Experimental Investigation of Performance & Emission Characteristics of 4 Stroke Single Cylinder CI Engine by using Palm Oil Biodiesel with Magnetic Energizer: A Review

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Abstract - The world today is faced with environmental pollution. As alternative fuel to diesel cold flow properties are the main issue for palm biodiesel usage. From the seeds of Palm tree, Palm seed oil can be obtained. .Due to increasing demands of hygienic products, cosmetics, food etc. the palm biodiesel industry has been growing over the last decades. The discovery resides in the field of hydrocarbon fuel treatment in liquid or gaseous form, to increase fuel-burning efficiency. Hydrocarbon powers have since quite a while ago fanned geometric chains of carbon iotas which tend to crease over onto themselves. When hydrocarbon fuels flow through the powerful magnetic field, intermolecular forces is considerably reduced hence oil particles are finely divided, thus magnetic effect reduce fuel consumption. The purpose of this study is to analyze the biodiesel fuel characteristics due to the exposure of the magnetic fields of these fuel molecules.

Key Words: Palm biodiesel, fuel magnetizer, emission, efficiency, performance

1. INTRODUCTION

Biodiesel viscosity is the most important property for starting combustion of fuel droplets into combustion chambers of the engine cylinder [J.Azagaral et al, 2014]. According to outlook for energy (2018 Outlook for energy, 2018), the world's population will reach about 9 billion from about 7.2 billion today by 2040. It is expected that oil will still be predominant in 2040, so that, there is a need to increase the supply of energy for transportation sectors [M.A.Ghadikolaci et al,2019].

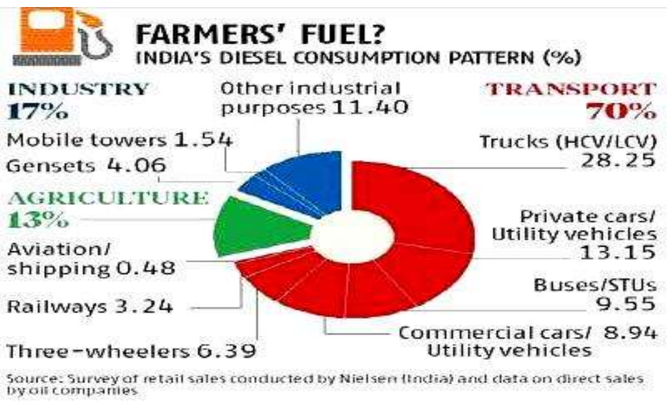

Figure 1.1 Sector wise diesel consumption (%)**[13]**

The use of biofuels policies encouraging have been introduced by several developed countries. For economic activity, energy is an essential and vital input. For the sustainable economic and social development of the country, it is a important factor to build a strong base of the energy resources [Venkata Ramesh Mamilla et al, 2012]. The application of diesel engine is also rising in other sectors like Agriculture, Industry, Aviation, Shipping etc. The Fig.1.1 shows key consumer of mineral diesel. It has been found that around 70% of diesel is being consumed in transport sectors [N. Acharya et al, 2017]

1.1 EFFECT OF EXHAUST EMISSION ON HUMAN HEALTH

The vehicular emission contains different harmful gases like carbon monoxide, carbon dioxide, oxides of nitrogen, oxides of sulphur, unburnt hydrocarbon and smoke, which affect the human health adversely. The impact of these gases/components on human health is outlined below **[14][15].**

Carbon Monoxide

The formation of carbon monoxide occurs due to incomplete combustion of fuel in the engine. It is an odourless and colourless gas which is toxic and harmful to the human body. If it reaches the bloodstream, it forms carboxyhaemoglobin and reduces the flow of oxygen in blood and may cause death.

Carbon Dioxide

It does not affect the health directly, but it is a greenhouse gas and the cause of global warming.

Sulphur Dioxide

As mineral diesel contains some amount of sulphur, it's burning causes formation of oxides of sulphur. When it comes in contact with atmospheric moisture and sunlight, sulphuric acid is formed and it leads to acid rain. It causes and aggravates the respiratory problem like asthma.

Hydrocarbon

Formation of hydrocarbon results from incomplete combustion of fuel. Their subsequent reaction with sunlight causes smog and ground-level ozone formation. The ozone reacts with tissues of the lung, causing inflammation which leads to decrease in its working ability and congestion of chest.

Oxides of Nitrogen

The oxides of nitrogen (NOx) refer to both NO and NO2. The NOx formation occurs at temperature around 17000C. At this temperature nitrogen and oxygen react as per Zeldovic mechanism. NOx is the major cause of formation of smog, acid rain and ground layer ozone. The NOx affect human health in the same way as sulphur dioxide and ozone.

Smoke

The Smoke in exhaust emission is caused due to the presence of tiny suspended particles. The higher concentration of smoke affects the respiratory passage of the human body and may cause irritation in the nose and throat.

Toxic Air Pollutants

There are some pollutants like benzene and formaldehyde emitted from engine exhaust are called toxic air pollutants. These are supposed to be the cause of cancer, genetic mutation, birth defect, etc.

1.2 What is bio-diesel?

Biodiesel is an elective fuel like regular or 'fossil' diesel. Biodiesel can be delivered from straight vegetable oil, creature oil/fats, fat and waste cooking oil. The procedure used to change over these oils to Biodiesel is called transesterification. The biggest conceivable wellspring of reasonable oil originates from oil yields, for example, rapeseed, palm or soybean. In the UK rapeseed speaks to the best potential for biodiesel creation. Most biodiesel created at present is delivered from squander vegetable oil sourced from eateries, chip shops, mechanical nourishment makers, for example, Birdseye and so on. In spite of the fact that oil directly from the farming business speaks to the best potential source it isn't being created economically essentially on the grounds that the crude oil is excessively costly. After the expense of changing over it to biodiesel has been included it is just too costly to even think about competing with fossil diesel. Squander vegetable oil can frequently be sourced for nothing or sourced effectively treated at a little cost. (The waste oil must be treated before change to biodiesel to expel debasements). The outcome is Biodiesel created from squander vegetable oil can rival fossil diesel.

