Tejesh et al. 2018. *Int. J. Vehicle Structures & Systems*, 10(5), 342-346
ISSN: 0975-3060 (Print), 0975-3540 (Online)
doi: 10.4273/ijvss.10.5.07

International Journal of
Vehicle Structures & Systems
Available online at www.maftree.org/eja

Performance and Emission Characteristics of a CI Engine Fuelled with Palm and Sesame Oil Blended Diesel

Pala Tejesh[a], Vinod Kotebavi[b], Pamarthi Shyam and P. Siva Durga Prasad

Dept. of Mech. Engg., Amirtha School of Engg., Amrita Vishwa Vidyapeetham, Bengaluru, India
[a]Corresponding Author, Email: palatejesh@gmail.com
[b]Email: k_vinod@blr.amirta.edu

ABSTRACT:

Biodiesel can be considered as a clean, renewable and domestically produced diesel fuel. At present, a lot of research is being carried out to make biodiesel more efficient so that it can be substituted for conventional diesel. In the present investigation, biodiesel is extracted from palm and sesame oil by transesterification method. The different properties of biodiesel like flash point, fire point, density, viscosity, pour point, cloud point and calorific value are measured. The obtained values are meeting the standards of biodiesel. This dual biodiesel was blended (0-40%) with diesel and was tested in a 4 stroke single cylinder diesel engine at different loads. The performance characteristics like thermal efficiency and BSFC are compared. BSFC increases and thermal efficiency decreases with the percentage increase in the blends at higher loads. At part loads, biodiesel blends are more efficient. Emission contents like carbon monoxide, carbon dioxide, hydrocarbon, oxides of nitrogen and smoke density are recorded. For B10 and for B20 blends these contents are more comparable to diesel fuel.

KEYWORDS:

Biodiesel; Methanol; Sodium hydroxide; Palm oil; Sesame oil; Free fatty acid; Transesterification

CITATION:

P. Tejesh, V. Kotebavi, P. Shyam and P.S.D. Prasad. 2018. Performance and Emission Characteristics of a CI Engine Fuelled with Palm and Sesame Oil Blended Diesel, *Int. J. Vehicle Structures & Systems*, 10(5), 342-346. doi:10.4273/ijvss.10.5.07.

1. Introduction

In the modern world, diesel engine plays a major role in industrial experiments and transportation. From decades it has been observed that the demand for energy has been increasing tremendously day by day for running automobiles, locomotives and for other energy consumption units. In the world, the majority of current energy resources are fossil fuel based, which will get depleted in a day. By developing the modern technology we could utilize alternative fuels for energy supply. So, we have selected the biodiesel which is non-toxic and biodegradable fuel, extracted from vegetable oil that has to be modified using the transesterification process to run the engine otherwise the engine has to be modified for running with the biofuel. As many of the experiments have been conducted on biodiesels, at present we are going to study about the Palm and Sesame oils blended biodiesel. The amounts of blend ratios indicated by a letter 'B' followed by a number from 0 to 100 in weights or volume basis are as follows:

- 100% biodiesel (50% Palm & 50% Sesame biodiesel) is referred as B100PSD
- 70% biodiesel (35% Palm & 35% Sesame biodiesel) is referred as B70PSD
- 50% biodiesel (25% Palm & 25% Sesame biodiesel) is referred as B50PSD
- 20% biodiesel (10% Palm & 10% Sesame biodiesel) is referred as B20PSD
- 10% biodiesel (5% Palm & 5% Sesame biodiesel) is referred as B10PSD

