Journal of Basic and Applied Engineering Research
Print ISSN: 2350-0077; Online ISSN: 2350-0255; Volume 2, Number 6; April-June, 2015 pp. 458-463

http://www.krishisanskriti.org/jbaer.html

On Mixing of Two Biodiesels Blended with Diesel as Alternative Fuel for Diesel Engines- An Experimental Investigations

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Abstract—*The world faces the crises of energy demand, rising petroleum prices and depletion of fossil fuel resources. Biodiesel has obtained from vegetable oils that have been considered as a promising alternate fuel. The researches regarding blend of diesel and single biodiesel have been done already. Very few works have been done with the combination of two different biodiesel blends with diesel and left a lot of scope in this area. The present study brings out an experiment of two biodiesels from palm oil and mustard oil and they are blended with diesel at various mixing ratios. The effects of dual biodiesel works in engine and exhaust emissions were examined in a single cylinder, direct injection, air cooled and high speed diesel engine at various engine loads with constant engine speed of 1500 rpm. The influences of blends on CO, CO_2, HC, NOx and smoke opacity were investigated by emission tests. The brake thermal efficiency of blend A was found higher than diesel. The emissions of smoke, hydro carbon and nitrogen oxides of dual biodiesel blends were higher than that of diesel. But the exhaust gas temperature for dual biodiesel blends was lower than diesel.*

Keywords: *Biodiesel; Dual biodiesel; Alternate fuel; Emission analysis*

1. INTRODUCTION

The preservation of energy is decreasing now a days and it alleged that it leads to energy demand. In the last two decades, alternative fuels have obtained and identified as essential. A potential biodiesel substitutes diesel oil, consisting of ethyl ester of fatty acids produced by the transesterification reaction of triglycerides of vegetable oils and ethanol with the help of acatalyst. In addition, biodiesel is better than diesel fuel in terms of very low sulfur content and it is also having higher flash and fire point temperatures than in diesel fuel. A lot of research work pointed out that biodiesel has received a significant attention and it is a possible alternative in the existing engine. Ghaly et al. (2010) reported that the research on the production of biodiesel has increased significantly in recent years because of the need for an alternative fuel which endows with biodegradability, low toxicity and renewability. The ansuwan and Triratanasirichai (2011) concluded that the biodiesel produced by transesterification showed similar properties to the standard biodiesel. Agarwal et al. (2008) investigated that the process of transesterification is found to be an effective method of reducing viscosity of vegetable oil.

Lawrence et al. (2011) revealed that prickly poppy methyl ester (PPME) blended with diesel could be conveniently used as a diesel substitute in a diesel engine. The test further showed that there was an increase in break thermal efficiency, brake power and reduction of specific fuel consumption for PPME and its blends with diesel.

Deepanraj et al. (2011) described that the lower blends of biodiesel increased the brake thermal efficiency and reduced the fuel consumption. In addition to this, biodiesel blends produce lower engine emissions than diesel. Rahimi et al. (2009) used Diesterol (combination of diesel fuel, bioethanol and sunflower methyl ester) as a fuel for diesel engines. The authors revealed that, as the percentage of bioethanol in the blends is increased, the percentage of CO concentration in the emission is reduced. This trend is due to the fact that bioethanol has less carbon than diesel. Mani et al. (2009) investigated the diesel engine runs with waste plastic oil as fuel. The authors concluded that, the smoke was reduced by 40% than diesel. Muralidharan and Govindarajan (2011) prepared biodiesel from non-edible palm oil by transesterification and used as a fuel in C.I engine. The authors reported that blend B5 exhibits lower engine emissions of unburnt hydrocarbon, carbon monoxide, oxides of nitrogen and carbon dioxide at full load. Venkatraman and Devaradjane (2011) performed the experiments in a single cylinder DI diesel engine fueled with a blend of pungam methyl ester for the proportion of PME10, PME20 and PME30 by volume with diesel fuel for validation of simulated results. The authors observed that there is a good agreement between simulated and experimental results.

Kumar et al. (2003) conducted the experiments using pure jatropha oil, jatropha methyl ester, blends of jatropha and methanol and dual fuel operation (0–80% methanol by volume is inducted and jatropha acts as pilot fuel). The authors reported that, brake thermal efficiency for jatropha esters, dual fuel operation and diesel was 29%, 28.7% and 30.2% respectively.

