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Comparative Study of Performance And Emission Characteristics For Different Diesel Blends

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Abstract - Most modern searches are directed to alternative fuels because the buffer stock from the petroleum oils reduces with time and the fossil fuels are worst impact on environmental pollution. Now days, there are many sources of renewable energy. Biodiesel is just one source, but a very important one. This work was focused to study the performance and emissions of combine blends of Jome 20, Sfome 20, Sbome, Jome 10 + butonal 10, Sfome 10 + butonal 10 and Sbome 10 + butonal 10 with conventional single cylinder diesel engine. The work scope included fundamental experimental studies on brake thermal efficiency and emission studies of diesel and their biodiesel blends. From the results, it is observed that at 100% load the brake thermal efficiency of the biodiesel with butonal blends are more compare to other test fuels. In the subsequent section, the engine emissions from test fuels and diesel are compared, paying special attention to the methonal and butanol test fuels, reasons behind prominent emissions such as $N0_X$, HC, CO_2, CO and smoke are comprehensively discussed.

Keywords— Jatropha, Sunflower, soybean, methyl ester, butonal Performance, Emissions, diesel engine.

1.INTRODUCTION

Energy is essential and major input for commercial growth of a country. Demand of energy is rising continuously due to increasing population and industrialization. The most widely utilized form of energy is fossil fuel. Among different source of primary energy, fossil fuel alone provides 80% of the total. Due to continuously increasing consumption and demand, fossil fuel reserves are diminishing day by day. According to the World Energy Forum prediction, reserves of fossil fuels will exhaust in less than another ten decades [1]. Excessive uses of fossil fuels, increasing crude oil price and environmental degradation are some worldwide concern that forced scientist to search and develop for sustainable, environment friendly and cost-effective alternative substitute renewable fuel. Solar, wind, biomass, and hydro-power are some renewable energy sources which have shown more potential as alternative sources of clean energy. In current scenario, biofuels are being proposed to replace fossil fuels [2-4]. Bio-fuel such as ethanol and biodiesel are getting more attention now days. Ethanol is produced from sugarcane, corn and sorghum, and can be used alternative to gasoline. Biodiesel fuels are produced from plant like camelina, jatropha, coconut, fish oil, karanja, rapeseed, soyabean, sunflower, sesame, rice bran, waste cooking oil, algae etc. Indian transportation system is unique in world and uses about five times more diesel fuel as compare to gasoline (petrol) while almost every country in the world use more amount of gasoline.So, in India, finding alternatives of diesel have special importance and using biodiesel have comparatively much more importance for us than any other countries [5]. Biodiesel is clean, renewable and sustainable biofuel which can be used as a fuel in diesel engines with minor or without modifications [6]. Furthermore, biodiesel can be blended with diesel in any proportion. It can be observed from literature that utilization of biodiesel with diesel in engines leads to lower smoke, HC emissions, CO, CO_2, but higher nitrogen oxides (NO_x) emission keeping engine efficiency unaffected or improved [6-13].

Various studies have been carried out to analysis combustion, performance and emission diesel-biodiesel blends. Muralidharan and Govindarajan (2011) run C.I engine with Karanja biodiesel and reported that blend B5 resulted in lower emissions at higher load [14].

Srivastava and Verma (2008) experimented on a two cylinder Kirloskar diesel engine fueled with diesel and karanja biodiesel blends. They found that engine performe better with with blends of diesel and karanja biodiesel in the comparison to pure diesel [15].Sahoo et al analyzed the comparative performance of a tractor diesel engine using Jatropha, Polanga and Karanja biodiesel and found that 20 % blend of jatropha gives better results than other biodiesel [16]. Vashist and Ahmad worked on short term performance and emission using jatropha castor biodiesel (5%, 10%, 15% and 20% biodiesel. They reported that engine perform with 13% and 18% more thermal efficiency in castor and jatropha biodiesel respectively than mineral diesel [17].Gopinath et al. (2014) run diesel engine on four types of fuel blends (100% D, 90% D+10% COME, 80% D+20% COME, 70% D+30% COME and 60% D+40% COME) to analysis emissions from engines. They found that 80% D(diesel)+20% COME (Corn oil Methyl Ester) is the optimum blend for engine emission as well as performance of the engine [18]. Kaimal et al (2015) studied the combustion and emission performance of Cotton biodiesel. They used different blends of biodiesel i.e. B10, B20, B30 and compared with diesel fuel performance. They concluded that B20 blend gives better combustion and performance with improved emissions than diesel [19].

