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Effect of Injection Pressure on the Emission and Performance of Diesel engine using Non Edible Rice bran oil [NERBO]

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Abstract:- The main aim of this study is to investigate the effect of injection pressures on emission and the Performance analysis of non-edible rice bran oil (NERBO), a straight vegetable oil [SVO] and its blends with diesel using DI diesel engines. The parameters like brake thermal efficiency, brake specific fuel consumption and exhaust emissions like NOx, CO2, CO were considered for comparing the performance of Rice bran oil , diesel and the blends. Experiments were conducted by blending diesel with non-edible rice bran oil in various proportions and with varying loads at various injection pressures. The initial experiments were done at injection pressure of 180 bar. Later the injection pressure was changed to 200 bar, 220 bar, 240 bar, 280 bar and lastly at 300 bar. It was observed that the Brake thermal efficiency increased as the injection pressure increased from 180 bar to 220 bar and later it reduced as injection pressure was further increased. The Nox emission reduced as the injection pressure increased from 180 bar to 220 bar and later it increased as injection pressure was further increased from 220 bar to 300 bar. The CO emission gradually decreases as the injection pressure increased from 180 bar to 300 bar.

Keywords:- Alternate fuels, Engine performances, emissions, injection pressure, Rice bran oil.

I. INTRODUCTION

The economic development of India and the requirement of energy are inter-related. With most of our fossil fuels used for Engine applications - either Transport, Power generation, Agriculture - being imported, the supply instabilities and the wild fluctuations in the prices of these imports have in recent past caused uproar across the country. On the other hand, agricultural sector contributing about 16% to the national GDP, engaging 50% of the labour force and earning approximately 10% of export earnings and with the second largest arable land, largest gross irrigated crop area and with the top three positions in the production of crops like rice, wheat and cotton oilseeds. Our country has a potential to use the waste agricultural products and their derivative oils as an alternative for a small number of fossil fuel applications.

Unhindered use of fossil fuels has also given rise to environmental issues. With high fuel adulteration, most of the diesel emissions in India have significantly higher amounts of particulate matter (PM), lead, oxides of nitrogen (NO_x) and other toxic air pollutants like carbon monoxide (CO_2). These cause an irreparable damage to the population exposed to these emissions. This has prompted the Government to implement stricter emission norms and compulsory use of hydrocarbon derived gases like the CNG and LPG in the public transport segment, which in turn have resulted in the additional expenses for equipment replacement and infrastructure set-up. However, due to various constraints, the availability of these gaseous fuels across India is not good, resulting in their localized use and continuous exposure therefore, of the rest of the population to the hazardous emissions [19].

The hunger of the citizens of our country is satisfied by the vibrant agricultural sector that produces food-grains. At the same time the agro-sector also produces a lot of by-products those have an ability to take care of the energy needs at a community level. However the use of these by-products is disorganized, sketchy, and not standardized.

The national policy on Bio-fuels by the Ministry of new and renewable energy of government of India, dated 11th September 2008 makes 20 % blending of bio-ethanol mandatory for petrol, progressively, with effect from 2008, whereas the blending levels of bio-diesel are currently recommendatory in nature.

With the rising consumption of high speed diesel from 56320000 tons in 2009-10 to 59990000 tons in 2010-11 [20] and the solvent extractors association of India working out methodologies to maximize India's potential to produce more of rice bran oil from the current production of 9 lakh ton [21], the scope for utilization of the results for such an experiment are phenomenal.

Therefore, this experimental study is an effort to homogenize the use of such available agricultural by-products viz. non-edible rice bran oil [NERBO] as an alternative to diesel, use in at least the sectors like irrigation; diesel fueled small, community electric power-plants etc.

A major physical advantage NERBO is its local availability in its unrefined, non-edible form. This reduces the necessity of transportation and huge-scale processing infrastructure thus reducing the cost. At the same time the presence of suspended particulate and high viscosity could be a hindrance.

The experimental investigation was done to learn the efficacy of the Non Edible Rice Bran Oil [NERBO] to deliver the performance comparable to diesel and thus as a possible alternative to conventional diesel.