Srivastava and Verma (2008) carried out the experiments using methyl ester of karanja oil. The authors reported that, the maximum thermal efficiency with methyl ester of karanja oil was about 24.9%, whereas that of the diesel was 30.6% at maximum power output. The authors concluded that, the methyl ester of karanja oil is a suitable substitute of diesel. Ramadhas et al. (2008) studied the dual fuel mode operation using coir-pith derived producer gas and rubber seed oil as pilot fuel. The authors reported that, non-edible oils can be used as pilot fuel, which eliminates the use of petroleum diesel.

Nwafor (2004) studied the potential of rapeseed methyl ester and its blends with diesel fuel as alternative substitute for diesel fuel. The author described that, the fuel consumption of rapeseed methyl ester was little higher than diesel fuel operation. Forson et al. (2004) found that, jatropha oil could be conveniently used as a diesel substitute, in a diesel engine. Wang et al. (2006) confirmed that, the vegetable oils possess almost the same heat values as that of diesel fuel. The engine power output and the fuel consumption of the vegetable oil and its blends are almost the same when the engine is fueled with diesel.

From the review of literatures, numerous works in the utilization of biodiesel as well as its blends in engines have been done. However, most of the literatures focused on single biodiesel and its blends. From previous studies, it is evident that single biodiesel offers acceptable engine performance and emissions for diesel engine operation.

Very few experiments have been conducted with the combination of dual biodiesel and diesel as a fuel . Most of the literatures suggested that palm oil is a suitable substitute of diesel and a few research works have also been carried out with mustard oil. So, the palm oil and mustard oil were selected for this current study which is easily and locally available. As a first level of experimentation, the properties of above said fuels in various combinations were found out in this work. This proved that the calorific value of the dual biodiesels and its blends with diesel fuel is more than the single biodiesel and its blends with diesel fuel. Hence it is decided to select palm oil, mustard oil and diesel as the fuel for this current analysis. In the second level performance and exhaust emission characteristics of a diesel engine with dual biodiesel and its blends and the results are compared with diesel.

2. MATERIALS AND METHODS

The two biodiesels (palm oil and Mustard oil) are prepared by the transesterification process. The dual biodiesel blends were prepared in different proportions as: Blend A-Diesel 90%, PPEE 5% and MEE 5% by volume basis; Blend B-Diesel 80%, PPEE 10% and MEE 10% by volume basis; Blend C-Diesel 60%, PPEE 20% and MEE 20% by volume basis; Blend D-Diesel 40%, PPEE 30% and MEE 30% by volume basis; Blend E-Diesel 20%, PPEE 40% and MEE 40% by volume basis and Blend F-Diesel 0%, PPEE 50% and MEE 50% by volume basis.

The various properties like kinematic viscosity, specific gravity, calorific value, flash point temperature and fire point temperature of baseline fuel, raw oils and two biodiesel mixed blends were determined by using ASTM methods and compared with diesel properties. The experiments were conducted on a stationary single cylinder four stroke air cooled diesel engine with electrical loading and the performance and emission characteristics were compared with baseline data of diesel fuel. Tests were conducted at a constant speed and at varying loads for all dual biodiesel blends. Engine speed was maintained at 1500 rpm (rated speed) during all experiments. Three experiments for each load were carried out for accuracy. Fuel consumption and exhaust gas temperatures were also measured. The smoke opacity of the exhaust gases was measured by the AVL make smoke meter. The exhaust emissions were measured by the Crypton make five gas analyzer. The experimental set up is shown in Fig. 1 and the detailed engine specifications are also given in Table 1.

3. RESULTS AND DISCUSSION

Various physical and thermal properties of dual biodiesels of palm oil and mustard oil and its blends were evaluated. The performance of the engine was evaluated using several parameters such as thermal efficiency, specific fuel consumption and exhaust gas temperature.

3.1. Calorific value of fuels

The digital bomb calorimeter is used to find out the calorific value of fuels. ASTM D420 procedure is followed to analyze the calorific value of different test fuels. Fig. 2 shows the calorific value of different fuels. The raw vegetable oil has lower calorific value than diesel. After transesterification process, the biodiesels have slightly higher calorific value than raw oil. The palm ethyl ester has higher calorific value than mustard oil ethyl ester. By blending the dual biodiesels with diesel, the calorific values of Blend A and Blend B are close to diesel which is more than single biodiesel blends. The calorific values of Blend C, Blend D and Blend E are almost equal to the single biodiesel blends. The calorific value of Blend F is lower than the single biodiesel blends due to the presence of pure biodiesel blends without diesel. Hence, dual biodiesel and its blends are utilized to analyze the performance and emission analysis experimentally.

