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EXPERIMENTAL INVESTIGATION OF PERFORMANCE ANALYSIS ON VCR DI DIESEL ENGINE OPERATED ON MULTI BLEND BIODIESEL

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ABSTRACT

In the present investigation experimental work has been carried out to estimate the performance and emission characteristics of a single cylinder, four stroke variable compression ratio CI engine with various blends like HOME, JOME and standard diesel. Tests has been conducted using the biodiesel blends on volume basis like 5%, 10%, 15%, 20%, 25% biodiesel with standard diesel, with varying compression ratio in the order of 18, 17 and 15, and an engine speed of 1500 rpm at different loading conditions of 0, 2.5, 5, 7.5 and 10kg. The performance parameters include brake thermal efficiency (BThEff), specific fuel consumption (SFC), brake power (BP), A/F ratio and mechanical efficiency (MechEff). The result of the experimental works has been compared with standard diesel and it concludes considerable improvement in the performance parameters. Thus the different blends may be use as alternative fuel for CI engine.

Keywords: Btheff-Brake Thermal Efficiency, SFC-Specific Fuel Consumption, Mecheff-Mechanical Efficiency, A/F-Air-Fuel Ratio, BP-Brake Power, HOME, JOME.

I INTRODUCTION

Increasing number of automobiles has led to increase in demand of fossil fuels (petroleum). The increasing cost of petroleum is another concern for developing countries as it will increase their import bill. The world is also presently confronted with the problem of fossil fuel depletion and environmental degradation. Fossil fuels have limited life and the ever increasing cost of these fuels has led to the search of alternative renewable fuels for ensuring energy security and environmental protection. One hundred years ago, Rudolf Diesel tested vegetable oils as a fuel for his engine. Biodiesel as a vegetable oil, biodegradable and nontoxic, has low emission profiles and so is environmentally beneficial. Biodiesel is a chemically produced vegetable oil to replace the traditional Diesel fuel. The chemical process is known as transesterfication and consists of treating vegetable oils, like soybean, sunflower and rapeseed, with reactants (methanol or ethanol) to obtain a methyl or ethyl ester and glycerine. In transesterfication, one ester is converted to another. The reaction is catalysed by a reaction with either an acid or base and involves a reaction with an alcohol, typically methanol if a biodiesel fuel is the desired product. Diesel engines are the prime source of transportation. Diesel engines are the prime source of transportation, power generation, marine applications, agriculture applications etc. hence diesel is being used largely, but due to gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need for suitable alternative fuels for use in diesel engines. In view of this, efforts are being made throughout the world to reduce the consumption of liquid petroleum fuels wherever is possible. Two general approaches are in use. First is to switch over the energy consumption devices on alternative energy source which are either abundant or are reproducible. The second is to enhance the efficiency of combustion devices. This can be achieved by understanding the physicochemical processes involved during the combustion. Non edible vegetable oils like Neem oil, Jatropha oil, Mahuva oil, karanja oil are considered as alternate fuels to diesel.The advantages of these oils are eco-friendly and can be produced easily in rural areas. Using optimized blend of biodiesel and diesel can help reduce some significant percentage of the world's dependence on fossil fuels without modification of CI Engine, and it also has important environmental benefits. For example using optimized blend of biodiesel and diesel instead of the conventional diesel fuel significantly reduces the exhaust emissions particulate matter (PM), carbon monoxide (CO), sulphur oxides (SOx), and unburned hydrocarbons (HC).

II LITERATURE REVIEW

In this chapter different area of work is carried out on variable compression ratio for different bio-fuels, used in variety of engines with and without modification of engine and different methods of producing biodiesel its compatibility as a fuel for CI engine are studied, in addition this the amount of pollutants produced are noticed along with the performance parameters using fuel from variety of seeds.

