Comparison of Performance and Emissions Characteristics of Mustard oil and Jatropha multi blended Bio-diesel with the Base Streak Diesel

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ABSTRACT
Globally petro diesel prices increasing rapidly in covid-19 season also. Extracting biodiesel oil from root vegetable oils has one of the great opportunity to use as fuel in internal combustion engines. Past three or four decades researchers concentrated on single biodiesel and its blend with diesel as alternate fuel for internal combustion engines. There is lot of research need to be conduct on bio dual fuels. The current research focusing on to run the diesel engine with the mixture of two biodiesels and diesel blends as a test fuel. The performance and exhaust gas emissions of the diesel, jatropha and mustard biodiesel fuel blends studied conducting the experiments in a single cylinder, direct injection, water-cooled with constant engine speed of 1500 rpm. All the observations of dual biodiesel blends recorded and compared with the diesel fuel. The test fuels emissions carbon monoxide (CO), carbon dioxide (CO_2); nitrogen oxide and smoke opacity were nearer values to the diesel fuel. The brake thermal efficiency (BTE) is higher in MJD-1 (Mustard oil 5%, Jatropha biodiesel 5% and Diesel 90%) compare to all other test fuels and less 1.6% of diesel fuel at higher brake power (BP) rates. At higher levels of BP the specific fuel consumption (SFC) maximum for MJD-5 (Mustard oil 40%, Jatropha biodiesel 40% and Diesel 90%) test fuel it is 25.58% more compared to normal diesel. MJD – 1, MJD -2 (Mustard oil 10%, Jatropha biodiesel 10% and Diesel 80%) and MJD – 3 (Mustard oil 20%, Jatropha biodiesel 20% and Diesel 60%) test fuels formed low carbon dioxide emissions compared to diesel fuel 50%, 40.38%and 36.8% respectively . MJD -5-multi blend - test fuel released high carbon monoxide gases compared to diesel of 133.3%. Blend MJD -1 smoke opacity equal to diesel fuel. Blend MJD -2 smoke opacity nearer to the diesel fuel. MJD – 1 and MJD – 2 would be used in diesel engines an alternative fuel for diesel without modifications.

Keywords: Performance, emissions, diesel engine, mustered oil, jatropha and diesel multi blended biodiesel.

1. INTRODUCTION

The consumption rate of fossil fuels drastically increasing year on year, the petro-diesel fuels utilized for basic human requirements, industry, transportation growth and agriculture. The global energy requirements will increase to nearly 40% by 2030 as the results reveled by British petroleum. This energy demand will create global pollution problems like Ozone depletion, environment changes, desertification and finally global warming. Hence, the need of identifying clean fuels and their importance increases worldwide. The availability of these fuels is limited reservoirs and run down progressively. Hence, ultimatum of energy levels to be fulfil by using alternative fuels. Biodiesel identified by researchers is giving new clean energy to the globe. One of the best fuel of alternative fuels is biodiesel [1-3]. It is superlative available source to accomplish the energy demand levels. Biodiesels produced from vegetable oils which consisting of fatty acids. It has higher flash and fire points and low Sulphur content compare to diesel fuel.

Research is vigorously conducting by researchers with different biodiesels on diesel-petro engines. With minor changes or without changes of internal combustion engines can run by these biodiesel fuels. All the researchers' analysis commonly emphasis on specific fuel consumption, thermal, mechanical efficiencies and emission characteristics for petro-diesel engines run with biodiesel fuels and assessment to conventional petro-diesel engines [4-7]. While selecting the biodiesel as the alternate fuel for internal combustion engines, it is greatly needed to maintain the factors that mark combustion phenomenon which will in turn undeviating outcome on performance of the engine and exhaust gases. Several researchers experimentally explained the methods to improve thermal efficiency and reduction of exhaust gas emissions. Day by day, the demand of fuel economy increase drastically due to the depletion of fossil fuels [8-10]. P.

