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# Performance and Emission Characteristics of Kirloskar Diesel Engine Operating on Blend of Sesame Oil and Diesel

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**Abstract**: Diesel engines play very vital role in the different sectors like transportation, industrial and agricultural. Depletion of fossil fuel reserves and increased environmental degradation has generated interest in the use of alternative fuels. Vegetable oils are found to be most promising alternative fuels. Since they are renewable fuels, biodegradable, non-toxic and eco-friendly. Above all, they operate in conventional engine just like diesel thereby requires no major engine modifications. In this experimental investigation, potential of blend of 10% sesame oil and 90% diesel as alternative fuel has been evaluated. Engine performance and emission characteristics obtained with this blend is compared with that obtained with pure diesel. But before that, important properties of sesame oil in comparison to diesel were discussed. When blend of sesame oil-diesel is used, slightly higher fuel consumption rate and lower brake thermal efficiency were obtained. Also, lower air-fuel ratio and higher exhaust gas temperature were obtained with blend of sesame oil-diesel. NOx and CO emissions of the engine were found to increase slightly when sesame oil-diesel blend was used. From this experimental investigation, it has been established that sesame oil-diesel can be substituted for diesel as fuel diesel engine without any engine modification.

**Keywords**: aternative fuel, vegetable oil, sesame oil, blend, performance and emission characteristics.

## I. INTRODUCTION

Depletion of fossil reserves and increased environmental pollution has generated interest in the use of alternative fuels. Further, there is tremendous increase in prices of petroleum products. Diesel engines play very significant role in the field of transportation, industrial and agricultural sector. It is therefore, essential that alternative fuel for Diesel engines be developed. Vegetable oils are found to be most promising alternative fuels. Further, they are renewable fuels, which are biodegradable, non-toxic and eco-friendly. Above all they can be used in existing Diesel engine design just like petro-diesel, hence requires no engine modification. [1-5]

It has been observed from the available literature [1,5-9] that there are various problems associated with vegetable oils being used as fuel in diesel engines, mainly caused due to their high viscosity. Although short-term tests using pure vegetable oil showed good results, long term tests shows various engine problems such as carbonization of injector, piston head and surfaces of cylinder, gum development, engine deposits, wear of vital parts, ring sticking and thickening of the lubricating oil etc [1,7-9]. These experiences led to the use of modified vegetable oil as a fuel. In order to use vegetable oils in existing engine design, their viscosity had to be reduced. Solution of the viscosity problem can be approached through various techniques such as blending with lighter oils [1-2,4-5,10-12], preheating (i.e. increasing fuel inlet temperature) [4,6,8-9,12-13] and trans-esterification i.e. conversion to methyl/ethyl esters referred as biodiesel [5,7,14].

Sesame oil is extracted from the dried seed of the herb Sesamum indicum. Sesame seed contains 35% of oil, which is extracted with the help of oil expeller. While de-oiled cake is used as cattlefeed. In India, substantial amount of edible oils are consumed mainly for cooking. Oil extracted from sesame seeds is not as much popular as other edible oils but it is used as a cooking medium in few parts of the country. Sesame oil is used for manufacturing perfumed oils and medicine. It is also used for baking and preparation of sweets and confectionery [15-16].

In this experimanetal investigation, potential of blend of 10% sesame oil and 90% diesel as alternative fuel has been studied. Blend of 10% sesame oil and 90% diesel were prepared on volume basis. Pure diesel was used as a reference fuel. The following nomenclature was used in this work- 10SO: 10% vol. of sesame oil and 90 % vol. of diesel and D: 100% diesel. Engine performance and emissions obtained with 10SO were compared with that

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obtained with diesel. But before that, properties of sesame oil were determined and compared with diesel.

## II. FUEL CHARACTERIZATION

Table I shows important properties of sesame oil in comparison to diesel. The flash point of sesame oil was observed to be significantly higher than diesel. Therefore, they are safer in handling and storage. The cloud point of sesame oil, through considerably lower, is still high enough to cause flow problems in cold climates. The calorific value is an important quantity, since it gives the heat produced by the fuel within the engine that enables the engine to perform useful work. Sesame oil has lower calorific value than diesel. The presence of chemically bound oxygen in sesame oil lowers its calorific value [7,14,17].

