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CHARACTERIZATION OF SMALL CAPACITY CI ENGINE OPERATED ON BLENDS OF FISH OIL METHYL ESTER

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ABSTRACT

Biodiesel (methyl esters of vegetable oils) are popular these days due to their potential as green alternative and low impact on environment. It is the most essential ecofriendly fuel for diesel engines. This fuel doesn't require and significant modification in the existing engine hardware. Trough transesterification process, Fish Oil Methyl Ester (FOME) is derived. Investigations based on experiments have been carried out to examine the performance, properties and emissions of different composites of FOME such as B20, B40, B60, B80 and B100 in comparison to diesel. A four stroke direct injection diesel engine with single cylinder, constant speed, water cooled and 3.75KW power is used as the experimental set up. This type of engine is used in agricultural sector for driving the pumps and small electrical generators. The results obtained shows that brake thermal efficiency is nearly same as that of HSD and also smoke emissions, carbon monoxide and hydrocarbon are reduced. NO_x emissions when fueled with FOME are increased. It is concluded that fish oil biodiesel is comparatively better substitute for CI engines with no modifications.

Keywords—FFA, Methyl Esters, CI engines, Fish oil, Biodiesel and transesterification.

I. INTRODUCTION

Economic growth, human welfare and social development are also dependent on the energy. Energy is the most precarious factor to be considered. Fossil fuels are the major conventional energy source with increasing trend of industrialization and modernization. To meet up demands, majority of the developing countries imports crude oil. This puts up extra burden on countries economy. In order to overcome and control this burgeoning import bill, substitution of petroleum fuels have been explored. India being well developed in fisheries and having vast coastline provides an opportunity for production of alternative fuel which is quite economical. Numerous industries and entrepreneurs use fish oil to manufacture biodiesel at economical cost in comparison with other non-edible oil sources. Fish oil is transesterified which can be used in any biodiesel engine et.al. [1].

Recently, global warming caused by CO_2 has huge impact of environment. To reduce the impact of unwanted emissions, biodiesel made from renewable sources are utilized et al [2]. Most of the research is made using plant based oil as feed stocks. Only a little research is carried by converting animal based oil into biodiesel. As per the estimation over million tons of fish by products are generated by fishing industry. 40% of these by products are transformed to fish meal and oil. The major fish by products include fish head, viscera and frame in which oil is stored. The fish by product can also be converted into hydrology- state using hydrolysis. Hydrolysis involves multiple enzymes and heat treatment to break proteins into smaller peptides. Finally, the hydrolysates product is

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stabilized by acidification and can be used fertilizer or as a feed. Hydrolysates product contains a significant amount of oil, which can be extracted or converted in biodiesel.

From et al it is seen that biodiesel is a fatty acid methyl or ethyl esters from vegetable oils or animal fats. It is renewable, biodegradable and oxygenated product as pointed by many researchers which reduces greenhouse gas emissions, promote sustainable rural development and improve income distribution, yet there exists some resistance for using it. The primary cause is anticipations that it may reduce engine life. Now, let us move on to the experimental procedure described in session II, which justifies that biodiesel is how far better an alternative fuel.

II. EXPERIMENTALPROCEDURES

2.1 Biodiesel Production

The biodiesel is produced by the method of transesterification. Three types of catalysts are permitted to use such as a strong alkali, enzyme and strong acid. A strong alkali catalyst is used due to its dominant advantage such as shorter reaction time and the amount required is also very small.

In due course of test, it is observed that fish oil having high acid number processed in the presence of sulphuric acid catalyzed transesterification, consumed higher amount of acid to decrease the acid number but with the increase in acid catalyst percentage, resulting in darkening of final product. Hence, it is processed through all the three stages. It has been optimized the first stage with oil to methanol volumetric ratio of 30:1 and 0.6% v/v of orthophosphoric acid as reagent with the reaction duration 1.5hr at a temperature of 55˚C , has resulted with the acid number of 10.48 mg KOH/g i.e. 5.24% of FFA. The FFA is more than 2%, the extra FFA is converted in to triglycerides in the second stage which has been optimized with the 0.6% v/v of sulphuric acid, oil to methanol volumetric ratio of 20:1, reaction duration of 1.5 hr. The experiment directed for base catalyzed transesterification shows that the oil to methanol volumetric ratio of 12:1 and 0.6% w/v of KOH is found to give the maximum conversion of 97.2% at 60˚C with the reaction duration of 2hr et al [9]. [3] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller.This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased.