Subramaniam et al.(2013) run engine on Punnai, Neem, Waste Cooking biodiesel and their diesel blends to analysisperformance, emission, and combustion characteristics. They found that B30 blends are more suitable for diesel engine in context of performance, combustion, and emissions [20-25].

Most of the earlier engine performance and emission studies are conducted with single type of biodiesel blend i.e. blending of only one type of biodiesel with diesel, however combine blend of two or more biodiesel with diesel and butanol are getting more attention in the present time due to improve fuel properties, the biodiesel economics and increasing fuel performance [26-32]. Habibullah et al. conducted experiment on unmodified direct injection diesel engine using 20% of palm and coconut (D80PB5CB15, D80PB10CB10 and D80PB15CB5) biodiesel and 30% palm, coconut and palm-coconut (D70PB15CB15) biodiesel blends .They found that engine shows better performance and reduced emission with combined blends of palm and coconut biodiesel [25]. Ruhu et al tested C. megalocarpus (CM) biodiesel, C. pentandra (CP) biodiesel and their combined blends (D80CM20, D80CP20, D80CM15CP05, D80CM10CP10, and D80CM05CP15) in a single-cylinder, four stroke diesel engine under varying speed ranging from1000 rpm to 2400 rpm at full load condition. They found that combine bled of CM and CP with diesel give better performance than individual biodiesel diesel blends [32-39]. However, very few studies were carried out on performance and emission of two or more combined biodiesel blends of jatropha, sunflower and soybean biodiesel with diesel and butanol. This paper aims to study the production of bio-diesel from jatropha, sunflower and soybean biodiesel making combined blends with conventional diesel and butanol (JOME 20, SFOME 20, SBOME 20, JOME 10+ But 10, SFOME 10+ But 10 SBOME 10+ But 10), studying their physico-chemical properties and testing on IC engine for performance and emissions characteristics. The blend which has least emissions and good performance will be taken into consideration.

2. MATERIAL AND METHODOLOGY

2.1 Biodiesel Production

Biodiesel was produced in a lab scale biodiesel reactor which made of a reaction flask (glass material), heating mantle, and an electric motor driven mechanical stirrer. Reaction flask had 2 litters of working capacity. A three neck reaction flask was used: one neck fitted with condenser, second as inlet of reactor and third was coupled with thermocouple for temperature observation. To collect the final product, a stop-cock was also provided at the bottom of the flask. Biodiesel was produced from jatropha, sunflower and soybean oil by 'acid–base' transesterification; acid-pre-treatment followed by main base-transesterification reaction [10-13]. During acid pre-treatment H_2SO_4 wasused as acid catalyst and methanol as reagent to reduce FFA less than 1% for both oils. After reduction of FFA, transesterification was performed in presence of KOH (as base catalyst) for 3 hour. Then, biodiesel was washed with warm water (55^oC) to remove impurities and glycerol. Moisture was removed from purified biodiesel using silica gel as moisture absorbent. Then purified biodiesel was filtered via whatmann 40 filter paper and biodiesel was used to make blends with diesel.

2.2Experimental set up

In this experiment, a four-stroke, single cylinder, water cooled, direct injection, 3.7 KW diesel engine was used. Specifications of the engine are mentioned in Table-1 and the schematic diagram of set-up is shown in Figure 1. An eddy current dynamometer was used in the experiments with digital data acquisition systems. Emission and performance characteristics were performed at different loads (0, 2, 4, 6, 8, and 10 Kg load) for each blends. Smoke opacity was measured by Smoke meter (AVL model 437C). Exhaust gas analyser (Model-AVL Di-gas

444) was used for analysis of emission gases i.e. CO, CO_2, NOx, and HC.

Table 1: Specifications of Engine

Make	**Kirloskar TV- 1 Engine**
Type	**Single cylinder, vertical, water cooled, 4-Stroke diesel engine**
Bore × Stroke	**87.5 mm × 110 mm**
Compression ratio	**17.5:1**
Fuel	**Diesel**
Rated brake power	**5.2 kW (7HP)**
speed	**1500 rpm**
Ignition system	**Compression Ignition**
Ignition timing	**23° BTDC (rated)**
Injection Pressure	**220 kgf/cm^2**
Loading Device	**Eddy current dynamometer**
Orifice Diameter	**0.02 m**
Dynamometer arm length	**0.195 m**

