EXPERIMENTAL STUDY ON EMISSION AND PERFORMANCE ANALYSIS OF NON EDIBLE RICE BRAN OIL AS AN ALTERNATIVE FUEL FOR DIRECT INJECTION DIESEL ENGINE

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ABSTRACT

The financial growth of the country is measured by efficient use of natural resources especially fuel. Fossil fuels have played a dominant role in the rapid industrialization of the world and thereby increased and improved quality of life. However, due to the threat of supply crunch ever rising prices and the effect of green house gases caused by conventional fuels there is an urgent need to explore the possibility of using straight vegetable oils (unmodified) as alternative fuels to reduce the pollution and to increase the energy self-reliance of the country, especially in rural areas. The study aims to investigate experimentally the performance analysis of non-edible rice bran oil, a straight vegetable oil [SVO] and its blends with diesel as fuel and also to investigate the exhaust emission characteristics in the single cylinder, direct injection, four stroke diesel engines typically used in Indian agricultural sector. Experiments were conducted by using the blends of diesel with non-edible rice bran oil in various proportions from ten to one hundred percentages by volume and at varying engine loads. Studies have found that the use of blends of more viscous non-edible rice bran oil and diesel in various percentages result in the decrease in the NO_X emission while the brake thermal efficiency reduces marginally.

Keywords: rice bran oil, alternate fuels, engine performances, exhaust emissions, straight vegetable oil.

1. INTRODUCTION

Fossil fuels have played a dominant role in the rapid industrialization of the world and thereby increased and improved quality of life. Unhindered use of these fuels has also given rise to environmental issues. These in turn have resulted in the additional expenses by way of additional spending on the protection of the citizens of the country from the ecological ill-effects, replacement of equipment, infrastructure for both the old and the new technology, etc. Indian agriculturists produce food grains to satisfy the hunger of the citizens of our country. The post-harvesting processes involved in the conversion of the agricultural produce to the final production in the form edible grains, pulses, oils, food-products, etc. also produces a lot of by-products those have a potential to take care of the energy needs at a very local level. However their use has not been comprehensive and not standardized. Therefore, this study is an effort to standardize the use of such available agricultural by-products viz. Non-Edible Rice Bran Oil which has a potential, because of its mineral diesel like properties, to augment the diesel use in at least the sectors like irrigation, water-ways transportation, small diesel fuelled community power-plants etc. A major physical advantage of non-edible rice bran oil, as this is unrefined oil, is its local availability without the need for transporting it over a large distance and large processing infrastructure while its limitation is its high density, viscosity and suspended particulates. The harvested produce from farms is known as paddy. Each grain consists of the edible portion that is covered with an outer layer known as the husk or hull. After drying the paddy, it is shelled and the protective husk is removed. Brown rice thus obtained has a thin bran layer surrounding the starchy white rice kernel. The milling machine removes the outer bran layer and white rice is obtained. White rice is eaten after remaining bran layers are removed by further polishing. From the rice milling process rice husk and rice bran are thus obtained as by-products. This Rice Bran about 10% of the weight of rough rice is rich in oil (15-22%), depending on the milling procedure and the rice variety. The rice bran thus obtained is further processed and the crude non-edible rice bran oil is extracted by a process known as solvent extraction.

2. METHODOLGY

2.1. Study of properties of diesel, non-edible rice bran oil and blends

The first part of the study involved evaluation of properties of diesel and non-edible rice bran oil like, Viscosity, Density, Flash point, Calorific Value, Fire points etc., The properties were determined by conducting the experiments as per the Bureau of Indian Standards, and are shown in the Table-1. Other properties of pure non-edible rice bran oil were noted as shown in Table-2.

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Table-1. Comparison of properties of blends of fuels.

Blends	Fuel blend specification by volume	Density *gm/cc*	Viscosity stokes	Flash point in ^oC	Fire point In ^oC	Heating value in KJ / Kg
HSD	100% Diesel	0.78	0.045	50	55	45100
10RBO	10% RBO + 90% HSD	0.7980	0.048	54	59	44100
20RBO	20% RBO + 80% HSD	0.7998	0..052	56	61	42860
30RBO	30% RBO + 70% HSD	0.8144	0.059	58	62	42100
40RBO	40% RBO + 60% HSD	0.8234	0.086	59	64	41825
50RBO	50% RBO + 50% HSD	0.8436	0.1033	62	66	41050
60RBO	60% RBO + 40% HSD	0.8452	0.185	68	72	40826
70RBO	70% RBO + 30% HSD	0.8456	0.239	74	79	40344
80RBO	80% RBO + 20% HSD	0.8480	0.2614	112	118	39860
90RBO	90% RBO + 10% HSD	0.8748	0.544	132	151	39400
100RBO	100% NON-EDIBLE RICE BRAN OIL	0.8768	0.5956	150	165	38623

Table-2. other properties of pure non-edible rice bran oil.

