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An Experimental Investigation on the Performance and Exhaust Emission of Diesel Engine Fuelled With Sal Seed, Mahua and Mix Oil Biodiesel

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Abstract: In the present study, nonedible oil (Mahua), edible oil (Sal seed) and their mixture have used to study the Emission and Performance characteristics on different blends such as B10, B20, B25, B30, B40. Mix oil biodiesel was studied on blends of B10, B20, B30.Emission and Performance characteristics are compared with base line data obtained with conventional diesel in a single cylinder, four stroke, water cooled, and natural aspirated direct injection (DI) diesel engine. Performance characteristics with non-edible Mahua oil biodiesel and with edible oil such as Sal Seed biodiesel blends was comparable with mineral diesel. Brake thermal efficiency for Mahua and Sal seed oil biodiesel was found to be higher than diesel at all blends Moreover, Minimum Brake thermal efficiency is 3.9% greater than Pure diesel and maximum Brake thermal efficiency is 20.93 % more than pure diesel. With increasing compression ratio BTE also increases. Mahua oil biodiesel blend B20 at CR 18 showed highest Brake thermal efficiency compared to their other blends. Mix oil biodiesel blends shows lower Brake specific fuel consumption at all compression ratio because it has more calorific value. Brake specific fuel consumption (BSFC) for each biodiesel was found to be higher compared to diesel except Mahua oil biodiesel blend B20 at CR 18 and in case of Mix Biodiesel blend B20, CR 16 has lower Brake specific fuel consumption as compared to diesel. Sal seed oil blend gave very much close value fuel consumption to diesel, but Mahua oil biodiesel blends resulted much higher value of fuel consumption compared to diesel While CO and NO_X emission is also more as compared to pure diesel because of incomplete combustion but unburned HC and smoke emissions for biodiesel blends fuelled engine were lower than mineral diesel.

Keywords: Biodiesel, Mahua oil, Salseed oil, Diesel Engine, Emissions.

I. INTRODUCTION

Now a day, in parliamentary procedure to meet the mounting energy needs as a result of spiraling demand and decreasing supply, alternative energy sources mostly biofuels are causing more attention. Indeed, the petroleum crisis exploded in the late 1970s and early 1980s, petroleum products became very scarce and expensive [1]. The cost of crude oil is skyrocketing and is presently $142 per barrel. World oil consumption was 1.5 million barrels per day and (768 trillion dollars/day) in 2007. The estimated World petroleum consumption is 900,000 barrels per day (bbl/d) in 2008. India's current monthly oil import is averaging at $7.7 billion (Rs. 33,000 crore) and at this rate our annual oil import bill will touch $112 billion (Rs. 470,000 crore) [2]. Diesel fuels have an essential function in the industrial economy of a country with applications in heavy trucks, city transport buses, locomotives, electric generators, farm equipment, Earthmoving and underground mining equipment. From the point of view of protecting the global environment and the business organization for long term supplies of conventional diesel fuels, it becomes necessary to build up alternative fuels which are corresponding to conventional fuels. The substitution of even a small fraction of total consumption by alternative fuels will have a significant impact on the economy and the environment [3]. Future projections indicate that economic and energy needs will increase the focus on the production, of synthetic fuels derived from nonpetroleum sources, including biomass and waste products among others [4]. Vegetable oils and animal fats come in this category of biomass and processed form of vegetable oil or animal fat (Biodiesel) is seen as the potential fuel to replace crude oil diesel. The attractive characteristics of biodiesel include higher cetane number, non-toxic emissions, bio-degradability (degrades four times faster than gasoline-diesel), absence of sulfur and aromatic compounds and excellent lubricity [1, 2, 3].

Methods of Biodiesel Production

Biodiesel has become recently more attractive because of its environmental benefits and the fact that it is made from renewable resources. The monetary value of biodiesel is

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the chief hurdle to commercialization of the merchandise. Recovery of high quality glycerol in the trans-esterification process of biodiesel is the by-product (glycerol) is primary options to be taken to lower the price of biodiesel. On that point are four main ways to create biodiesel, direct use and blending, micro-emulsions, thermal cracking (paralysis) and trans-esterification. The most commonly practiced method is trans-esterification of vegetable oils and animal fatty tissues.

Micro-emulsions

This is another method to resolve the problem of the high viscosity of vegetable oils, micro-emulsions with solvents such as methanol, ethanol and 1-butanol. A micro-emulsion is defined as a colloidal equilibrium dispersion of optically isotropic fluid microstructures with dimension generally in the 1–150 nm range, formed spontaneously from two normally immiscible liquids. Their spray characteristics can be improved by explosive vaporization of the low boiling constituents in the micelles. Srivastava et al. [5] found short term performance of micro-emulsions of aqueous ethanol in soybean oil were almost same as that of no. 2 diesel, in spite of the lower cetane number and energy content of it.

Pyrolysis (thermal cracking)

Pyrolysis is the process of conversion of one substance into another by means of heat or by heat in the presence of a catalyst. The paralyzed material can be vegetable oils, animal fats, natural fatty acids or methyl esters of fatty acids. Many investigators have studied the pyrolysis of triglycerides to obtain products suitable for diesel engine. Thermal decomposition of triglycerides produces alkanes, alkenes, alkadines, aromatics and carboxylic acids [6].

Transesterification

Transesterification is the most usual method of exchanging the organic group of an ester with the organic group of alcoholics. In organic chemistry, trans-esterification is the procedure of exchanging the alkoxy group of an ester compound by another alcohol. The responses are often catalyzed by an acid or a root. Trans-esterification is crucial for producing biodiesel from biolipids. The trans-esterification process is the reaction of a triglyceride (fat/oil) with a bio-alcohol to form esters and glycerol [7].

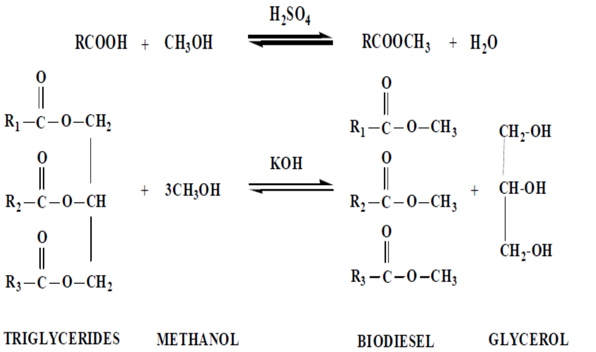

Figure 1.1: Mechanism of biodiesel synthesis by two-step catalyzed process.

II. OBJECTIVE OF PRESENT STUDY

- T o extract biodiesel from Saal seed oil, Mahua oil and Mixture of both.
- To evaluate the performance, emission and combustion characteristics of a compression ignition engine fuelled with different blends of biodiesel extracted from Saal seed biodiesel, and Mahua oil biodiesel and their Mixture.
- Comparison between Saal seed oil biodiesel, Mahua oil biodiesel and their Mixture.
- To find out the best biodiesel among three regarding performances, emission andcombustion characteristics.

These oils are non-edible in Indian setting. Biodiesel can be made from non- edible oil seeds like Jatropha, Karanja, Castor and Mahua can be produced in the wastelands of the nation. Other non-edible oilseed tree such as name, cotton, rubber and Polanga (undi), etc. have an estimated annual production potential of more than 20 megatons, of which Polanga contributes 70 thousand metric tons. These oils have a great potential to produce biodiesel for diesel engine application [8]. The lessening of world oil reserves and high energy demand in the power industries and transport sector has called for the demand for an alternative source of vitality.

III. METHODOLOGY

Biodiesel Preparation Methodology

Total three non-edible oils (Saal Seed oil and Mahua oil) are taken to make biodiesel.

Engine performance evaluation

Followings are the evaluation of the engine performance given below

- Engine description
- Operation
- Parameters evaluated

Fig. 3.1 Bomb calorimeter

It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams.

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Figure 3.2 Computerized single cylinder diesel engine with smoke meter and gas analyser

Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator Rota meters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency.

IV. RESULTS AND DISCUSSIONS

Experiments with Mahua Oil Biodiesel

The aim of the experiments has been categorized in the following manner: Comparison of the Mahua oil biodiesel blends with diesel in terms of operation parameters (BTE ,BSFC and FC), emission parameters (CO, unburned HC, NOx and CO2) at different compression ratio of 15:1, 16:1, 17:1, 18:1.

Blends of Mahua oil biodiesel Vs. Diesel

Table 4.1 shows calorific value and density of different blends of Mahua oil biodiesel and Pure diesel Comparative results of engine performance and exhaust emission characteristics of the different blends of Mahua oil biodiesel with that of diesel under variable loads (0,2,4,6,8,10,12 kg) at a constant speed of 1800

RPM are discussed. Blends used are as follows:

- Mahua BD B10
- Mahua BD B20
- Mahua BD B25
- Mahua BD B30
- Mahua BD B40

Regarding the engine performance in term of BTE is as follows:

Figure 4.1 (a),(b),(c),(d) shows that the variation of Brake thermal efficiency (BTE) with different loads for different blends at compression ratios 15,16,17,18.

Table 4.1 Calorific value and Density of Diesel, Pure Mahua oil and their Blends

Sr. No.	Blends of Mahua oil Biodiesel and Diesel	Calorific value (MJ)	Density (Kg/m^3)
01	B 10	39.76	820
02	B 20	37.78	839
03	B 25	37.21	840
04	B 30	36.82	853
05	B 40	36.55	858
06	Pure Mahua	34.47	991.5
07	Pure Diesel	41.70	823.7

It has been observed that the brake thermal efficiency for all test fuel is increasing with the increase in applied load. It happens due to a reduction in heat loss and increase in power developed with increase in load [107].BTE of all the blendings is higher than diesel except few loads reason is the calorific value .Calorific value of pure Diesel is higher as compared to all blendings of Mahua oil. Calorific value is increasing with increasing in Blends. Minimum value of BTE for Pure diesel is obtained at CR 16 and maximum value is obtained at CR 18. In comparing to all blendings Minimum BTE is obtained at B10 of CR 18 and maximum BTE is obtained at B20 of CR 18, Minimum BTE is 3.9 % greater than diesel and Maximum BTE is 20.93 % greater than pure diesel. 0.43 % is increased in BTE for Pure diesel at CR 18.

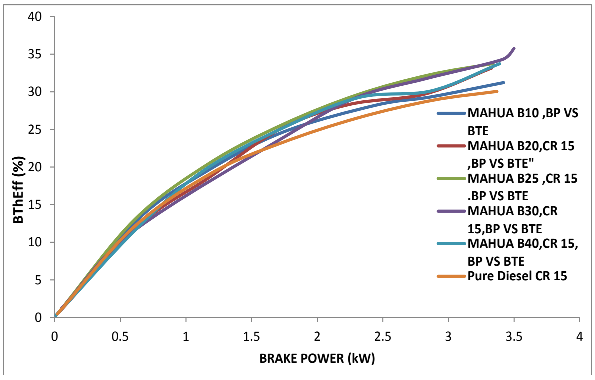

Fig 4.1 (a) BP vs BTE at CR 15 for Mahua oil biodiesel for blending ratios

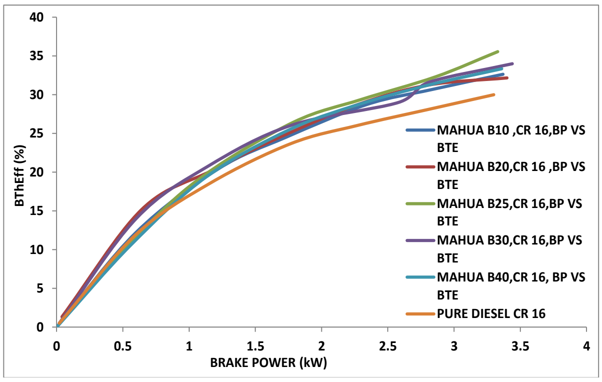

Fig 4.1 (b) BP vs. BTE at CR 16 for Mahua oil biodiesel for blending ratio

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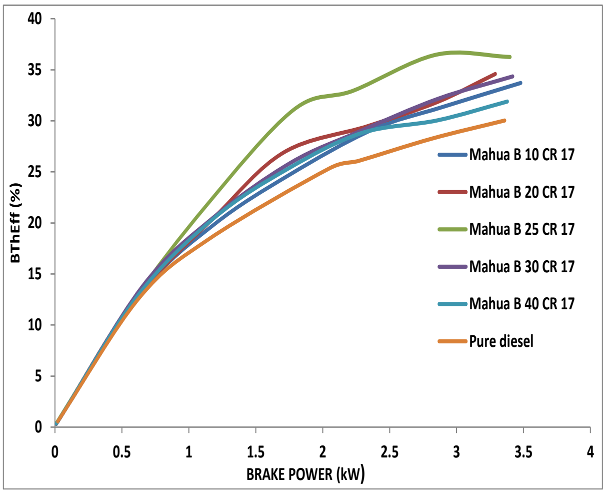

Fig 4.1 (c) BP vs BTE at CR 17 for Mahua oil biodiesel for blending ratios

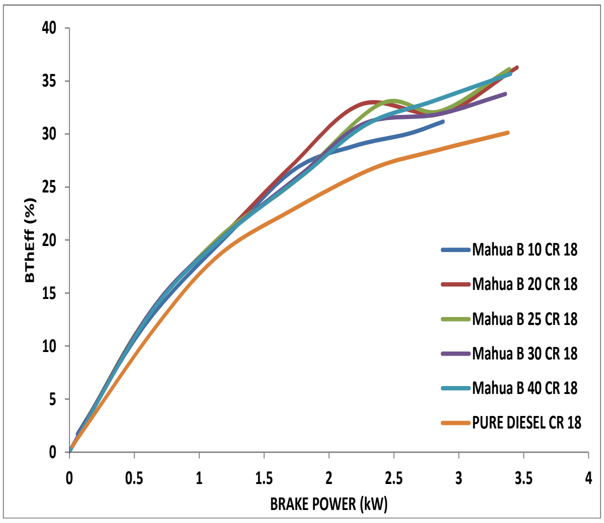

Fig 4.1 (d) BP vs BTE at CR 18 for Mahua oil biodiesel for blending ratios

Regarding the engine performance in term of BSFC is as follows:

Figure 4.2 (a),(b),(c),(d) shows that the variation of Brake specific fuel consumption with different loads for different fuel blends at compression ratios 15,16,17and 18. In the same pattern to BTE, BSFC for different blending is higher as compared to Diesel except few blending at some load. Minimum BSFC for pure Diesel is obtained at compression ratio 15 and at above compression ratio Maximum BSFC is obtained but at initial loading.