Fig.1 SCHEMATIC DIAGRAM OF SET-UP WITH SMOKE METER

3. RESULTS AND DISCUSSION

3.1 Performance Analysis

3.1.2 Brake Thermal Efficiency and Fuel consumption

Figure 2 shows brake thermal efficiencies of the engine at different loads for test the fuels. It was noticed that for all the test fuels brake thermal efficiency has the tendency to increase with increase in the applied load due to the more fuel consumption and reduction in heat loss causes high thermal energy is released and hence power is increased. In case of jome 10+ butanol 10, Sfome 10+ butanol 10 and Sbome 10+ butanol 10 break thermal efficiency was higher at higher loads while for other blends Jome 20, Sfome 20, BTE was lower than diesel for all loads. Maximum BTE was observed 37.78 % at 10 kg load which was 2.63% higher than diesel fuel. It was also found that BTE increased with increasing biodiesel concentration with methonal at higher loads which is due to oxygenated characteristics of biodiesel blends, and advancement of the diffusive combustion phase due to oxygen enrichment (23). Due to these reasons, the energy consumption rate of blends falls. This resulted in an increased brake thermal efficiency. On the other hand, the injection and combustion durations was found to be increased (24).Habibullah also examined the impact of combined blend of jome 10+ butanol 10 on engine performance and found that engine perform better on combine blends than individual jome 10 and Sfome 20 biodiesel blends (25).

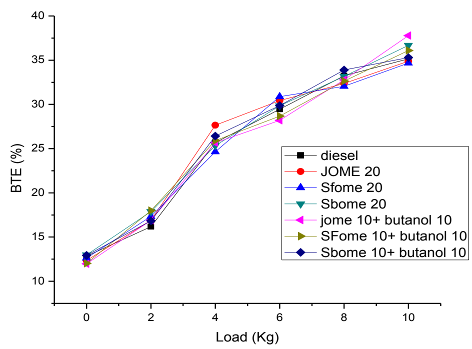

Fig 2.EFFECT OF LOAD ON BTE OF ENGINE

The BSFC is decreased with the increasing load for all blends. Furthermore, BSFC was decreased as concentration of biodiesel was increased in fuel blends. A close at the graph for test fuels indicates that more amount of fuel is consumed for jome 10+ butanol 10 and sbome 20 blends respectively this is because diesel has more calorific value as compared to that of test fuels. Therefore jome 10+ butanol 10 and sbome 20 are the recommended fuel blend when all the blends are compared with respect to brake specific fuel consumption against load over the entire range of operation. At higher loads brake specific fuel consumption more for JOME 20 compare to diesel fuel due to diesel has more calorific value as compared to that of JOME 20. The brake specific fuel consumption more due to lower calorific value of biofuels. Increasing consumption of biodiesel and their blends are due to decreasing energy value of the fuel blends. It was observed due to higher cetane number of biodiesel as well as injection timing changes may be the another reason for the rise in BSFC similar trend was obtained by Ozener et.al 2015.

3.2 Emission Analysis

3.2.1Carbon monoxide emissions

Figure 3 explains the trend of carbon mono oxide with varying loads for the test fuels. It was observed that carbon mono oxide emission was reduced for SFome 10+ butanol 10, at higher loads compare to diesel, Jome 20, Sfome 20, Sbome 20, jome 10+ butanol 10 and Sbome 10+ butanol 10. The maximum CO emissions are observed in diesel due to less oxygen content in diesel compare to biodieseland their blends. However, CO emission was found slightly more for Jome 20, Sfome 20, Sbome 20, jome 10+ butanol 10 and Sbome 10+ butanol 10. The reseon behind the lower CO emissions may be that biodiesel blends rich in oxygen content, which helps in more clean combustion of fuel at high temperature in the cylinder [23]. Furthermore, it is also noticed that emissions of CO gradually increased with the increasing concentration of biodiesel with the diesel. With increasing biodiesel concentration in fuel blends, viscosity increased which results in less homogeneous mixtures and lead to incomplete combustion [27]. Increase in ignition delay may be another reason for rising of CO emissions [33].