3.2. Specific gravity of fuels

Specific gravity of different dual blends is measured using a precision hydrometer. The specific gravity of dual biodiesel blends Blend A, Blend B and Blend C is 0.816, 0.830 and 0.839, respectively whereas for diesel it is 0.814. The other blends have more deviation than diesel.

3.3. Viscosity of fuels

Calibrated Redwood viscometer is used for determining the kinematic viscosity. ASTM D0445 procedure is followed to analyze the viscosity of fuels. The viscosity of the blends increases with the blend ratio and the viscosities of dual biodiesel blends and they are higher than diesel fuel. The viscosity of the raw palm oil and the mustard oil is very high compared to diesel. However, the high viscosities of raw oils are reduced by the transesterification process. Viscosity of dual biodiesel blends Blend A and Blend B is nearer to diesel. The viscosity of diesel is 4 Cs whereas for the Blend A and Blend B it is 4.2 Cs and 4.4 Cs respectively.

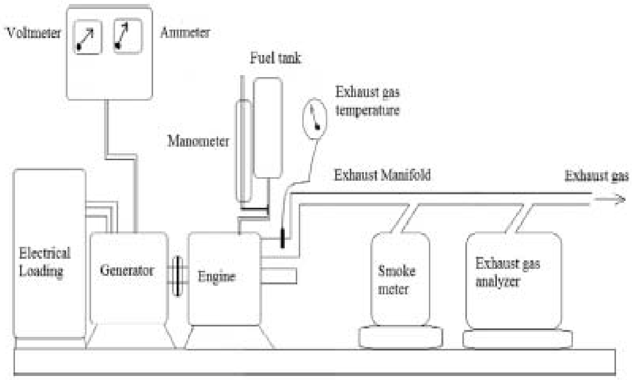

Figure 1 Test engine setup.

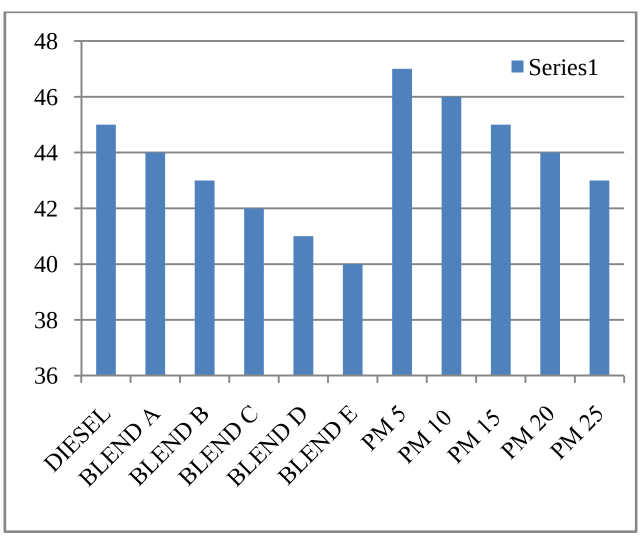

Fig. 2: Calorific values for fuels

Table 1: Test engine specifications.

Items	Specifications
Model	Kirloskar engine
Type	Single cylinder
Bore · stroke	68 mm · 76 mm
Compression ratio	18:1
Type of cooling	Air cooling
Speed	1500 rpm
BHP	4.5

3.4 Performance analysis

The effect of brake power on specific fuel consumption is shown in fig.3. As brake power increases the SFC reduces for all dual biodiesel blends. For the maximum load, the value of SFC of Blend A is 0.32 kg/kW h, Blend B is 0.35 kg/kW h, Blend C is 0.37 kg/kW h whereas diesel fuels have 0.31 kg/kW h. The higher SFC for the dual biodiesel fuel consumption is due to the lower calorific value of the blends. Brake specific energy consumption (BSEC) was used for comparing engine performance of fuels with different calorific values. Fig. 4 signifies the brake specific energy consumption for dual biodiesel, its blends and diesel. It shows that the BSEC is the highest for all dual biodiesel blends compared with min- eral diesel. BSEC is an ideal variable because it is dependent on calorific value of the fuel. The high specific energy consump- tion is due to the lower energy content of the ester. Hence, the brake specific energy consumption of the dual biodiesel blends increases as compared to that of diesel.