Shivakumar et al. 2010 - in this study "Performance and Emission characteristics of a 4 stroke CI engine operated on Honge methyl ester using artificial neural network" biodiesel was prepared from Honge oil (Pongamia) and used as a fuel in C.I engine. Performance studies were conducted on a single cylinder four-stroke water-cooled compression ignition engine. Experiments were conducted for different percentage of blends of Honge oil with diesel at various compression ratios. Artificial Neural Networks (ANNs) were used to predict the Engine performance and emission characteristics of the engine. ANN results showed good correlation between the ANN predicted values and the desired values for various engine performance values and the exhaust emissions. Brake thermal efficiencies of Pongamia oil methyl ester blends are very close to diesel and 20% blend with diesel, B20 provided the maximum efficiency for biodiesel operation for all compression ratios. An improvement in BTE was observed for higher compression ratios. Brake specific energy consumption for biodiesel blends is more than that of diesel and decreases for higher compression ratios. Exhaust emissions Smoke, CO, HC were reduced for Diesel-biodiesel blends when compared with diesel values for all compression ratios and higher compression ratios have the advantage further reduction in those emissions. Increase in NOx emission was observed for biodiesel blends compared to that of diesel for all compression ratios. Authors concluded that ANN approach can be used for the prediction of engine performance and emission characteristics of I.C engines by performing a limited number of tests instead of detailed experimental study thus saving both engineering effort and funds.

Banapurmath et al., (2008) have reported tests on a single cylinder C.I. engine with 3 different biodiesels viz methyl esters of honge, jatropha and sesam. All the fuels gave slightly lower efficiency. HC and CO emissions were slightly higher and NOx emission decreased by about 10%. Recep Altin et al., [2] have studied the potential of using vegetable oils and their methyl esters in a single cylinder diesel engine. They have used raw sunflower, cottonseed, soyabean oils and their methyl esters. Their results indicate a reduction in NOx emission and methyl esters are better than raw oils due to their inherent property of high density, higher viscosity, gumming and lower cetane number.

Ayush Kumar Raghuvanshi et al,2014 - "Extraction of biodiesel from Jatropha oil and performance study of diesel engine with biodiesel fuels" Brake horse power reduces as quantity of biodiesel increases in blending conditions and with increase in load Brake horse power increases for each of the three blend. Engine performance tests and other tests shows that Jatropha Oil as a fuel does not differ greatly from that of diesel. A slight power loss, combined with an increase in fuel consumption, was experienced with Jatropha Bio diesel. This may be due to the lower heating value of the ester. From the testing results and experimentation and study it can be clearly observed that the biodiesel made from Jatropha Oil can be used as an alternative fuel to conventional fuel as it showed better results than diesel in terms of engine performance and emission.

Dr. Mohammed Yunus et al, 2015 - "Study and Analysis of Performance Characteristics of Biodiesel Formed by Different Blends of Honge and Mustard Oil using 4 Stroke C.I. Engine" It can be observed from the graphs that with the increase in the blend quantity performance of the engine reduces. B0 (Pure diesel) has highest brake thermal efficiency and least brake specific fuel consumption and B30 has the least brake thermal efficiency and highest brake specific fuel consumption. This is due to the reason that with the increase in the blend calorific value of the fuel decreases and hence in the brake thermal efficiency and increase is BSFC. Exhaust gas temperature increases with increase in the blend.

III METHODOLOGY

3.1Transesterification Process

The biodiesel production is given by the transesterification reaction which consists of three consecutive and reversible reactions. First, the triglyceride is converted in diacylglycerol, and running at monoglyceride and glycerine. In each reaction one mole of methyl ester is released as shown in Figure