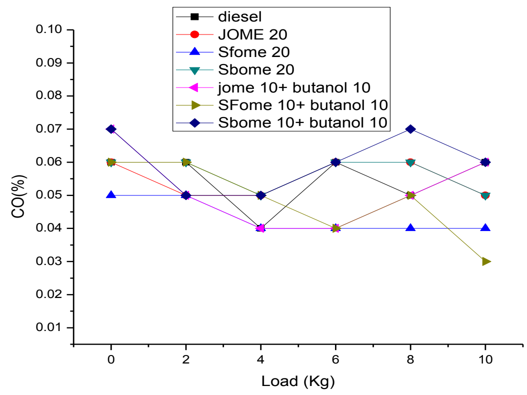

Fig 3. EFFECT OF LOAD ON CO EMMİSSİON

3.2.2 Carbon dioxide Analysis

The trend of carbon dioxide for biodiesel blends at different loads was shown in Figure 4. The results showed that carbon dioxide emission was increased with increasing load. However, at higher loads, carbon dioxide emissions were higher for all bio fuel blends with methyl ester and butanol than diesel i.e. 1.7%, 3.23%, 3.4%, 3.9%, 3.74%, 5.1% and 5.27% for diesel, jome 20, Sfome 20, Sbome 20, jome 10+ butanol 10, SFome 10+ butanol 10 and Sbome10+ butanol 10. respectively. This can be explained by the fact that Biodiesel led to more complete combustion and hence maximum amount of CO was transformed into CO_2 [32]. İt was also analysed that carbon dioxide emission was also increased as concentration of biodiesel was found more in fuel blends. However, it is asumed that CO_2emited by combustion of biodiesel was re-utilized by plants, trees and crops via photosynthesis process [3].

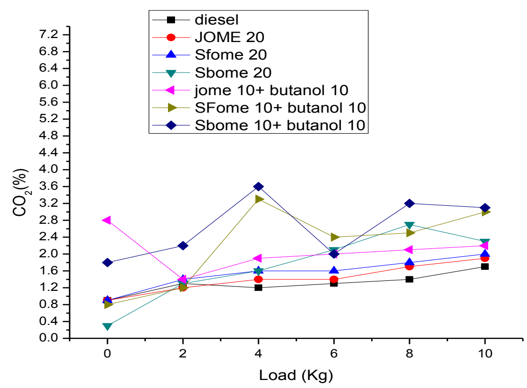

Fig 4.EFFECT OF LOAD ON CARBON DİOXİDE EMMİSSİONS

3.2.3 Hydrocarbon emission

Figure 5 shows the effect of analysed fuel on the unburned hydrocarbon (HC) emission variation with engine loads. Unburnt hydrocarbon (HC) emissions were found to be increased at higher load, while HC improved with increasing percentage of biodiesel with methyl ester and butonal in fuel blends. It was also observed that HC emission was decreased for the test fuels compared to diesel. It was also observed that HC emission was decreased from 4% to 9 % for Jome 20, 3% to 12 % less for Sfome 20, 3% to 17% less for Sbome 20, 7% for Jome 10+butonal 10 at higher loads, 0 to 6% for Sfome 10+butonal 10 and 2% for Sbome 10+butonal 10 at higher load. This decrease in hydrocarbon emissions may be because of higher cetane number and increased gas temperature. Higher cetane number leads to the decrease in combustion delay which results in lower HC emissions [33]. However, HC emission was found to increase from 5% to 7% for engine fueld with Jome10+butonal 10 and Sbome 10+butonal 10 at lower load . This is due to increase viscosity of fuel blends which lead to poor atomisation and incomplete combustion and resulted in higher HC emissions [23-33].

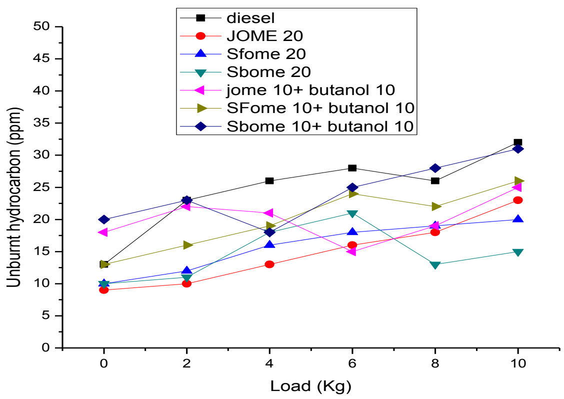

Fig 5. EFFECT OF LOAD ON HYDROCARBON EMMISSIONS

3.2.4 NOx emission

The NOx emissions of diesel, biofuels with methyl ester and butonal fuels are plotted in graph is shown in Figure 6. It shows for all the fuels and fuel blends, the increased engine load promoting NOx emissions. Results also revealed that with higher loads Jome 20 has lower NOx emissions 315 ppm compare to diesel and other test fuels. This was mainly due to lower exhaust temperature [33]. Another important observation was NOx emissions for Sfome 20 and Jome 10+butonal 10 were 106 ppm and 156 ppm lower than diesel at 100% load respectively. These lower emissions of NOx may be due to lower temperatures in combustion chamber. It was also analysed that with Sfome 10+butonal 10 andSbome 10+butonal 10 increasing concentration of butonal to Sfme and Sbome, NOx again found more in comparison to fuel blends containing more butonal in biodiesel.