The effect of brake power on mechanical efficiency is shown in Fig. 5. Indicated power and engine friction are essential for calculating the mechanical efficiency of the engine. Efficiency is measured as a ratio of the measured performance to the per- formance of an ideal machine. Mechanical efficiency measures the effectiveness of a machine in transforming the energy and power that is given as an input to the device into an output force and movement. Hence, mechanical efficiency indicates how good an engine is, in converting the indicated power to useful power. Blend A gives the maximum mechanical effi- ciency of 79.3% for the maximum brake power, whereas the diesel gives 78.2% at the same brake power. For the other blends, mechanical efficiency is lower than diesel.

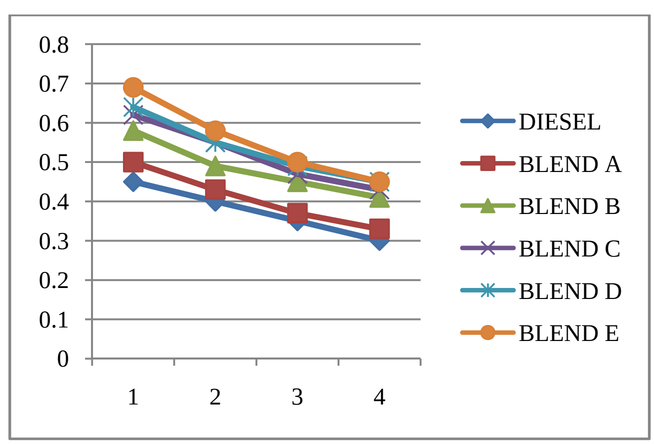

Fig. 3: Variation of brake power on specific fuel consumption

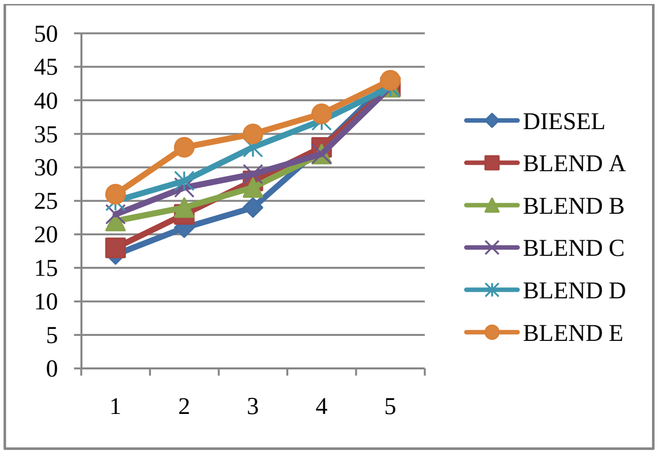

Fig. 4: Effect of brake power on brake specific energy consumption

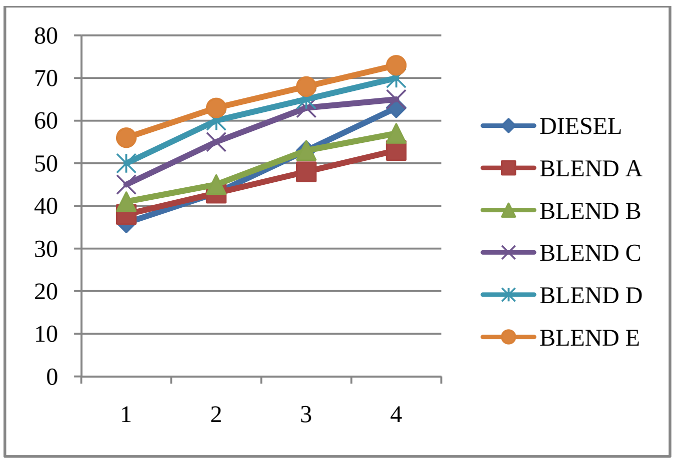

Fig. 5: Effect of brake power and mechanical efficiency

The variations of brake power on exhaust gas temperatures are shown in Fig.6.Exhaust temperature increases with the increase in brake power in all cases. Exhaust gas temperature is an indicative of the quality of combustion in the combustion chamber. The increase in exhaust gas temperature with engine load is clear from the simple fact that, more amount of fuel is required by the engine to produce the extra power which is also needed to take up the additional loading. At the same time, all the blends are having less exhaust temperature than the diesel values for any brake power due to its lower heating value and the improved oxygen content provided by the dual bio diesel which increases better combustion (Suresh Kumar et al.,2008). Hence, the dual biodiesel blends are better than \ diesel while considering the exhaust temperature effect.