Parameters	Readings
Density @ Room temperature	0.9153 gm/cc
Total acid number	15.27 mg KOH/g
Sediments	Nil
Sulphur content	21 mg/kg
Water content	0.15 % by Vol

2.2. Study of performance of diesel, non-edible rice bran oil and blends

Experimental tests were conducted on a stationery, vertical, single cylinder, four-stroke, direct injection, water cooled diesel engine, popularly used in the agricultural sector. The specifications of the engine are given in Table-3. The exhaust gas emissions were noted and analyzed using 5 gas exhaust gas analyzer.

Table-3. Engine specification.

Make	**Kirloskar model AV1**
No. of strokes per cycle	4
No. of cylinders	Single
Combustion chamber position	Vertical
Cooling method	Water cooled - open system
Starting condition	Cold start
Ignition technique	Compression ignition
Bore (D)	80 mm
Stroke (L)	110 mm
Rated speed	1500 rpm
Rated power	5 hp (3.72 kW)
Compression ratio	16.5 : 1

The schematic layout of the experimental set-up is given below in Figure-1.

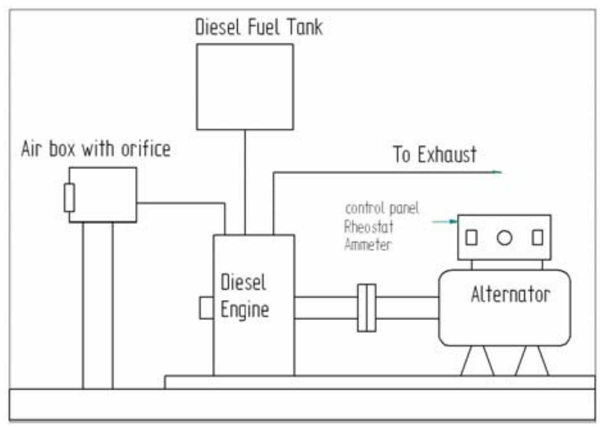

Figure-1. Schematic layout of the experimental setup.

The methodology of tests on the above engine is as below:

(i) The engine was initially started with 100% Diesel in the fuel tank of the engine and after it operated for a seven minutes at the rated rpm of 1500, without any load the initial base readings for the Diesel were noted. The engine was then electrically loaded from 0 amperes to 10 amperes at an interval of 2.5 amperes.
(ii) The engine parameters viz. rpm, fuel consumption, exhaust gas temperature, inlet and outlet coolant (water) temperature were noted at each load.
(iii) Exhaust emission parameters like CO, CO_2, O_2, NOx and HC were noted.
(iv) Three sets of readings were noted and mean of the readings were recorded. Similarly recordings for various blends Table-1 were thus obtained after allowing the engine to run on Diesel for few minutes after every loading and blend fuel cycle.

(v) The engine was run with pure non-edible rice bran oil for 24 hours continuously to check for fuel clogs, injector clogs and carbon deposits on the combustion chamber.

(vi) The experiments were also conducted using 6 months old non-edible rice bran oil and results were tabulated. This was to ascertain the effect of viscosity, which decreases with increasing time due to natural sedimentation process.

3. RESULTS AND DISCISSIONS

As pointed in table the non-edible rice bran oil has a higher viscosity as compared to diesel and with its higher flash point at 150°Cand fire point at 165°C it is less explosive. With a viscosity of 0.8768 gm/cc as against the 0.78 gm/cc it is less volatile and therefore it does not have storage and transport related issues that need specialized storage / handling. Hence the cost involved in such storage / handling is minimized.

3.1. Performance parameters

3.1.1. Brake thermal efficiency

The brake thermal efficiency increases as the load on the engine increases. The brake thermal efficiency decreases as the proportion of non-edible rice bran oil increases Figure-2. This can be explained by the fact that as the viscosity of the blend increases, the atomization of fuel is not as good as pure diesel.