For CI engines, there are two main methods in which the alternative fuel could work:

1 To modify the fuel - by way of blending, heating, trans-esterification, use of dual fuels etc.
2 To modify the fuel delivery system to use Straight Vegetable Oil (SVO). There could be additional alterations / improvements /conversions that could be carried out to the pistons / fuel lines and injectors / pumps etc. to do this.

A. Structure of rice grain and the process of obtaining rice bran oil

The paddy is harvested from farms. It consists of the edible portion of rice 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. Thus rice husk and rice bran are obtained as by-products of the rice milling industry. The structure of rice grain is shown in Fig. 1. 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.

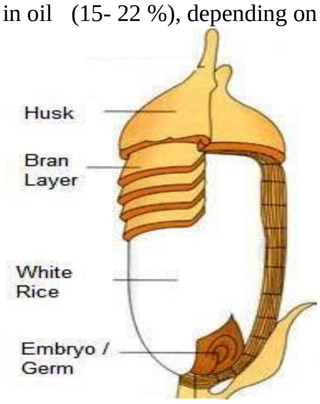

Fig. 1 Structure of rice grain

II. METHODOLOGY

The Methodology of tests carried out using the engine is:

A. Determination of the properties of Diesel, Rice Bran Oil and Blends

The blending of the rice bran oil with diesel by volume was first done by measuring rice bran oil using the graduated beakers and adding to the measured diesel. The blends were then vigorously shaken in a sealed container. The blends were tested and evaluated for density, viscosity, calorific value, flash point, fire point and compared with the same properties of diesel. The above properties were determined by conducting the tests as per the Bureau of Indian Standards, and are as summarized in Table 1.

B. Experimental investigation and set up

The measured rice bran oil blends were kept for settling for a few hours and then the tests were conducted on the test rig to determine their operation parameters as a fuel. Experiments were conducted at different injection pressures ranging from 180 to 300 bar. The detailed specification of the engine and the test rig are tabulated in Table 2. A five gas exhaust gas analyser was used to note exhaust emissions like CO, CO_2 ,O_2 , NO_x and HC. The schematic layout of the experimental setup is shown in Fig. 2. The Fig 3 shows the photograph of the experimental setup. The experimental procedure adopted for the conduct of experiments is mentioned below:

1 The engine was initially run at an injection pressure of 180 bar, then the injection pressure was increased to 200 bar, 220 bar, 240bar, 280 bar and 300 bar.
2 For each of the injection pressure setting, the engine was initially started with 100% high speed oil in the fuel tank of the engine and after it operated for a few minutes at the rated rpm of 1500, without any load the initial base readings for the high speed diesel were noted. An eddy current dynamometer was used to load the engine from no load to 12 kg at an interval of 2.5 kg.
3 The engine parameters such as fuel consumption, exhaust gas temperature, inlet and outlet coolant (water) temperature were noted automatically by the sensors of the test rig.
4 Then, fully replacing the fuel and draining the fuel lines, 10RBO (10 % rice bran oil + 90 % high speed diesel) was used to obtain the readings, as described above in paragraph 1. Similarly recordings for various blends as specified in the Table 1 were thus obtained.
5 Exhaust emissions were noted using a 5 gas analyzer.
6 The engine was run with pure rice bran oil for 24 hours continuously to check for fuel clogs, injector clogs and carbon deposits on the combustion chamber.

Table I: Comparison of Properties of Blends of Fuels

BLENDS	**Fuel Blend specification By Volume**	**Density g/cc**	**Viscosity Stokes**	**Flash Point, °C**	**Fire point, °C**	**Heating Value in kJ / kg**
HSD	100% High Speed diesel	0.78	0.045	50	55	45100
10RBO	10% RBO + 90% HSD	0.798	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	0.848	0.2614	112	118	39860
90RBO	90% RBO + 10% HSD	0.8748	0.544	132	151	39400
100RBO	100% RICE BRAN OIL	0.8768	0.5956	150	165	38623