It is observed from Fig.7, that the smoke percentage increases with the increase in the brake power. For the maxi- mum load, the smoke for diesel was 60%, whereas the Blend A gives 64% and Blend B gives 68% with the same maximum load. Blend A has a closer smoke value with diesel. In other

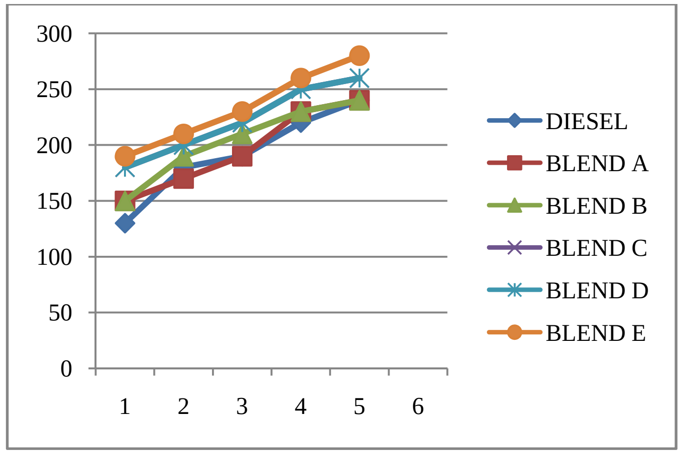

Fig. 6: variation of brake power on exhaust gas temperature

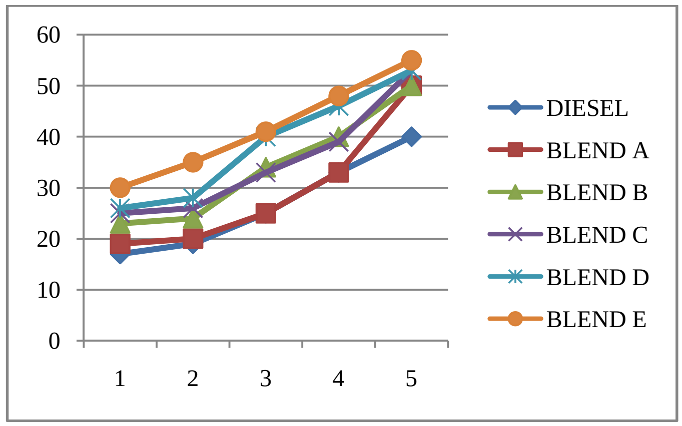

Fig. 7: Effect of brake power on exhaust smoke

blends, the smoke percentage was more than the diesel with the same brake power. The higher density and viscosity may be the reason for more smoke emissions as compared to neat diesel. The high viscosity of pure biodiesel deteriorates the fuel atomization and increases exhaust smoke.