2.2 Fuel Properties

Crude fish oil is brought from Mangalore, Karnataka, India, filtered to remove the impurities and then transesterified by the above said method. The fish oil methyl ester has no suspended matter but has an undesirable smell atypical to fish oil. The color is light yellow and transparent. The physical characteristics of fish oil methyl ester are nearer to that of diesel oil. The fuel properties are tested in Bangalore Test House Bangalore, India. Optimized results for biodiesel production from the oils are shown in Table 2.1.

Table 2.1 Properties of Biodiesel

Properties	Diesel	Fish oil biodiesel
Density (kg/m^3)	850	875
Specific gravity	0.850	0.875
Kinematic viscosity at 40^{0}C (Cst)	3.05	4.0
Calorific value (KJ/kg)	42800	41325
Flash point (^{0}C)	56	175
Fire point (^{0}C)	63	188
Oxygen content (%)	Nil	10.8

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2.3 Experimental Setup

The experiment was carried out at Reva Institute of Technology and Management, Bengaluru, India. Four stroke, water cooled, single cylinder, direct injection diesel engine was used to run the set up. Table 2.2 shows the engine specifications. Constant speed of 1500rpm and 210 bar injection pressure is maintained. Fish oil biodiesel and its blends such as B20, B40, B60, B80 and B100 are used at various loads. The performance parameters such as BTE, BSFC, EGT, BSEC and emission characteristics like CO, CO_2, HC and NO_2 are evaluated. The results were compared with diesel performance shown in Table 2.2 and figure 2.3.

Table 2.2 Engine Specifications

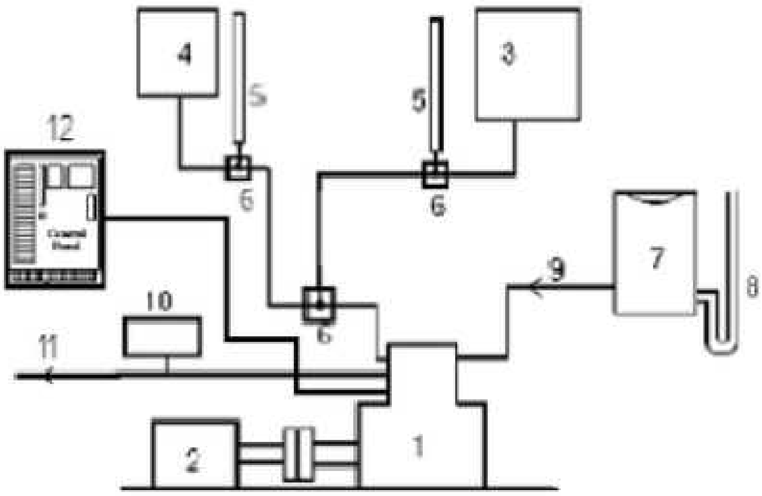

Figure 2.3: Schematic Layout of Experimental Setup.

1) Engine
2) Dynamometer
3) Diesel Tank
4) Fuel Tank (Bio-diesel)
5) Burettes
6) Three way valve
7) Exhaust Analyzer
8) Air Box
9) Manometer
10) Air flow direction
11) Exhaust flow
12) Control Panel

III.RESULTS AND DISCUSSIONS

3.1 Fuel properties

The color is transparent and light yellow. Various properties of fish biodiesel are determined in shown in table 2.1. It is inferred that the characteristics of biodiesel chosen is closed to mineral diesel. Hence, biodiesel becomes a strong replacement unit against mineral diesel if need arises. Also Table 2.1 summarizes the result of fuel tests of FOME.

Model	Kirloskar – AV1 Diesel Engine
Engine Type Water Cooled , Vertical	Direct Injection, Single cylinder,
Bore/Stroke	80mm/110mm
Compression Ratio	16.5:1
Total Displacement Volume	0.553L
Specific Fuel consumption	245 g/KW-hr.
Speed	1500 rpm

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3.2 Performance analysis

3.2.1 Brake Specific Energy Consumption (BSEC)

The variation in BSEC is shown in figure 3.2.1 Specific energy consumption is an ideal variable because it is independent of the fuel. Hence, one can compare energy consumption rather than fuel consumption. It is required to develop unit power. As load increases, the BSEC for FOME is nearer to diesel. At maximum load BSEC and FOME is approximately same as that of diesel. It is because of combined effect of both calorific density and value of FOME.