After comparing all blended fuels at different CR the least BSFC is at B10 full loading and highest fuel consumption is obtained at B30 on initial loading. For pure diesel with increasing CR the BSFC rate is increasing .Maximum BSFC is obtained at B 40 , CR 16 and minimum BSFC is obtained at B 10 , CR 15 as the BP is directly proportional to loading so at minimum Brake power ,BSFC is higher. Increase in BSFC for maximum value is 10 % in comparison to other compression ratios.

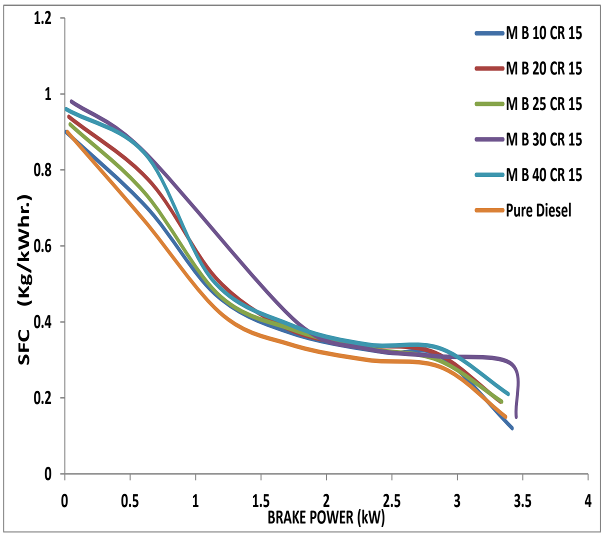

Fig 4.2 (a) BP vs. BSFC at CR 15 for Mahua oil biodiesel for blending ratios

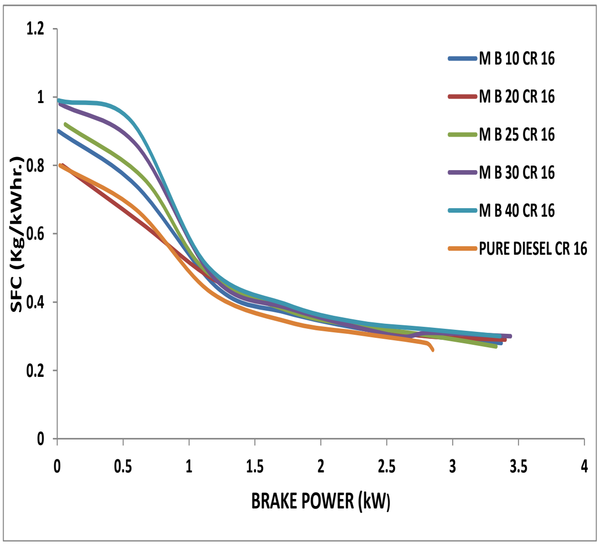

Fig 4.2 (b) BP vs. BSFC at CR 16 for Mahua oil biodiesel for blending ratios

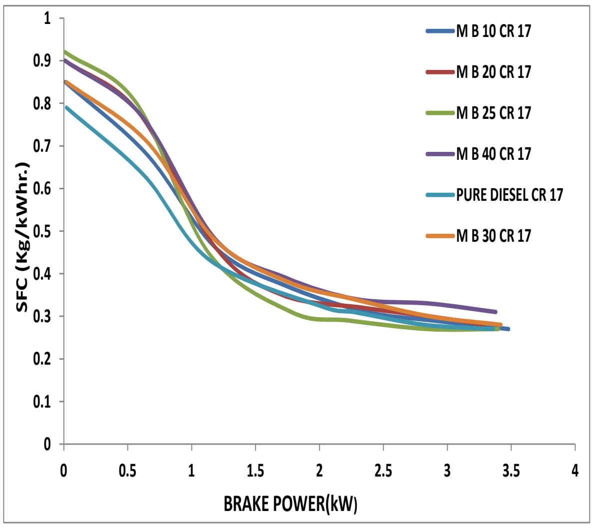

Fig 4.2 (c) BP vs. BSFC at CR 17 for Mahua oil biodiesel for blending ratios

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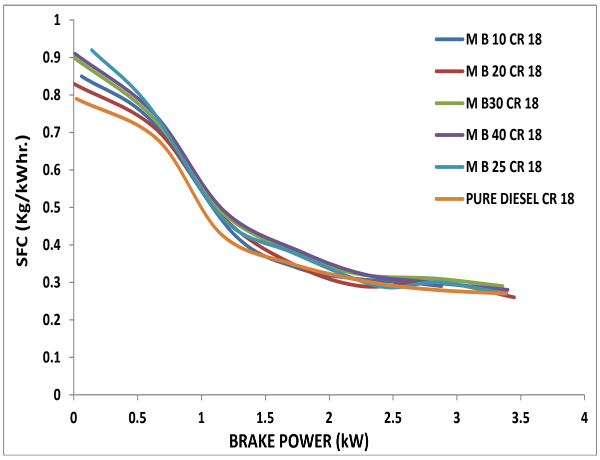

Fig 4.2 (d) BP vs. BSFC at CR 18 for Mahua oil biodiesel for blending ratios

Regarding the engine performance in term of FC is as follows:

Figure 4.3 (a),(b),(c),(d) shows that the variation of Fuel consumption rate with different loads for different fuel blends at compression ratios 15,16,17and 18. Figure 4.21 (a) shows that the Fuel consumption rate of pure diesel is increasing linearly w.r.t increasing Brake power. Fuel consumption rate for all the Mahua blends is more as compared to pure Diesel at different compression ratio.

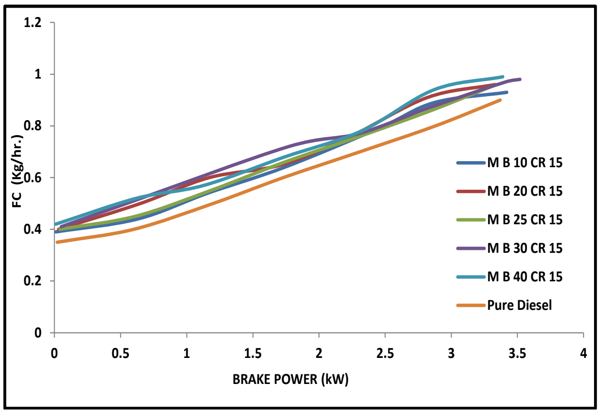

Fig 4.3 (a) BP vs. FC at CR 15 for Mahua oil biodiesel for blending ratios

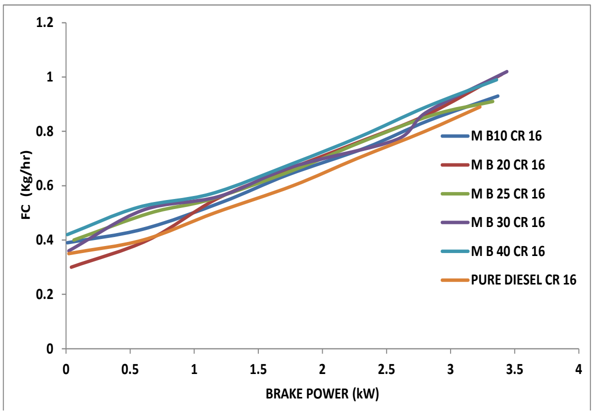

Fig 4.3 (b) BP vs FC at CR 16 for Mahua oil biodiesel for blending ratios

At initial loading fuel consumption rate is low and with increasing load fuel consumption rate increases. Minimum fuel consumption rate of Pure Diesel is at CR 17 and at initial loading. Maximum fuel consumption rate for pure diesel is obtained at CR 15 and at full load. After comparing all the results for different Mahua blends minimum fuel consumption rate is obtained at B 20 and CR 16. Maximum fuel consumption rate is obtained at CR 16 for B 30. 14 % increase in fuel consumption rate is increased in comparison to pure diesel.

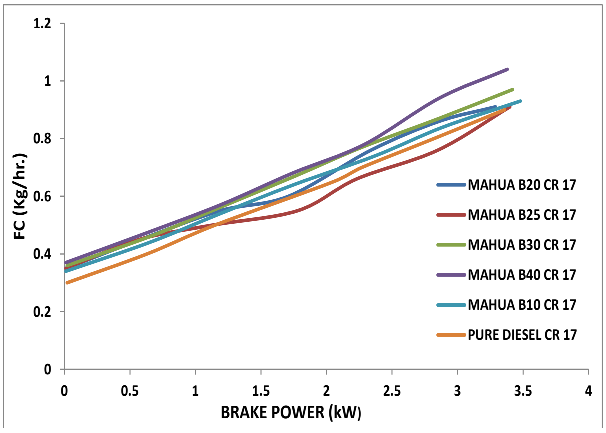

Fig 4.3 (c) BP vs. FC at CR 17 for Mahua oil biodiesel for blending ratios

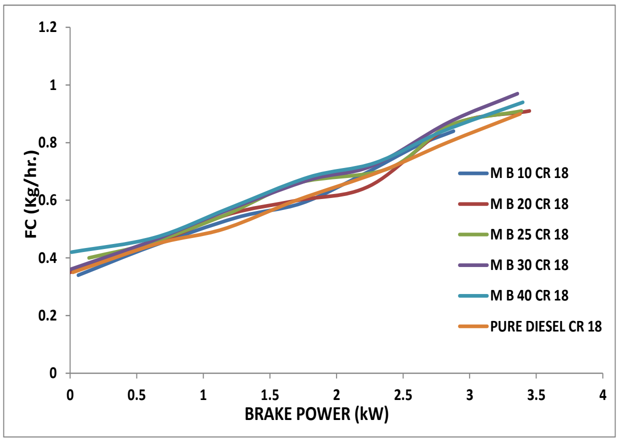

Fig 4.3 (d) BP vs. FC at CR 18 for Mahua oil biodiesel for blending ratios

Regarding the engine emission in terms of CO is as follow.

Fig 4.4 (a), (b), (c), (d) shows the emission of Carbon monoxide with respect to corresponding Brake power. Emission of CO at CR 15, 16 and 17 is more at all blends of Mahua oil biodiesel. As the BP is increasing emission of CO decreases and after 75 % loading emission rate become about to constant. Emission rate of CO is approximately same at CR 18 w.r.t pure diesel. The discharge of CO is found to be diminished with increasing load. More fuel accumulates at higher load to produce more power due to which higher temperature occurs in the fumes. This increased temperature helps in the oxidation of CO on account that its value decreases. Even so, at full

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load air-fuel ratio was decreased up to that much limit when sufficient oxygen was not available to oxidize completely that is why higher CO is obtaining.

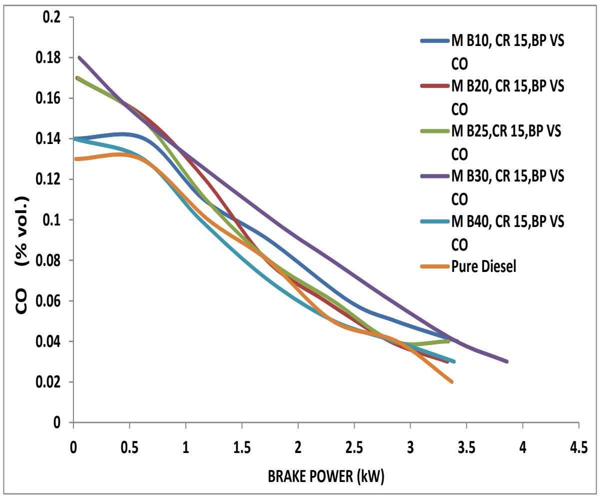

Fig 4.4 (a) BP vs. CO at CR 15 for Mahua oil biodiesel for blending ratios

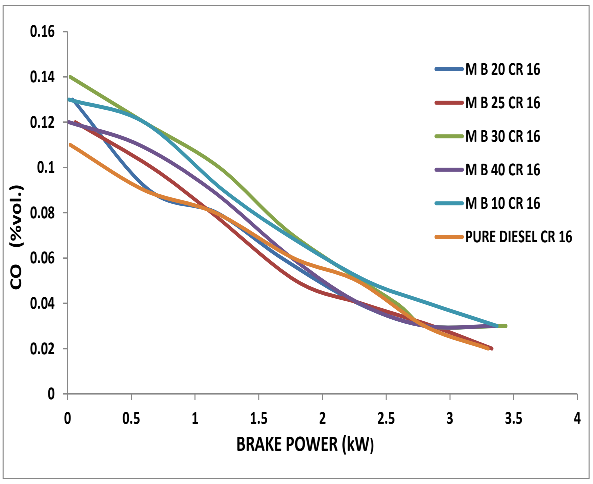

Fig 4.4 (b) BP vs. CO at CR 16 for Mahua oil biodiesel for blending ratios

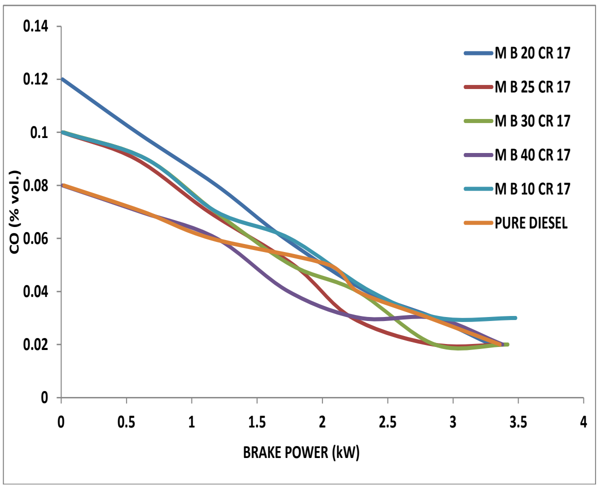

Fig 4.4 (c) BP vs. CO at CR 17 for Mahua oil biodiesel for blending ratios

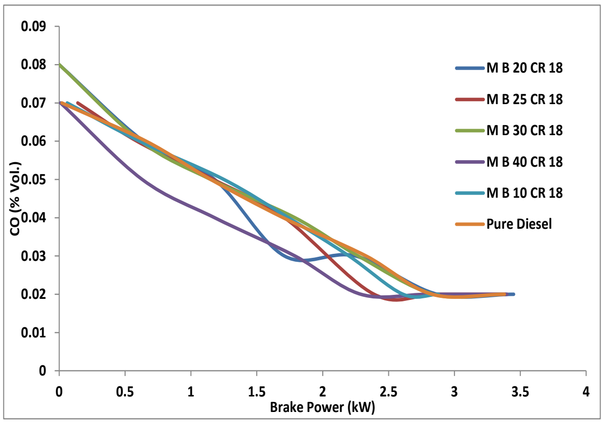

Fig 4.4 (d) BP vs CO at CR 18 for Mahua oil biodiesel for blending ratios

Regarding the engine emission in terms of CO_2 is as follow.