Suresh kumar and N. Prasanthi kumari conducted the tests jatropha biodiesel and diesel as a fuel. This analysis concludes that the brake thermal efficiency, specific fuel consumption and low exhaust emissions occurs at 15% jatropha and 85% diesel as fuel. Hence, the above-mentioned blend is best compared to other fuel blends. K. A. B. Subramanian [6] et.al performed the investigations with jatropha and Neem oil as biofuels at constant speed of 1500 rpm by varying the loads for the diesel engine. Throughout the test, it is observed that the diesel engine is running with finest by these biodiesel blended fuels. The investigational consequences proved that dual biodiesel of jatropah and Neem test fuels had almost same performance level but emissions increased slightly compared with neat diesel fuel operations. Wang et.al [11-14] results proved that the vegetable oil fuels carries the same calorific value as that of petro-diesel fuels. The brake power out - put and specific fuel consumption of nonedible test fuels and its blends are similar with the petro-diesel as a fuel for the engine. Ghaly et. al [2010] testified that the need of alternate fuels increased drastically due to depletion of fossil fuels like petrol, diesel and gas fuels and bestows with very low grade exhaust discharges, bio - degradability and re utilize of energy sources. M. Dharan et. al [15-18] Using transestirification procedure developed a non-edible biodiesel fuel which is pongamaia pinnata. This test fuel used to run the diesel engine with different blends on that B5 gives good results compared to other test fuel blends. This B5 test fuel at full load discharges low carbon monoxide, oxides of nitrogen and unburnt hydrocarbons compared to diesel and other test fuel blends. Y. Lurat [19-21] conducted the experiments on four stroke naturally aspirated water - cooled diesel engine with the test fuels of mustered biofuel-butanol-diesel and yellow mustered biofuel -diesel n-petanol and comparative analysis completed. He reported the results the brake specific fuel consumption increase with increasing the alcohol percentage and with the same rate brake power and engine torque also decreased. Smoke opacity and oxides of nitrogen reducing when compared to diesel fuel. Their conclusion states that n- pentanol blended fuels have higher performance and low emissions rate compared to I-butanol blends. P. Suresh and N. Prasanthi kumari [22-24] examined that the using emission reduction techniques like exhaust gas recirculation and selective catalytic method and states exhaust gas recirculation suitable for low load engines. Increase of specific fuel consumption the efficiency also varies. The selective catalytic method is suitable for high load engines and there is no effect on engine efficiency while varying the specific fuel consumption. P. Suresh kumar et .al [25] performed the experiments on IDI diesel engine with the testing fuels of combination of jatropha biodiesel and diesel fuel. The results states that with the exhaust gas recirculation oxides of nitrogen emissions reduced from 10 to 24% with the different mass flow rates and Particulate matter , carbon monoxide and soot emission increases slightly higher side. Kumar et. al [26] presented their results that using of higher alcohols in diesel, biodiesel and their blends, it gives higher efficiency and lower the exhaust emissions while compared to the normal diesel fuel. Li et. al [27] results proved that pentonol 30% added to the diesel, biodiesl blends for a single cylinder diesel engine runs at the 1600 rpm constant speed gives higher in efficiency, low emission results and better combustion properties. Hence, this combination provides the economically feasible fuel for diesel engines compared to other test fuels. Zhang et. al [28-30] the diesel engine is operated different loads with the blended test fuels like n-pentanol and n-butanol with the biodiesel. They established the results that polycyclic aromatic hydrocarbons decreasing in the order. Imdadul et. al [31-32] reported in his team investigations to increase the cetane number for biodiesel fuels better to add the cetane improver. Generally, alcohol have lower ceatne numbers due to that specific fuel consumption and oxides of nitrogen more. While adding cetane improvers to alcohol blended fuels, it reduces the brake specific fuel consumption and oxides of nitrogen but increase the unburnt hydrocarbons and carbon monoxide levels. Lawrence et.al [33] showed that thermal efficiency and brake power increased but decreasing of specific fuel consumption while selecting the test fuel with the combination of prickly poppy methyl ester mixed with the diesel fuel. Rakopoulos et. al [34] explained by their experimental set of results there is notable reduction of carbon monoxide and oxides of nitrogen compared to diesel fuel exhaust emissions. Here they used blended test fuel with diesel. The blending test fuel contains diethyl ether, ethanol and butanol of different volume ratios. Hosoz [35] experimented with the isobutanol diesel blends and stated that reduction in carbon monoxide and oxides of nitrogen emissions reduced emissions but hydrocarbon emissions increases when the team run the engine at variable speed range1200 to 2800 rpm. Forsen et. al experimented with the jatropha biodiesel and states that for diesel engines jtropha biodiesel supernumerary of diesel fuel. It gives the almost same results without major changes of diesel engine. D. Raj et. al proved that low percentage of biofuel blends gives good results that means higher brake thermal efficiency and reduced exhaust gas emissions. Result of this team said lower biofuel blends have reduced specific fuel consumption also [36-37]. Based on duel fuel blends much more research scope in future. Recent research studies mustered oil using as biodiesel fuel which gives the increasing the brake thermal efficiency and reduces the engine emissions. Hence jatropha and mustered oil biodiesel selected as test fuel for this present study. For the current analysis the combination of mustered oil, jatropha and diesel fuel mixed biodiesel test fuels are preparing in the first stge. Then comparative analysis with the diesel fuel [38]. The best blend fuel and diesel fuel further passing through the three-way catalytic converter to analyze the exhaust emissions. Atmanli et al proved from their results of the multi fuel blends, specific fuel consumption increased for brake thermal efficiency and brake power decreased compared to the diesel. In the point of exhaust analysis, for multi blend fuels increasing trend of nitric oxide and carbon monoxide emissions and decreasing hydrocarbon and carbon dioxide emissions as compared to diesel [39]. Authors reported that engine efficiency and emissions of B100, B20 and DRSOnB (diesel rapeseed oilen-butanol) increased BSFC an average of 25.02%, 30.16% and 34.81%. B20, B100 and DRSOnB increased NO_x emissions as 4.55%, 16.78% and 44.25%. HC emission test results showed that the effectiveness of test fuels was ordered as DRSOnB > B100 > B20 [40]. The authors results states that the exhaust temperature, carbon monoxide, carbon dioxide, nitric oxide and smoke density of test fuel comparison with the diesel fuel less [41-42].

