International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 2, February 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Investigations on a Diesel Engine Run on used Lubricating Oil-Biodiesel Blend as an Alternative Fuel

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ABSTRACT
Exhaust emission coming from IC engines affects not only the environment but also the human health. This serious issue has got attention by the government as well as from the researchers throughout the world. In this regard it is necessary to find out alternative to not only fossil fuel but also environment cooperative fuel. In this regard, investigations were carried out by using Jatropha biodiesel and its blend with used lubricating oil which was discarded after use. The test was carried in a single cylinder diesel engine and different terms such as performance and emissions of diesel engine were found out and compared with diesel operation. It was noticed that engine can be run by using these kinds of fuels. By using these fuels not only we are solving waste disposal problem but also replacing diesel fuel and environment friendly fuel. The used lubricating oils were blended with Jatropha biodiesel in different proportions and test were done.

KEYWORDS: *Compression ignition engine; Jatropha Biodiesel; Used lubricating oil; Regeneration*

How to cite this paper*:* Pranav Kumar | Ravindra Mohan | Jagdeesh Prasad "Investigations on a Diesel Engine Run on used Lubricating Oil-Biodiesel Blend as an Alternative Fuel" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-2, February 2020, pp.872-877, URL: www.ijtsrd.com/papers/ijtsrd30158.pdf

IJTSRD30158

1. INTRODUCTION

Fast depletion of fossil fuels and increasing number of vehicle population, and their detrimental effect on the environment results in urgent need of alternative fuels for meeting the sustainable energy demand with minimum environmental impact [1]. Therefore, there is a necessity to find suitable alternative fuels for diesel engines that are cheaper and eco-friendly. Figure 1.1 depicts that the main sources of energy as per 2018 are still coal, oil and natural gas. But, a significant amount of share is of energy from Biofuels and waste which directly tells the shift in the mindset of people to move towards more eco-friendly fuel and towards renewable energy. Also, it depicts the tremendous amount of research and effort put in by the scientists and researchers to make this dream of sustainable development and cleaner and greener fuel possible. 155,505 Terawatt-hour (TWh) was the approximate primary energy supply of the world in 2012 [3-5].

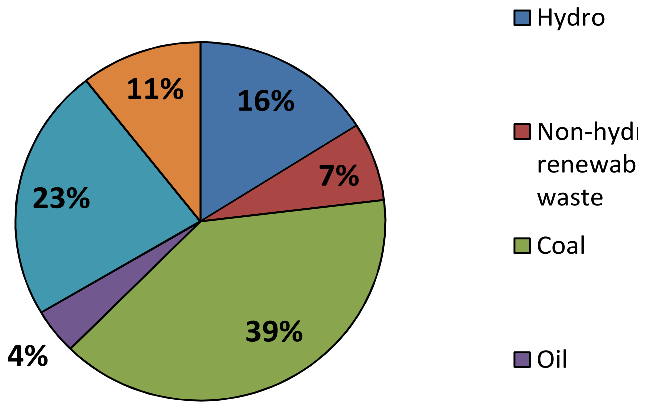

Figure 1.1: Total Primary Energy Supply (TPES) by fuel in 2019 [4].

Biomass is a very good source for deriving different kind of alternative fuels. Biomass is available in the form of agriculture residue, vegetable seeds, animal waste, crop residue, food waste, industrial waste, municipal waste etc. [2]. Biomass is an organic matter and is renewable over time. There are two methods commonly adopted to derive alternative fuels from biomass sources which are; (i) Biochemical method (ii) Thermo-chemical method. In biochemical method, fermentation and anaerobic digestion are used to convert some of the biomass wastes into alcohol and biogas respectively. Biomass sources such as crop residue, cow dung, pig manure, spent wash etc. are converted into biogas through anaerobic digestion. If the biomass source is properly converted into an alternative fuel especially for diesel engine, then the demand for diesel fuel will be considerably reduced [3-5].