Fig 4.5 (a), (b), (c) and (d) show the emission of Carbon dioxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. The Behavior of Brake power vs. Carbon dioxide in all the cases having parabolic nature of curve. Emission of CO_2 is increasing w.r.t Brake power till 50 or 60 % loading but after that emission rate decreases and become similar to the initial loading. Percent of CO_2 in the exhaust is the direct

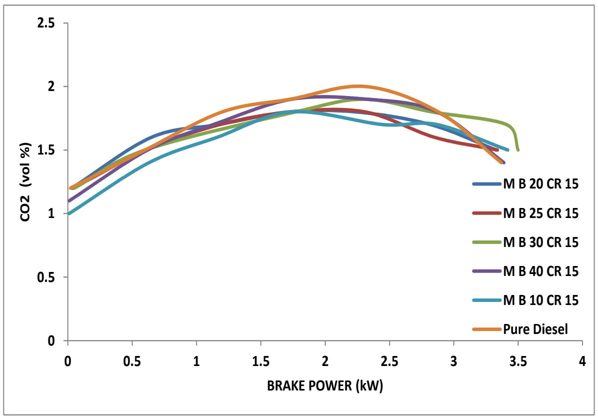

Fig 4.5(a) BP vs. CO_2 at CR 15 for Mahua oil biodiesel for blending ratios

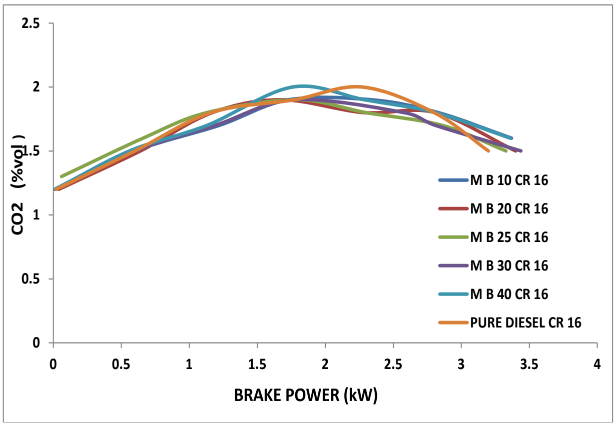

Fig 4.5 (b) BP vs. CO_2 at CR 16 for Mahua oil biodiesel for blending ratios

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indication of perfect combustion of fuel in the combustion chamber [84. At higher CR maximum Carbon dioxide emission is obtained it means with increasing CR values complete combustion is occurring and complete carbon chain is formed.

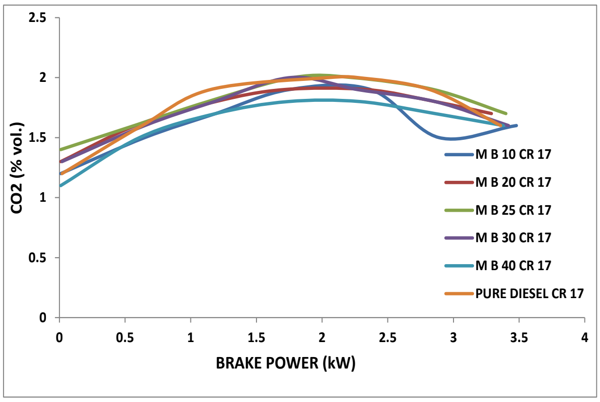

Fig 4.5 (c) BP vs. CO_2 at CR 17 for Mahua oil biodiesel for blending ratios

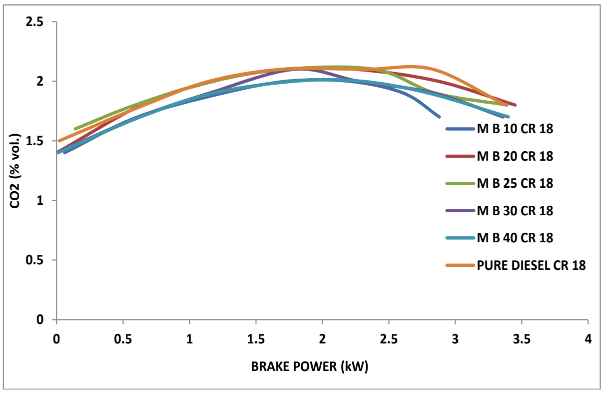

Fig 4.5 (d) BP vs. CO_2 at CR 18 for Mahua oil biodiesel for blending ratios

Regarding the engine emission in terms of NO_X is as follow.

Fig 4.6 (a), (b), (c) and (d) shows the variation of NO_X with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. NO_X emission is lower as compared to pure diesel for all blends of Mahua oil at different Compression ratio.

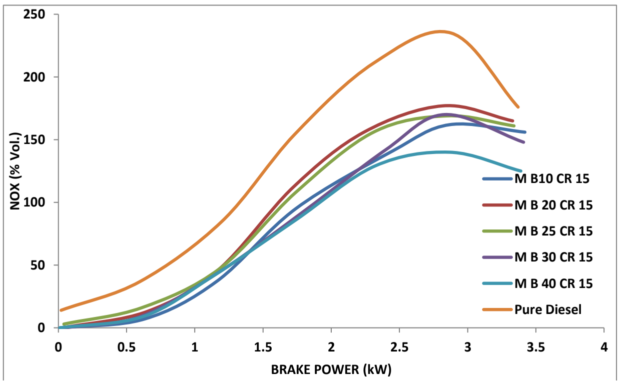

Fig 4.6(a) BP vs. NO_X at CR 15 for Mahua oil biodiesel for blending ratios

Fig. 4.24 (a) shows that till 2.8 kW Brake power emission of NO_X is increasing means till 90 % load emission rate is increasing after that it decreases with same ratio. 32 % of NO_X emission is decreases at CR 15 w.r.t pure diesel. With increasing CR and load i.e. Brake power emission rate increases. Maximum NO_X is obtained at CR 18 which is about 48 % greater in comparison to CR 15.

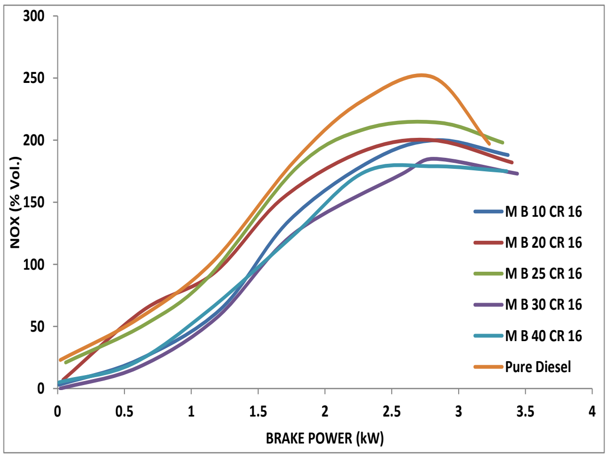

Fig 4.6 (b) BP vs NO_X at CR 16 for Mahua oil biodiesel for blending ratios

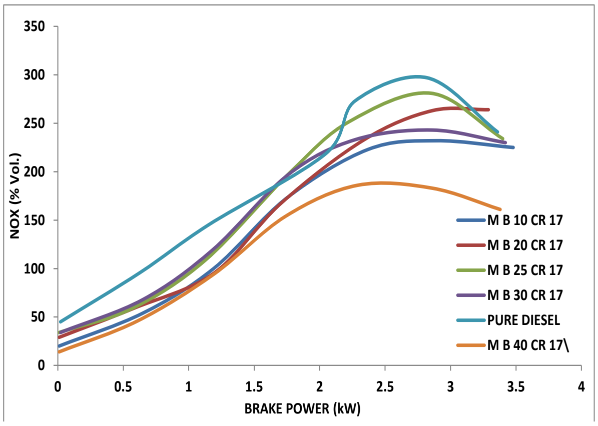

Fig 4.6 (c) BP vs. NO_X at CR 17 for mahua oil biodiesel for blending ratios

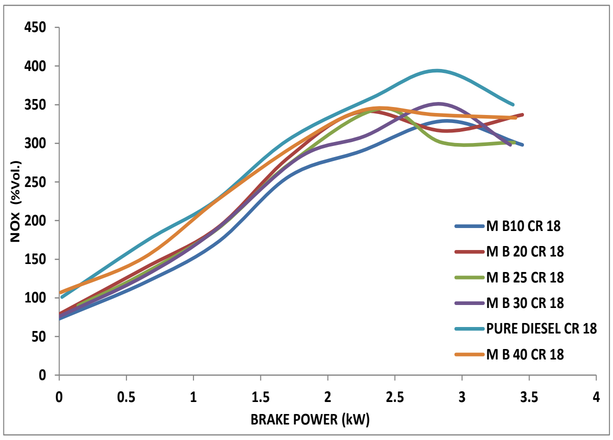

Fig 4.6 (d) BP vs. NO_X at CR 18 for Mahua oil biodiesel for blending ratios

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Regarding the engine emission in terms of unburned Hydrocarbon are as follow.

Fig 4.7 (a), (b), (c) and (d) shows the emission of Carbon dioxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. At initial loading HC emission is more and with increasing load unburnt HC emission decreases. Maximum Hydrocarbon emission of pure diesel is at CR 15. 79 % emission of HC is reduced at CR 18 for pure diesel.

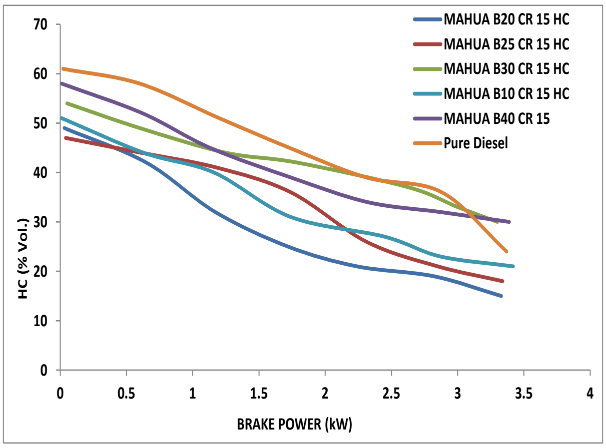

Fig 4.7 (a) BP vs HC at CR 15 for mahua oil biodiesel for blending ratios

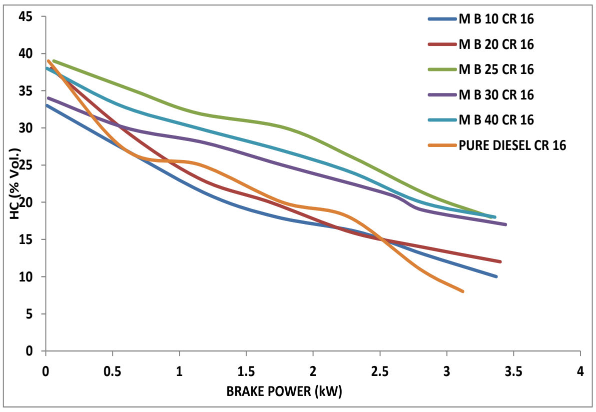

Fig 4.7 (b) BP vs. HC at CR 16 for Mahua oil biodiesel for blending ratios

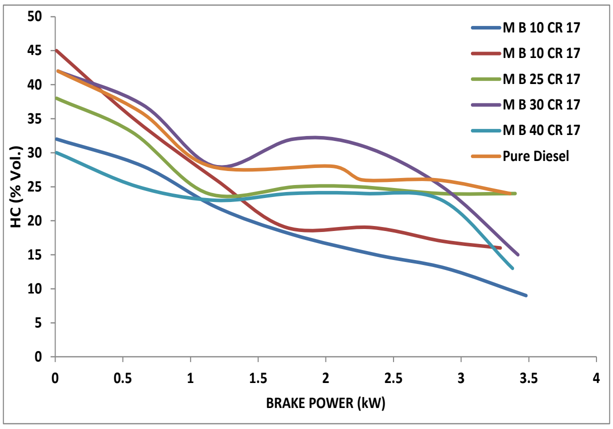

Fig 4.7 (c) BP vs. HC at CR 17 for Mahua oil biodiesel for blending ratios

At CR 18 Hydrocarbon emission decreases linearly. From fig. 4.25 (a) it is clear that at CR 15 emission of unburnt hydrocarbon is less at all blends w.r.t diesel. At compression ratio 16 Mahua blends of B10, B20, B25, and B30 have higher hydrocarbon emission in comparison to pure diesel. The behavior of hydrocarbon emission at CR 17 is such that except B30 all blends have lower emission w.r.t pure diesel. At compression ratio 18, B20, B25, and B30 have higher emission of hydrocarbon but B10 and B40 have low emission w.r.t pure diesel.

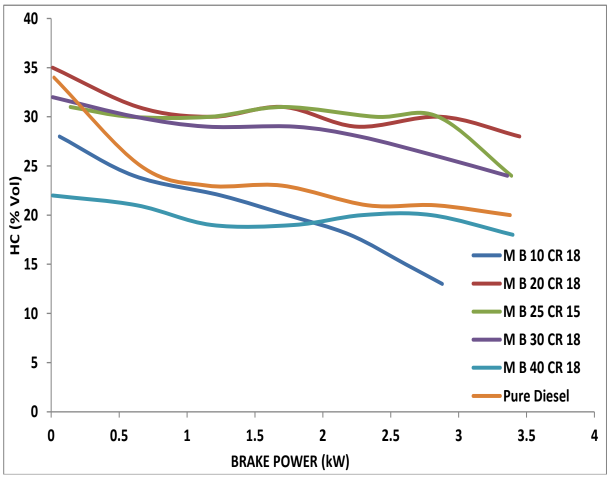

Fig 4.7 (d) BP vs. HC at CR 18 for Mahua oil biodiesel for blending ratios

Experiments with Saal Seed Oil Biodiesel

The aim of the experiments has been categorized in the following manner: Comparison of the Saal seed oil biodiesel blends with diesel in terms of operation parameters (BTE ,BSFC and FC), emission parameters (CO, unburned HC, NOx and CO2) at different compression ratio of 15:1, 16:1, 17:1, 18:1.