Kotebavi et al [1] said that for running the engine with vegetable oil, the engine has to be modified otherwise the oil has to be modified. Hence to run the engine in the smooth condition, the vegetable oil has to be converted into biofuel by transesterification. Sunil Kumar et al [2] said that the biodiesel has a very high fire and flash point compared with diesel so it is better to use biofuel as an alternative fuel in the engine. The oil needs to contain a high free fat content for using the oil as biodiesel. Transesterification is the process where triglyceride molecule or complex fatty acid is neutralized by removing glycerine and to form an alcohol ester [3]. This was achieved by adding methanol and sodium hydroxide to the solution. Ajeet Kumar et al [4] said that non-edible oils like jatropha curcas, castor oil, mahua oil, Pongamia pinata / Karanja oil, Canola oil and edible oils like coconut oil, palm oil, rapeseed oil, soybean oil, mustard oil, sunflower oil, rice bran oil, waste cooking oil can be used as blends of biodiesels to run the engine.

The vegetable oil biodiesels give a comparable brake thermal efficiency with diesel. The raw vegetable oil can be used in an engine with some modifications in it. Dawodu et al [5] said that sesamum indicium can be used as biodiesel for running the engine. The sesame oil contains sesaminol ligands and sesame in its non-glycerol fraction, which are known to play a major role in antioxidant activity and oxidative stability.

2. Experimental work

The raw oil is purchased from the market and filtered using oil filter machine. 25 ml of 0.1N NaOH solution prepared is taken into a clean and dry burette. 10 grams of palm and sesame oil is measured and taken in a clean and dry conical flask. About 50ml of isopropyl has been added to the oil and well shaken. The solution is made to heat up to 60°C using a magnetic stirrer and allowed to cool. Four droplets of phenolphthalein are added to the solution and it is titrated against 0.1N NaOH solution until the solution turns to pink. The free fatty acid (FFA) content is calculated using,

$$FFA\ Cotent = \frac{0.1N * 28.2 * Burette\ reading}{10} \quad (1)$$

Based on the FFA content, the number of stage processes i.e. either single stage or double stage has been found. If FFA content found is < 4% then it is single stage or else it is a double stage process. From Table 1, as it is single stage process, it is a base catalyst process. The raw material for this stage is settled lower layer of the earlier stages having low FFA. The product of earlier stages is made to react with 6:1 molar ratio of methanol and 1% w/v of NaOH catalyst for 1ltr of oil. It is heated to 60°C with constant stirring for 90 minutes. The reacted product of this stage is made to settle down under gravity. The methyl esters are separated from glycerol and other impurities. About 4.5 grams of NaOH and 300 ml Methanol (CH_3OH) are required per litre of oil for transesterification process.

Table 1: Measure of free fatty acid content

Oil	FFA content	Stage process
Palm oil	0.282%	Single stage
Sesame oil	1.2972%	Single stage

The fuel properties like viscosity, flash and fire point and calorific value are found out using Redwood viscometer, flash and fire point apparatus and bomb calorimeter respectively. In the present study, a five gas analyser and smoke meter are used for measuring the emissions of the dual biodiesel blends. The exhaust gas is diverted with the probe into the smoke chamber of smoke meter and the smoke density is measured. The exhaust gas has also been sent into the inlet of five gas analyser. Non-dispersive infrared sensor (NDIR) technology is used for measuring carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HC). Electrochemical sensor is used for measuring oxygen (O_2) and nitrogen (N_2) content. Tests are carried on AV-1 Kirloskar vertical single cylinder, water cooled, four stroke cycles, and compression ignition diesel engine having a compression ratio of 16.5:1. Time taken for fuel consumption of 10 grams, speed and exhaust gas temperature during tests are tabulated at varying loads for dual biodiesel blends and diesel.

3. Results and discussions

3.1. Fuel test results

Fig. 1 shows the kinematic viscosity of palm and sesame oils at different temperatures varying from 30°C to 70°C. Comparing the palm and sesame, the palm oil is more viscid at lower temperatures. At high temperatures they are almost same. Fig. 2 shows the viscosity of biodiesels after transesterification process with NaOH catalyst and methanol. Palm biodiesel is more viscid compared to sesame biodiesel and diesel. Fig. 3 shows the variation of viscosity of biodiesel blends namely B10, B20, B30, B40 compared with diesel. Based on results B30 and B40 biodiesel blends are more viscid than pure diesel.