2. PREPARATION OF MATERIALS

Mustered oil, jatropha and diesel established as test fuels for the current analysis. Table 1 shows the properties resembling the fuel density, kinematic viscosity, flash point and calorific values of the Mustered oil, jatropha and diesel fuel blends. The experimental investigation conducted the following dual fuel diesel and biodiesel blends and prepared on volume basis as below.

MJD -1 (Mustard oil 5%, Jatropha biodiesel 5% and Diesel 90%),
MJD - 2 (Mustard oil 10%, Jatropha biodiesel 10% and Diesel 80%),
MJD - 3 (Mustard oil 20%, Jatropha biodiesel 20% and Diesel 60%),
MJD - 4 (Mustard oil 30%, Jatropha biodiesel 30% and Diesel 40%),
MJD - 5 (Mustard oil 40%, Jatropha biodiesel 40% and Diesel 90%)
and D100 (Diesel fuel 100%).

Table 1. Properties of the test fuels (by Hanna et. al[13])

Properties / Fuel samples	Fuel density Kg/m^3	Kinematic viscosity @40^{0}C cSt	Flash point ^{0}C	Calorific value Kj/kg
Diesel	833	3.1	54	45786
MJD_1	839	3.7	59	39857
MJD_2	843	4.6	66	37693
MJD_3	849	5.1	73	36684
MJD_4	861	5.9	91	35723
MJD_5	869	6.7	164	33989
ASTM standards	Hydrometer	Water bath viscometer	Pensky-Marten's	Bomb calorimeter

3. EXPERIMENTAL TEST BED SET UP

Figure 1 shows photograph of the experimental setup and figure 2 shows the schematic diagram of the test bed. Stationary four - stroke single cylinder water cooled diesel engine used for conduct the experiments. The specifications as shown in table 2. Mustared, jatropha based dual biofuel has the following fuel properties shown in table1. The properties are fuel density, kinematic viscosity, flash point and calorific value. ASTM D90 standard test procedure used for finding flash point of bio test fuels. ASTM D445 regular test procedure method used for calculating the kinematic viscosity of bio test fuel. Calorific value indicates the energy potential involve in the fuel. ASTM 2382 normal test procedure technique has been applied to calculate the calorific value of the bio test fuel. For fuel, density is determined by using laboratory hydrometer equivalent to ASTM D1500. Experiments established at different loads and at constant speed of 1500 rpm for above-mentioned biodiesel test fuels. At each load three times conducted the test fuel experiments for exactness purpose. Specific fuel consumption (SFC) and temperatures noted from the different sections of the engine inlet and exhaust outlets. Exhaust gases were analyze by using five -gas analyzer. Smoke opacity measured by smoke meter. The details of the smoke meter and five- exhaust gas analyzer as shown in schematic diagram.