4.2.1 Blends of Sal seed oil biodiesel Vs. Diesel

Table 4.2 shows Calorific value and density of of pure diesel, Pure Mahua oil biodiesel and their blendings. Procedure of finding the Calorific value is discussed above. In this experiment Saal seed biodiesel is mixed Diesel in definite quantity for example in B10 we mix 100 ml Saal seed oil and 900 ml Diesel for B20 we mix 200 ml Saal seed and 800 ml Diesel. We prepare five Blendings of Saal seed oil biodiesel which is explained below. In this experiment We study Comparative results of engine performance and exhaust emission characteristics of the different blends of Sal seed oil biodiesel with that of diesel under variable loads (0, 2, 4,6,8,10,12 kg) at a constant speed of 1800 RPM are discussed. Blends used are as follows:

Sal seed BD B10
Sal seed BD B20
Sal seed BD B25
Sal seed BD B30
Sal seed BD B40

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Table 4.2 Calorific value and Density of Diesel, Pure Saal seed oil biodiesel and their Blendings.

Sl. No.	Blends of Sal seed oil Biodiesel and Diesel	Calorific value (MJ)	Density (Kg/m^3)
01	B 10	38.66	760
02	B 20	37.97	820
03	B 25	37.44	830
04	B 30	36.68	840
05	B 40	36.19	850
06	Pure Saal seed	33.45	991.5
07	Pure Diesel	41.70	823.7

Regarding the engine performance in term of BTE is as follows:

Figure 4.8 (a), (b), (c), (d) shows that the variation of Brake thermal efficiency (BTE) with different loads for different blends at compression ratios 15,16,17,18. From the entire graph it is clear that with increasing load and compression ratio BTE increases, so maximum BTE is obtained at CR 18. Percent increase of BTE for Pure diesel is 0.43% from CR 15 to 18. For B10 and B40 3.5% and 7.9% BTE increases respectively. It has been noticed that the brake thermal efficiency for all test fuel is increasing with the increase in applied load. It happens due to a reduction in heat loss and increase in power developed with increase in load [107].

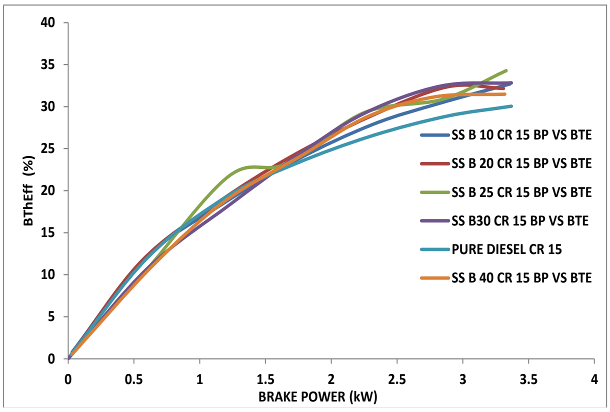

Fig 4.8(a) BP vs BTE at CR 15 for Sal seed oil biodiesel for blending ratios

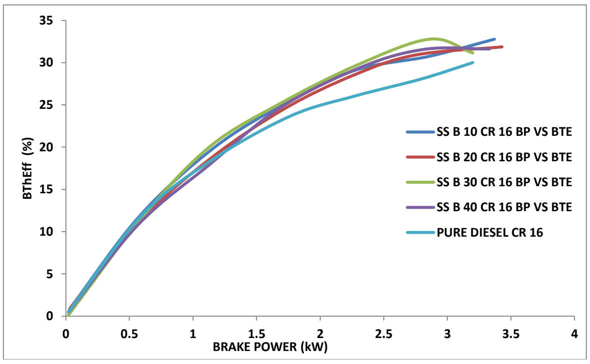

Fig 4.8 (b) BP vs BTE at CR 16 for Sal seed oil biodiesel for blending ratio

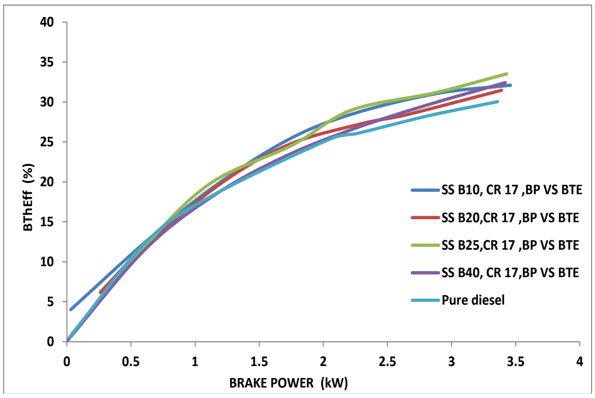

Fig 4.8 (C) BP vs BTE at CR 17 for Sal seed oil biodiesel for blending ratios

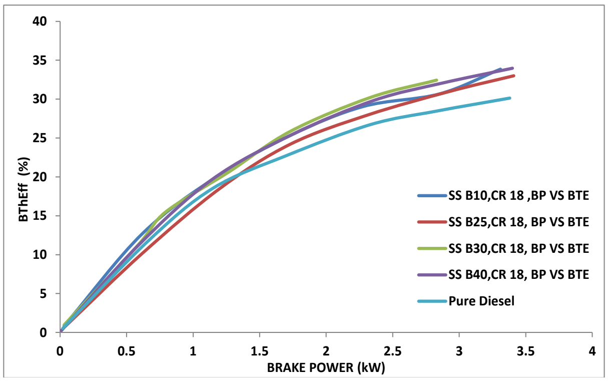

Fig 4.8 (d) BP vs. BTE at CR 18 for Sal seed oil biodiesel for blending ratios

Regarding the engine performance in term of BSFC is as follows:

Figure 4.19 (a),(b),(c),(d) shows that the variation of Brake specific fuel consumption (BSFC) with different loads for different blends at compression ratios 15,16,17,18. BSFC also depends on calorific value , Pure Sal seed biodiesel has less calorific value and with increasing Blends calorific value decreases very minutely so the BSFC does not changes on high rate. Pure diesel has less BSFC to other blends of Sal seed biodiesel because it has highest calorific value. At CR 18 all the blends have very close BSFC to Pure Diesel. With increasing load BSFC decreases for all blendings of Sal seed biodiesel.

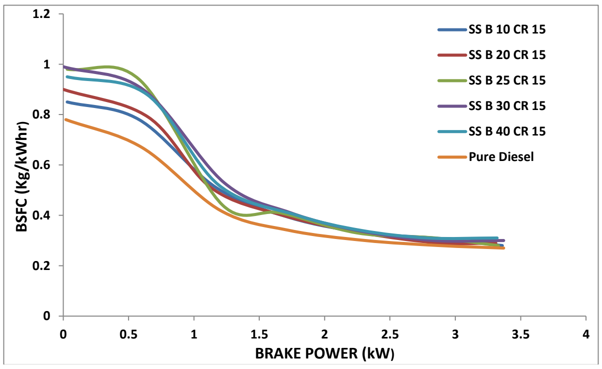

Fig 4.9 (a) BP vs BSFC at CR 15 for Sal seed oil biodiesel for blending ratios

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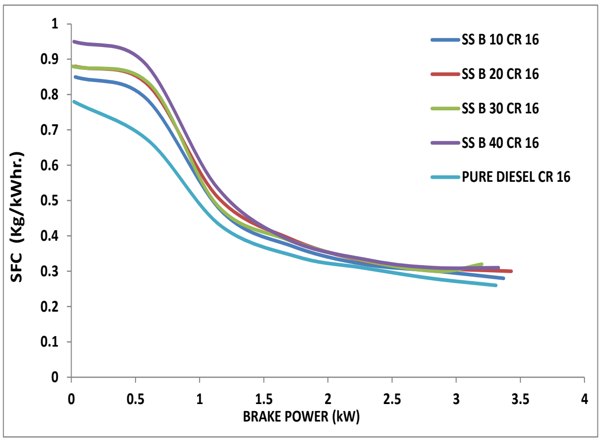

Fig 4.9 (b) BP vs. BSFC at CR 16 for Sal seed oil biodiesel for blending ratios

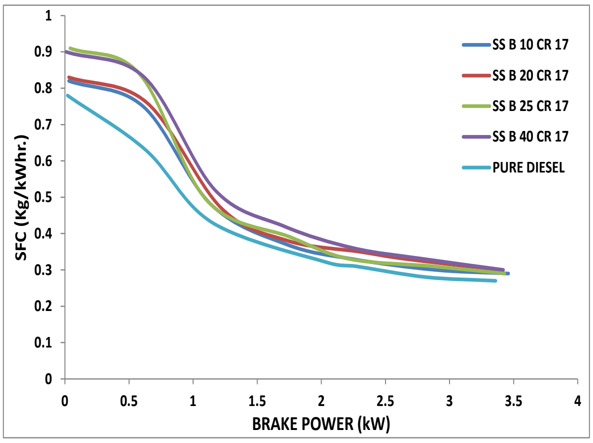

Fig 4.9 (c) BP vs. BSFC at CR 17 for Sal seed oil biodiesel for blending ratios

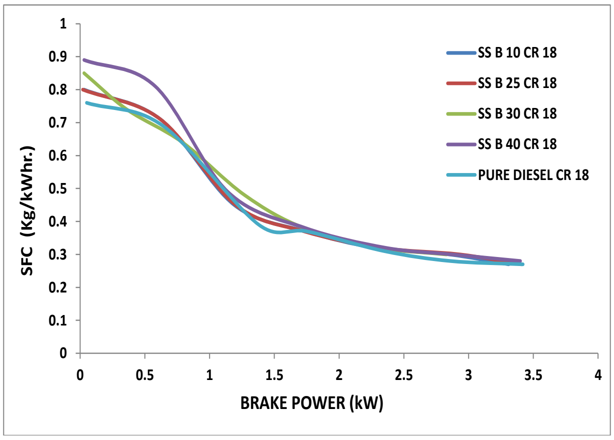

Fig 4.9 (d) BP vs BSFC at CR 18 for Sal seed oil biodiesel for blending ratios

Regarding the engine performance in term of FC is as follows:

Figure 4.10 (a), (b), (c), (d) shows that the variation of fuel consumption (FC) rate with different loads for different blends at compression ratios 15,16,17,18. Fuel consumption rate is more than Pure diesel at all blending and compression ratio with increasing load fuel consumption rate increases and it is maximum at CR 18. Fuel consumption rate is increasing linearly at CR 16. 8.33% FC rate is increases at B10 on zero loads from CR 15 to 18.

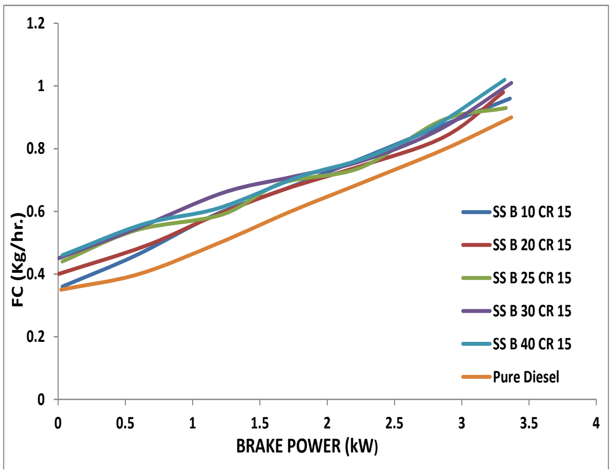

Fig 4.10 (a) BP vs. FC at CR 15 for Sal seed oil biodiesel for blending ratios

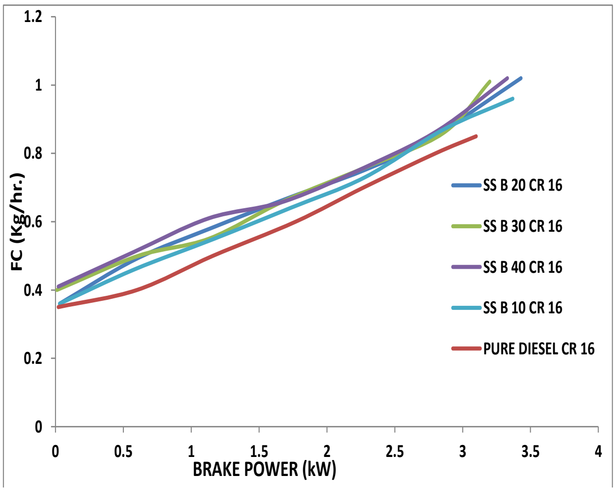

Fig 4.10 (b) BP vs. FC at CR 16 for Sal seed oil biodiesel for blending ratios

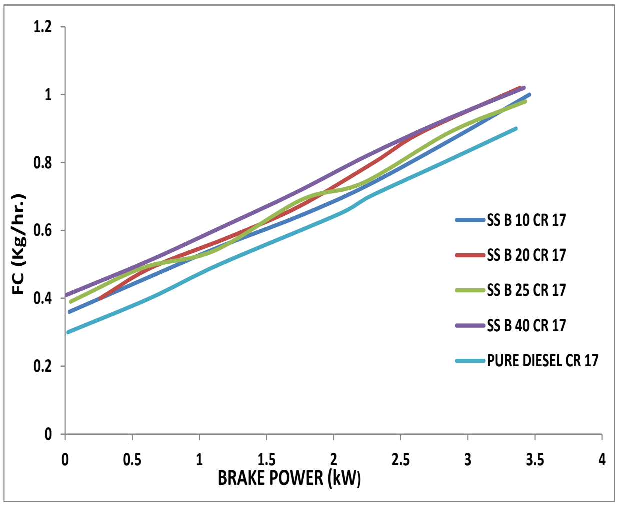

Fig 4.10 (c) BP vs. FC at CR 17 for Sal seed oil biodiesel for blending ratios

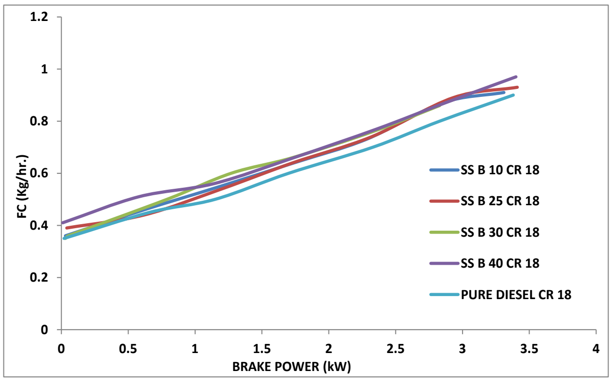

Fig 4.10 (d) BP vs. FC at CR 18 for Sal seed oil biodiesel for blending ratios

Regarding the engine emission in terms of Carbon monoxide are as follow

Fig 4.11(a), (b), (c) and (d) show the emission of Carbon monoxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. Carbon monoxide emission is more as compared to pure diesel for all Blends and at all compression ratios. At B20 for CR 15 has maximum CO emission, for CR 16 B30 and B40 has high emission rate of CO .With increasing Compression ratios emission of Carbon monoxide decreases.