Table II: Engine Specifications

Engine	Kirloskar make, Model TV1, Single cylinder, 4 stroke, water cooled, stroke 110 mm, bore 87.5 mm, 661 cc with a rated power of 5.2 kW at 1500 rpm, Compression Ratio(CR) 16.5 :1
Diesel mode:	3.5 kW, 1500 rpm, CR range 12 to 18. Injection variation:0 to 25^0 BTDC
Dynamometer Type	Eddy current, water cooled, with loading unit and connected by Propeller shaft With universal joints to the Engine
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 litre, Type: Dual compartment, with fuel metering pipe of glass Calorimeter Type Pipe in pipe
Sensors	Piezo sensor, Crank Angle Sensor, Temperature sensor and transmitter, Load Sensor, Fuel flow transmitter, Air flow transmitter and Data acquisition device
Software	'Lab view ' based "Engine soft" Engine performance analysis software
Rotameter	Engine cooling 40 to 400 LPH; Calorimeter 25to 250 LPH with a Monoblock pump

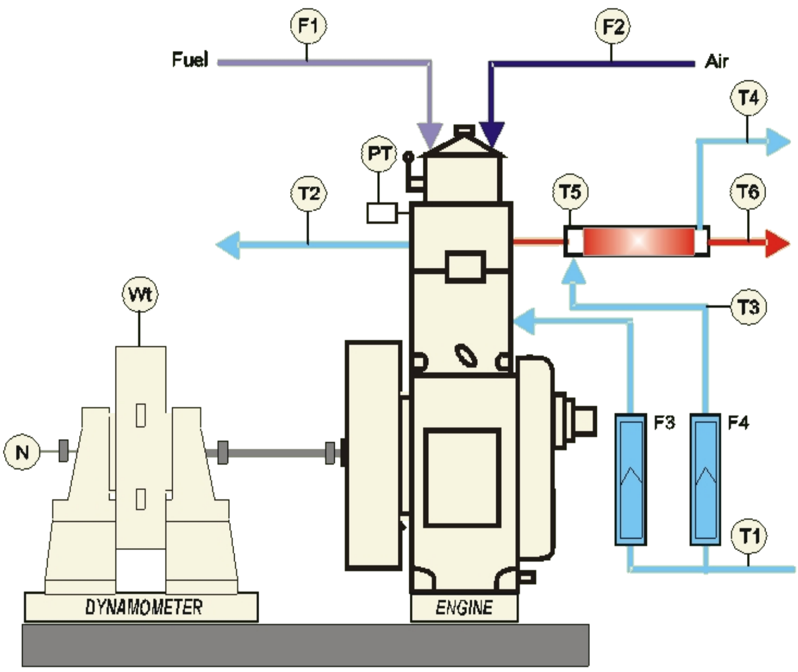

Fig. 2 Schematic layout of test-setup

Fig. 3 Photograph of test rig

III. RESULTS AND DISCUSSIONS

The non-edible rice bran oil has a higher viscosity as compared to diesel. The flash point and the fire point of NERBO at 150^{o}C and fire point at165^{o}C as compared to 50 and 55 for diesel. So rice bran oil 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 and handling. The calorific value of NERBO is around 85% that of diesel.

Fig. 4 shows the brake thermal efficiency at various injection pressures. The Brake Thermal efficiency increases as the injection pressure increases from 180 to 220 bar, and then slightly decreases as the injection pressure is further increased [18]. This may be explained by the fact that increase in the injection pressure leads to faster heat release.