TABLE I Properties of sesame Oil in comparison to diesel

| Fuel/ Properties | Sesame Oil | Diesel |
|---|---|---|
| Flash Point (°C) | 260 | 76 |
| Cloud Point (°C) | -3.3 | -5 |
| Calorific Value (MJ/kg) | 39.73 | 42.01 |
| Density (kg/m3) | 0.916 | 0.858 |
| Cetane No * | 40.2 | 50 |
| Kinematic Viscosity at 38˚C (cSt) | 35.17 | 2.96 |

* Reproduced from literature [7]

The density of sesame oil is slightly higher than that of the diesel. The higher density means higher fuel consumption rate is expected for sesame oil operation. The viscosity of sesame oil is found to be several times higher than that of diesel at standard temperature (38°C).

This is due to the large molecular mass and complex chemical structure of vegetable oil [7,17]. The cetane number of sesame oil is lower as compared to that of diesel. Thus, the propensity is higher for diesel knock in case of sesame oil operation.

## III.EXPERIMENTAL METHODOLOGY

Experimentations were carried out on a stationary Diesel engine. Fig. 1 shows photograph of experimental setup. The test engine specifications are given in Table II. Engine setup is provided with air intake tank and fuel supply tank. A fuel supply tank mounted on a suitable stand. The fuel supply system with instrument action facilitates the fuel consumption measurement. Necessary instrumentation has been provided to measure temperature and flow.

Test engine is connected with dynamometer and load cell. A computer pressure sensor is mounted on the cylinder, which measure the pressure values. Opposite shaft of the engine is attached with crank angle sensor for measuring crank angle and rpm of the shaft.

Fig. 1. Photograph of Experimental Setup

TABLE III Specifications of test engine

| | |
|---|---|
| Engine | Kirloskar (Model AV1), single cylinder, 4 stroke and water cooled C.I. engine. |
| Stroke | 0.110 m |
| Bore | 0.080 m |
| Rated power | 3.7 kW @ 1500 rpm |
| Design Fuel | Diesel |
| Alternator | Kirloskar (Model: KBM –104), 50Hz, 1500 rpm, 230V, 17.4Ampere |

Fig. 2 Photograph of Computer Control Room

The pressure sensor and crank angle sensor in combination detects cylinder pressure at different angle of crank. The whole assembly is installed on rigid frame. This frame is provided anti-vibration pads. The experimental setup is interfaced with computer using software. This software is capable of tabulating the readings as per the requirement of the experiment. Software allows the user to have control on data logging, printing, stored data and preparing spreadsheet in excel. Fig. 2 shows photograph of computer control room. Constant speed engine performance tests were performed on this engine with two fuels.

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## IV. RESULTS AND DISCUSSIONS

Fig. 3 shows variation of fuel consumption rate in relation to brake power (BP). It can be seen that fuel consumption rate for blend of sesame oil-diesel (10SO) is higher than that for diesel. This may be due to influence of density, viscosity and calorific value of the blended fuel [18]. Premanand [19] et al. concluded that mahua oil based biodiesel blends has higher fuel consumption than that with diesel. Similar results are reported by other researchers [20-22].