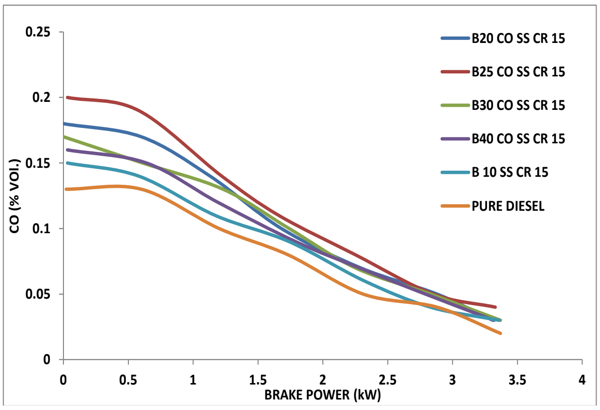

Fig 4.11 (a) BP vs. CO at CR 16 for Sal seed oil biodiesel for blending ratios

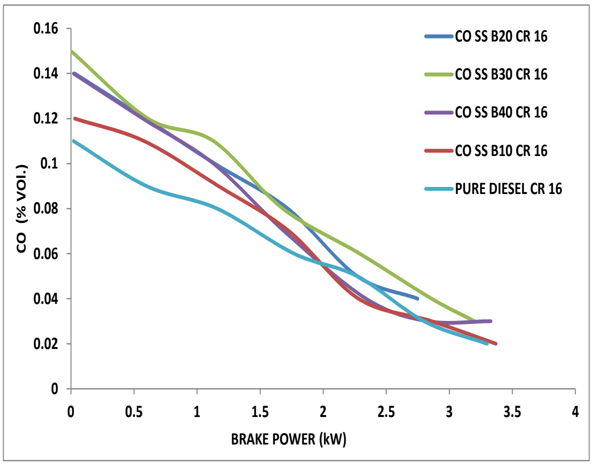

Fig 4.11 (b) BP vs. CO at CR 16 for Sal seed oil biodiesel for blending ratios

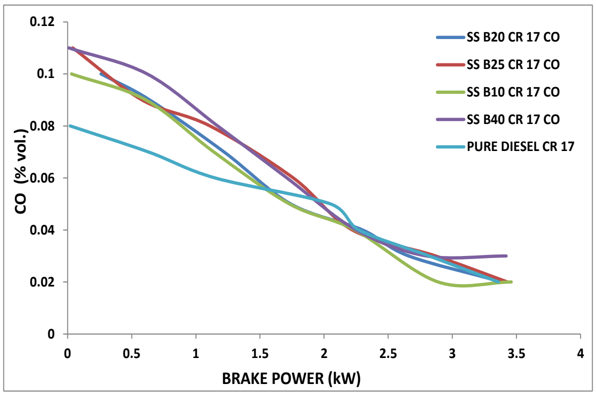

Fig 4.11 (c) BP vs. FC at CR 17 for Sal seed oil biodiesel for blending ratios

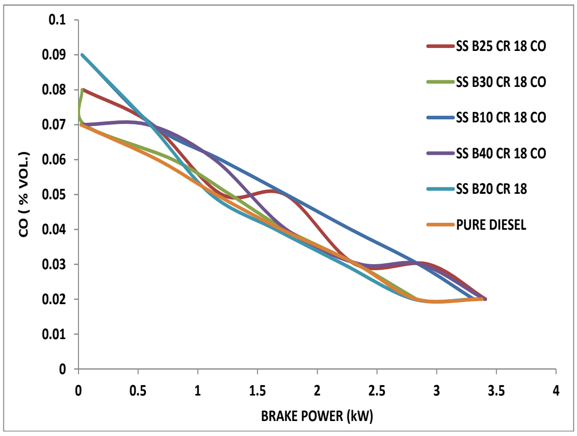

Fig 4.11 (d) BP vs. FC at CR 18 for Sal seed oil biodiesel for blending ratios

Regarding the engine emission in terms of Carbon dioxide are as follow

Fig 4.12(a), (b), (c) and (d) shows the emission of Carbon dioxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. Percent of CO2 in the exhaust is the direct indication of perfect combustion of fuel in the combustion chamber [84]. All test fuels show increasing trends, CO2 emission with increase in shipment due to increase in accumulation of fuel. CO2 emission level can relate for the increase in

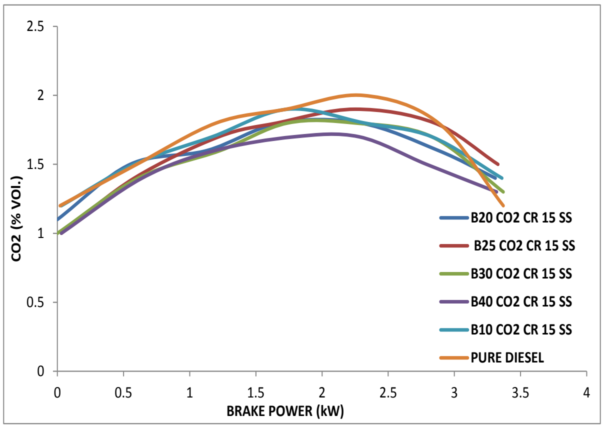

Fig 4.12 (a) BP vs. CO_2 at CR 15 for Sal seed oil biodiesel for blending ratios

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exhaust gas temperature, therefore more emission of CO2 means high temperature is there. Up to 50 percent loading emission of CO2 is more and then after it decreases. The graph is parabolic in nature.

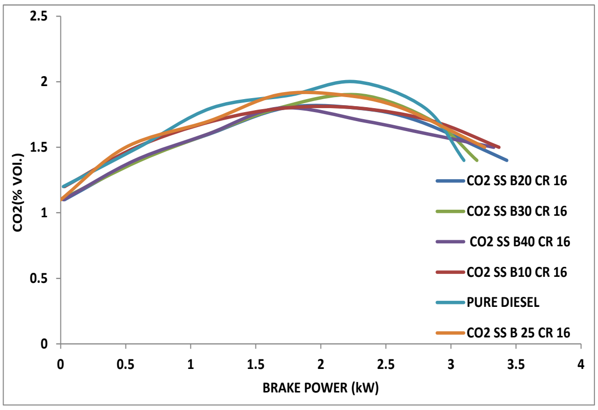

Fig 4.12 (b) BP vs CO_2 at CR 16 for Sal seed oil biodiesel for blending ratios

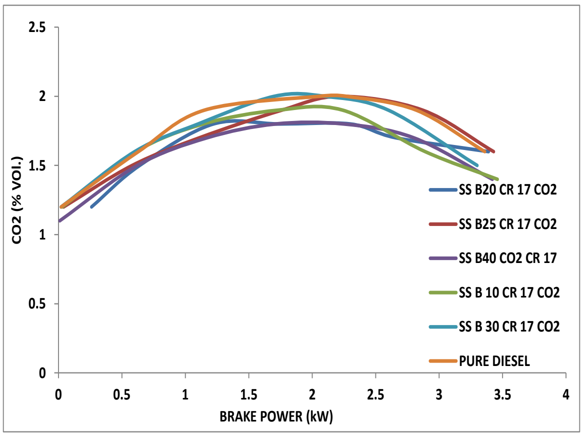

Fig 4.12 (c) BP vs. CO_2 at CR 17 for Sal seed oil biodiesel for blending ratios

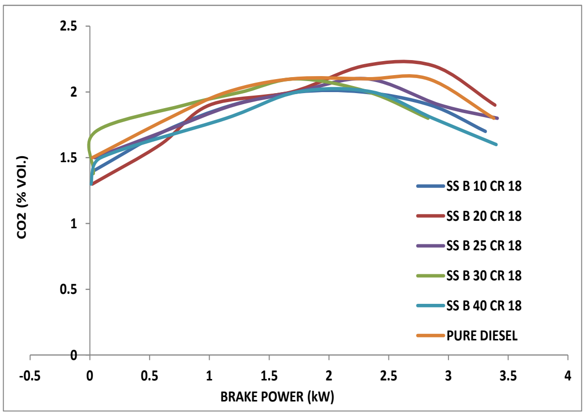

Fig 4.12 (d) BP vs CO_2 at CR 18 for Sal seed oil biodiesel for blending ratios

4.2.2.6 Regarding the engine emission in terms of NOX are as follow

Fig 4.13 (a), (b), (c) and (d) show the emission of Nitrogen oxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. After studying all the results of NO_x emission, We observe that all the Blends of Saal seed oil biodiesel has less emission of NO_x as compared to pure diesel except at CR 18. With increasing load emission of nitrous oxide increases up to certain load of 75% and then decreases. 32%, 33% and 24% of emission is less for CR 15, 16, 17 at B10 compared to pure diesel

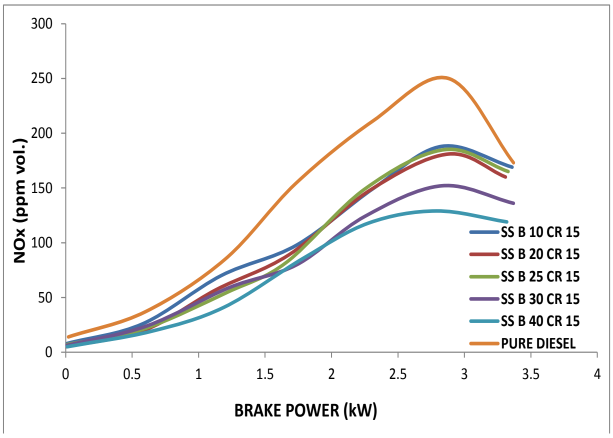

Fig 4.13 (a) BP vs. NO_X at CR 15 for Sal seed oil biodiesel for blending ratios

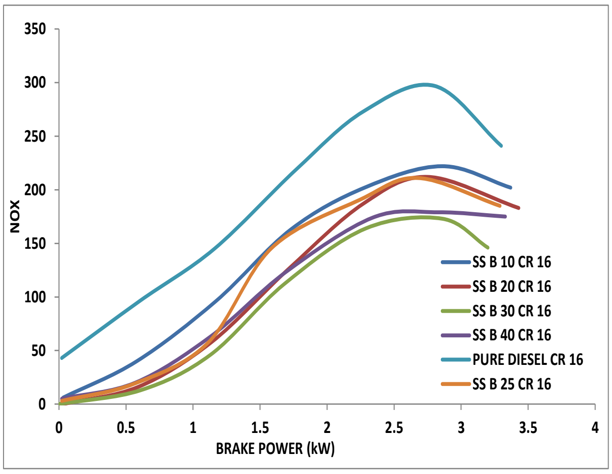

Fig 4.13 (b) BP vs. NO_X at CR 16 for Sal seed oil biodiesel for blending ratios

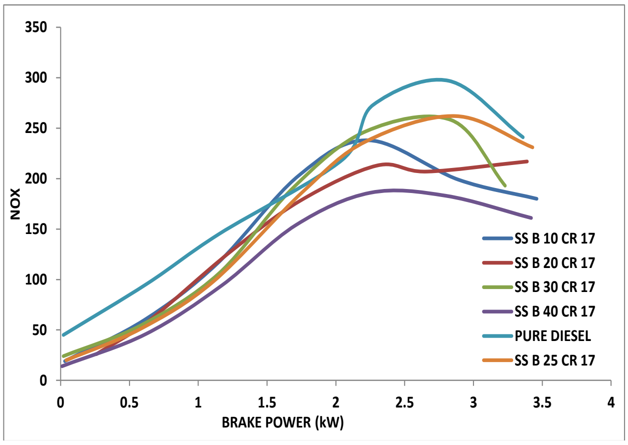

Fig 4.13 (c) BP vs. NO_X at CR 16 for Sal seed oil biodiesel for blending ratios

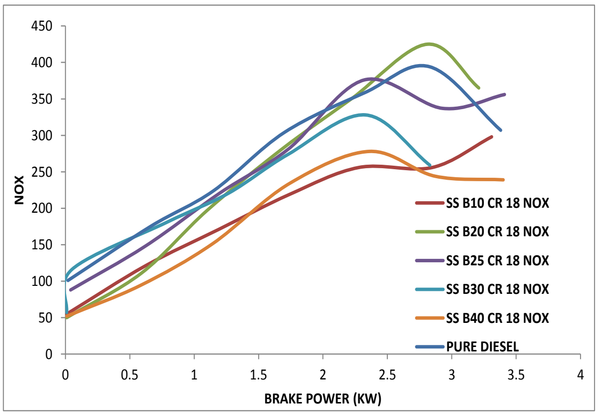

Fig 4.13 (d) BP vs. NO_X at CR 16 for Sal seed oil biodiesel for blending ratios

4.2.2.7 Regarding the engine emission in terms of Unburnt Hydrocarbon are as follow

Fig 4.14(a), (b), (c) and (d) show the emission of unburnt Hydrocarbon with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. Emission of unburnt Hydrocarbon is approximately equal at initial loading of all blendings as compared to pure diesel but with increasing loads emission of hydrocarbon decreases because of incomplete combustion. At CR 18 minimum emission of Hydrocarbon occurs for B40.