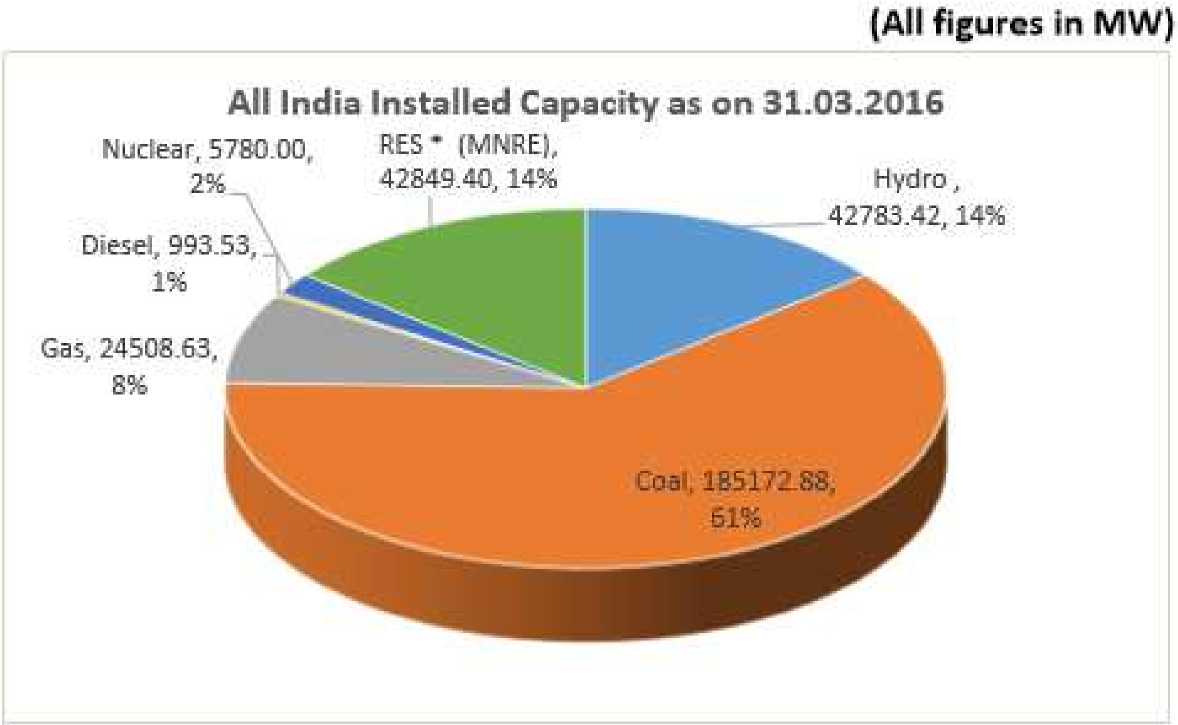

Fig. 2 Energy Scenario

Energy consumption is growing exponentially due to rapid progress in the population, industrialization and increase in number of automotive vehicles. Nowadays, the petroleum fuels play a vital role in the mobility, industrial sectors, and agricultural sectors. Meanwhile, the availability of petroleum resources is limited in nature, available in restricted area and they are getting depleted day by day [6-10 Furthermore, problems related to the environment are the most important consequences of consumption of more petroleum fuels. The issue of energy security and environment issues made countries and researchers to look for alternate means of renewable as well as environment-friendly fuels. The most promising and economically viable alternative fuels which can be a replacement of petroleum fuels are biofuels [11-13]. Various sectors are looking for alternative fuels because of the energy crisis and the fear of society for depleting earth's non-renewable resources. Among various researchers from all over the world started proposing various methods to use vegetable oils in internal combustion engines. These methods include pyrolysis, micro-emulsification, direct blending with diesel, transesterification. etc. [14-19].

Many investigations have been done on the utilization of biodiesel derived from different feed stock in diesel engine [20-22]. From those work it can be pointed out that the selection of biodiesel is very important. The biodiesel derived from non-edible feed stock is always a better choice due to food security issue because use of edible oil as feed stock of biodiesel will affect this issue critically. The different non-edible feed stock used for production of biodiesel is Jatropha curcas, karanja, tobacco seed, rice bran, mahua, neem, rubber Plant, castor, linseed, and microalgae [23-24], etc. In this chapter application of biodiesel derived by Jatropha oil is described. The bio-diesel thus produced is blended with waste lubricating oil at different volume proportions and tested in diesel engines.

2. Test Fuel

In the present study fuel was produced by transesterification process. In this process Jatropha oil reacts with alcohol in the presence of suitable catalyst. The process yields biodiesel. In this research work discarded lubricating oil was blended with Jatropha biodiesel to use in diesel engine. The designations of the test fuels and their compositions used in this study are given below.