Table 2. Specifications of test engine

Items	Specifications
Brand	Field marshal Diesel engines
Rated Brake Power (BHP/kW)	10/7.35110
Rated speed (rpm)	1500
Type	Single cylinder
Bore x Stroke	120 mm x139.7 mm
Compression ratio	18:1
Type of cooling	Water Cooling
Type of Lubrication	Forced Feed lubrication
CC	1580 cc
Injection Pressure	145 kg/cm^2
SFC	265 gm /kWhr OR 195 gm / bhp /hr

Figure 1 Investigational test bed

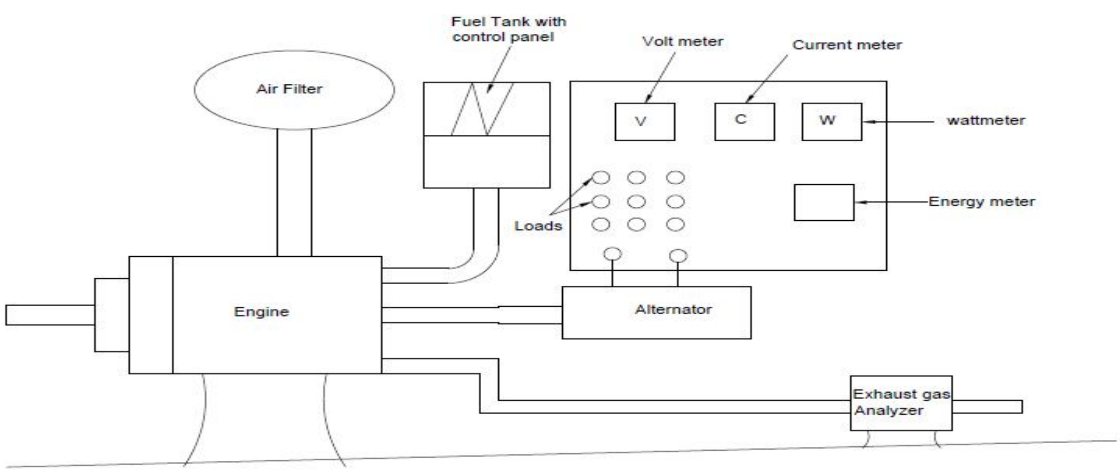

Figure 2. Investigational lay out

4. RESULTS AND DISCUSSION

The test fuel results discussed in current section. The investigate results made on engine performance and exhaust gas. The diesel engine functioned at constant speed of 1500 rpm, the results attained are noted and compared with the pure diesel fuel.

