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Experimental Investigation of Single Cylinder Diesel Engine with Sesame Oil and Ethanol Blends at Various Compression Ratio.

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Abstract - *Continuous rise in the conventional fuel prices and shortage in supply have increased the interest in the field of alternative fuels for internal combustion engines. Diesel engines are mostly trusted source of transportation and power generation. In present work, experimentation was carried out on single cylinder VCR diesel engine which is connected to the eddy current dynamometer, emission gas analyzer and smoke meter. The test was performed with four different blends of sesame oil, ethanol and diesel in the ratios of 5%, 15%, 35% and 55% of sesame oil keeping ethanol at constant 5% and remaining diesel. The experimental results were compared for neat diesel operation with ethanol and sesame oil blends at compression ratio 16, 17 and 18. There is 12.23%, 13.55%, 9.93% and 6.68% improvement observed in brake thermal efficiency. Also, there is 9.52%, 11.90%, 7.69% and 5.76% reduction in specific fuel consumption at full load condition. Improvement was observed not only in performance parameters but also in emission reduction. There is an average 25%, 14%, 10%, and 8.97% reduction in HC and average 67%, 56%, 53% and 40% reduction in CO observed at full load condition. But increase in NO could not be prevented which was increased from220 ppm to 262 ppm and found decreased with varying blends of ethanol and sesame oil for higher compression ratio. The experimental results obtained shows that sesame oil, ethanol and diesel blends works better at higher compression ratio.*

***Key Words*: Sesame oil, ethanol, diesel engine, emissions.**

1. INTRODUCTION

Diesel engines have been widely used in almost all engineering machinery, automobile and shipping power equipment due to their excellent drivability and economy. At the same time, diesel engines are major contributors of various types of air pollutants such as carbon monoxide (CO), oxides of nitrogen (NOx), particulate matter (PM) and other harmful compounds. With the increasing concern of the environment and stringent emission norms, the reduction in engine emissions is a major research objective in engine development. Based on the depletion of fossil fuels and environmental considerations has led to investigations on the various alternative fuels such as CNG, LPG, ethanol, hydrogen, biodiesel etc [1].

Conventional diesel fuels could be replaced by various possible alternatives fuels like ethanol and biodiesel. Research continues on the development of high efficient, low cost process for producing ethanol from other feed stock such as waste from agricultural crops, food and beverage processing wood and paper processing [2]. Fuels like alcohol, biodiesel, liquid fuel from plastics etc are some of the alternative fuel for diesel engine. Plastics have become an indispensable part in today's world, due to their light weight, durability, energy efficiency, coupled with a faster rate of production and design flexibility, these plastics are employed in entire industrial and domestic areas hence plastics have become essential materials and their applications in the industrial field are continuously increasing day by day. At the same time, waste plastics have created very serious environmental challenges because of their huge quantities and their disposal problems [3, 4].
Ethanol could be one of the possible renewable fuels for diesel substitution in diesel engines. It can be made from any starch bearing crops such as sugarcane, sorghum, corn, barley, cassava, and sugar beets. Besides being a biomass-based renewable fuel, ethanol has a cleaner burning characteristics and a high octane rating. The auto-ignition temperature of ethanol is higher than that of diesel fuel, which makes it safer for transportation and storage. The application of ethanol as a supplementary fuel will reduce environmental pollution. The major problem associated with use of alcohol in diesel engine is the limited miscibility at lower temperature and the required minor variations in fuel delivery systems restricts the use of ethanol in diesel. One of the effective approaches is adding oxygenated fuel to solve the above problem without any modification of the engine. The selections of oxygenated fuels is based on economic viability, toxicity and fuel blending properties [5, 6].

1.2 Sesame oil

Sesame oil is a refined vegetable oil from sesame seeds. which are unusually high in oil, around 50% of seed weight. Sesame is an oil seed and is one of the oldest cultivated plants in the world. Vegetable oils have different chemical structures up to three fatty acids linked in a glycerol molecules with ester linkage. The fatty acid varies in the carbon chain length and its number of double bonds. Higher structure of fatty acids in oil gives a higher cetane number and the oil is less prone to oxidation, due to its high percentage of saturated fatty acid and free fatty acids [7].

Table 1 gives properties of Diesel, Sesame oil and Ethanol

Table 1 Properties of fuels [8, 9].