3.2.2 Brake specific fuel consumption (BSFC)

Figure 3.2.2 shows the variation in BSFC with load for different fuels. In general, BSFC was found to increase as the proportion of B100 was increased in the fuel blends, when compared with HSD. In case of HSD it decreases sharply with increase in load. BSFC is calculated on weight basis and it is observed that as density of B100 is 4% higher than that of HSD. From this it is concluded that consumption of same fuel on volume basis resulted in 4% higher BSFC in case of B100. For same volume, the higher densities of biodiesel mixtures cause higher mass injection, maintainingsame injection pressure. The heat content of B100 is lesser than HSD by 12%. Because of this reasons, the other blends are higher than that of HSD. Similar leanings of BSFC are also reported by other researches [2, 4 and 10] when testing biodiesels from karanja and rubber seed oils.

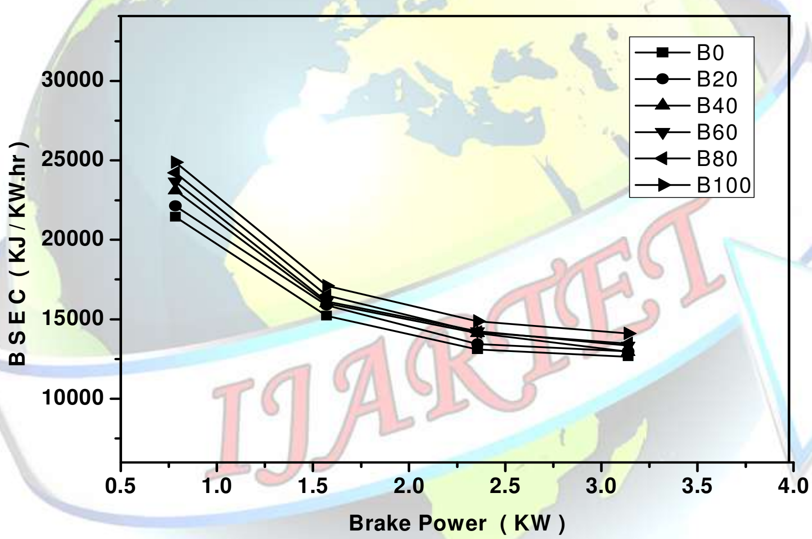

Fig.3.2.1 Comparison of BSEC with BP for diesel, FOME and its blends

3.2.3. Exhaust Gas Temperature (EGT)

Commonly, the EGT increases with increase in engine loading for all fuel tested. The reading of EGT w.r.t. engine loading is obtained as shown in figure 3.2.3. It is observed the exhaust gas temperature increases with load. This is because more amount of fuel is burnt to meet the power requirements. It is also seen ETG increases with percentage of FOME in test fuels for all loads. The reason for such results is due to the O_2 content of FOME (enhances combustion). Similar results are shown by Jatropha Curcus et al [13].

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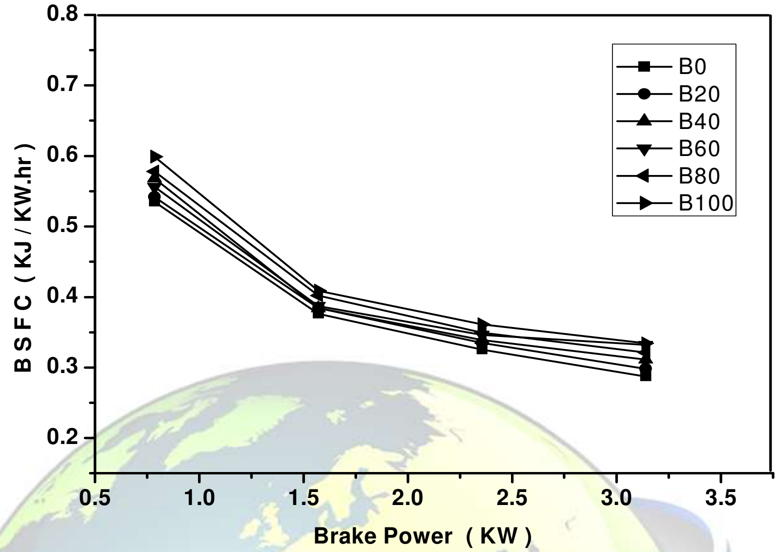

Figure 3.2.2 Comparison of BSFC with BP for diesel, FOME and its blends

3.2.4. Brake Thermal Efficiency (BTE)

BTE indicates the ability of the combustion system to accept the experimental fuel and gives the analytical means for effective utilization of the energy of fuel into mechanical output. From figure 3.2.4 activity it is observed that heat loss is reduced and power is increased with increment in load. BTE for biodiesel blends such as B40, B60, B80 and B100 are less as that for diesel. In comparison with B20, the above said BTE obtained for blends could be due to reduction in calorific value and increased fuel consumption. Similar results are obtained by researchers at [10].