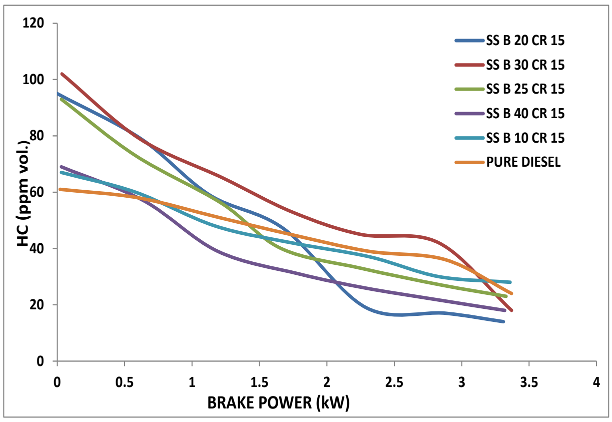

Fig 4.14 (a) BP vs. HC at CR 15 for Sal seed oil biodiesel for blending ratios

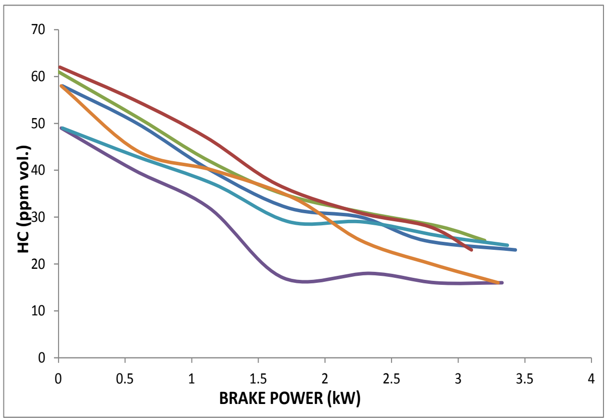

Fig .14 (b) BP vs. HC at CR 16 for Sal seed oil biodiesel for blending ratios 4

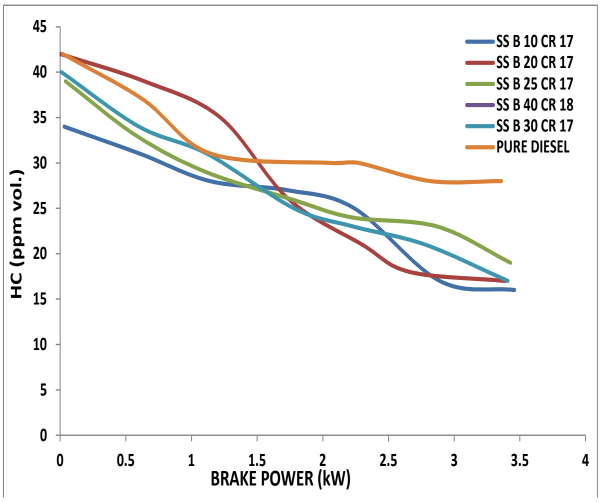

Fig 4.14 (c) BP vs. HC at CR 17 for Sal seed oil biodiesel for blending ratios

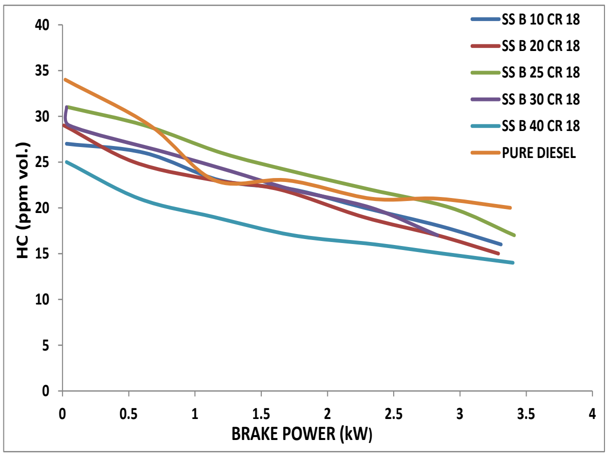

Fig 4.14 (d) BP vs. HC at CR 18 for Sal seed oil biodiesel for blending ratios

Experiments with Mix Oil Biodiesel (Mahua 25% And Sal Seed 75%)

In this experiment Mix oil biodiesel is prepared of Mahua and Saal seed oil biodiesel., Mahua contained 25% and Saal seed oil biodiesel 75%.The objective of the experiments has been categorized in the following manner: Comparison of the Mix oil biodiesel blends (Mahua and Sal Seed oil) with diesel in terms of performance parameters (BTE ,BSFC and FC), emission parameters (CO, unburned HC, smoke, NOx and CO2) at compression ratio 15:1, 16:1, 17:1, 18:1.

Blends of Mix oil biodiesel (MAHUA 25% AND SAL SEED 75%) vs. Diesel

Comparative results of engine performance and exhaust emission characteristics of the different blends of Sal seed oil biodiesel with that of diesel under variable loads (0, 2, 4, 6, 8, 10, 12 kg) at a constant speed of 1500 RPM are discussed. Blends used are as follows:

MIX OIL BD B10
MIX OIL BD B20
MIX OIL BD B30

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Table 4.3 Calorific value and Density of Diesel, Mix oil biodiesel and their Blendings.

Sl. No.	Blends of Mix oil Biodiesel and Diesel	Calorific value (MJ)	Density (Kg/m^3)
01	B 10	40.41	820
02	B 20	39.10	826
03	B 30	38.49	835
06	MIX OIL BD	36.45	930
07	Pure Diesel	41.70	823.7

Regarding the engine performance in term of BTE is as follows:

Figure 4.15 (a), (b), (c), (d) shows that the variation of Brake thermal efficiency (BTE) with different loads for different blends at compression ratios 15,16,17,18. From all the graph it is clear that with increasing load and compression ratio BTE increases, B30 at CR 18 of mix oil biodiesel has higher value of BTE by 37.76% compared to pure diesel .BTE of all Mix oil Biodiesel is better as compared to other blendings of Sal seed and Mahua oil biodiesel because of the calorific value of Mix oil biodiesel is high. 20.6%, 5% and 4.8% of BTE is higher at CR 15, 16 and 17 for B30 of Mix oil Biodiesel.

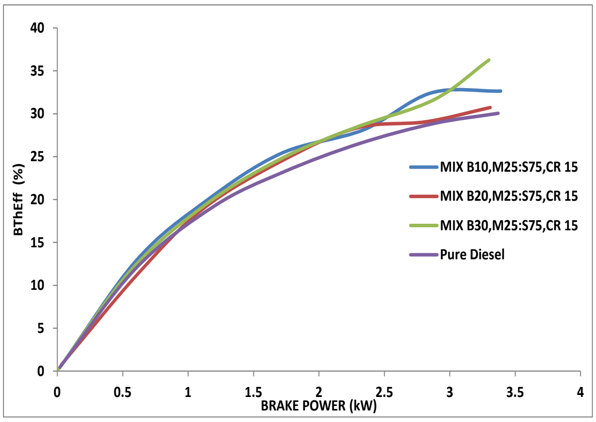

Fig 4.15 (a) BP vs. BTE at CR 15 for mixed oil biodiesel for blending ratios

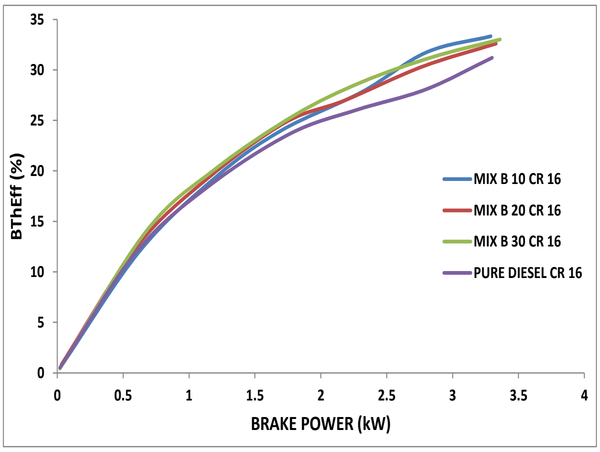

Fig 4.15 (b) BP vs. BTE at CR 16 for mixed oil biodiesel for blending ratios

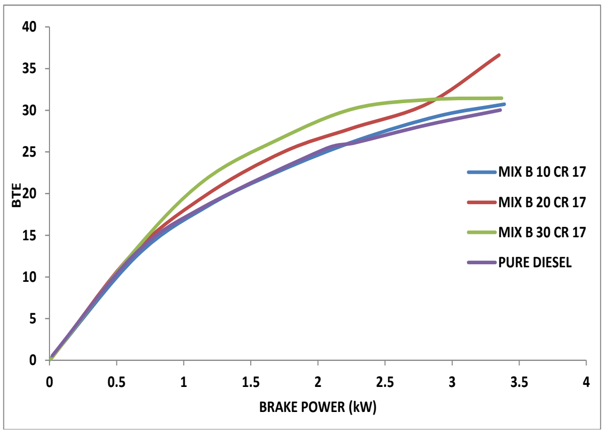

Fig 4.15 (c) BP vs. BTE at CR 17 for Mixed oil biodiesel for blending ratios

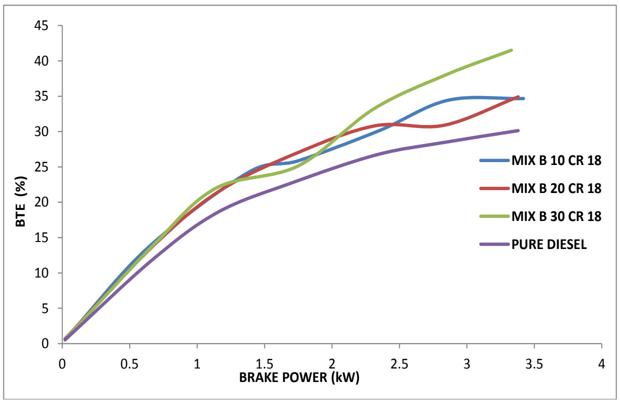

Fig 4.15 (d) BP vs. BTE at CR 18 for mixed oil biodiesel for blending ratios

4.3.1.1.2 Regarding the engine performance in term of BSFC (Brake specific fuel consumption) is as follows:

Figure 4.16 (a), (b), (c), (d) shows that the variation of Brake specific fuel consumption (BSFC) with different loads for different blends at compression ratios 15,16,17,18. At initial loading BSFC is more for all blendings at all value of Compression ratios after 50% of full loading graph becomes linear.

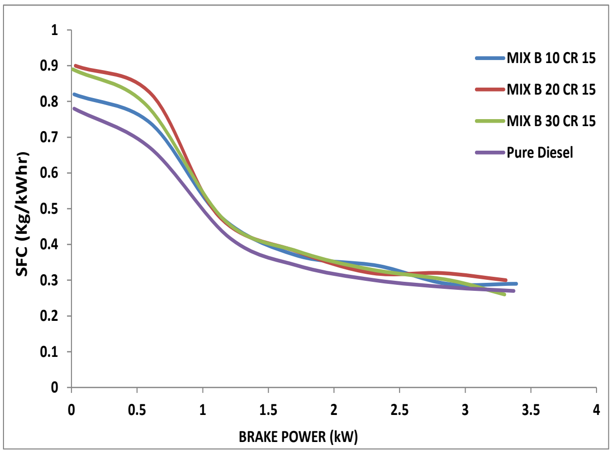

Fig 4.16 (a) BP vs. BSFC at CR 15 for mixed oil biodiesel for blending ratios

At compression ratio 15 Brake specific fuel consumption is more as compared to diesels at all Blendings. 5.12% BSFC is more as compared to diesel for CR 15. 3.48 % of BSFC is more as compared to diesel for CR 16. 11.53 % of BSFC is more as compared to diesel for CR 17. At CR 18 BSFC is approximately equal to pure diesel.

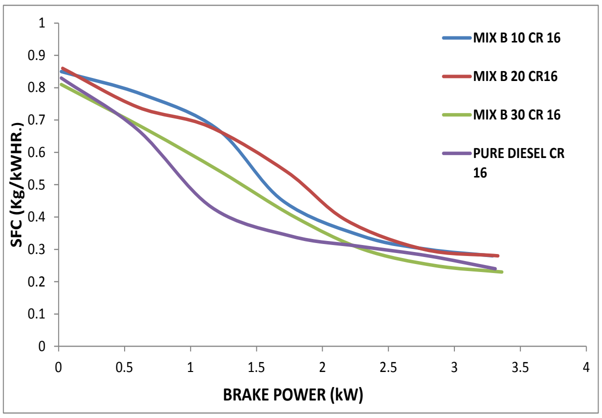

Fig 4.16 (b) BP vs. BSFC at CR 16 for mixed oil biodiesel for blending ratios

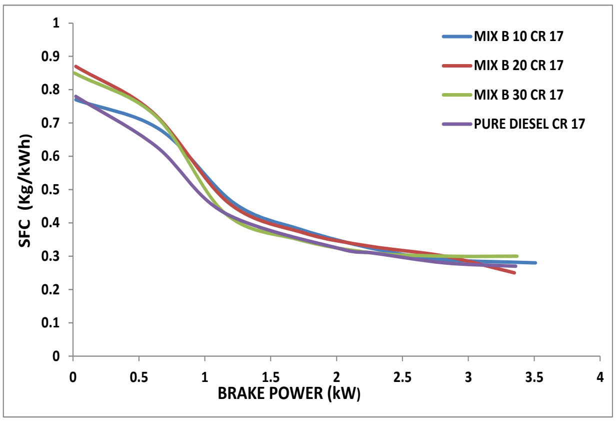

Fig 4.16 (c) BP vs. BSFC at CR 17 for Mixed oil biodiesel for blending ratios

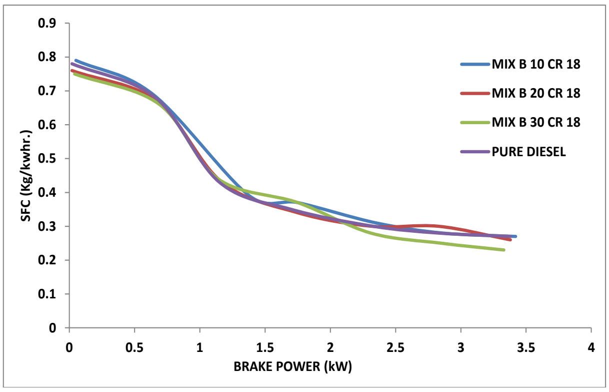

Fig 4.16 (d) BP vs BSFC at CR 18 for Mixed oil biodiesel for blending ratios

4.3.1.1.3 Regarding the engine performance in term of FC (Fuel consumption) is as follows:

Figure 4.17 (a), (b), (c), (d) shows that the variation of Fuel consumption (FC) with different loads for different blends at compression ratios 15,16,17,18. From all the graph it is clear that with increasing load and compression ratio ,Fuel consumption rate increases, At all Blendings Fuel consumption rate is more as compared to Pure diesel. Maximum fuel consumption rate is obtained at CR 15.