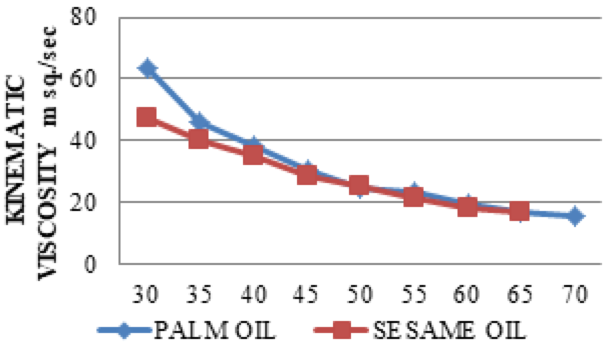

Fig. 1: Viscosity of oil

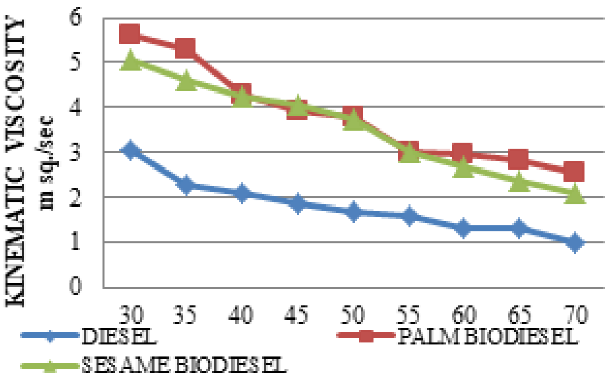

Fig. 2: Viscosity of biodiesels after transesterification process

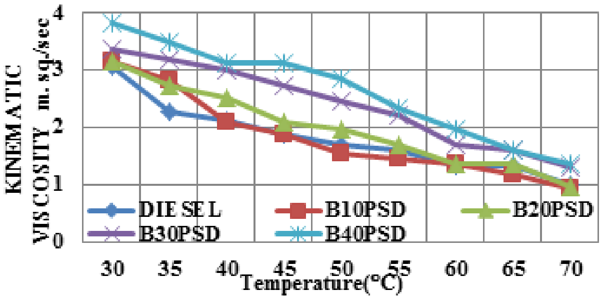

Fig. 3: Viscosity of biodiesel blends

Fig. 4 shows the comparison of flash and fire points with diesel, palm oil, sesame oil, palm biodiesel and sesame biodiesel. Palm oil, sesame oil and their biodiesel blends have higher flash and fire points than diesel. Fig. 5 shows the flash and fire points of diesel, B10PSD, B20PSD, B30PSD and B40 PSD biodiesels. The biodiesels B20PSD and B40PSD show the highest flash and fire points than the diesel and other biodiesel blends. Fig. 6 shows the comparison of calorific value of different fuels namely palm oil, sesame oil, palm biodiesel, sesame biodiesel, diesel, B10PSD, B20PSD, B30PSD and B40PSD. The sesame biodiesel gave the highest calorific value because of its high contents in proteins and energy supplements in sesame seeds. Biodiesel B10PSD showed the highest calorific value compared with other biodiesels.