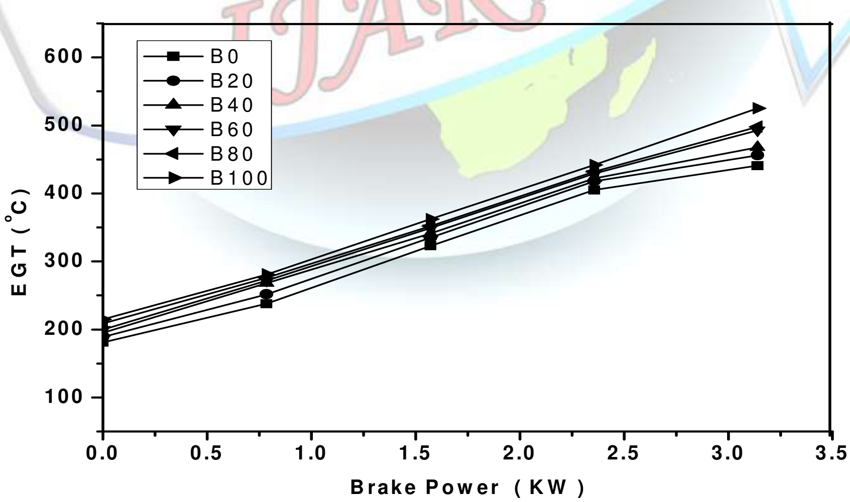

Figure 3.2.3: Comparison of EGT with BP for diesel, FOME and its blends

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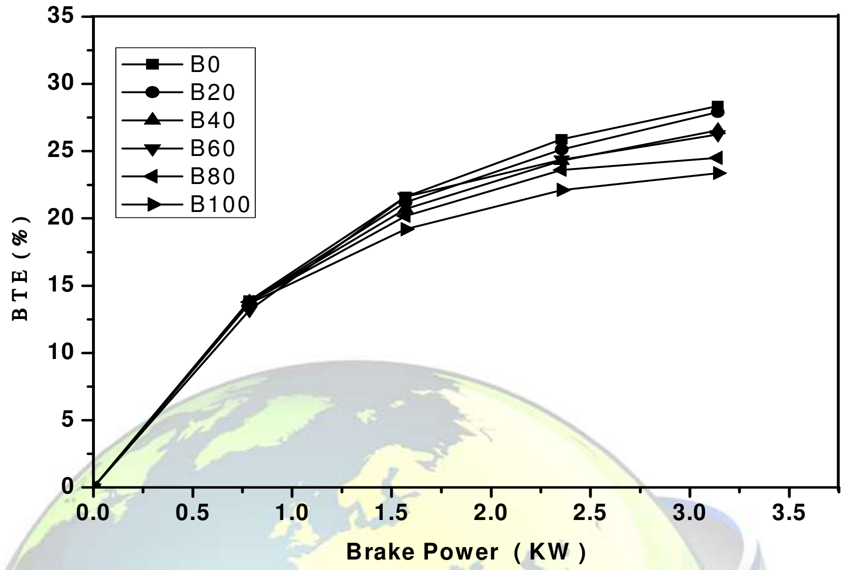

Figure 3.2.4: Comparison of BTE with BP for diesel, FOME and its blends

3.3 Emission analysis

3.3.1. Carbon Monoxide (CO)

The variations in CO are shown in figure 3.3.1. It is noted as follows, for petro diesel and blends of FOME, CO emission initially decreases with increase in load. Later at some minimum value it starts to increase. This behavior can be explained by the fact that at lower output, engine gets lean mixture and at higher output, rich mixture is supplied to the engine that results in incomplete combustion and therefore, higher % of CO. Further point to be noted is that for low power output, CO emission is less with petro diesel as compared to the blends of FOME.