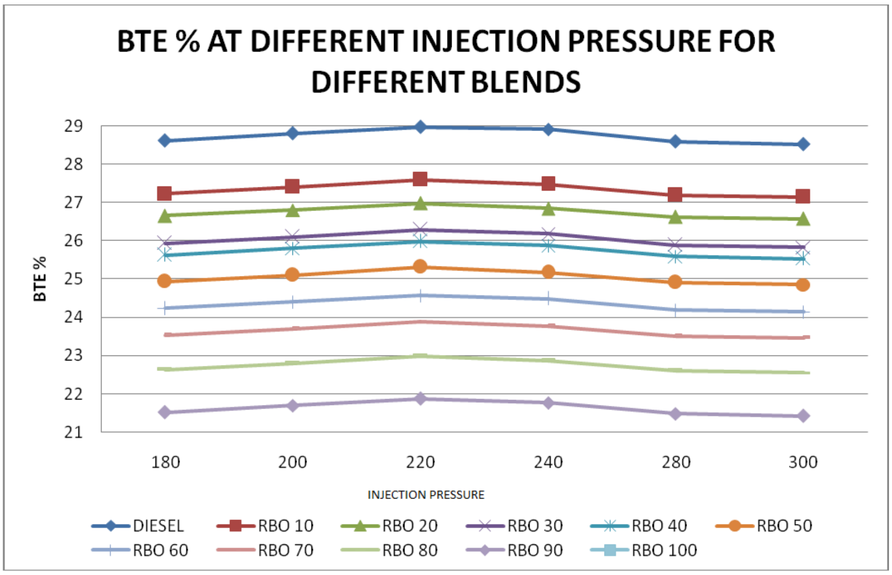

Fig. 4 Brake thermal efficiency at various injection pressures for all blends

Fig. 5 shows that NO_x decreases initially as the injection pressure increases from 180 to 220 bar and then slightly increases as the injection pressure increases. Another observation is that NO_x decreases as the Rice bran proportion increases and the NO_x increases as the load increases. The vital factor that causes NO_x formation is due to availability of oxygen and high combustion temperatures. As the load on the engine increased so also the NO_x emission increased, this is perhaps due to the increase in the combustion temperature.

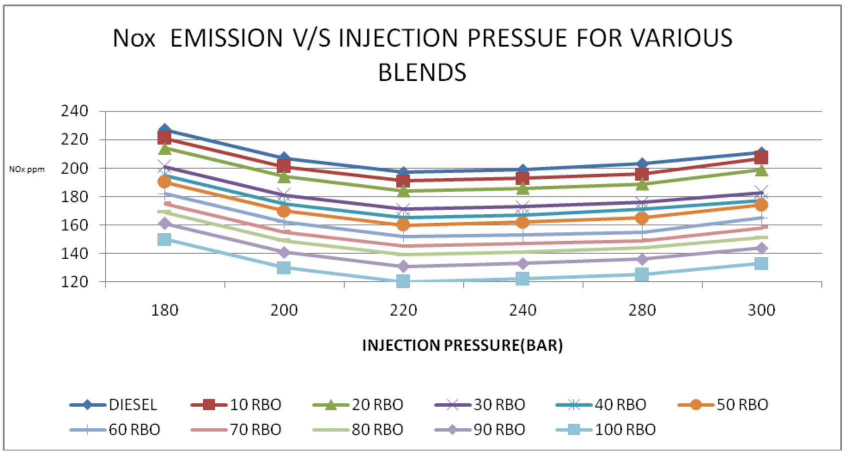

Fig. 5 NO_x emission at various injection pressures for different blends

Fig. 6 shows that NO_x 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 NO_x emission is considered to be one of the most harmful emissions . Similar results have been observed by many researchers [3, 4, 6].