4.1. Brake thermal efficiency

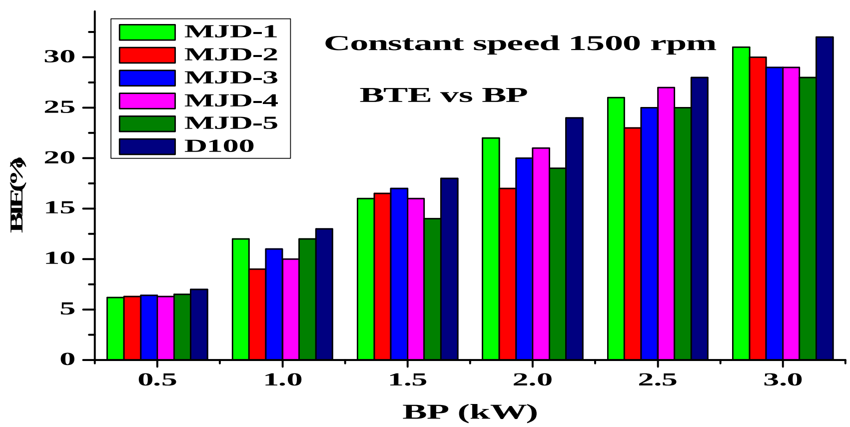

Figure 3. Brake power Vs Brake thermal efficiency

The figure3. indicates that brake thermal efficiency higher at higher levels of brake power and brake thermal efficiency increases lower level to higher level of brake power for diesel and as well as biodiesel of multi – blended of test fuels. The reason behind that at higher loads more fuel burned with the availability of oxygen. Hence, brake thermal efficiency increases with increasing the brake power. Diesel fuel has higher brake thermal efficiency compared to multi - blend biodiesel fuel. The reason may be multi – blend biodiesel test fuel have low heating value, higher density and higher viscosity than diesel fuel. Fuel vaporization and atomization fuel depends on the viscosity and density factors. If the viscosity and density more, then the heat developed in the combustion is low. Further, brake thermal efficiency low for multi – blend biodiesel test fuel compare to diesel fuel. Other than diesel fuel MJD -1 has higher brake thermal efficiency compared to all other multi – blended of test fuels.

4.2 Specific fuel consumption

The specific fuel consumption more in multi – blend biodiesel test fuel compare to diesel fuel. This can clearly identified from above figure. 4 which is drawn brake power against to specific fuel consumption. Specific fuel consumption increases with decreasing brake power. The multi – blend biodiesel test fuel have higher densities compared to diesel test fuel, Hence multi – blend biodiesel test fuel have higher rate of specific fuel consumption. MJD – 5, test fuel has higher viscosity compared to all other test fuels due to this it effects the vaporization and atomization rate and decreasing pattern of brake thermal efficiency as shown in figure 3.