Properties	Diesel	Sesame oil	Ethanol
Density *(kg/m^3)*	820-950	930	789
Specific gravity *(mm^2/sec)*	0.81	0.92	0.78
Viscosity @40˚C *(poise)*	0.00055	--	0.01
Calorific value *(MJ/kg)*	0.045	0.039	0.0297
Cetane No.	45-55	45	5
Autoignition temp. *(^{0}C)*	210	310-360	363
Octane No.	-25	85	107

2. Experimentation Work

Figure 1 shows the experimental setup used for investigating the performance and emissions of single cylinder diesel engine with various blends of sesame oil and ethanol at various compression ratios of 16, 17 and 18. The engine specifications are as shown in Table 2. The engine is coupled to eddy current dynamometer. AVL DiGas 444 5-channel emission gas analyzer and AVL 437 diesel smoke meter was used to measure emissions and smoke opacity respectively. Experimentation was carried out on neat diesel before using various blends at different compression ratios. The readings were noted for different loading conditions at constant speed of 1500 rpm. The Performance data using engine software package and emissions were recorded. After recording the performance and emission parameters on neat diesel operation, investigation was carried out on different blends proportions of B10, B20, B40 and B60, for different compression ratio of 16, 17 and 18.

Figure -1: Experimental set up.

The engine specification are given in table 2.

Table 2 Engine Specifications.

Sr. No.	Descriptions	Specifications
1	Make	Kirloskar TV1 Engine
2	No. of cylinder	1
3	No. of stroke	4
4	Cylinder diameter	87.5 *mm*
5	Stroke length	110 *mm*
6	Connecting rod length	234 *mm*
7	Dynamometer arm length	185 *mm*
8	Fuel	Diesel
9	Power	3.5 *kw*
10	Speed	1500 *rpm*
11	CR Range	12:1 To 18:1
12	Injection Point	0 To 20 *C*

3. Results and discussion

The performance and emission characteristics of sesame oil, ethanol and diesel blends at different compression ratio were compared with baseline diesel operation.

3.1 Brake thermal efficiency

The figure 2 shows variation of break thermal efficiency with various compression ratios for which all blends were tested at 16, 17 and 18 respectively at full load condition. For compression ratio 16, the increase in break thermal efficiency for blends B10, B20, B40 and B60 was found to be 9.49%, 6.83%, 2.7% and 3.41%. Whereas for compression ratio 17 it increases by 8.58 %, 4.93%, 2% and 4.9%. The break thermal efficiency for compression ratio 18, the increase was observed 12.59%, 10.25%, 6.49%, 11.14%, for same blends compared to neat diesel.

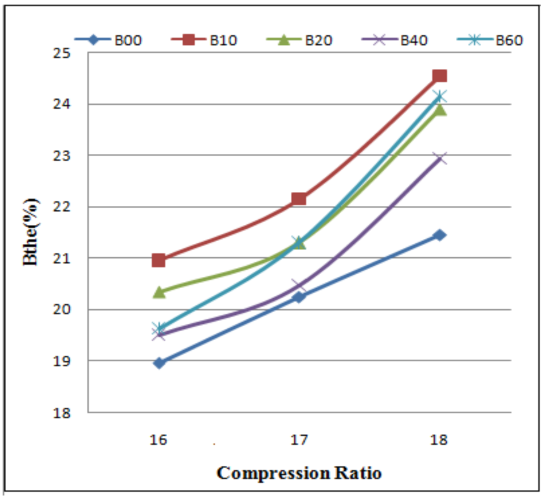

Figure 2: Variation of Brake Thermal Efficiency with Compression Ratio.

The thermal efficiency of diesel engine increases with increase in compression ratio and found to be higher than

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neat diesel. Break thermal efficiency increases due to increase in calorific value of overall mixture and better mixing of sesame oil ethanol and diesel blends with air results in better combustion.

3.2 Specific Fuel Consumption

Figure 3 shows the variation in the specific fuel consumption at various compression ratios 16, 17 and 18 for neat diesel and various blends. It was observed that, fuel consumption is minimum at compression ratios 18 for all blends as compared to neat diesel. At compression ratio16 the specific fuel consumption is reduced by 6.66% , 13.33%, 17.77% and 11.11% for the blends B10, B20, B40 and B60. At compression ratio17 the specific fuel consumption is reduced by 9.30%, 16.27%, 16.27% and 13.95%. The specific fuel consumption is reduced by 9.52%, 14.28%, 19.04% and 16.66% for the all blends at compression ratio18 as compared to neat diesel. The reduction in specific fuel consumption is due to uniform mixing of blends with air as well as better combustion at full load condition. Higher compression ratio is preferable to reduce the specific fuel consumption.