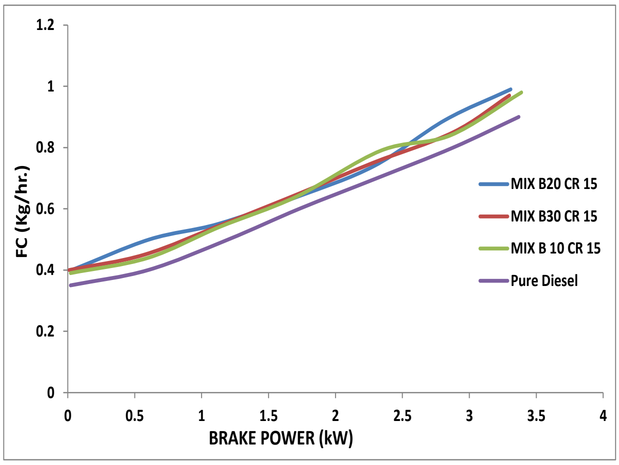

Fig 4.17 (a) BP vs FC at CR 15 for Mixed oil biodiesel for blending ratios

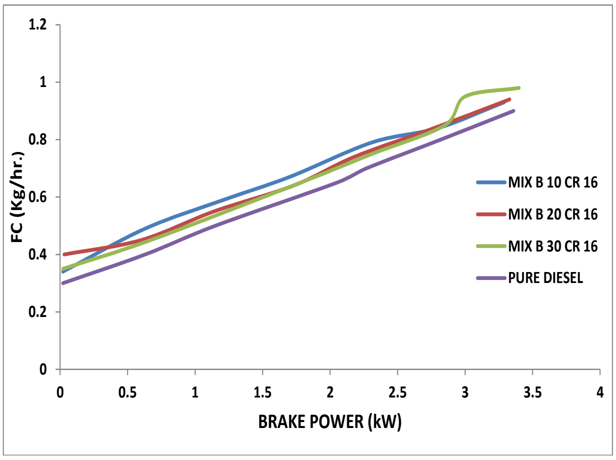

Fig 4.17 (b) BP vs FC at CR 16 for Mixed oil biodiesel for blending ratios

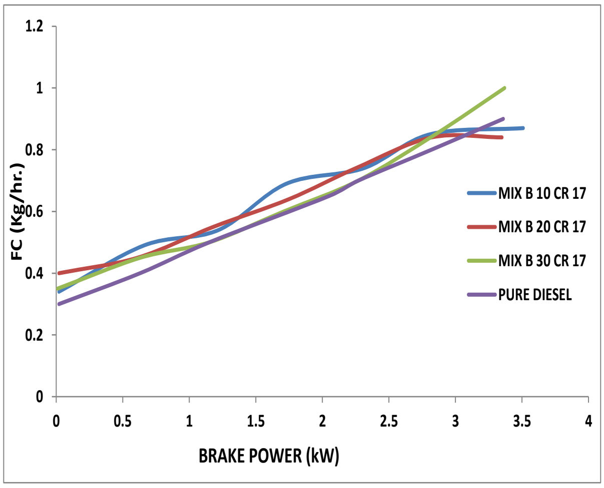

Fig 4.17 (c) BP vs FC at CR 17 for Mixed oil biodiesel for blending ratios

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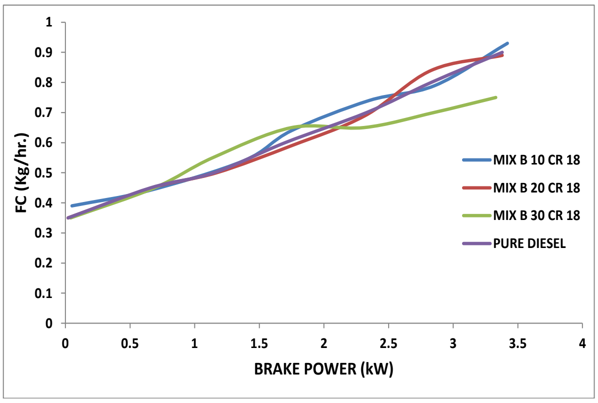

Fig 4.17 (d) BP vs FC at CR 18 for Mixed oil biodiesel for blending ratios

4.3.1.1.4 Regarding the engine emission in terms of Carbon monoxide are as follow

Fig 4.18 (a), (b), (c) and (d) show the emission of Carbon monoxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. When there is no load emission of Carbon mono oxide is more, with increasing load CO emission decreases and after 80% of loading emission values becomes constant and graph becomes linear. Carbon monoxide is more at CR 15.

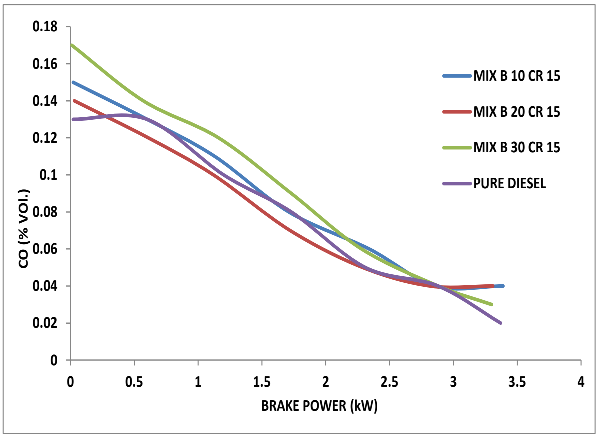

Fig 4.18 (a) BP vs. CO at CR 15 for mixed oil biodiesel for blending ratios

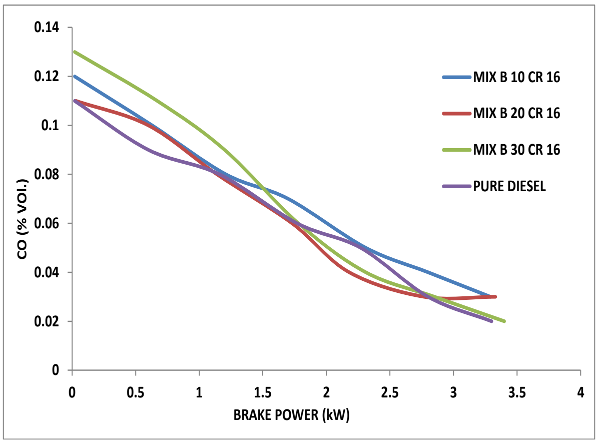

Fig 4.18 (b) BP vs. CO at CR 16 for Mixed oil biodiesel for blending ratios

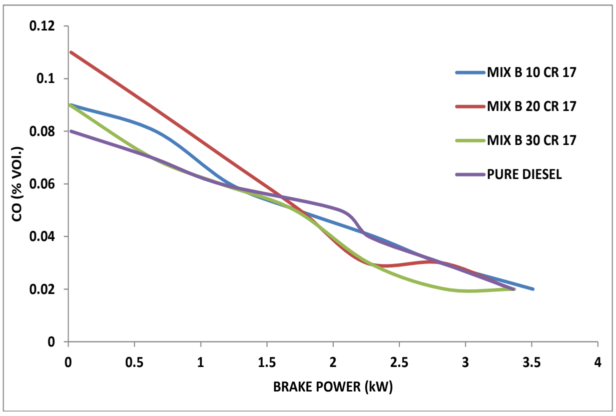

Fig 4.18 (c) BP vs. CO at CR 17 for mixed oil biodiesel for blending ratios

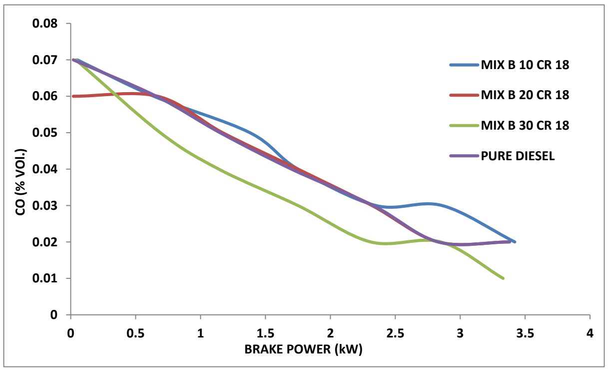

Fig 4.18 (d) BP vs. CO at CR 18 for mixed oil biodiesel for blending ratios

Regarding the engine emission in terms of Carbon dioxide are as follow

Fig 4.19 (a), (b), (c) and (d) show the emission of Carbon dioxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. Emission of CO_2 is increasing with increasing Brake power and after certain value of loading emission of CO_2 decreases. At full load emission rate decreases, in comparison to pure diesel emission of CO_2 is approximately equal. Graph of emission properties is parabolic in nature maximum emission is obtained at CR 18; approx. 15 % emission of CO_2 is less at CR 15 as compared to CR 18.

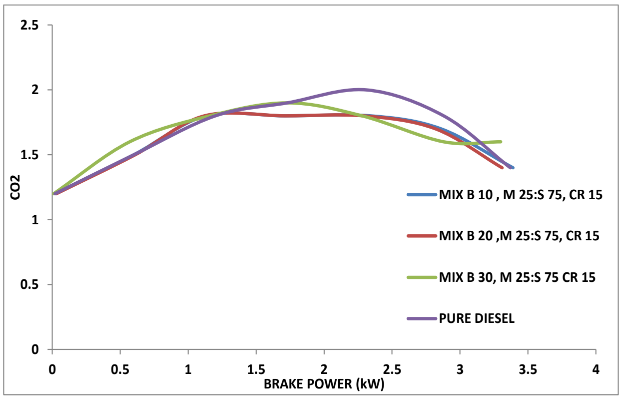

Fig 4.19 (a) BP vs. CO_2 at CR 15 for Mixed oil biodiesel for blending ratios

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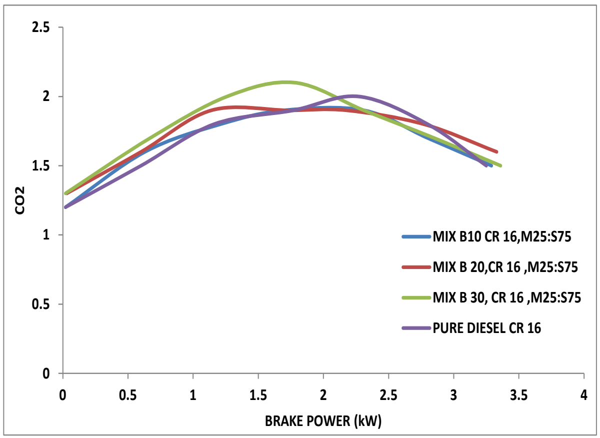

Fig 4.19 (b) BP vs. CO_2 at CR 16 for Mixed oil biodiesel for blending ratios

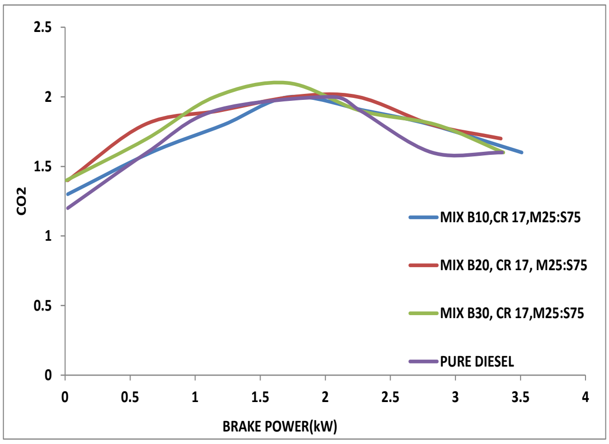

Fig 4.20 (c) BP vs. CO_2 at CR 17 for Mixed oil biodiesel for blending ratios

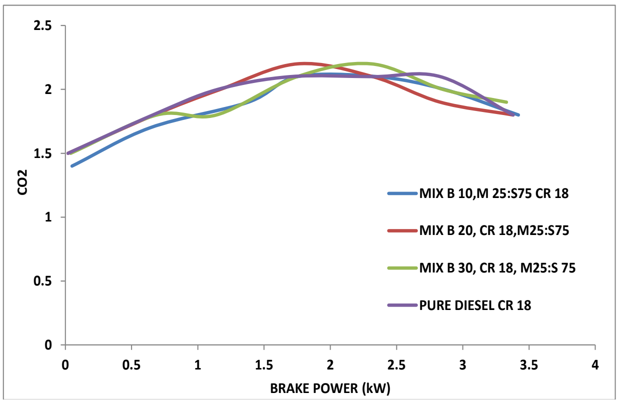

Fig 4.19 (d) BP vs. CO_2 at CR 18 for Mixed oil biodiesel for blending ratios

Regarding the engine emission in terms of NO_x are as follow

Fig 4.20 (a), (b), (c) and (d) show the emission of Nitrous oxide with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. Emission of NO_x as compared to pure diesel is approximately equal at all compression ratios except CR 15. At compression ratio 15 pure diesel has higher emission of NO_x as compared to all three blendings. Maximum emission of NO_x is obtained at CR 18. With increasing load emission of nitrous oxide increases after certain limit it decreases. Emission rate at CR 18 is much higher than CR 15.

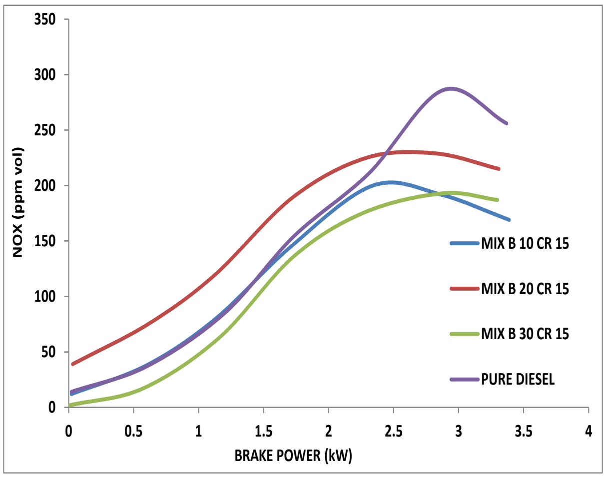

Fig 4.20 (a) BP vs. NO_X at CR 15 for Mixed oil biodiesel for blending ratios

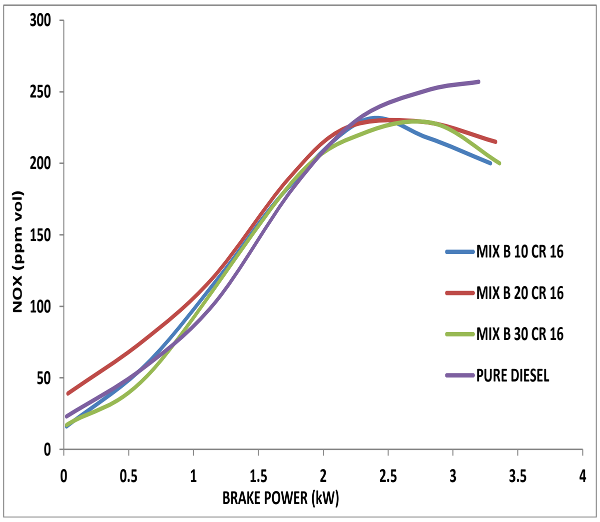

Fig 4.21 (b) BP vs. NO_X at CR 16 for Mixed oil biodiesel for blending ratios

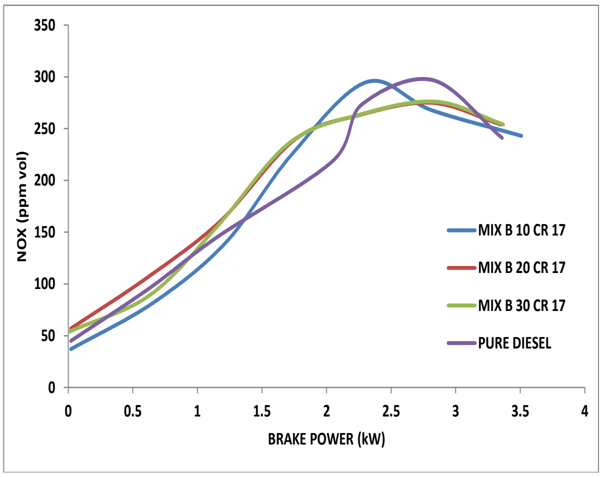

Fig 4.20 (c) BP vs NO_X at CR 17 for Mixed oil biodiesel for blending ratios

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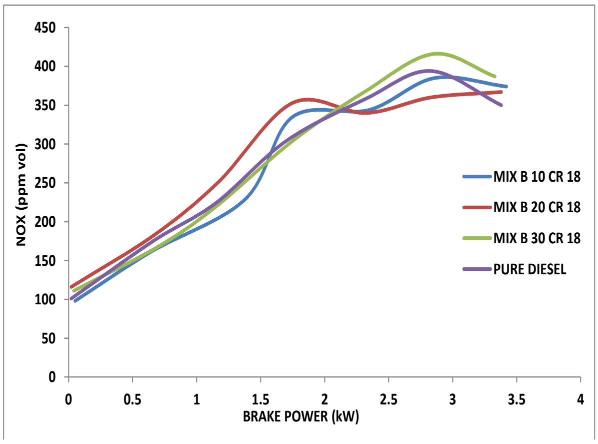