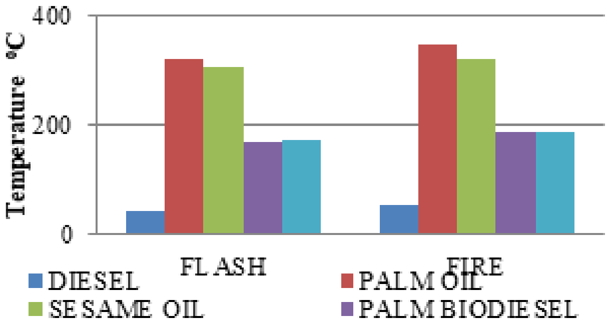

Fig. 4: Flash and fire point

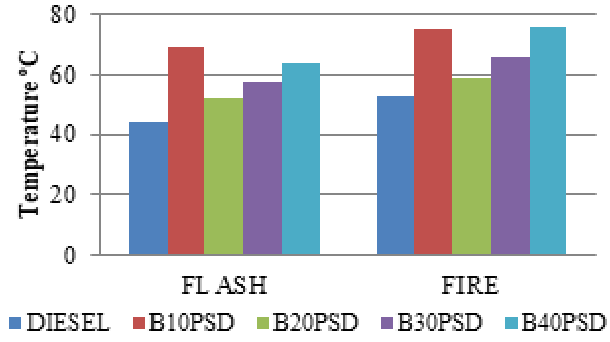

Fig. 5: Flash & fire point

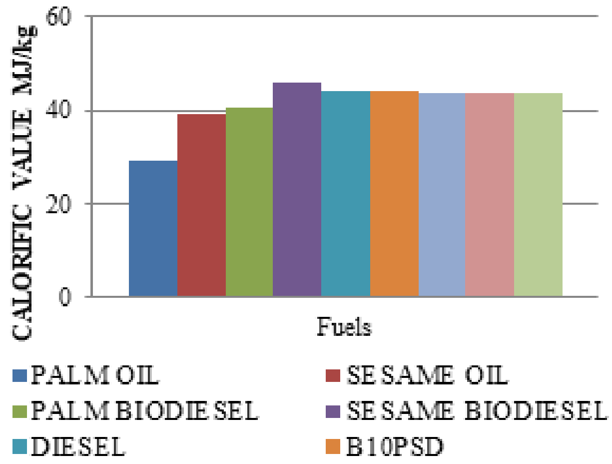

Fig. 6: Comparison of calorific value with oil, bio-diesel, diesel and biodiesel blends

3.2. Performance characteristics

Fig. 7 shows us the variation of brake thermal efficiency (BTE) across the load for different blends of biodiesel and for diesel. At part loads, the BTE is low when compared to diesel and biodiesel blends. The highest is found out to be B30PSD at higher load. This is because the biodiesel blends are of low calorific. The diesel has the highest BTE of 28.25% at highest load. The highest BTE in biodiesel blends is found out to be 23.93% for highest load i.e. 13 kg. Fig. 8 shows the comparisons of BSFC on varying load from 3.3kg to 13kg. BSFC is more for B30PSD biodiesel compared to diesel and biodiesel blends and least for B20PSD biodiesel at the lowest load of 3.3 kg. At the highest load, the BSFC is at its maximum for B10PSD i.e. 0.3679 kg/kW-hr and the lowest for diesel i.e. 0.28959 kg/kW-hr compared with diesel and biodiesel blends. As the oxygen content in biodiesel blends is more this leads to having low calorific value for biodiesel blends. This is the main cause for more consumption of fuel for biodiesel blends than diesel. Fig. 9 shows the comparison of exhaust gas temperature for diesel and biodiesel blends with different loading on the engine. B10PSD biodiesel blends is having low exhaust temperatures i.e. 147°C at low load and high exhaust temperature i.e. 258°C compared with the diesel and biodiesel blends.