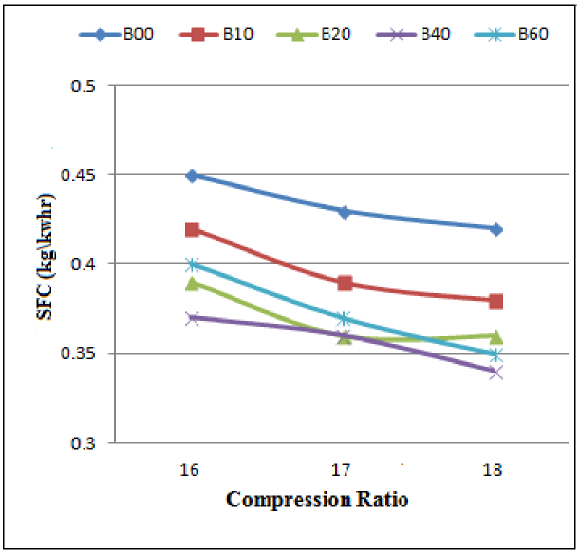

Figure 3: Variation of Specific fuel consumption with Compression Ratio.

3.3 HC

The HC emission of various blends was lower compared to neat diesel for all compression ratios as shown in figure 4. The HC emission decreases with increase in the compression ratio for neat diesel and various blends. The HC was found to be decreased by 13.26%, 9.1%, 4.08% and 2.04% for the various blends of B10, B20, B40, B60 at compression ratio16. At compression ratio17, the decrease in HC was recorded as 17.14%, 17%, 14.28% and 7% and for compression ratio 18, HC decreases by 25.64%, 15.38%, 10.25% and 8.97% compare to neat diesel operation. The decrease in HC was due to the complete combustion of all blends.

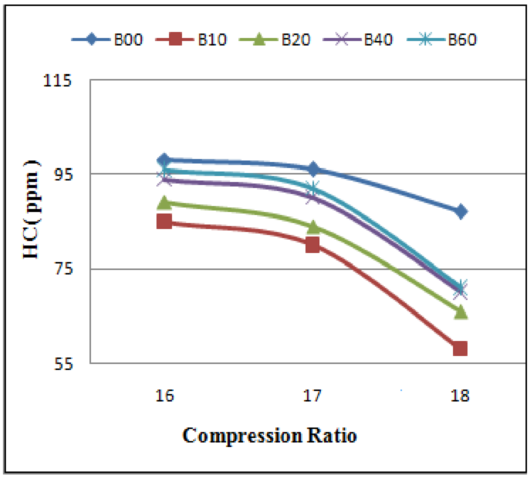

Figure 4: Variation of HC Emission with Compression Ratio

3.4 CO

The CO of various blends was found lower compared to neat diesel for all compression ratios as shown in figure 5. It was observed that the carbon monoxide decreases with blends for all compression ratios. The CO decreased by 3.41%, 1.70%, 8.54% and 4.27% for compression ratio 16 for the various blends of B10, B20, B40, and B60. The CO decreased by 9.25%, 10.18%, 20.37% and 14.81% for compression ratio 17 and for compression ratio18, it reduced by 50%, 56%, 53% and 40% for all blends as compare to neat diesel. As the compression ratio increases, CO percentage decreases due to complete combustion of fuel resulting in less oxygen contents.

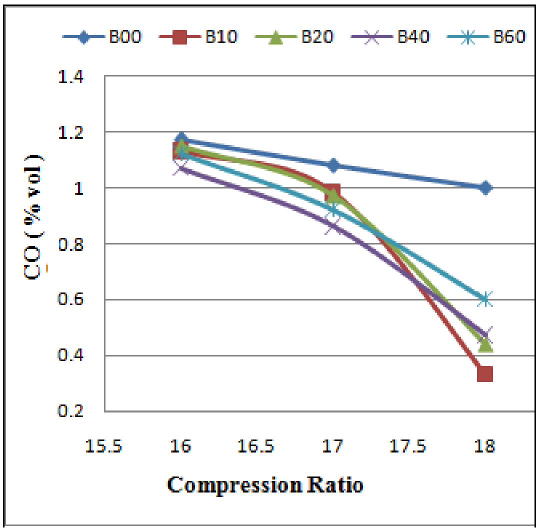

Figure 5: Variation of CO Emission with Compression Ratio

3.5 NO_x

The NO_x emission of various blends is higher compared to neat diesel for all compression ratios as shown in figure 6. The formation of oxides of nitrogen is due to the peak combustion temperature, the oxygen concentration in the combustion chamber and the residence time of high temperature gas in the cylinder. The blends which has high calorific value as compared to diesel, causes temperature rise in the combustion chamber leads to increase in NO_x emission. NO_x is increased with various blends for all compression ratio. The maximum value of NO_x is observed at compression ratio 18 is 262 *ppm*. At full load condition the NO_x increases from 175 *ppm* to 208 *ppm* for compression ratio 16 and from 191 *ppm* to 218 *ppm* for compression ratio 17.

