The inlet and exhaust valves are operated by an overhead camshaft driven from the crankshaft through two pairs of bevel gears. The fuel pump is driven from the end of camshaft.

A voltmeter, ammeter and wattmeter were connected between alternator and load bank. The thermocouples were mounted in the exhaust manifold to measure the exhaust temperature. The AVL 437 smoke meter and AVL Di-Gas Analyzer were also kept in proximity for the measurements of various exhaust gas parameters. The engine was started at no load by pressing the exhaust valve with decompression lever and it was released suddenly when the engine was hand cranked at sufficient speed. Then feed control was adjusted so that engine attains rated speed and was allowed to run about half hour till the steady state condition was reached. With the fuel measuring unit and stop watch, the time elapsed for the consumption of 20cc of fuel was measured. Fuel consumption, RPM, exhaust temperature, smoke density, CO, NOx, HC, CO_2 and power output were also measured. The engine was loaded gradually keeping the speed with in the permissible range and the observations of different parameters were evaluated. Short term performance tests were carried out on the engine with diesel to generate the base line data and subsequently Linseed Oil and Diesel was used to evaluate its suitability as a fuel. The performance and emission characteristics of Linseed Oil was evaluated and compared with diesel fuel.

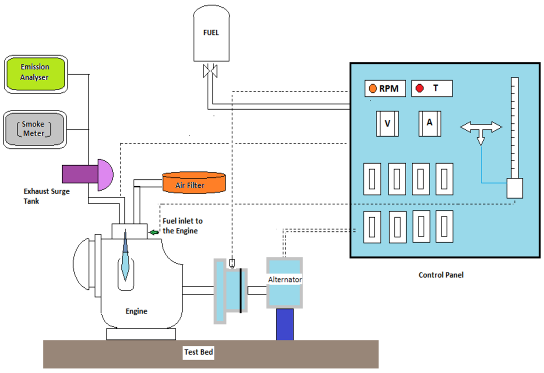

Fig. 3 Schematic diagram of experimental test rig

IV. RESULT & DISCUSSION

The variation of the brake thermal efficiency (BTE) of the engine with linseed oil and diesel is shown in Fig. 4. With increasing brake power, the BTEs of vegetable oils and diesel also increased; however, they tended to decrease when further increase in brake power was observed. The BTEs of the linseed oil are lower than those of diesel fuel throughout the entire range, possibly due to the lower calorific value and the high viscosity of linseed oil compared with diesel fuel.

The brake-specific fuel consumptions (BSFC) were also higher in the case of linseed oil than in diesel fuel, as evident in Fig. 5. This is mainly due to the combined effects of the relative fuel density, viscosity, and heating value.

Within the experimental range, the CO emission from linseed oil is higher than neat diesel fuel, as seen in Fig. 6. This is possible due to the high viscosity of vegetable oils; the higher the viscosity, the more difficult it is to atomize vegetable oils. This resulted in locally rich mixtures in the engine.

The CO_2 emissions are shown in Fig. 7. In the range of the whole engine load, the CO_2 emissions of diesel fuel are higher than that of the other fuels because vegetable oil contains oxygen element. The carbon content is relatively lower in the same volume of fuel consumed at the same engine load, and consequently, the CO_2 emissions from the vegetable oil and its blends are lower.

The value of unburned HC emission from the diesel engine in the case of straight vegetable oil is higher than that of diesel fuel, as seen in Fig. 8. HC emissions are lower at partial loads but tend to increase at higher loads for both fuels. This is due to the lack of oxygen, which is caused by engine operation at a higher equivalence ratio.

The NO_x emissions, shown in Fig. 9, increase along with the increasing engine load due to the higher combustion temperature. This proves that the most important factor for the emissions of NO_x is the combustion temperature in the engine cylinder and the local stoichiometry of the mixture. Within the NO_x emissions were reduced at full load, possibly due to the smaller calorific value of vegetable oils.

Fig. 10 shows that the exhaust gas temperature increases with the increase in brake power in all cases. This is due to the poor combustion characteristics of the linseed oil because of its high viscosity.

V. CONCLUSIONS

The results of the experiment showed that the performance of the engine on Linseed oil was slightly inferior to that on diesel fuel. The thermal efficiency of the engine was lower and the brake specific energy consumption of the engine was higher when the engine was fueled with Linseed oil compared to diesel fuel. The oxides of nitrogen from during the whole range of experiment were lower than diesel fuel. The Carbon monoxide, unburned hydrocarbon from the fuel was found higher than diesel fuel during the whole experimental range. The results from the experiments suggest that linseed oil is potentially good substitute fuel for diesel engine and performance and emissions characteristics were found to be comparable to diesel fuel.