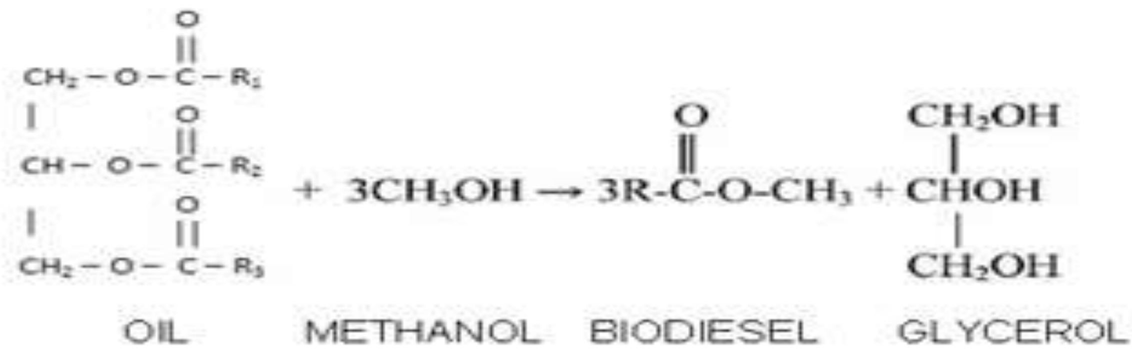

Fig.1- Transesterification Process

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Transesterification is the process by which biodiesel is produced. In this process an ester reacts with an alcohol to form another ester and another alcohol. The catalyst for this reaction is KOH or NaOH. Three mol methanols react with one mol triglyceride which produces mixture of fatty esters and glycerine. The industrial-scale processes for transesterification of vegetable oils were initially developed in the early 1940s to improve the separation of glycerine during soap production. The primary input is assumed to be oil that has previously been extracted from jatropha oilseed. To accomplish the transesterification reaction described, the oil, methanol, and catalyst are mixed together in a stirred reactor. 55 º-60 º C temperatures will cause the reaction to reach equilibrium more rapidly; in most cases the temperature is kept below the normal boiling point of the methanol (65ºC) so the reactor does not need to be pressurized. As shown in the reaction equation below, three moles of methanol react with one mole of triglyceride. In practice, most producers will use at least 100% excess methanol (6:1 molar ratio) to force the reaction equilibrium towards a complete conversion of the oil to biodiesel. The reaction is slowed by mass transfer limitations since at the start of the reaction the methanol is only slightly soluble in the oil and later on, the glycerine is not soluble in the methyl esters.

Since the catalyst tends to concentrate in the glycerine, it can become unavailable for the reaction without agitation. A common approach to overcome this issue is to conduct the transesterification in two stages. First, the oil is combined with 75% to 90% of the methanol and catalyst and this mixture is allowed to react to equilibrium. Then, the glycerine that has formed is separated by gravity separation and the remaining 10% to 25% of the methanol and catalyst is added for a second reaction period. At the conclusion of this second reaction period, the remaining glycerine is separated and the biodiesel is ready.

Blends:

(J-H-D)

J15-H10-D75 **J10-H15-D75** **J10-H10-D80** **J15-H15-D70**

Fig.2-Blends

Table no.1- Fuel Properties: (J-H-D)

Sl. no	Properties	Diesel	HOME	JOME	J15-H10-D75	J10-H15-D75	J10-H10-D80	J15-H15-D70	Determined by
1)	Density (kg/m^3)	825	890	876	839	840	836	842	Mass/Volume
2)	Viscosity (cSt)	2.52	4.7	4.8	3.08	3.075	2.966	3.189	Redwood viscometer
3)	Calorific value (KJ/Kg)	45843	36840	39455	43984	43853	44303	43534	Bombs calorimeter
4)	Flash point (°C)	55	178	210	91	89	83	97	Cleveland apparatus
5)	Fire point (°C)	58	190	215	95	94	87	101	Cleveland apparatus

IV EXPERIMENTAL SETUP

Fig.4- Engine Setup

Table no.2

ENGINE	SPECIFICATION
Make	Kirloskar oil engine
No. of cylinders	1
No. of stroke	4
Fuel	Diesel
Rated power	3.5kw@1500rpm

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Compression ratio vary	12 to 18:1
Cylinder diameter	87.5mm
Stroke length	110mm
Orifice diameter	20mm

The experiments are conducted on direct injection, single cylinder four stroke Kirloskar diesel engine. The layout of experimental test rig and its instrumentation is shown in fig. It is water cooled engine with a rated power of 3.5 kw at 1500 rpm having bore 87.5 mm and stroke 110 mm, compression ratio of 17.5, injection pressure of 200 bar. It consists of a test bed, a diesel engine with an eddy current dynamometer, a computer with a software called engine soft, a MARS Technologies inc make (5-gas analyzer) exhaust gas analyzer, a pressure sensor to measure the cylinder pressure.

The engine is connected to eddy current dynamometer. The eddy current dynamometer is mounted on base frame and connected to engine. The engine is subjected to different loads with the help of dynamometer. A rota meter is provided for engine cooling water flow measurement. A pipe in pipe type calorimeter is fitted at the exhaust gas outlet line of engine. The calorimeter cooling water is measured and adjusted by the rota meter. Temperature sensors are fitted at the inlet and outlet of the calorimeter for temperature measurement. The pump is provided for supplying water to eddy current dynamometer, engine cooling and calorimeter. A fuel tank is fitted inside control panel along with fuel measuring unit. An air box is provided for damping pulsation in airflow line. An orifice meter with manometer is fitted at the inlet of air box for flow measurement. Piezo-electric type sensor with water cooled adapter is fitted in cylinder head for combustion pressure measurement. This sensor is connected to an engine indicator fitted in control panel, which scan the pressure and crank-angle data is interfaced with computer through COM port. An encoder is a device, circuit, transducer, software program, algorithm that converts information from one format to another. Rotary encoder is an optical sensor used for speed and crank angle measurement. The sensor is mounted on dynamometer shaft and connected to engine indicator. Thermocouple type temperature sensor measure cooling water inlet, outlet and exhaust temperatures. These temperatures are digitally indicated on indicator suited on control panel. The exhaust gas analyzer is used to measure the relative volumes of gaseous constituents in the exhaust gases of the engine.