3. Experimental setup

The test was carried out on a single cylinder, four stroke, naturally aspirated, air cooled, DI diesel engine which has a maximum power out of 4.4 kW. The test engine specifications are provided in Table 1.

Table 1 Test Engine Specification

Type	Kirloskar TAF1 Vertical diesel engine
No. of cylinder	1
Type of injection	Direct
Rated power at 1500 rpm, kW	4.41
Bore, mm	87.5
Stroke, mm	110
Compression ratio	17.5
Displacement volume, litres	0.662
Fuel injection timing bTDC, °CA	23
Number of injector nozzle holes	3
Nozzle-hole diameter, mm	0.25
Inlet valve opening bTDC, °CA	4.5
Inlet valve closing aBDC, °CA	35.5
Exhaust valve opening bBDC, °CA	35.5
Exhaust valve closing aTDC, °CA	4.5
Type of fuel injection	Pump-line-nozzle injection system
Connecting rod length, mm	220

4. Result and Discussions

This section discusses the results of the performance and emission parameters obtained from the test engine run on diesel, JME and different JME-UTO blends.

4.1. Performance parameters

4.1.1. Brake thermal efficiency

The brake thermal efficiency gives information regarding how efficient the energy in the fuel was converted into power output [25]. Figure 1 discusses about the efficiency of present engine when different test fuels were used. At full load the diesel gave highest brake thermal efficiency compared to all the test fuels used in the present study. This can be pertained to the higher calorific value of the diesel fuel compared among all test fuel used. The poor atomization of test fuels due to the higher viscosity may also be one of the causes for lower brake thermal efficiency than that of diesel. Among blends U20 produces highest brake thermal efficiency.

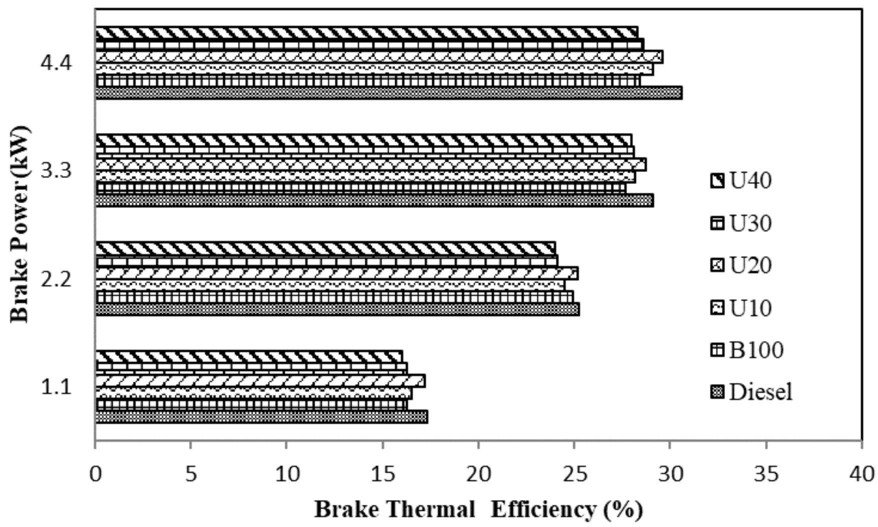

Figure 2 BP Vs BTE

4.1.2. Exhaust gas temperature

It can be seen from the figure that the EGT always increased with rise in engine load, because of the increase in fuel quantity injected. At full load the values of EGT are found to be about 303 and 335 C for diesel and the blend respectively. At full load the values of EGT are recorded as 325, 285, 298, 315 and 334 C respectively. The EGT value of the blend is lower up to nozzle opening pressure of 220 bar. This may be attributed to the distribution of the finer fuel droplet size distribution inside the combustion chamber, which encouraged homogeneous combustion at higher NOP of 220 bar. The EGT is found to be increased with the increase in the NOP after 220 bar. This may be due to the much finer droplet size that results in lesser fuel-air mixing leading to the occurrence of premixed heat release further away from the TDC, which increased the EGT.