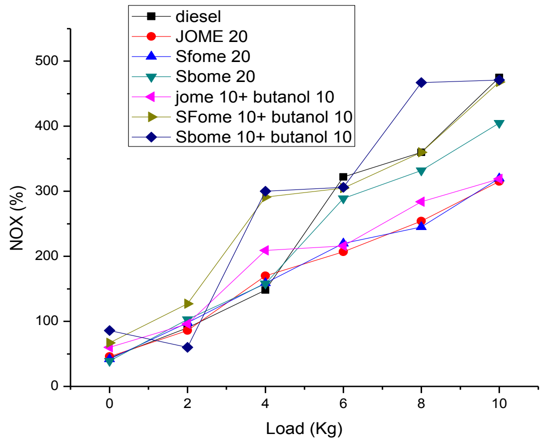

Fig 6. EFFECT OF LOAD ON NOX EMISSIONS

3.2.5 Smoke Opacity

The effect of test fuels and their blends in reference to smoke opacity at different loads is shown in Figure 7. It was observed that Smoke opacity was increased with increasing load. It was also found that the smoke opacity of Jome 10+ butanol 10 blends was significantly reduced than neat diesel. Moreover, biodiesel blends containing butonal showed less smoke opacity. Average reduction in smoke opacity compare to diesel for Jome 10+ butanol 10, Sfome 10+butonal 10 andSbome 10+butonal 10 was found to be 9.03 % , 5.36% and 2.09% and respectively. This may be because of improved combustion due to presence of higher oxygen content in fuel blends [23]. However Jome 20, Sfome 20 and Sbome 20 blends leads to increase in smoke opacity and showed 3.3%, 3.o8% and 6.02% % higher smoke opacity than neat diesel respectively. This may be due to incomplete combustion of the fuel blends and partial reaction of the carbon content in the liquid fuel due to poor atomization (due to higher density, viscosity and flash point) [23].

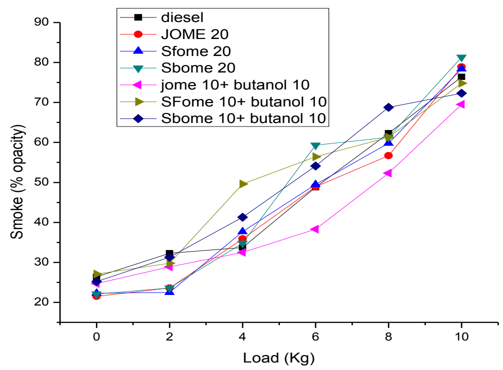

Fig 7. EFFECT OF LOAD ON SMOKE EMISSIONS

4.CONCLUSION

In this manuscript, butonal was blended together with the test fuels in different proportion to make 10% butonal blends. Physico-chemical properties of all the test fuels were examined. In addition, performance and emission tests using these blends were also carried out on single cylinder diesel engine. From the above experimental observations, following conclusion can be withdrawn.

1. Jome 10+ butanol 10, SFome 10+ butanol 10, Sbome 10+ butanol 10 and Sbome 20 test fuels produces the more Brake thermal efficiency of 6.96%, .60%, 4.24% and 4.17% respectively compared to diesel at higher load. JOME 20 and Sfome 20 low brake thermal efficiency of 0.739% 1.36% respectively compared to diesl test fuel.
2. Jome 10+ butanol 10, Sbome 20 test fuels produces low specific fuel consumption of 3.94%, 2.63% respectively compared to diesel at higher load. SFome 20, Jome 20, SFome 10+ butanol 10, Sbome 10+ butanol 10 butanol has higher brake specific fuel consumption of 3.2%, 3.21%, 0.127% and 1.67% respectively compared to diesel test fuel.
3. SFome 10+ butanol 10 fuel has high level of carbon dioxide compared to all other test fuels owing to its more oxgen content.
4. Sbome 20 has very low level of unburnt hydrocarbons compared to all other test fuels due to low specific fuel consumption of 2.63% and brake thermal efficiency more compared to diesel.
5. Oxides of nitrogen are more in Sbome 10+ butanol 10 has more specific fuel consumption of 1.67% compared to diesel. Hence cylinder temperature is high while combustion this leads to more oxides of nitrogen compared to remaining test fuels
6. Smoke content is more in Sbome 20 fuel compared to
all other test fuels due to its viscosity.

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