Fig 4.20 (d) BP vs. NO_X at CR 18 for Mixed oil biodiesel for blending ratios

4.3.1.1.7 Regarding the engine emission in terms of Hydrocarbon are as follow

Fig 4.21 (a), (b), (c) and (d) show the emission of unburnt hydrocarbon with respect to corresponding Brake power at CR 15, 16, 17 and 18 respectively. At initial loading HC emission is more and with increasing load unburnt HC emission decreases. Maximum Hydrocarbon emission of Pure diesel is at CR 15. Lowest emission of unburnt hydrocarbon is obtained at CR 18.

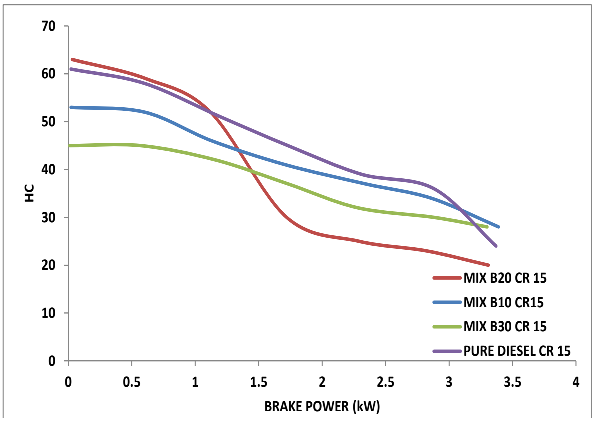

Fig 4.21 (a) BP vs. HC at CR 15 for Mixed oil biodiesel for blending ratios

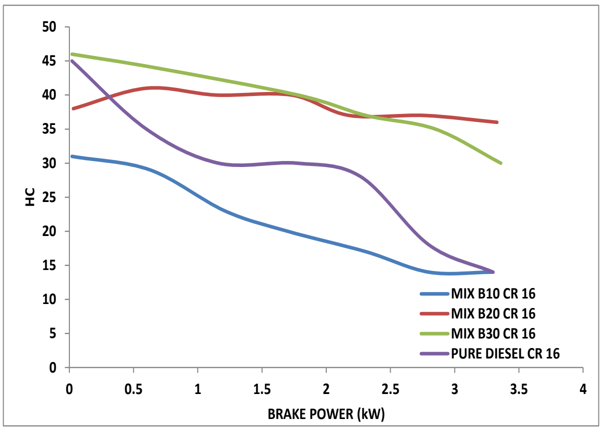

Fig 4.21 (b) BP vs. HC at CR 16 for mixed oil biodiesel for blending ratios

After studying all graph of unburnt hydrocarbon emission it is clear that at all blendings and compression ratio pure diesel has more emission comparable to all. Approx. 44 % emission is less at compression ratio 18 in comparison to compression ratio 15 for pure diesel.

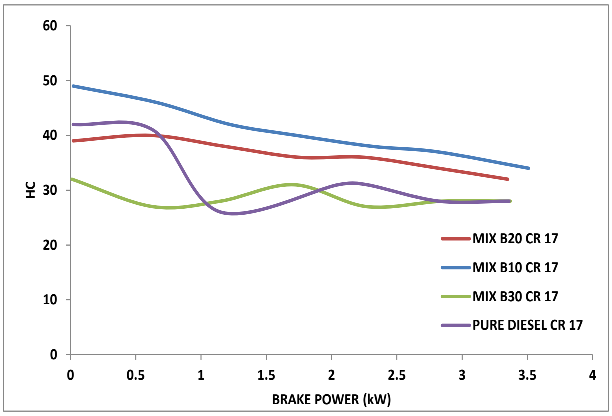

Fig 4.21 (c) BP vs. HC at CR 17 for mixed oil biodiesel for blending ratios

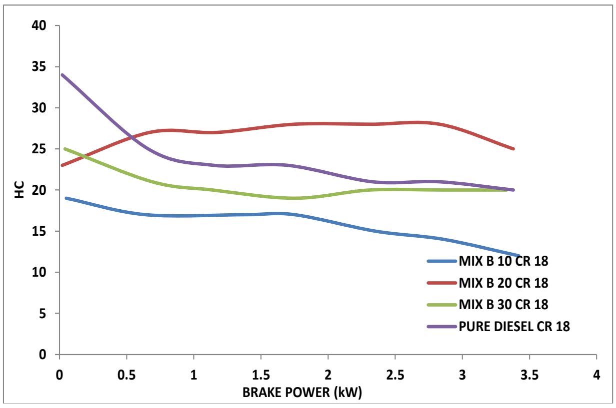

Fig 4.21 (d) BP vs. HC at CR 18 for mixed oil biodiesel for blending ratios

V. CONCLUSION

This conclusion can be categorized in the following manner:

a. Comparison between Mahua oil biodiesel, Sal seed oil biodiesel and Mix oil biodiesel on following parameter are discussed and given below.

b. Performance in terms of BTE, FC and BSFC.

c. Emissions characteristic in terms of CO, unburned HC, NOx and CO2.

Performance Characteristics

Regarding BTE and BSFC results are as follows:

Figure 5.1 shows the comparison between biodiesels, Mahua oil biodiesel, Sal seed oil biodiesel and Mix oil biodiesel. Blends B25 of Sal seed and Mahua oil biodiesel and B30 of Mix oil biodiesel at Compression ratio 18l has been resulted higher efficiency compare to other blend ratio under varying load condition on an average base. In blending ratios B30, Mix oil biodiesel has shown highest BTE as 24.15 % compared to diesel, even so it is higher than diesel 34.57% at full cargo mode. Otherwise Sal seed and Mahua oil biodiesel blends B25 gave 16.60 % and 9 %.

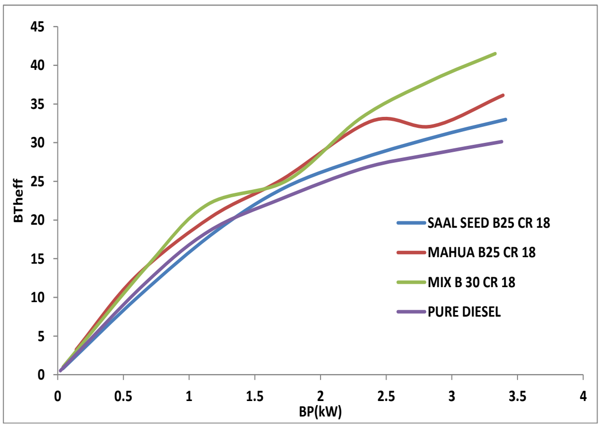

Figure 5.1 BTE Vs BP

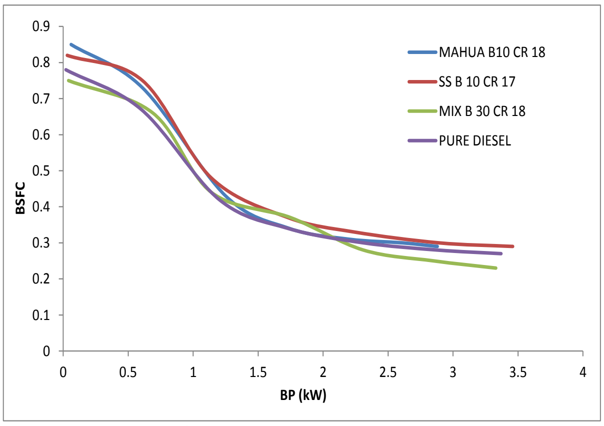

Figure 5.2 BSFC vs. BP

Figure 5.2 shows the results regarding brake specific fuel consumption that have been obtained when the engine was run on blending ratio B30. At this blend, Mahua oil biodiesel has been shown lowest BSFC (0.23 kg/kWh) to their other blends and diesel (0.27 kg/kWh) at full load condition. Whereas, B10 of Mahua and Sal seed oil BD gave 0.29 kg/kWh respectively, and 0.27 kg/kWh BSFC respectively at full cargo mode.

EMISSION CHARACTERISTICS

Regarding CO, unburned HC, NOx and CO2

Figure 5.3 shows the best results regarding CO emission that has been obtained with blending ratios B40 of Mahua and Sal seed and B30 of Mix oil biodiesels at Compression ratio 18. Total five blending ratios were studied to see CO emission for each biodiesel. Not many differences were found to be seen among them, only B40 blending ratios for each biodiesel have been observed better resulted comparative to the other blending ratio, therefore only B40 blend results have been studied in comparing between them. On an average base, blend B40 of Mahua, Sal seed and B30 of Mix oil biodiesel have resulted 0.02 (%V), 0.02 (%V) and 0.01 (%V) respectively, compared to diesel 0.02 (%V) of carbon monoxide.

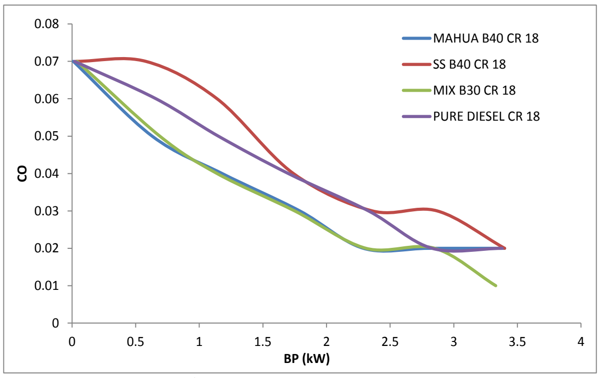

Figure 5.3: CO Vs BP

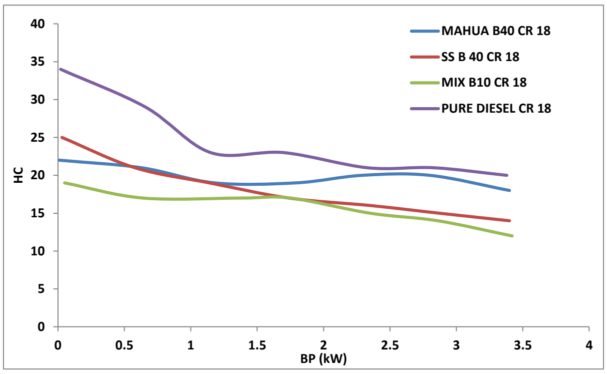

Figure 5.4 HC vs. BP

Figure 5.4 shows the results of unburned hydro carbon that has been obtained when engine was run on blending ratio B10. At this blend, Mix oil biodiesel has been shown lowest HC (12 p.m.) while, other biodiesel has given the approximate same or little higher than diesel (20 p.m.).

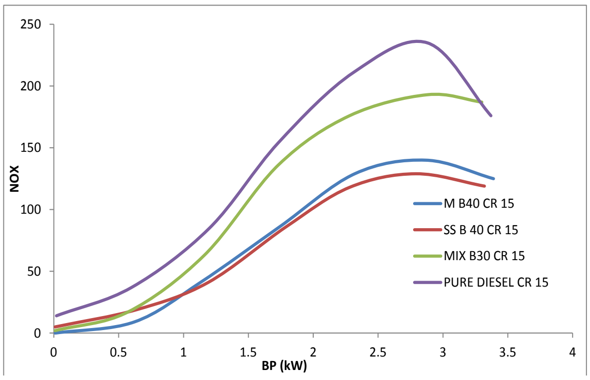

Figure 5.5: BP vs. NOx

Figure 5.5 shows the variation of NOx emission with varying load condition for blending ratios B30 of Mix oil biodiesel and B40 with each of biodiesel (Sal seed and Mahua oil). All oil biodiesel has been shown less value of NOx compare to diesel and other biodiesel in same compression ratio 15. Mahua, Sal seed, Mix oil, biodiesel and diesel have been given 125 ppm, 119 ppm, 187 ppm and 176 ppm of NOx respectively.

Figure 5.6 shows the best results regarding CO_2 emission that has been obtained with blending ratios B10 of Mahua, B40 of Saal seed and B10 of Mix oil biodiesel. Blending

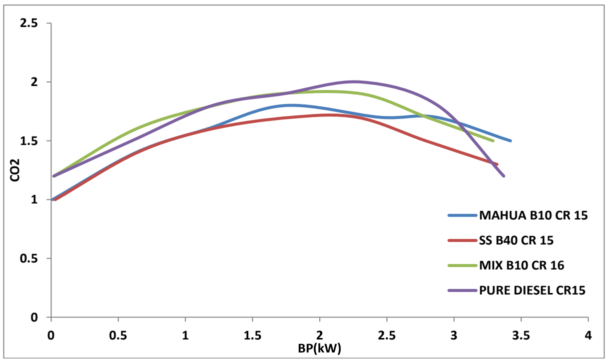

Figure 5.6: CO_2 vs. BP

B40 has been shown lower value of CO_2 that is obtained 1.5 (%V), 1.3 (%V) and 1.5 (%V) of emission with Mahua, Sal seed and Mix oil biodiesel respectively, in comparison of diesel 1.2 (%V).

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