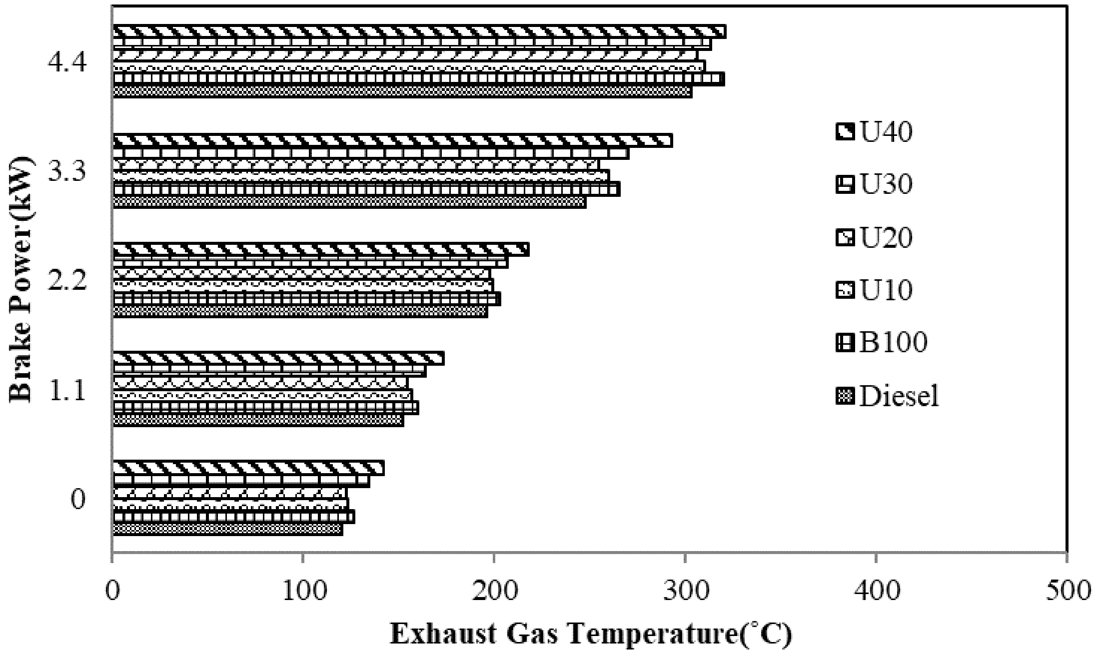

Figure 3 BP Vs EGT

4.2.1. CO Emission

The trend for CO emission is shown in Fig. 2. The formation of CO occurs due to incomplete combustion of fuel. If enough oxygen will not be available, then CO emission will form. But availability of enough oxygen generates CO2 [26]. The value of CO emission at full load for the diesel, JME, U10, U10, B15 and U20 blend was found to be 0.044, 0.035, 0.037, 0.04, 0.046 and 0.052%.