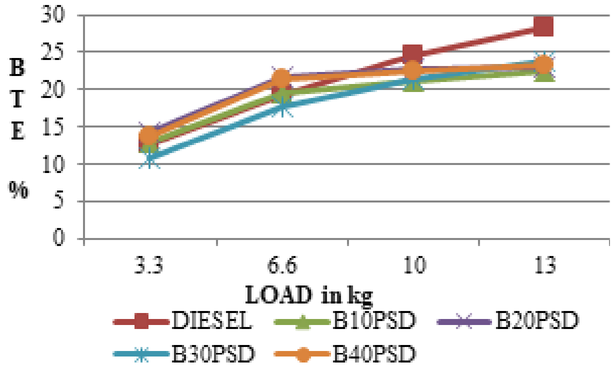

Fig. 7: Variation of BTE vs. Load

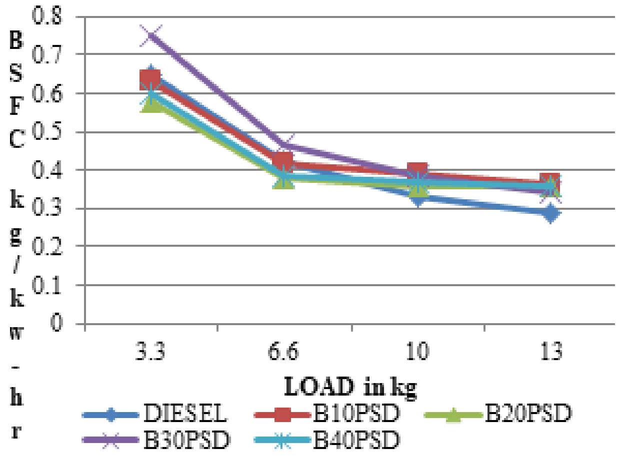

Fig. 8: Variation of BSFC vs. Load

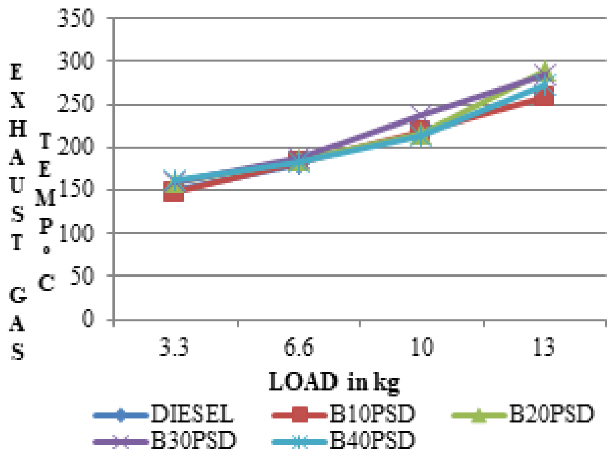

Fig. 9: Variation of BSFC Vs. Load

3.3. Emission characteristics

Fig. 10 infers that B10PSD and B20PSD are having relatively high smoke density compared with diesel and biodiesel blends. Compared with diesel, all biodiesel blends gave high smoke density. Because of the high fuel consumption the smoke density may be increased in varying loads from 3.3kg to 13kg. Fig. 11 shows the un-burnt HC present in the fuel varied with increasing loads from 3.3kg to 13kg. As the dual biodiesel blends are having more oxygen content in fuels it helps the fuel to combust more at higher loads Comparatively, the biodiesel blend B30PSD had the lowest HC content. Fig. 12 shows the variation of CO with respect to increasing loads from 3.3kg to 13 kg. CO emissions are lower compared to biodiesel blends with increasing loads. This may be because of the presence of the high content of oxygen in fuels which contributes to less emission of CO. At increasing loads, the CO emissions decreased.