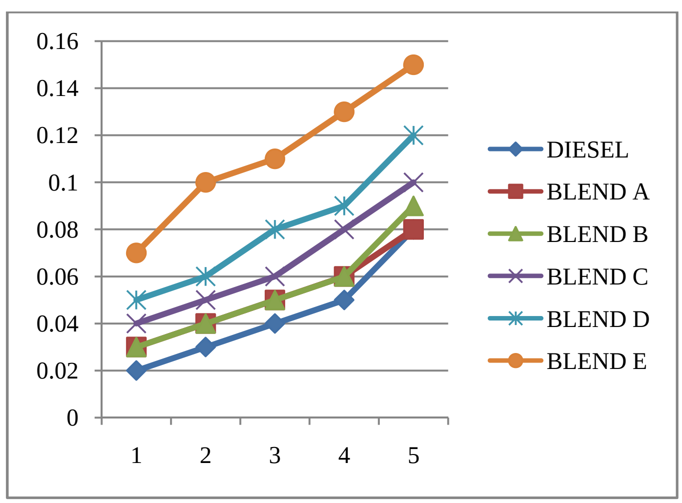

Fig. 8: Variation of brake power and carbon monoxide emission

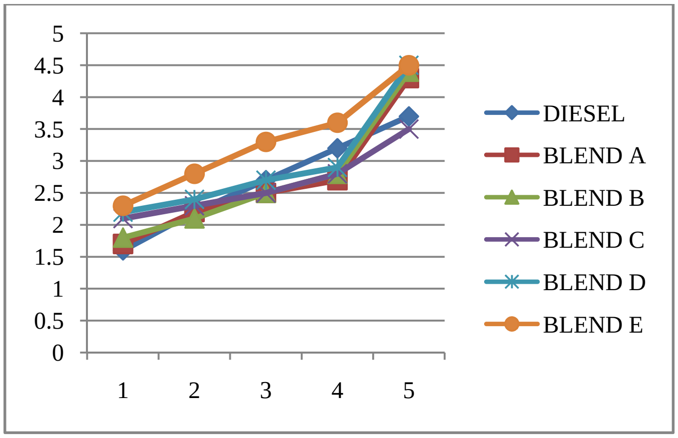

Fig. 9: Variation of brake power and carbon monoxide emission

166 ppm whereas diesel gives 150 ppm, Blend B gives 180 ppm, Blend C gives 190 ppm at the same maximum load. From the results, NOx emission is higher for dual biodiesel blends than diesel. However, Blend A gives lesser NOx than other dual bio- diesel blends. The vegetable oil based biodiesel contains a small amount of nitrogen. This contributes toward NOx pro- duction. All the blends give higher NOx than diesel. The higher average gas temperature, the presence of fuel oxygen and res- idence time at higher load conditions with the blend combus- tion caused higher NOx emissions.

Fig. 11 shows that, the relation between brake power and hydro carbon (HC) increased by increasing the load for each blend. All the Blends give higher HC than diesel. From the results, Blend A gives lesser HC than other blends. The dual biodiesels and blends generally exhibit lower HC emission at lower engine loads and higher HC emission at higher engine loads. This is because of the relatively less oxygen available for the reaction when more fuel is injected into the engine cyl- inder at high engine load. The lower calorific value and the higher viscosity of biodiesel oil result in the highest HC emissions.

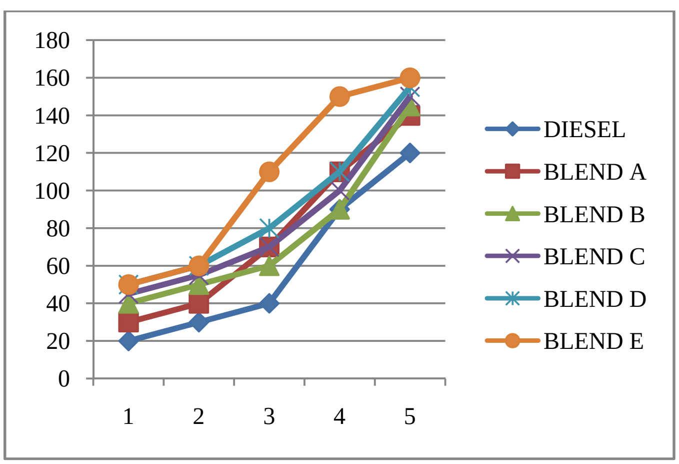

Fig. 10: Effect of brake power on nitrogen oxide emission.

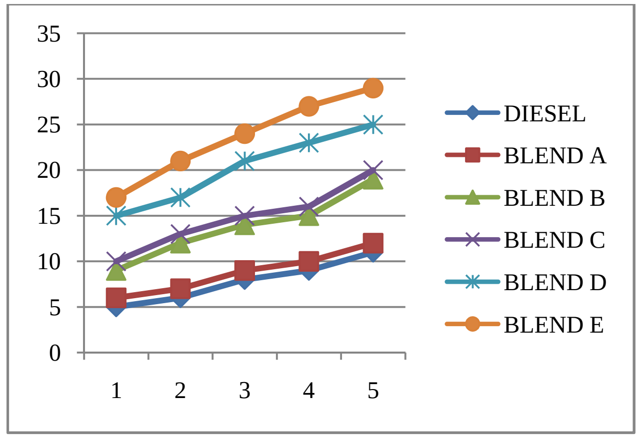

Fig. 11: Effect of brake power on hydro carbon emission.