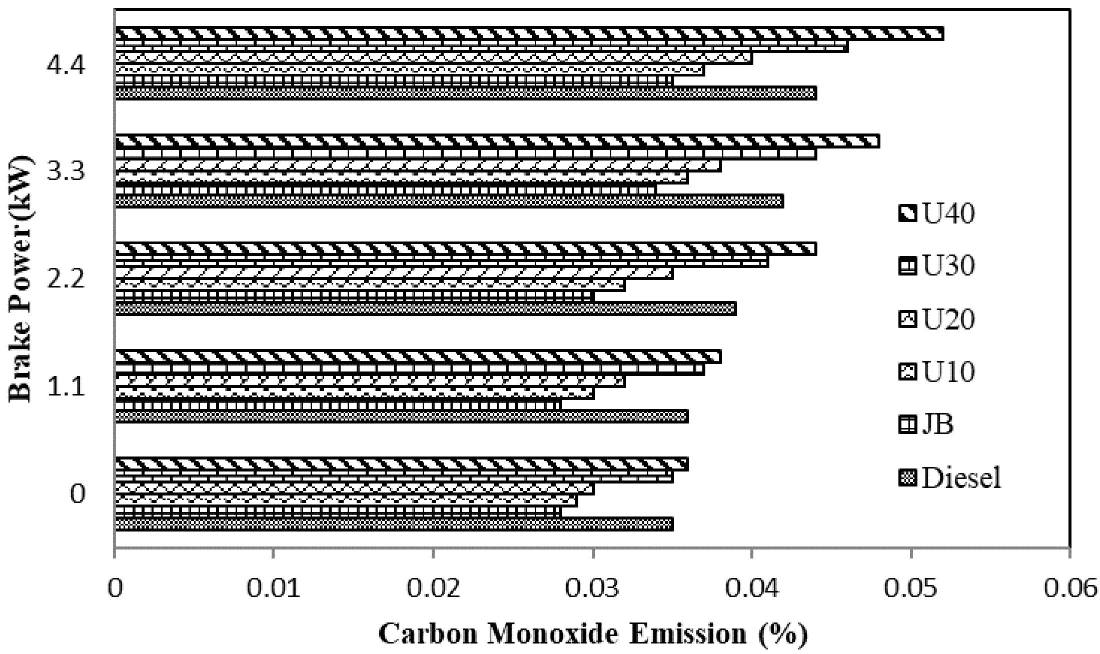

Figure 4 BP Vs Carbon monoxide emission

The CO emission for the JME, U10 and U20 is marginally lower than those of diesel fuel. The reason for this can be say due to oxygen of JB. This may be due presence of aromatic content which results in incomplete combustion and may lead to higher CO emission [27].

4.2.2. HC Emission

The variation of hydrocarbon (HC) emission for diesel, JME and different test fuel blends is shown in Fig. 3. It is observed that hydrocarbon emission increases with the increase in percentage of UTO in the JME-UTO blends. The HC emission is lowest for JME and it was about 18 ppm at full load operation. This can be due to oxygen molecule present in biodiesel [28]. The highest value of HC emission was obtained with U20 blend and was noticed to be 31 ppm. But the addition of the tire derived liquid percentage results in higher HC emission. This is since UTO has higher aromatic content, and hence may result in incomplete combustion and more HC emission for B15 and U20 compared to the other test fuels used in this study. The HC values for diesel, JME, U10, U20, U30 and U40 are 23, 18, 19, 21,25 and 31 ppm are at full load.

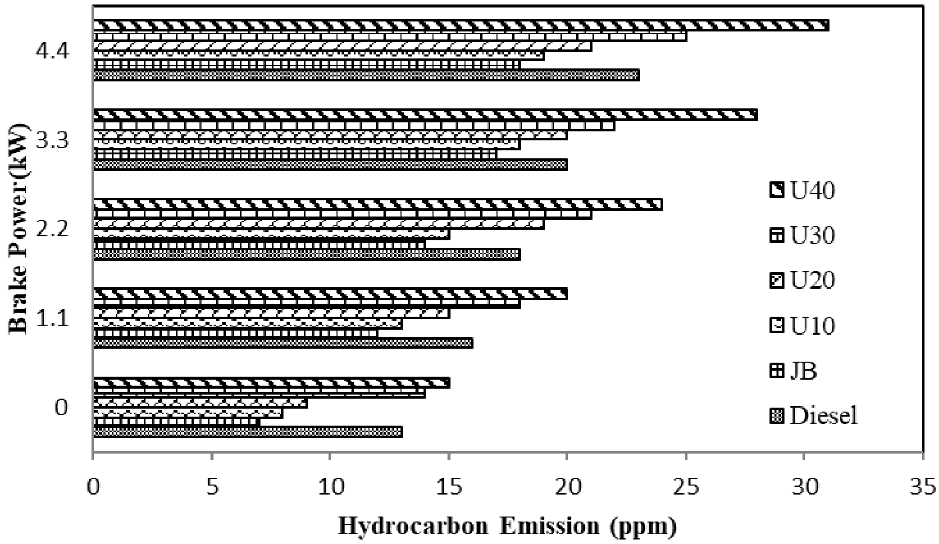

Figure 5 BP Vs Hydrocarbon emission

4.2.3. Soot Concentration

The soot concentration depends on the how combustion takes place. i.e. the incomplete burning of the hydrocarbon fuel, and partially reacted carbon content in the liquid fuel [29]. The results of soot particles are depicted in Fig. 6 at standard compression ratios. It is apparent from the figure that the smoke opacity grows with rise in the engine load due to the overall richer combustion, longer duration etc.