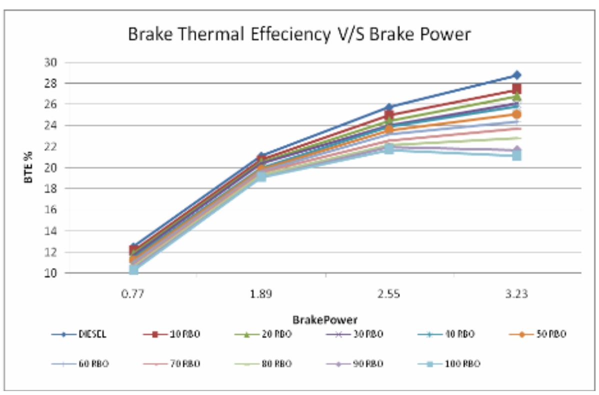

Figure-2. Comparison of brake thermal efficiency and brake power.

3.1.2. Brake specific fuel consumption

As the proportion of non-edible rice bran oil increases in the blends, specific fuel consumption increases as shown in Figure-3. Higher proportions of Rice bran oil in the blends increases the viscosity which in turn increases the specific fuel consumption due to poor atomization of the fuel [1, 2].

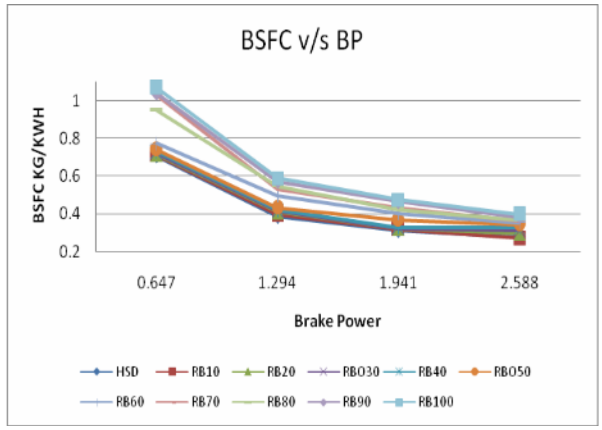

Figure-3. Comparison of brake specific fuel consumption and brake power.

3.1.3. Exhaust gas temperature

For all blends exhaust gas temperatures increase with increase in the load. At same load exhaust temperatures decreases with increase in non-edible rice bran oil proportion Figure-4.

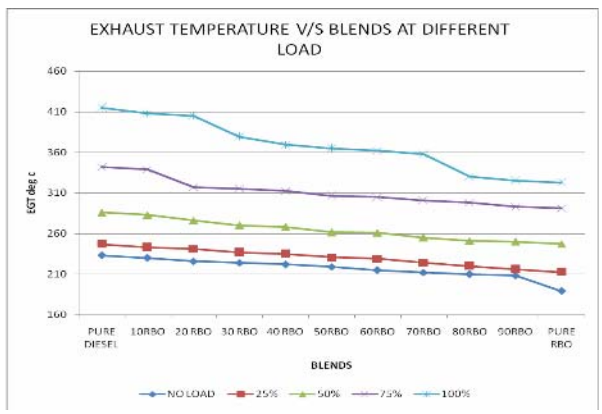

Figure-4. Exhaust gas temperature at various loads for different blends.

3.2. Emission parameters

3.2.1. Nitrogen oxide

The Nitrogen Oxide (NOx) emission values of all blends against various loads Figure-5. The vital factor that causes NOx formation is due to availability of oxygen and high combustion temperatures. As the load on the engine increased so also the NOx emission increased, this could be attributed to the increase in the combustion temperature.

Another observation is that NOx emission reduces as the proportion of the non-edible rice bran oil increases, this is a encouraging fact for usage of non-edible rice bran oil as an alternate fuel as NOx emission is considered to be one of the most harmful emissions. Similar results have been seen in other experiments conducted. [1], [3], [4].