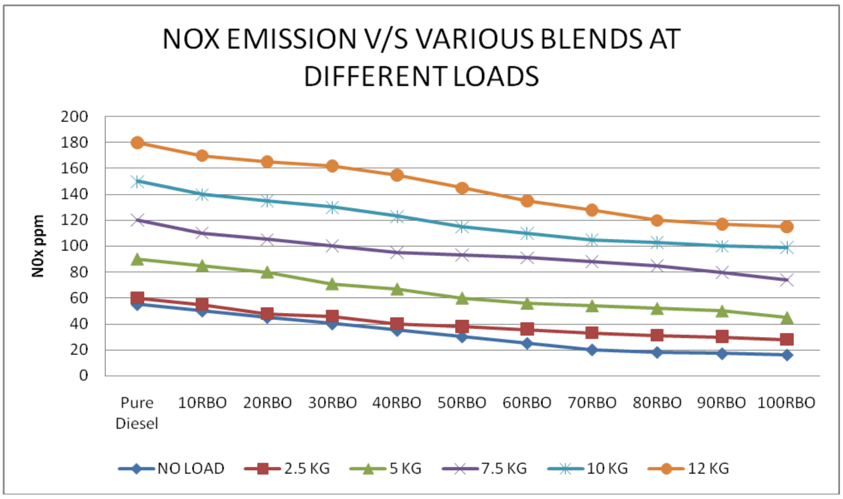

Fig. 6 NO_x emission at various loads for all blends

Fig. 7 shows that the CO emission decreases with the increase in the injection pressure of 180 bar to 300 bar. The Carbon monoxide emission increases with the increase in proportion of non-edible rice bran oil in the blends. This may be due to the fact that at higher injection pressure complete combustion occurs.

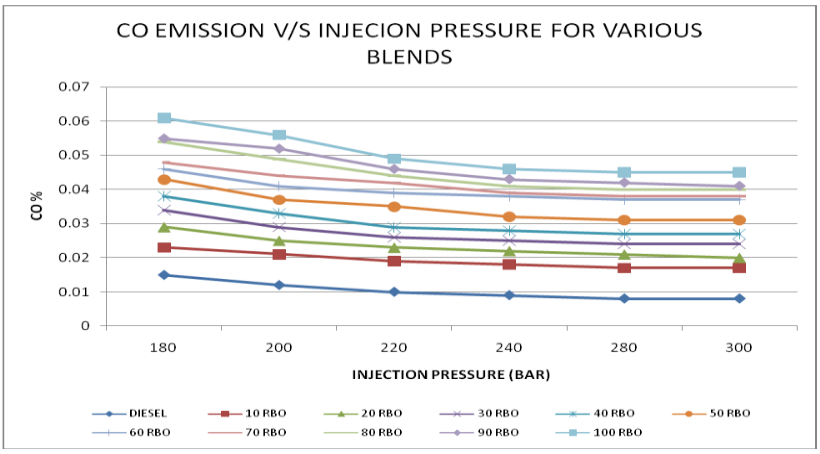

Fig. 7 CO emission at various injection pressures for all blends

Fig. 8 shows that carbon monoxide emission at 200 bar injection pressure. The CO emission for all blends reduces as the load increases from no load to 10 kg load and then slightly increases at full load. The CO emission increases with the increase in the proportion on rice bran oil in the blends. This increase may be due to relatively incomplete combustion as the blend becomes more viscous.

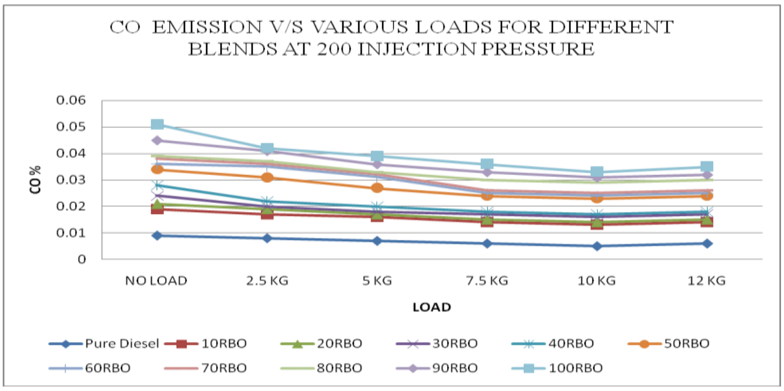

Fig. 8 CO emission at various loads for all blends at 200 bar injection pressure

IV. CONCLUSIONS

The performance and emission characteristics of high speed diesel, rice bran oil and the blends were investigated on a single cylinder diesel engine. The following were the conclusions of the investigation:

- The maximum thermal efficiency was found to be 28.4% for RBO 10 (excluding diesel) at an injection pressure of 220 bar.
- The carbon monoxide emission decreased as the injection pressure increased. This is due to the fact that at higher injection pressures, complete combustion occurs.
- The NO_X emission decreased initially as the injection pressure increases from 180 to 220 bar and then slightly increase as the injection pressure increases.

It was also concluded that by using rice bran oil the engine runs on 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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