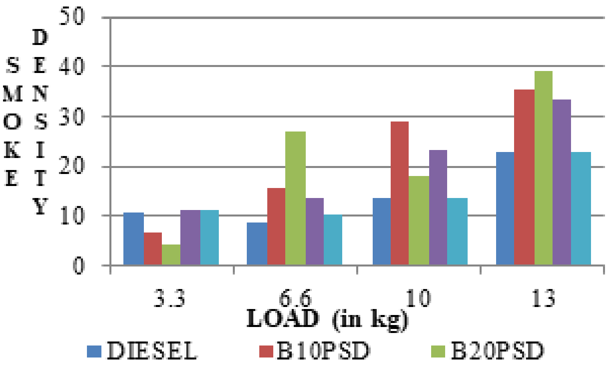

Fig. 10: Smoke density vs. Load

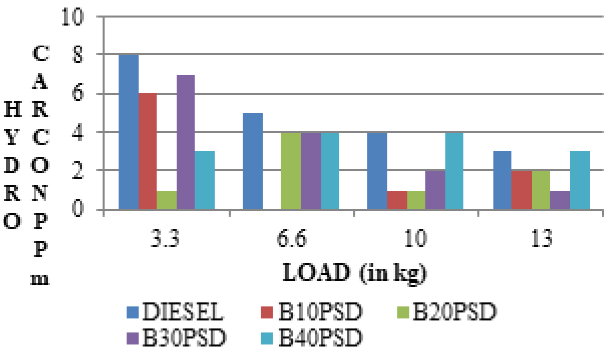

Fig. 11: Un-burnt hydrocarbon vs. Load

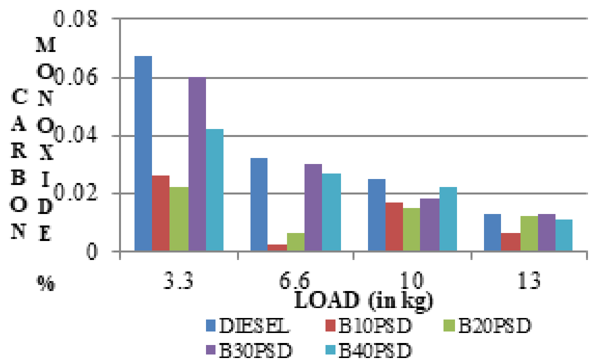

Fig. 12: Variation of CO emission vs. Load

Fig. 13 shows the CO_2 for varying load in increasing order. The dual biodiesel blends give almost the same emissions at higher load but at a lower load, there is a decrease in CO_2 content that is being emitted. This may be because of more combustible nature of the biodiesels when compared to diesel. Fig. 14 shows the variation of NO_X emissions varying at an increasing load from 3.3kg to 13kg. Compared to diesel the biodiesel emits a large amount of NO_X content for an increase of load. It depicts that the increased NO_X emissions may be due to the presence of more oxygen in biofuels compared with diesel and the high temperature inside the engine cylinder.