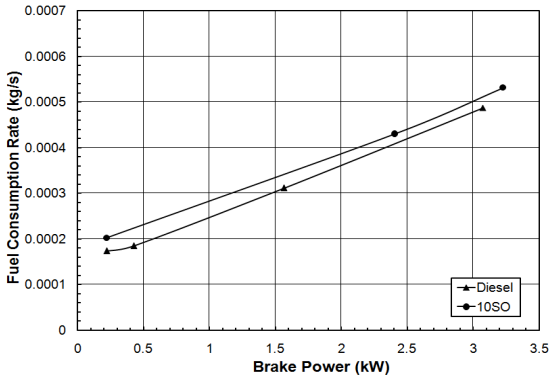


Fig. 3. Fuel Consumption rate Vs BP

The comparison of brake thermal efficiency (BTE) for diesel and blend of sesame oil-diesel blended fuel is shown in Fig. 4. It can be seen that as the brake power increases, BTE also increases for blend of sesame oil-diesel as well as for reference fuel. It can be further seen that, BTE for sesame oil blend is lower than reference fuel. Experimentations of Pramanik [1] showed that BTE values obtained with the blends of jatropha curcas oil and diesel remains lower than that with diesel through the load range. The low BTE for sesame oil blended fuel may be due to the lower calorific value and the high viscosity of blended fuel. Bhatt et al. [23] observed that BTE values decreased with an increase in the percentage of mahua oil in diesel. Khan et al [24] concluded in their experimental investigation that BTE values obtained with pure linseed oil is lower than that obtained with diesel.

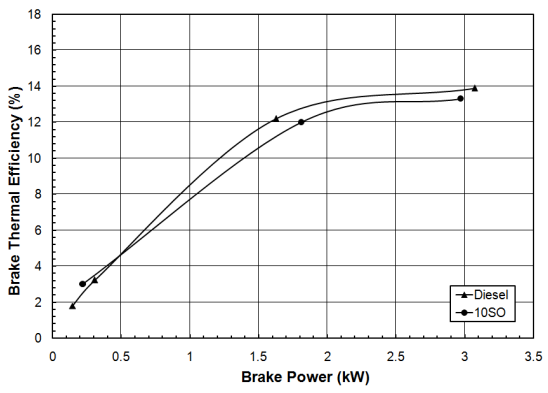


Fig. 4. Brake Thermal Efficiency Vs BP

The BTE values were found to increase with addition of diesel. The maximum BTE was observed with the blend containing 10% linseed oil which was close to pure diesel operation. Variation of air-fuel ratio with respect to BP is shown in Fig. 5. It can be observed that air-fuel ratio decreases with increase in BP. Further, higher air-fuel ratio is obtained for reference fuel operation.

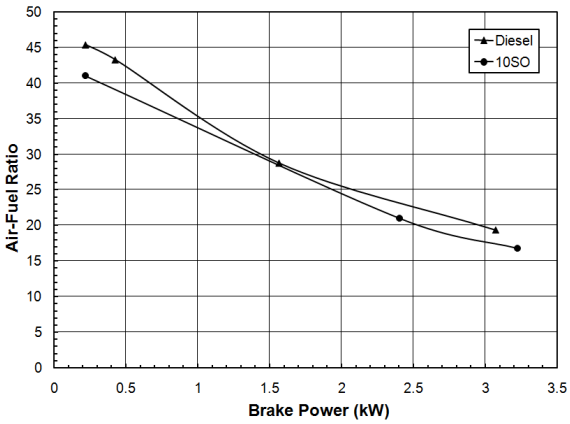


Fig. 5. Air-Fuel Ratio Vs BP

Fig. 6 shows variation of exhaust gas temperature with respect to brake power. It can be observed that exhaust gas temperature increases with increase with BP for both fuels. Further, it can be seen that exhaust gas temperature for blend containing 10% sesame oil is higher than that for reference fuel. In case of blended fuel operation, higher delay period results in slow combustion. Because to this, injected fuel particles may not get enough time to burn completely before TDC. Hence, some fuel particles tend to burn during early part of expansion stroke (after burning takes place) [6]. Khan et al. [5] obtained that exhaust gas temperature with jatropha curcas oil-diesel blends are higher that with diesel, particularly at high loads.

Fig. 7 shows the NOx emissions for diesel and blend of sesame oil-diesel at various power output of the engine. It can be seen that NOx emission varies directly with engine power output. It is due to the fact that NOx emssions are related to exhaust gas temperature. As the engine load increases, the exhaust gas temperature increase as a result of which the formation of NOx increases [25].