III RESULT AND DISCUSSION

3.1 BThEff v/s LOAD graph for CR 15

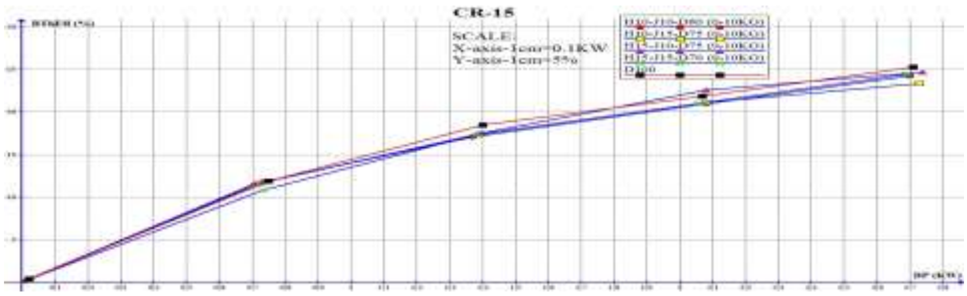

Fig.4- BThEff v/s LOAD graph for CR 15

The above graph shows the effect of CR 15 on Brake Power and BThEff for different blends. From the graph as the LOAD increases gradually the BThEff also increases. The graph shows the BThEff is increases with respect to increase in LOAD for the blend H15-J10-D75. But this blend gives nearer BThEff as that of pure diesel D100. The decrease in brake thermal efficiency with increase in biodiesel oil concentration is due to the poor atomization of the blends due to their higher viscosity.

3.2 BThEff v/s LOAD graph for CR 18

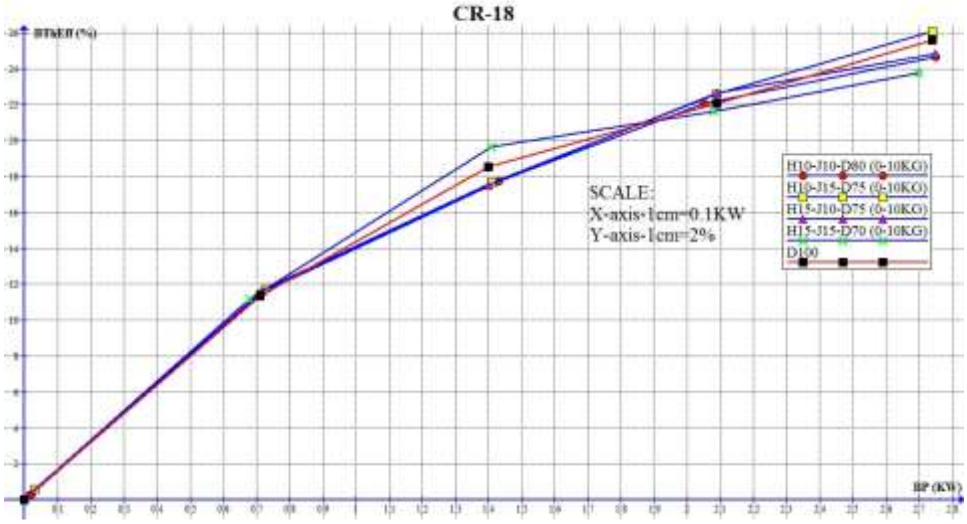

Fig.5- BThEff v/s LOAD Graph for CR 18

The graph shows the effect of CR 18 on Brake Power and BThEff for different blends. From the graph as the LOAD increases gradually the BThEff also increases. The graph shows the BThEff is increases with respect to increase in LOAD for the blend H10-J15-D75. But this blend gives nearer BThEff as that of pure diesel D100.