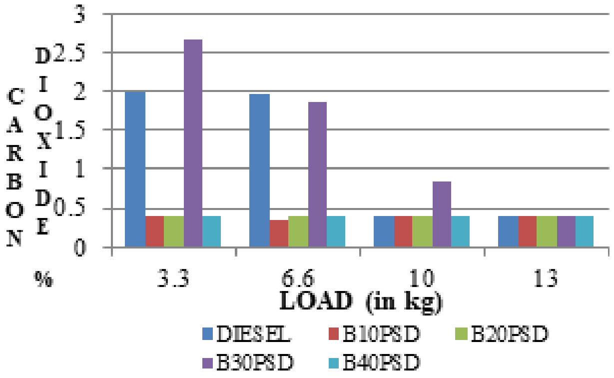

Fig. 13: Variation of CO_2 vs. Load

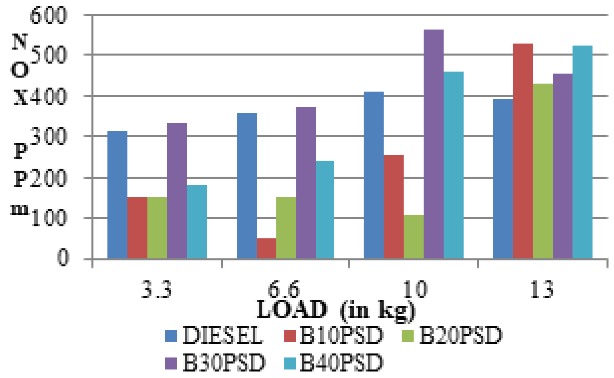

Fig. 14: Variation of NO_X emissions vs. Load

4. Conclusions

The performance and emission characteristics of a single cylinder, water cooled diesel engine fuelled with the increasing ratio of biodiesel in the blends as compared with the pure diesel. The fuel consumption increased may be due to the low energy of the biofuel with an increase in the percentage of biodiesel. The dual biodiesel blend fuels satisfy the biodiesel standards. The brake thermal efficiency is decreased with increasing ratio of biodiesel in blends. The B30PSD biofuel has a maximum brake thermal efficiency compared with other fuels. There is an increase in brake specific fuel consumption with an increase in blend ratios of biofuel due to low calorific content in the biofuels. The BPSD blends show that due to increase in the oxygen content, the exhaust gas temperature increases for B30PSD. This result in an increase of NO_X content in fuels and about 4%-27% increase compared with diesel at increasing loads and is observed with B30PSD dual-biofuel. Emissions depict that B30PSD is having less CO and HC compared with the other biofuels and diesel. So B30PSD can be selected as an alternative fuel for running diesel engines with lesser emissions and moderate brake thermal efficiency compared to diesel fuel.

REFERENCES:

[1] V. Kotebavi, D. Sahu and D. Shetty. 2016. Performance and emission characteristics of a CI engine run on waste cooking oil-diesel blends, *EM Int. Poll. Res*., 35(1), 159-166.

[2] M. Sunil kumar, M. Vinod and M. Kotebavi. 2016. Performance analysis of a diesel engine fuelled with blends of neem and simarouba oils, *Indian J. Sci. and*

Tech., 9(45), 1-5. https://doi.org/10.17485/ijst/2016/v9i45/104590.

[3] P.V. Ramana, P.R. Reddy, C. Balaram and A.S. Kumar. 2015. Experimental study on CI engine performance using biodiesel blends, *Int. Research J. Engg. and Tech.*, 2(02), 1107-1116.

[4] A. Kumar, S.K. Shukla and J.V. Tierkey. 2015. A review of research and policy on using different biodiesel oils as fuel for C.I. engine, *Proc. 5th Int. Conf. Advances in Energy Research,* Mumbai, India.

[5] F.A. Dawodu, O.O. Ayodele and T.B. Ojo. 2014. Bio-diesel production from sesamum indicum L. seed oil: An optimization study, *Egyptian J. Petroleum Research,* 23(2), 191-199. https://doi.org/10.1016/j.ejpe.2014.05.006.

[6] A. Nalgundwar, B. Paul and S.K. Sharma. 2016. Comparison of performance and emissions characteristics of DI CI engine fuelled with dual biodiesel blends of palm and jatropha, *Fuel*, 173, 172-179. https://doi.org/10.1016/j.fuel.2016.01.022

[7] K. Srithar, K.A. Balasubramanian, V. Pavendan and B.A. Kumar. 2017. Experimental investigations on mixing of two bio-diesels blended with diesel as alternative fuel for diesel engines, *J. King Saud University - Engg. Sci.*, 29, 50-56. https://doi.org/10.1016/j.jksues.2014.04.008.

[8] N.H. Azeman, N.A. Yusof and A.I. Othman. 2015. Detection of free fatty acid in crude palm oil, *Asian J. Chemistry*, 27(5), 1569-1573. https://doi.org/10.14233/ajchem.2015.17810.

[9] M.V. Kumar, A.V. Babu and P.R. Kumar. 2016. The impacts on combustion, performance and emissions of biodiesel by using additives in direct injection diesel engine, *Alexandria Engg. J.*, 57(1), 509-516. https://doi.org/10.1016/j.aej.2016.12.016.

[10] A.S.D. Shetty, L. Dinesh kumar, S Koundinya, K. Swetha and K. Mane. 2017. Experimental investigation on CRDI engine using butanol – biodiesel - diesel blends as fuel, *Proc. AIP Conf.*, 1859(1). https://doi.org/10.1063/1.4990181.