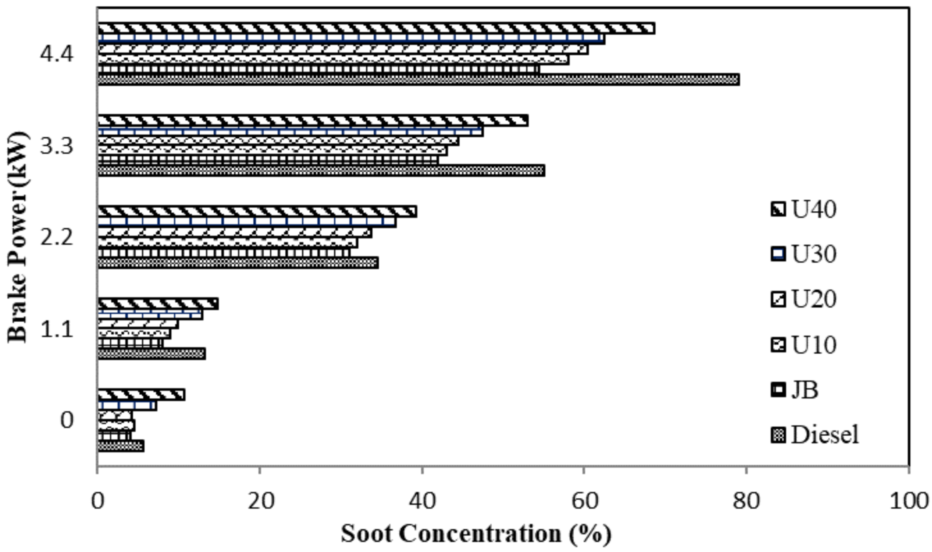

Figure 6 BP Vs Soot Concentration

Conclusion

Overall, we can conclude that if we use waste lubricating oil then not only we are solving the waste disposal problem also replacing the diesel fuel.

Reference

[1] Bridjanian H, Sattarin M. Modern recovery methods in used oil re-refining. Petroleum & Coal. 2006; 48(1):40-3.

[2] Diphare MJ, Muzenda E, Pilusa TJ, Mollagee M. A comparison of waste lubricating oil treatment techniques. International Conference on Environment, Agriculture and Food Sciences (ICEAFS'2013).

[3] Peter SC. Reduction of CO2 to Chemicals and Fuels: A Solution to Global Warming and Energy Crisis. ACS Energy Letters. 2018 Jun 13; 3(7):1557-61.

[4] Georgescu-Roegen N. Energy analysis and economic valuation. In Green Accounting 2018 Jan 12 (pp. 75-110). Routledge.

[5] Alexander S, Yacoumis P. Degrowth, energy descent, and 'low-tech'living: Potential pathways for increased resilience in times of crisis. Journal of cleaner production. 2018 Oct 1; 197:1840-8.

[6] Bonyadi N, Johnson E, Baker D. Technoeconomic and exergy analysis of a solar geothermal hybrid electric power plant using a novel combined cycle. Energy conversion and management. 2018 Jan 15; 156:542-54.

[7] Basu P. Biomass gasification, pyrolysis and torrefaction: practical design and theory. Academic press; 2018 Jun 29.

[8] Hosseini, S.E. and Wahid, M.A. Necessity of bio-diesel utilization as a source of renewable energy in Malaysia.

Renewable and Sustainable Energy Reviews, Volume 16 Issue 8 (2012), 5732–5740.

[9] Lloyd, A,C. and Cackette, T.A. Diesel engines: environmental impact and control. Journal of the Air & Waste Management Association, Volume 51 Issue 6 (2001), 809-847.

[10] Kannan, M., Karthikeyan, R., Deepanraj, B. and Baskaran, R. Feasibility and performance study of turpentine fueled DI diesel engine operated under HCCI combustion mode. Journal of Mechanical Science and Technology, Volume 28 Issue 02 (2014) 729-737.

[11] Haldar, S.K., Ghosh, B.B. and Nag A. Studies on the comparison of performance and emission characteristics of a diesel engine using three degummed non-edible vegetable oils. Biomass and Bioenergy, Volume 33 Issue 8 (2009), 1013-1018.

[12] Saravanan, S., Nagarajan, G., Lakshmi Narayana Rao, G. and Sampath, S. Feasibility study of crude rice bran oil as a diesel substitute in a DI-CI engine without modifications. Energy for Sustainable Development, Volume 11 Issue 03 (2007) 83-92.

[13] Mehta RN, Chakraborty M, Mahanta P, Parikh PA. Evaluation of fuel properties of butanol– biodiesel–diesel blends and their impact on engine performance and emissions. Industrial & Engineering Chemistry Research. 2010 Jul 15; 49(16):7660-5.