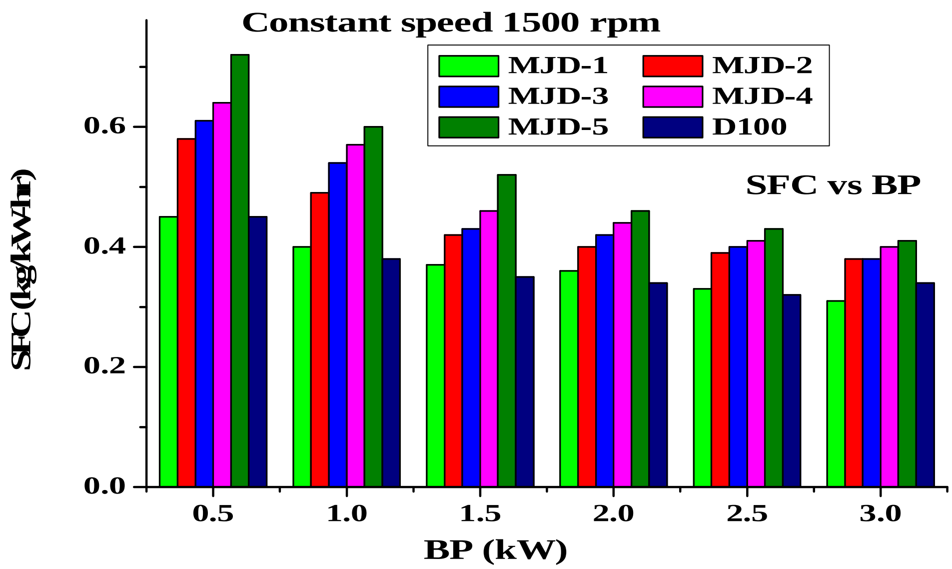

Figure 4. Brake power Vs Specific fuel consumption

4.3 Carbon monoxide emission

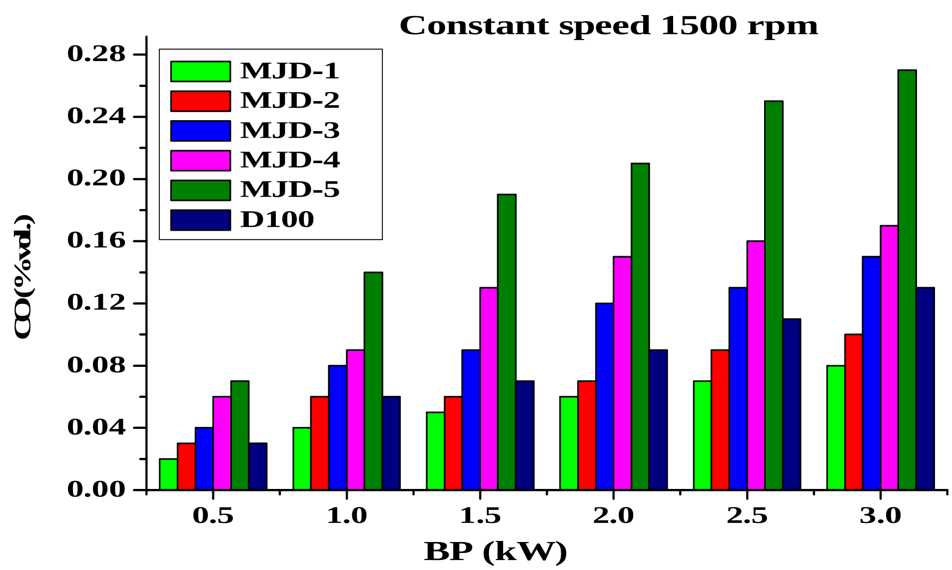

Figure 5. Brake power Vs CO emission

Figure 5. Indicates that the variation of carbon monoxide on brake power. MJD-1 and MJD-2 test fuels have lower carbon monoxide values compared to all other test fuels including diesel fuel also. The percentage of oxygen content more in biodiesels due to these reasons complete combustion takes place the above test fuels compared to all other test

fuels. MJD-3, MJD-4 and MJD-5 have higher the carbon monoxide percentage compared to diesel fuel because of higher the viscosity values. Higher the viscosity lower the atomization and vaporization of test fuels hence, carbon monoxide more for the above mentioned test fuels.

4. 4 Carbondioxide emission

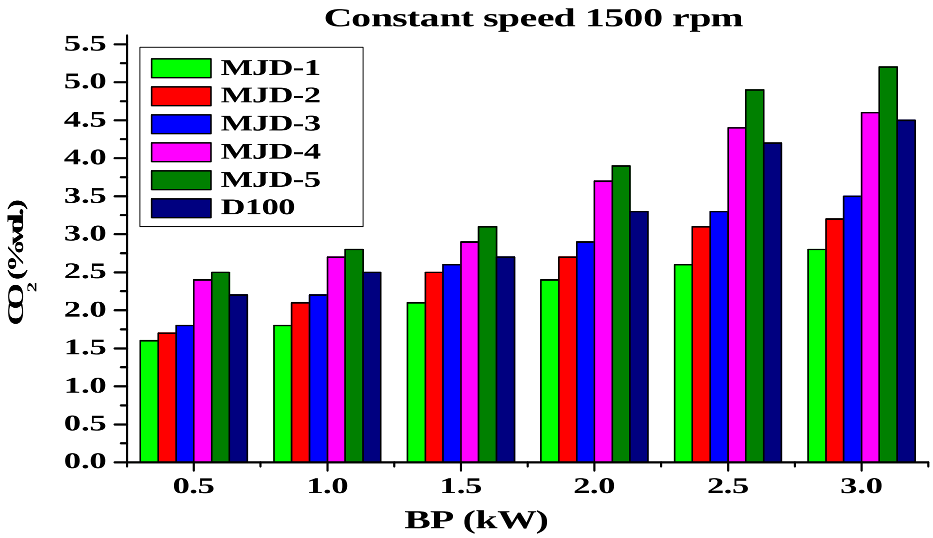

Figure 6. Brake power Vs CO_2 emission

Figure 6 shows the Carbon dioxide emission variation on brake power. MJD-1, MJD-2 and MJD-3 have lower Carbon dioxide emission compared to all other test fuels. The availability of oxygen more for the above-mentioned test fuels, hence complete combustion takes place. Richer air-fuel mixture supplied at higher loads hence, carbon dioxide more for MJD-4 and MJD-5 test fuels compared to diesel fuels. Due to high viscosity of MJD-4 and MJD-5 fuels, atomization and vaporization effect the combustion process. Hence more carbon monoxide and carbon dioxide values for MJD-4 and MJD-5 fuels compared to diesel fuel.