3.3 A/F v/s LOAD graph for CR 15

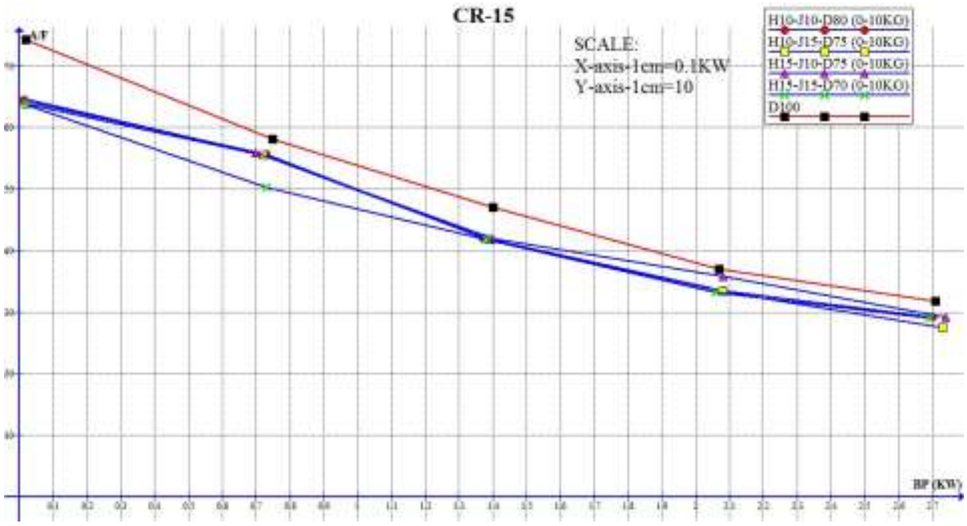

Fig.6- A/F v/s LOAD Graph for CR 15

The graph shows the effect of CR 15 on Brake Power and Air-Fuel ratio for different blends. From the graph as the LOAD increases gradually the A/F ratio decreases. The graph shows the A/F ratio is gradually decreases with respect to increase in LOAD for the blend H10-J15-D75. So this blend has less A/F ratio as compare to pure diesel D100. Biodiesel itself contains of O_2 (OXYGEN), so if air supply is less it will not affect the combustion of fuel. Thus it gives the complete combustion.

3.4 A/F v/s LOAD graph for CR 18

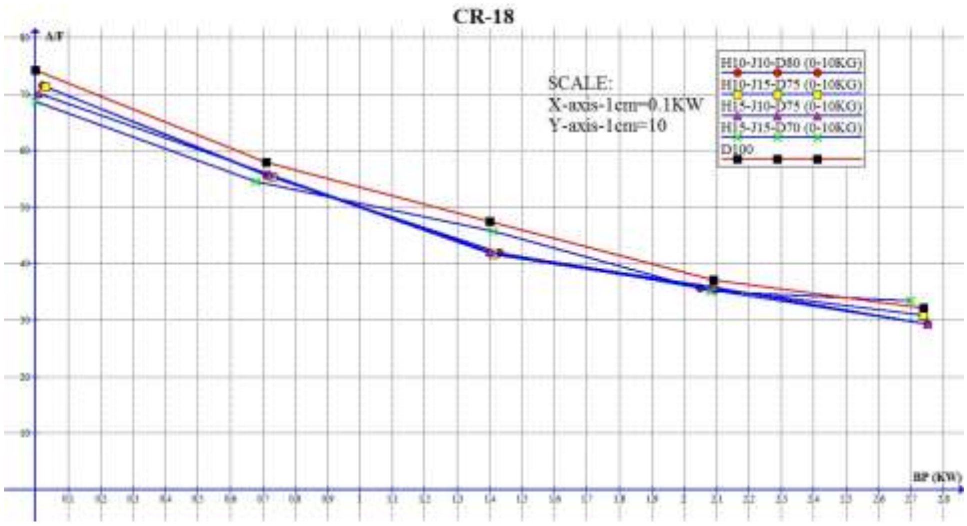

Fig.7- A/F v/s LOAD graph for CR 18

The graph shows the effect of CR 18 on Brake Power and Air-Fuel ratio for different blends. From the graph as the LOAD increases gradually the A/F ratio decreases. The graph shows the A/F ratio is gradually decreases with respect to increase in LOAD for the blend H15-J10-D75. So this blend has less A/F ratio as compare to pure diesel D100