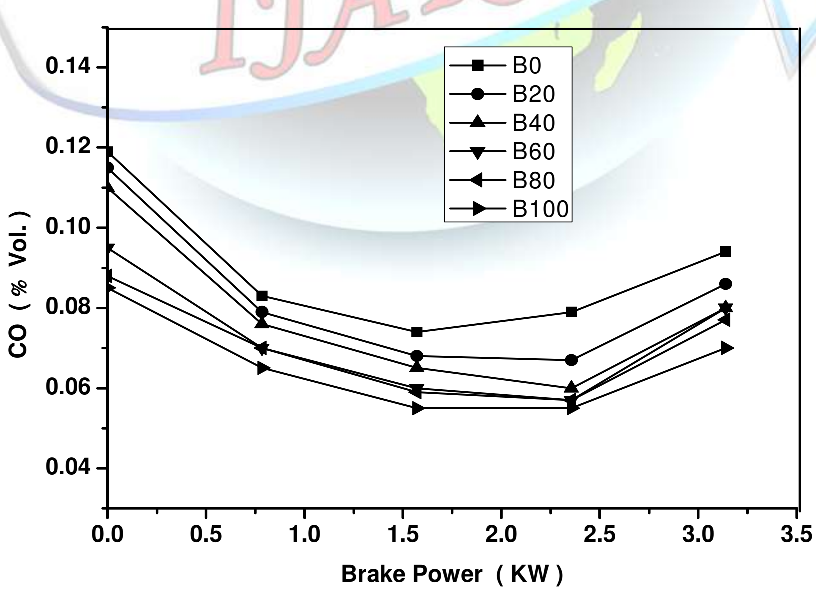

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Figure 3.3.1: Comparison of CO with BP for diesel, FOME and its blend

3.3.2 Hydrocarbons (HC)

Figure 3.3.2reveals a significant decrease in the HC emission level with mixtures of FOME Reduction from 75 ppm to 49 ppm at the maximum power output is observed. These reductions indicate that more complete combustion of the fuels thus decreases HC level significantly. Reduced HC is linear with the addition of biodiesel for the combination. Similar results were obtained by the researchers for mahua biodiesel [10, 14].

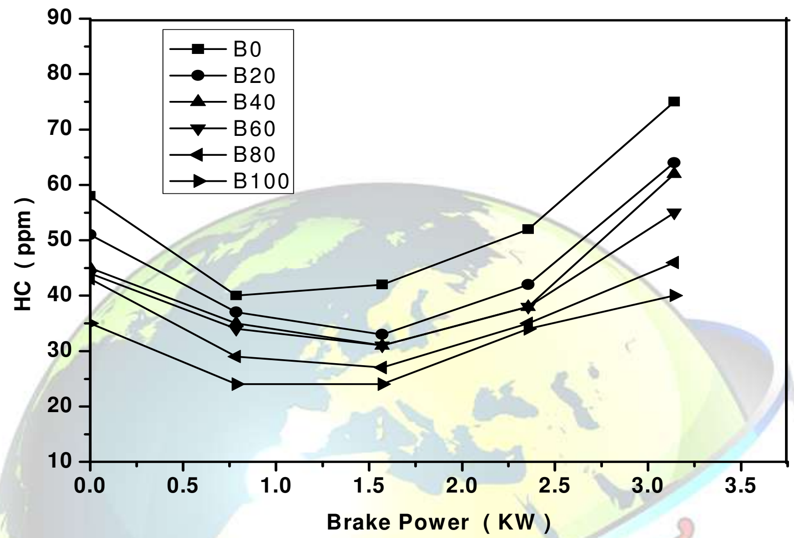

Figure 3.3.2: Comparison of HC with BP for diesel, FOME and its blends

3.3.3 Oxides of Nitrogen (NO_X)

The comparative results of NO_X with BP diesel, FOME and its blends are shown in figure 3.3.3. The NOx emission is strongly related to lean fuel with higher temperature or high peak combustion temperature. A fuel with high heat release rate at premix or rapid combustion phase and lower heat release rate at mixing the controlled combustion phase will produce NOx emission. NOx emission increases with increase in load for diesel, biodiesel. From figure 3.7it can be seen that the increasing proportion of biodiesel in the blends was found to increase NOx emissions, when compared with that of pure diesel. This can be attributed to the increased exhaust gas temperatures and the fact that biodiesel had some oxygen content in it which facilitated NOx formation.