4. 5 Nitrogen oxide emission

It is clear that from the figure 7. The Nitrogen oxides emission more for multi – blend biodiesel test fuels compared to diesel fuel. Here the multi – blend biodiesel test fuels comes under vegetable oil based biofuels it contains some amount of nitrogen with in it. This nitrogen content helps to increase the nitrogen oxides emission in the multi – blend biodiesel test fuels. As well as oxygen content also high in the test fuels, it contributes to perfect combustion and leads to higher temperatures in the combustion chamber to form more nitrogen oxides emission [24]. While increase the blend percentage of these biofuels leads to increase the nitrogen oxides emission. Hence, for the multi – blend biodiesel test fuels have higher percentage of nitrogen oxides emission compared to diesel fuels.

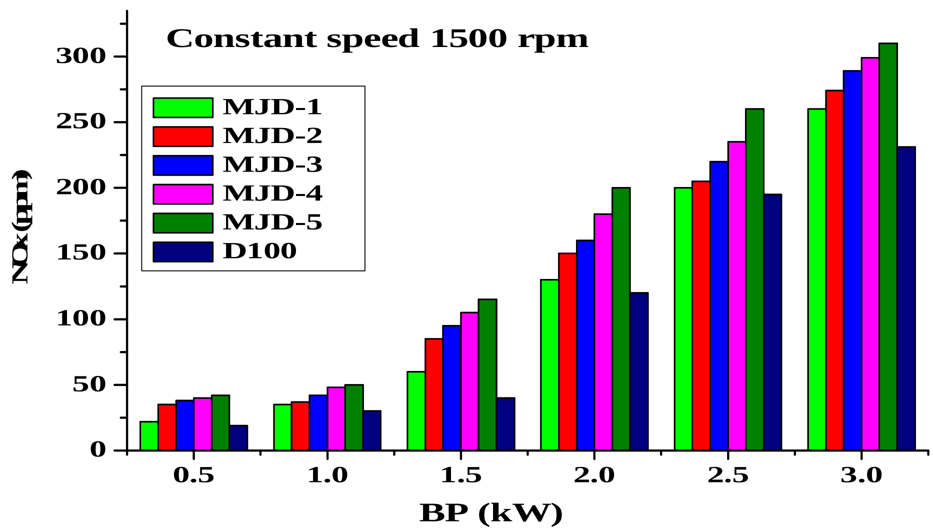

Figure 7. Brake power Vs Nitrogen oxide emission

4. 6 Hydrocarbon emission

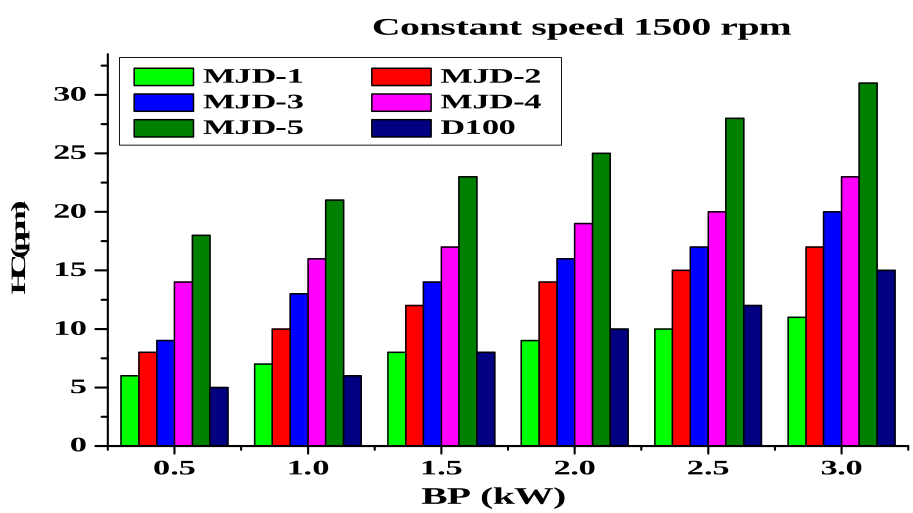

Figure 8. Brake power Vs Hydro carbon emission

Figure 8. Explained that with increasing the load hydrocarbon emissions increasing gradually for all the test fuels. MJD – 1 gives low hydrocarbon emissions compared to all test fuels because oxygen availability more in this test fuel compared to all other test fuels. More amount of fuel supplying at higher brake power rates, hence the deficiency of oxygen occurs at higher loads. Other test fuels have higher hydrocarbon emissions compared to diesel the reason that low calorific value and higher viscosity rates of biodiesel effects the vaporization and atomization of the test fuel.