4. CONCLUSION

Single cylinder high speed diesel engine ran successfully during tests on dual biodiesels and its blends. The blends of diesel and the dual biodiesels of palm oil and mustard oil were characterized for their various physical, chemical and thermal properties. From the experimental analysis results, the thermal efficiency and mechanical efficiency of Blend A were slightly higher than the diesel. Blend B and Blend C were very closer to the diesel values. The specific fuel consumption values of dual biodiesel blends were comparable to diesel. Blend A and Blend B produced slightly lower CO and CO_2 than die- sel. This is a considerable advantage over diesel while using the dual biodiesel blends. The dual biodiesel blends gave higher smoke opacity, HC and NOx than diesel. But for the Blend A, Blend B and Blend C the smoke opacity was nearer to diesel. Therefore, it may be concluded that dual biodiesel blends of Blend A, Blend B and Blend C would be used as an alternative fuel for diesel in the diesel engines. Various dual biodiesel blends with diesel can be focused for further recommendations.

REFERENCES

[1] Agarwal, D., Kumar, L., Agarwal, A.K., 2008. Performance evalua-tion of a vegetable oil fuelled compression ignition engine. Renew. Energy 33, 1147–1156.

[2] Deepanraj, B., Dhanesh, C., Senthil, R., et al, 2011. Use of palm oil biodiesel blends as a fuel for compression ignition engine. Am. J. Appl. Sci. 8, 1154–1158.

[3] Forson, F.K., Oduro, E.K., Hammond-Donkoh, E., 2004. Perfor-mance of jatropha oil blends in a diesel engine. Renew. Energy 29, 1135–1145.

[4] Ghaly, A.E., Dave, D., Brooks, M., et al, 2010. Production of biodiesel by enzymatic transesterification: review. Am. J. Biochem. Biotechnol. 6, 54–76.

[5] Kumar, M.S., Ramesh, A., Nagalingam, B., 2003. An experimental comparison of methods to use methanol and jatropha oil in a compression ignition engine. Biomass Bioenergy 25, 309–318.

[6] Lawrence, P., Mathews, K., Deepanraj, B., 2011. The effect of prickly poppy methyl ester blends on CI engine performance and emission characteristics. Am. J. Environ. Sci. 7, 145–149.
[7] Mani, M., Subash, C., Nagarajan, G., 2009. Performance, emission and combustion characteristics of a DI diesel engine using waste plastic oil. Appl. Therm. Eng. 29, 2738–2744.
[8] Muralidharan, K., Govindarajan, P., 2011. The effect of bio-fuel blends and fuel injection pressure on diesel engine emission for sustainable environment. Am. J. Environ. Sci. 7, 377–382.
[9] Nwafor, O.M.I., 2004. Emission characteristics of diesel engine operating on rapeseed methyl ester. Renew. Energy 29, 119–129.
[10] Prabhakar, S., Annamalai, K., Lalvani, K., JoshuaRamesh, Issac, 2012. Experimental study of hybrid vegetable oil blends in diesel engine. J. Sci. Ind. Res. 71, 612–615.
[11] Rahimi, H., Ghobadian, B., Yusuf, T., et al, 2009. Diesterol: an environment-friendly IC engine fuel. Renew. Energy 34, 335–342.
[12] Ramadhas, A.S., Jayaraj, S., Muraleedharan, C., 2008. Dual fuel mode operation in diesel engines using renewable fuels: rubber seed oil and coir-pith producer gas. Renew. Energy 33, 2077–2083.
[13] Srivastava, P.K., Verma, Madhumita., 2008. Methyl ester of karanja oil as an alternative renewable source energy. Fuel 87, 1673–1677.
[14] Suresh Kumar, K., Velraj, R., Ganesan, R., 2008. Performance and exhaust emission characteristics of a CI engine fueled with methyl ester (PPME) and its blends with diesel. Renew. Energy 33, 2294–2302.
[15] Theansuwan, W., Triratanasirichai, K., 2011. The biodiesel production from roast Thai sausage oil by transesterification reaction. Am. J. Eng. Appl. Sci. 4, 130–132.
[16] Venkatraman, M., Devaradjane, G., 2011. Computer modeling of a CI engine for optimization of operating parameters such as compres-sion ratio, injection timing and injection pressure for better performance and emission using diesel-diesel biodiesel blends. Am. J. Appl. Sci. 8, 897–902.
[17] Wang, Y.D., Al-Shemmeri, T., Eames, P., et al, 2006. An experimen-tal investigation of the performance and gaseous exhaust emissions of a diesel engine using blends of a vegetable oil. Appl. Therm. Eng. 26, 1684–1691.