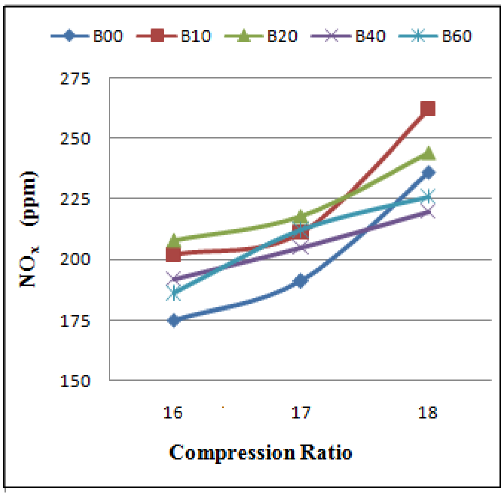

Figure 6: Variation of NO_x Emission with Compression Ratio

3.6 Smoke

The figure 7 compares the amount of smoke opacity for all blending ratio.

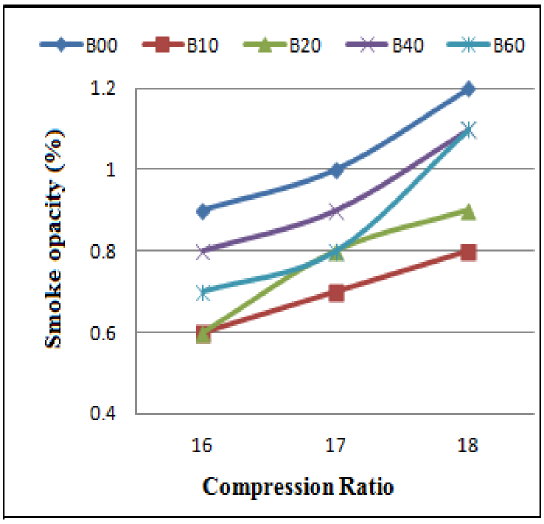

Figure 7: Variation of Smoke Emission with Compression Ratio.

It is observed that smoke opacity decreases at full load condition for all blends. At compression ratio16 smoke opacity was decreased by 33%, 32.9%, 11% and 20% for the various blends of B10, B20, B40, and B60 compared to neat diesel. At compression ratio17 smoke opacity decreased by 30%, 20%, 10% and 15% for the same blends and at compression ratio 18, it was decreases by 33.3%, 25%, 8.3% and 8% as compared to neat diesel. The smoke is formed due to the incomplete combustion of the fuel-air mixture. Due to the homogeneous mixture formed, complete combustion takes place and smoke opacity reduces.

4. CONCLUSIONS

The following conclusions are drawn from the results of the investigation on the performance and emissions of a single cylinder four stroke, diesel engine with various blends and at constant speed of 1500 *rpm*. It is seen that, the all blends at higher compression ratio results in improvement of performance and reduction in emissions except NO_x. The result from the experiment shows that blends works better at compression ratio 18.

From the experimented results, following conclusions are made:

- The maximum thermal efficiency is observed for compression ratio 18 i.e. increase of 13.55% comparing to neat diesel was observed.
- There is maximum reduction in specific fuel consumption which is reduced at an average 14.87% for compression ratio 18 at full load condition. For blends B10, B20, B40 and B60 respectively.
- The HC is reduced at an average of 15.07% due to complete combustion at compression ratio 18.
- The CO is reduced maximum for all compression ratios with an average of 22.5% reduction of CO.
- NO_x increases for all compression ratios for all blends. The NO_x increased from 220 *ppm* to 262 *ppm* for compression ratio 18.
- The maximum smoke opacity is reduced by 33% and 25% as compared neat diesel. For compression ratio 18 and 16 respectively. For blends B10 and B20 respectively.

The increase in NO_x could not be prevented but the techniques like exhaust gas recirculation can be used to reduce NO_x emission.

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