3.5 MechEff v/s LOAD graph for CR 15

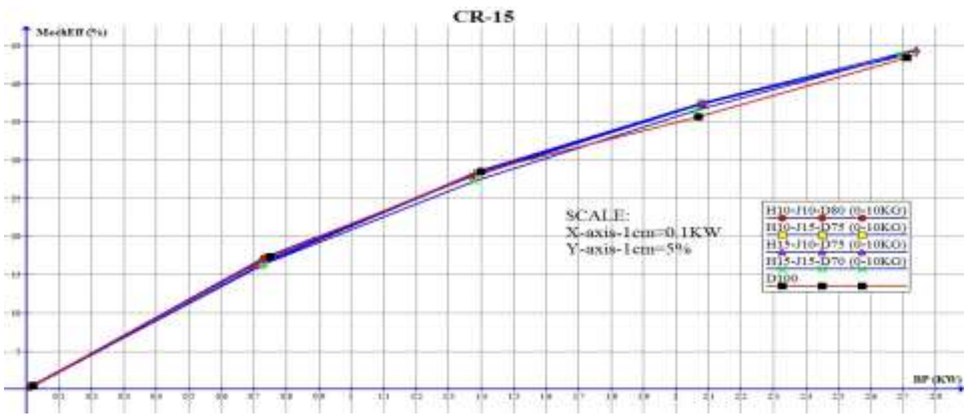

Fig.8- MechEff v/s LOAD graph for CR 15

The above graph shows the effect of CR 15 on Brake Power and MechEff for different blends. From the graph as the LOAD increases gradually the MechEff also increases. The graph shows the MechEff is increases with respect to increase in LOAD for the blend H15-J10-D75. But this blend has slight higher MechEff as compare to pure diesel D100.

3.6 MechEff v/s LOAD graph for CR 18

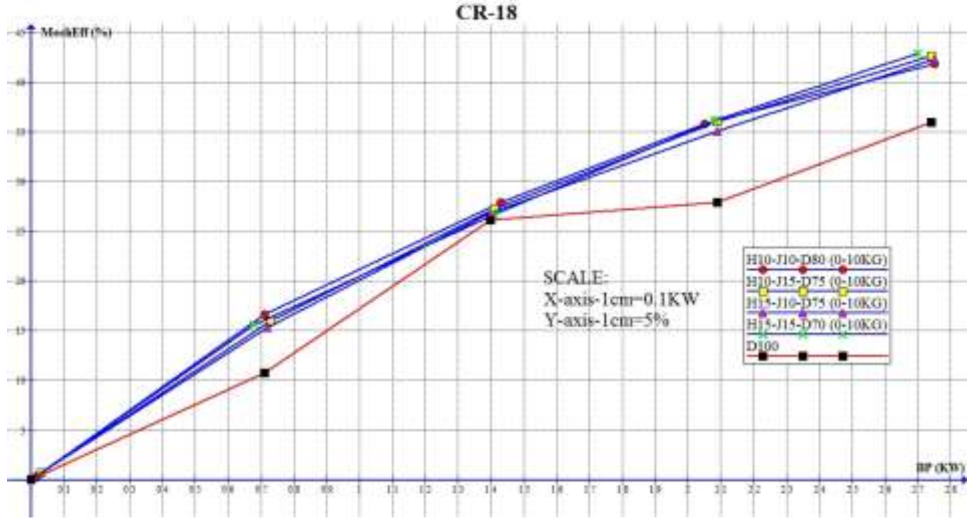

Fig.9- MechEff v/s LOAD graph for CR 18

The graph shows the effect of CR 18 on Brake Power and MechEff for different blends. From the graph as the LOAD increases gradually the MechEff also increases. The graph shows the MechEff is increases with respect to increase in LOAD for the blend H15-J15-D70. But this blend has better MechEff as compare to pure diesel D100.