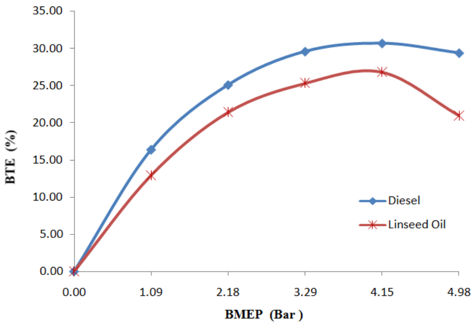

Fig. 4 Variation of brake thermal efficiency with brake means effective pressure

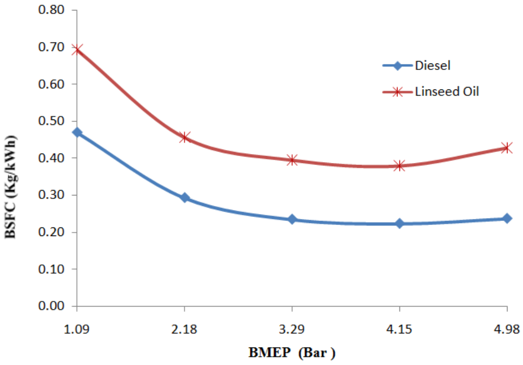

Fig. 5 Variation of brake specific fuel consumption with brake means effective pressure

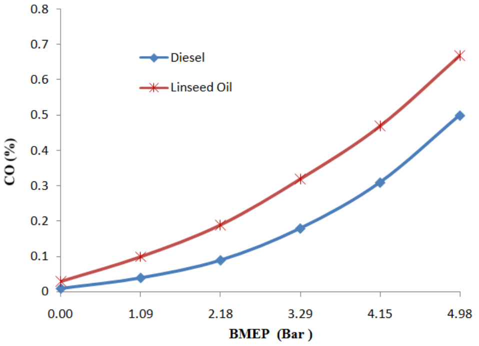

Fig. 6 Variation of carbon mono oxide with brake means effective pressure

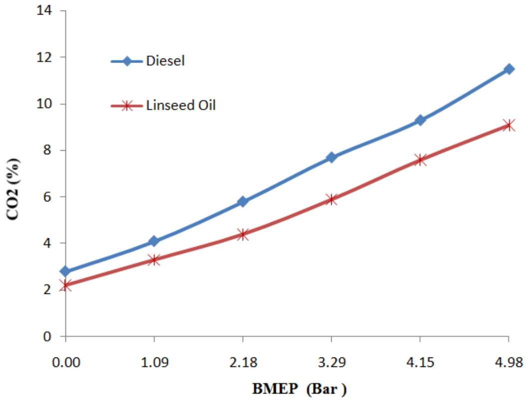

Fig. 7 Variation of carbon di oxide with brake means effective pressure

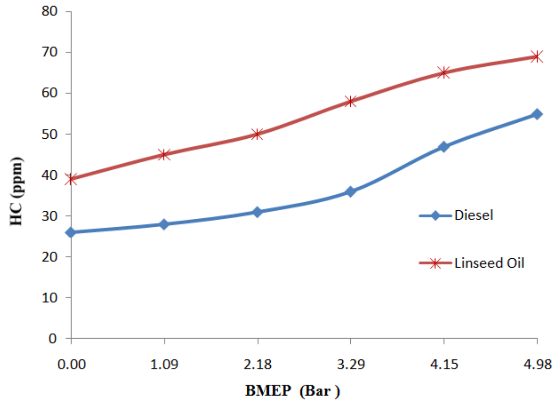

Fig. 8 Variation of unburned hydrocarbon with brake means effective pressure

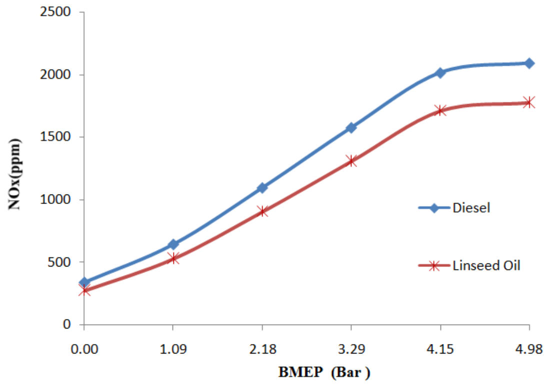

Fig. 9 Variation of oxides of nitrogen with brake means effective pressure

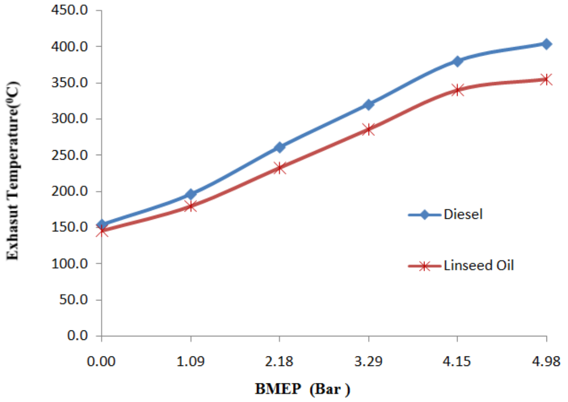

Fig. 10 Variation exhaust temperature with brake means effective pressure

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