[14] Hulwan DB, Joshi SV. Performance, emission and combustion characteristic of a multicylinder DI diesel engine running on diesel–ethanol–biodiesel blends of high ethanol content. Applied Energy. 2011 Dec 31; 88(12):5042-55.

[15] Kannan D, Pachamuthu S, Nabi MN, Hustad JE, Løvås T. Theoretical and experimental investigation of diesel engine performance, combustion and emissions analysis fuelled with the blends of ethanol, diesel and jatropha methyl ester. Energy Conversion and Management. 2012 Jan 31; 53(1):322-31.

[16] Prakash R, Singh RK, Murugan S. Experimental investigation on a diesel engine fueled with bio-oil derived from waste wood–biodiesel emulsions. Energy. 2013 Jun 15; 55:610-8.

[17] Imtenan S, Masjuki HH, Varman M, Kalam MA, Arbab MI, Sajjad H, Rahman SA. Impact of oxygenated additives to palm and jatropha biodiesel blends in the context of performance and emissions characteristics of a light-duty diesel engine. Energy Conversion and Management. 2014 Jul 31; 83:149-58.

[18] Sanjid A, Masjuki HH, Kalam MA, Rahman SA, Abedin MJ, Reza MI, Sajjad H. Experimental investigation of palm-jatropha combined blend properties, performance, exhaust emission and noise in an unmodified diesel engine. Procedia Engineering. 2014 Dec 31; 90:397-402.

[19] Sanjid A, Masjuki HH, Kalam MA, Rahman SA, Abedin MJ, Palash SM. Production of palm and jatropha based biodiesel and investigation of palm-jatropha combined blend properties, performance, exhaust emission and noise in an unmodified diesel engine. Journal of Cleaner Production. 2014 Feb 15; 65:295-303.

[20] Imtenan S, Masjuki HH, Varman M, Fattah IR, Sajjad H, Arbab MI. Effect of n-butanol and diethyl ether as oxygenated additives on combustion–emission-performance characteristics of a multiple cylinder diesel engine fuelled with diesel–jatropha biodiesel blend. Energy Conversion and Management. 2015 Apr 30; 94:84-94.

[21] Senthilkumar P, Sankaranarayanan G. Effect of Jatropha methyl ester on waste plastic oil fueled DI diesel engine. Journal of the Energy Institute. 2015 Sep 3.

[22] Nalgundwar A, Paul B, Sharma SK. Comparison of performance and emissions characteristics of DI CI engine fueled with dual biodiesel blends of palm and jatropha. Fuel. 2016 Jun 1; 173:172-9.

[23] Kalnes TN, Shonnard DR, Schuppel A. LCA of a spent lube oil re-refining process. InComputer Aided Chemical Engineering 2006 Jan 1 (Vol. 21, pp. 713-718). Elsevier.

[24] Li S, Devlin MT, Liesen GP, West CT, Jao TC. Low Temperature Rheology of Engine Lubricants: Investigation of High Used Oil Pumping Viscosity. SAE transactions. 2000 Jan 1:2895-905.

[25] Arpa O, Yumrutas R, Demirbas A. Production of diesel-like fuel from waste engine oil by pyrolitic distillation. Applied Energy. 2010 Jan 1; 87(1):122-7.

[26] Arpa O, Yumrutas R. Experimental investigation of gasoline-like fuel obtained from waste lubrication oil on engine performance and exhaust emission. Fuel Processing Technology. 2010 Feb 1; 91(2):197-204.

[27] Meher LC, Sagar DV, Naik SN. Technical aspects of biodiesel production by transesterification-a review. Renewable and sustainable energy reviews. 2006 Jun 30; 10(3):248-68.

[28] Meher LC, Sagar DV, Naik SN. Technical aspects of biodiesel production by transesterification-a review. Renewable and sustainable energy reviews. 2006 Jun 30; 10(3):248-68.

[29] Sellnau M, Foster M, Moore W, Sinnamon J, Hoyer K, Klemm W. Pathway to 50% Brake Thermal Efficiency Using Gasoline Direct Injection Compression Ignition. SAE Technical Paper; 2019 Apr 2.

[30] Vidya Sagar Mishra | Dr. Nitin Tenguria "Experimental Analysis of a Diesel Engine Run on Different Biodiesel Fuel Blends" Published in International Journal of Trend in Scientific Research and Development, Volume-3 | Issue-2, February 2019, pp.1033-1036