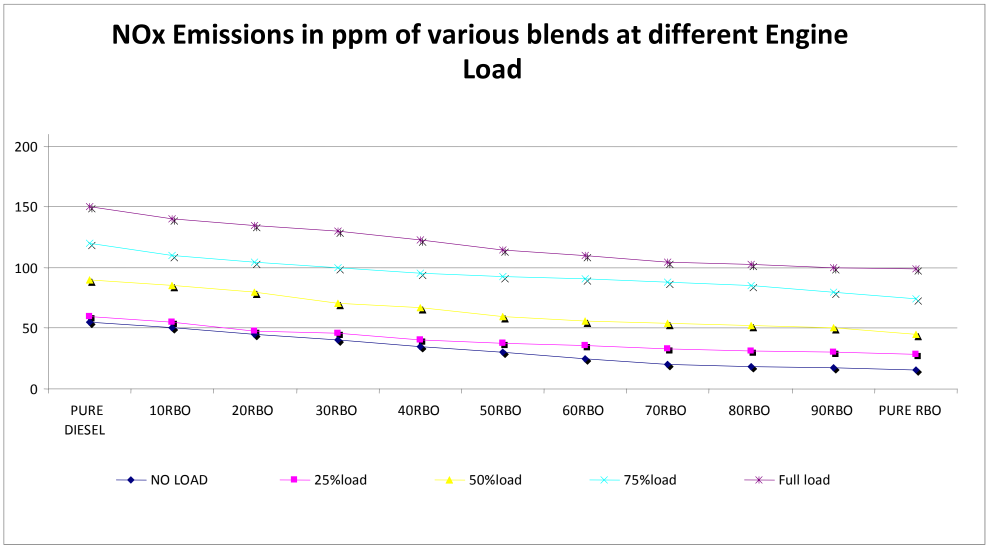

Figure-5. Nitrogen oxide emissions.

3.2.2. Carbon monoxide

From the Figure-6 it is observed that Carbon Monoxide (CO) emissions decrease as the load increases from No load to 75% load and then the emissions increase at full load. Figure-7 shows that the CO emission increases with the increase in proportion of non-edible rice bran oil in the blends. This increase may be due to relatively incomplete combustion as the blend becomes more viscous. Similar results have been seen in [5] but partial contrasting results in [1].

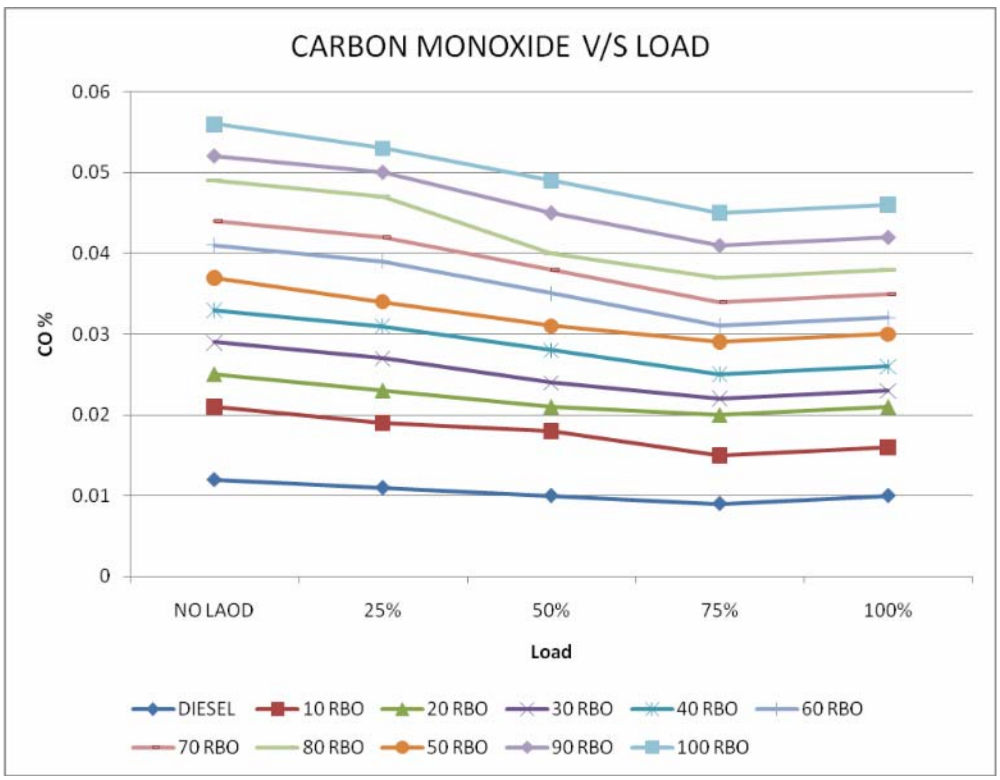

Figure-6. Carbon monoxide emissions at different loads.