4. 7 Smoke emission

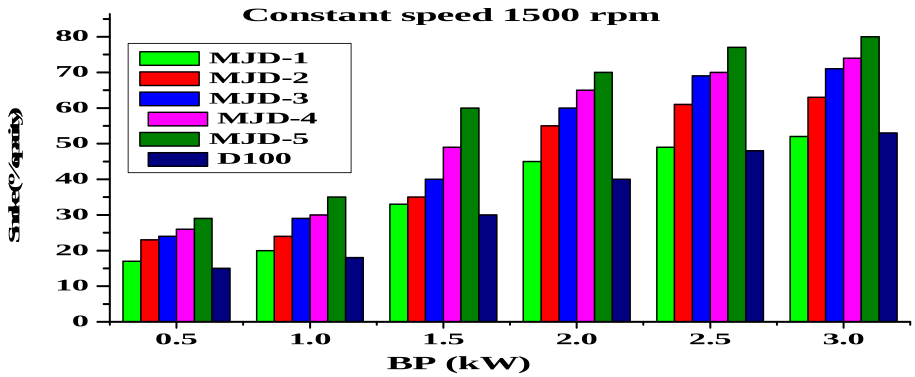

Figure 9. Brake power Vs Smoke emission

Figure 9. shows the variation of smoke with brake power. The smoke level increases with the increasing the brake power of all the test fuels. MJD – 1 and diesel have almost all same level of smoke at higher loads. The other test fuel blends the level of smoke more compared to the diesel fuel at the higher brake power rates. Normally biodiesel blend percentage increase the percentage of the viscosity and density. Due to this high viscosity, factors atomization deteriorates and the smoke percentage increase with increasing the biodiesel blend percentage at higher brake power rates.

5. Conclusions

A novel conceivable source of alternative fuel for diesel considered in the present study, mustered oil, jatropha and diesel as multi fuel test blends used as a test fuels for single cylinder, water-cooled diesel engine. The multi fuel test blends efficiency, specific fuel consumption and emission characteristics compared with the streak diesel fuel.

- Brake thermal efficiency of MJD – 1 nearer to the diesel fuel compared to the other test fuels. Brake thermal efficiency MJD – 5 and MJD -4 test fuels decreased to a acceptable level.
- Specific fuel consumption increases with increasing the percentage of biofuel blends and were comparable to diesel test fuel.
- MJD – 1, MJD -2 and MJD -3 test fuels formed low carbon dioxide emissions compared to diesel fuel. This is the main advantage of multi blend fuels.
- MJD -5-multi blend test fuel released high carbon monoxide gases compared to diesel and other blends. MJD – 1 and MJD -2 produced low carbon monoxide gases.
- Nitrogen oxide emissions more in all the dual biodiesel blends compared to diesel engines because complete combustion occurs in biodiesel blends.
- Blend MJD -1 smoke opacity equal to diesel fuel. Blend MJD -2 smoke opacity nearer to the diesel fuel the reason behind that higher density of multi blend biodiesel fuels leads to poor atomization. Blends MJD- 3, MJD – 4 and MJD – 5 have very high smoke opacity rates compared to diesel fuel.
- Current study investigations concluded that multi biodiesel of Mustered oil, jatropha and diesel blends exhibited favorable fuel properties and emission characteristics compared to other alternative conservative biodiesels.
- MJD – 1 and MJD – 2 would be used in diesel engines an alternative fuel for diesel without modifications. Various exhaust gas emission-reducing technologies will be involving in reducing the emissions of above multi -bend biodiesel fuels; can be focused for further investigations.

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