It is further observed that NOx emissions for sesame oil-diesel blend is slightly higher than that for pure diesel. This may be due to the fact the exhaust gas temperature for blended fuel is higher as compared to reference fuel. CO emissions variation for test fuels is shown in Fig. 8. It can be seen from the figure that CO emissions levels for blended fuel are observed to be slightly higher as compared to diesel at all power outputs. This difference is more significant at high loads. Martin et al. [26] observed that CO emissions for cottonseed oil to be higher as compared to diesel. The blending with diesel reduced CO emissions.

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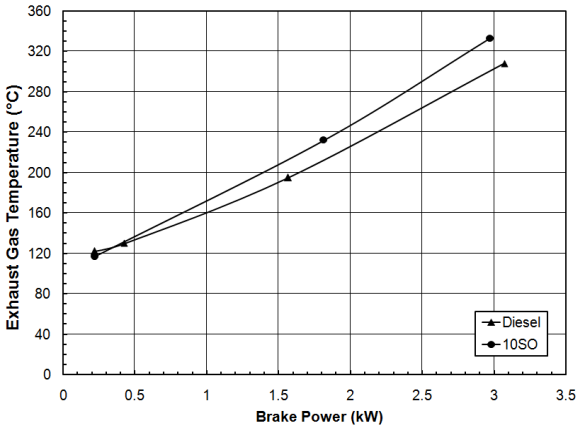


Fig.6. Exhaust Gas Temperature Vs BP

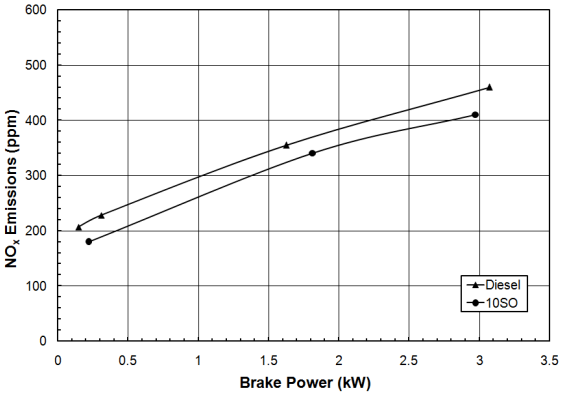


Fig. 7. NOx Emissions Vs BP

## V. CONCLUSION

Performance and emission characteristics of engine have been evaluated using blend 10% sesame oil and 90% diesel. The properties of sesame oil were compared with those of diesel and found to be in good agreement. However, viscosity of sesame oil was found to be significantly higher. The blend of 10% sesame oil and 90% diesel was prepared on volume basis. Performance of Diesel engine with blend of sesame oil-diesel was evaluated and was found to be acceptable without any engine modification. With blend of sesame oil-diesel, slightly higher fuel consumption rate and lower brake thermal efficiency was obtained. Lower air-fuel ratio and higher exhaust gas temperature was observed with blend of sesame oil-diesel. NOx and CO emissions for sesame oil-diesel blend were found to be slightly higher than that for reference fuel at all power outputs. A single cylinder four stroke Kirloskar Diesel engine was operated successfully using blend of sesame oil-diesel and pure diesel. On the whole, it can be concluded that Diesel engine can be operated successfully using 10% sesame oil-90% diesel blend without any alteration in existing engine design. Detailed research work related to combustion characteristics and engine deposit formation using this fuel blend must be carried out.

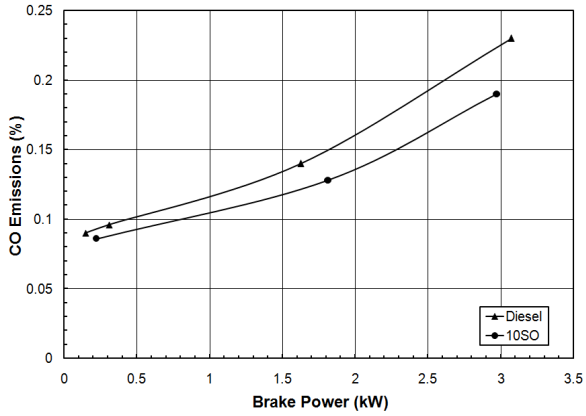


Fig. 8. CO Emissions Vs BP

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## BIOGRAPHIES

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