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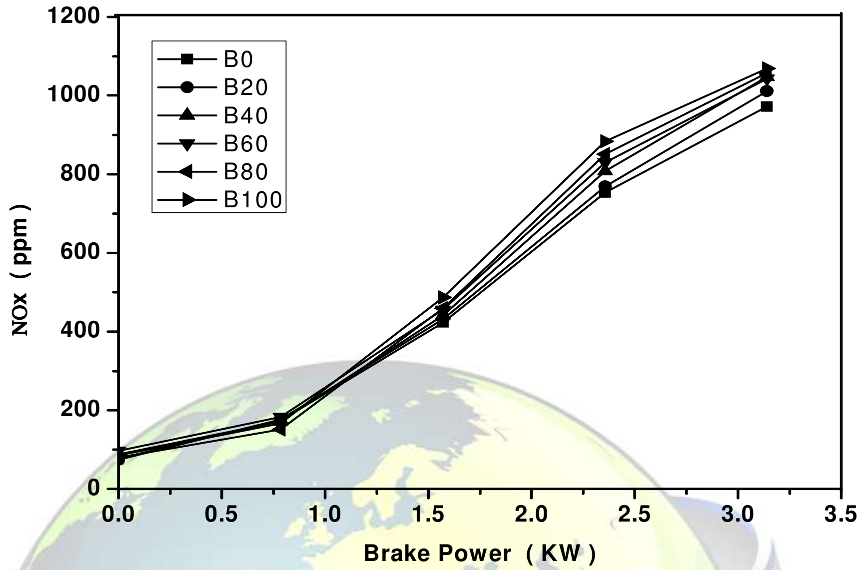

Figure 3.3.3: Comparison of NO_X with BP diesel, FOME and its blends

3.3.4 Carbon dioxide (CO_2)

The carbon dioxide emission from the diesel engine with different blends is shown in figure 3.3.4. The CO_2 is increased with increase in load conditions for diesel and for biodiesel blended fuels. The CO_2 emissions for B20 and B100 are higher than diesel. Mixture such as B40 produces very low emissions compared to diesel, for blend such as B20, B60, B80 and B100 is 1.6 and for diesel it is 2.3 and it is low by 30.4% compared to diesel. This is due to the fact that biodiesel is a low carbon fuel and has lower elemental carbon to hydrogen ratio than diesel fuel.

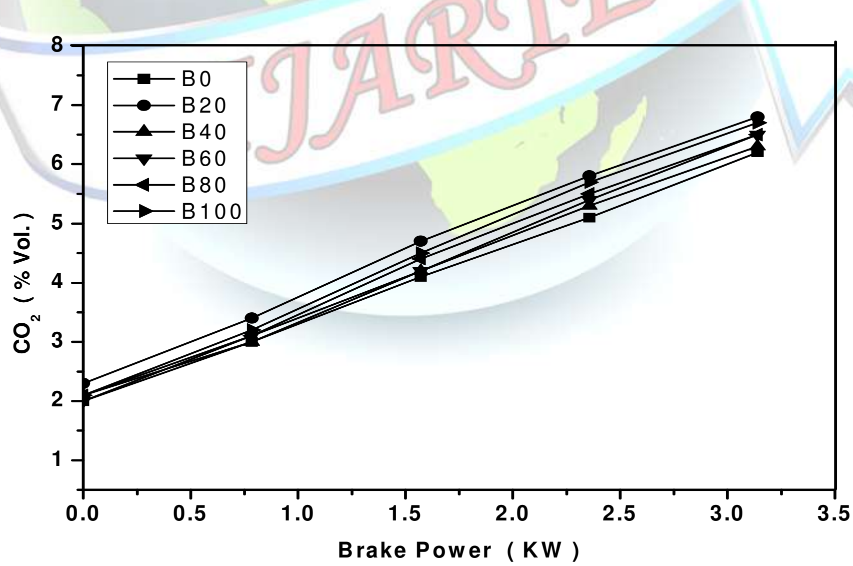

Figure 3.3.4: Comparison of CO_2 with BP for diesel, FOME and its blends

IV. CONCLUSIONS

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The following conclusions are drawn from results obtained:

1. In case of fuel properties and exhaust emission characteristics, fish biodiesel are regarded as an alternative to diesel fuel.
2. BSFC for blends is higher than the diesel. The blends B80 and B100 have shown higher BSFC.
3. The maximum thermal efficiency for B20 (27.89%) which is close to diesel. The BTE obtained for B40, B60, B80 and B100 are less than diesel.
4. The exhaust temperature increase as a function of the concentration of biodiesel blends i.e. higher the percentage of FOME.
5. Increase in the exhaust temperature of a biodiesel-fueled engine led to increase in NOx emissions for B100. This is because of higher temperatures and presence of oxygen molecules present in biodiesel.
6. The reduction in CO and HC is linear with the addition of biodiesel for the blends tested. These reductions in CO and HC indicate the complete combustion of the fuel.

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