3.7 SFC v/s LOAD graph for CR 15

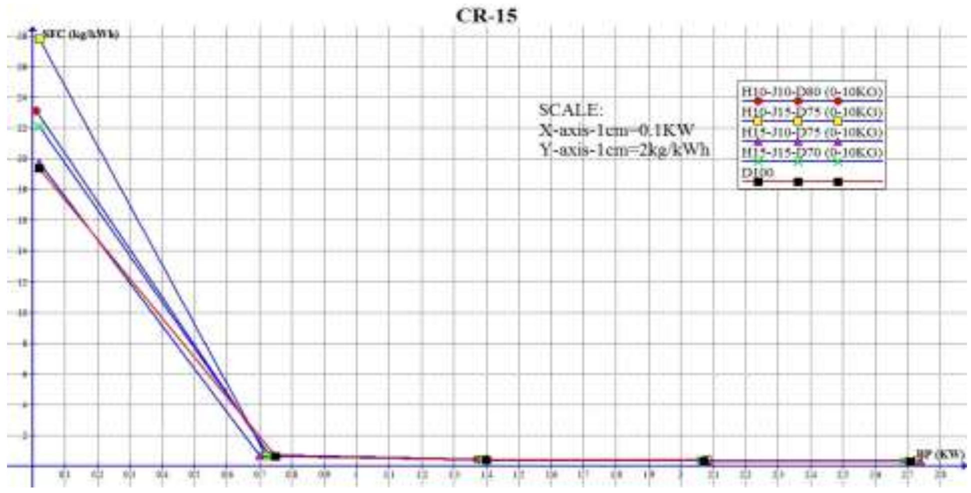

Fig.10- SFC v/s LOAD graph for CR 15

The graph shows the effect of CR 15 on Brake Power and SFC for different blends. From the graph as the LOAD increases gradually the SFC also gradually decreases. The graph shows the SFC is decreases with respect to increase in LOAD for the blend H15-J10-D75. So this blend has lesser SFC as compare to pure diesel D100.

3.8 SFC v/s LOAD graph for CR 18

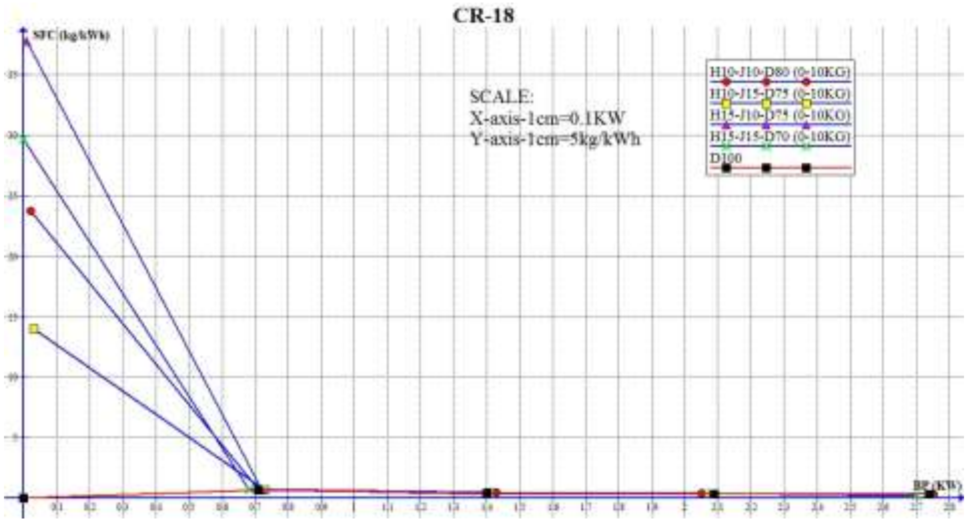

Fig.11- SFC v/s LOAD graph for CR 18

The graph shows the effect of CR 18 on Brake Power and SFC for different blends.

From the graph as the LOAD increases gradually the SFC also gradually decreases. The graph shows the SFC is decreases with respect to increase in LOAD for the blend H10-J15-D75. So this blend has slight higher SFC as compare to pure diesel D100.

IV CONCLUSION

Based on the performance and emissions of Bio fuel, it is concluded that the bio fuel oil represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the analysis the bio fuel shows better performance compared to the Diesel in the sense of better performance characteristics like Brake thermal efficiency, Specific fuel consumption, Mechanical efficiency, A/F ratio. Hence the bio fuel can be used as a substitute for diesel.

- BThEff: at CR-18 BThEff of H10-J15-D75 blend gives better performance than all other blends and also gives optimum result with compare to pure diesel D100.
- A/F ratio: at CR-18 A/F ratio of H15-J15-D70 blend gives better performance than all other blends and also gives optimum result with compare to pure diesel D100.
- MechEff: at CR-18 MechEff of H15-J15-D70 blend gives better performance than all other blends and also gives optimum result with compare to pure diesel D100.
- SFC: at CR-15 SFC of H15-J10-D75 blend gives better performance than all other blends and also gives optimum result with compare to pure diesel D100.

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