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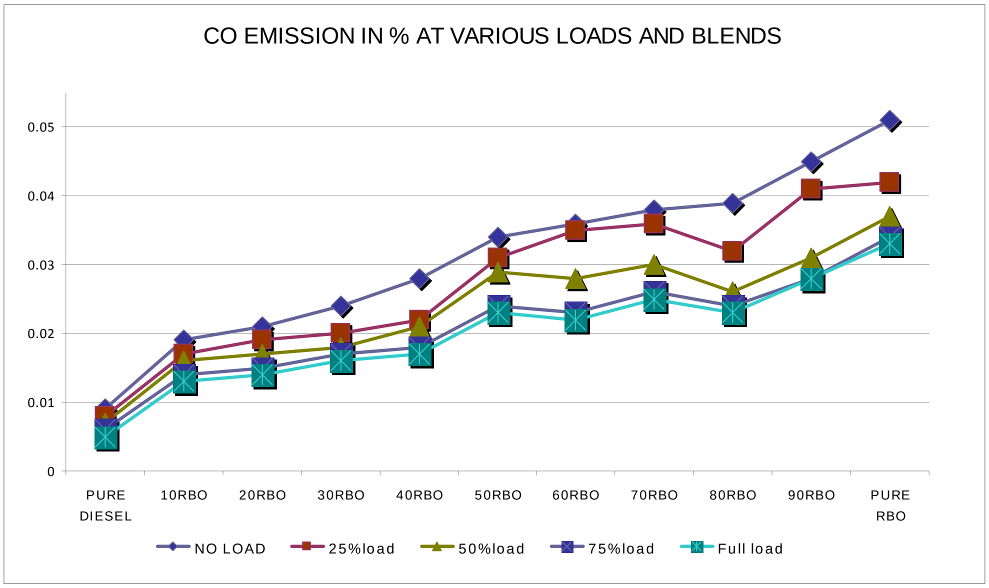

Figure-7. Carbon monoxide emissions for different blends.

3.2.3. Carbon dioxide

The Carbon dioxide (CO_2) exhaust emission increases as the load increases and also increases as the proportion of non-edible rice bran oil increases Figure-8.

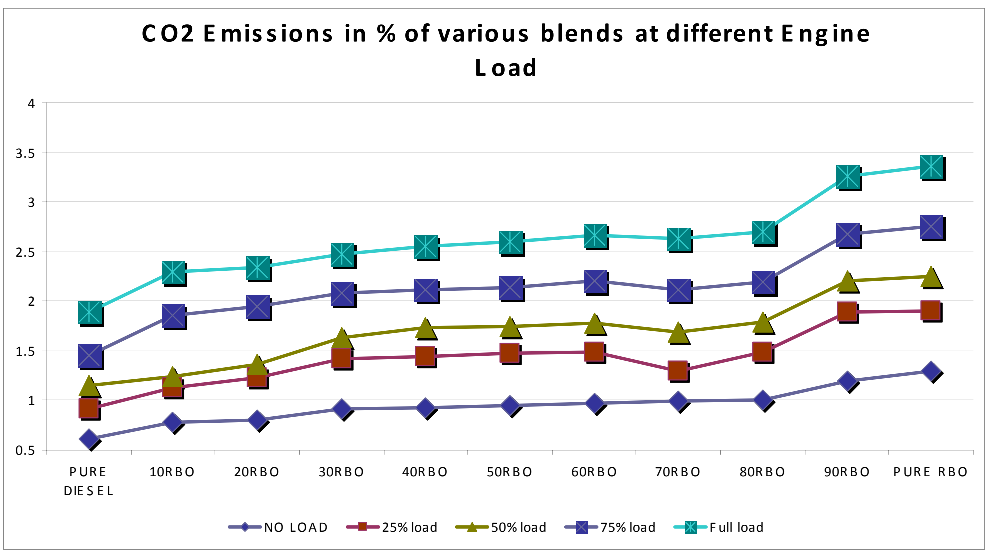

Figure-8. Carbon-dioxide emissions.

4. CONCLUSIONS

The performance and emission characteristics of diesel, non-edible rice bran oil and the blends obtained from the experiment on a single cylinder, four stroke, and direct injection diesel engine can be concluded as follows:

a) The maximum thermal efficiency was found to be 27.8% for RBO 10 (excluding diesel). The brake specific fuel consumption for all the blends was higher than that of diesel.
b) The exhaust gas temperature reduces as the proportion of rice bran in the blend increases.
c) The carbon monoxide emission increased as the proportion of the rice bran in the blend increased. This is due to relatively incomplete combustion as the blend becomes more viscous.
d) The carbon dioxide emission also increases with increase in the proportion of rice bran. This is due to the fact that the rice bran oil has more component of oxygen.

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e) The NOx emission decreased as the proportion of the rice bran increased in the blend. This is due to the lower temperature attained.

It was also concluded that by using rice bran oil the engine runs without any problem, the nozzle orifices were not clogged or choked and no major carbon deposits were observed on the combustion chamber.

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