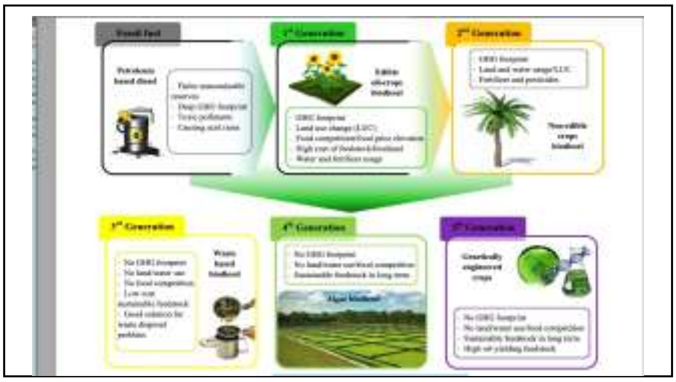

Figure 1.2 Classification of Biofuel Feedstock

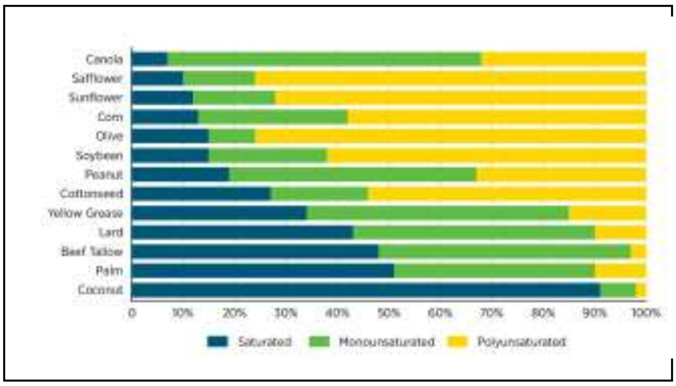

Figure 1.3 Composition of various biodiesel feedstocks in order of increasing saturated fatty acid content [16]

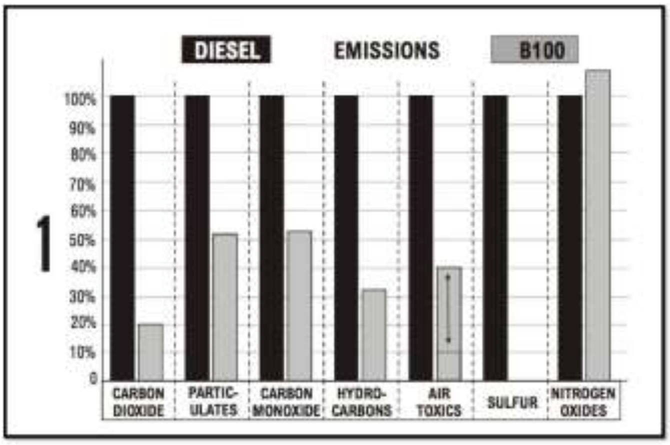

Figure 1.4 Bio-fuel Vs Diesel Emissions

2. Literature Review

Venkata Ramesh Mamilla, M.V.Mallikarjun, Dr.G.Lakshmi Narayana Rao, 2013

In this paper, they investigated Jatropha methyl esters with diesel. They studied the performance and emission characteristics of the diesel engine with different combustion chamber geometries (spherical, toroidal and re-entrant). Brake thermal efficiency for the toroidal combustion chamber was found higher than of the other two combustion chambers. In view of brake warm effectiveness

B20 and B40 mixes are superior to B100. B20 Jatropha methyl ester have better brake thermal efficiency compared to diesel. Smoke density, carbon monoxide and hydrocarbon was lower for toroidal combustion chamber **[1].**

Swarup Kumar Nayak, Bhabani Prasanna Pattanaik ,2014

In this paper, they studied the production of biodiesel from neat mahua oil. The biodiesel prepared by catalyzed transesterification and used dimethyl carbonate as additive. All the test results significantly improved with an increase in the additive percentage in biodiesel **[2].**

M. Mofijur, Mohammad Rasul, N.M.S. Hassan, M. N. Uddin (2019) Science direct

Emissions study of a diesel engine using waste cooking biodiesel as an alternative fuel. The biodiesel was produced through the conventional transesterification process using the base catalyst (KOH). A multi-cylinder diesel engine was used to evaluate the emission of 20% (B20) waste cooking biodiesel fuel at different engine speeds and full load conditions. Engine emission results indicated that waste cooking biodiesel fuel sample reduces the average carbon monoxide (CO) and particulate matter (PM) emissions except nitrogen oxides (NOx) than diesel fuel. The authors concluded that 20% of waste cooking biodiesel can significantly contribute to lowering the harmful emission of an unmodified stationary diesel engine to the environment **[3].**

K.A. Abed, M.S. Gad, A.K. El Morsi, M.M. Sayed, S. Abu Elyazeed (2019)

A study was performed on the effect of Biodiesel blends produced from algae, Jatropha, palm and waste cooking oil named AB10, AB20, JB10, JB20, PB10, PB20, WCOB10, and WCOB20, respectively. Exhaust emissions such as CO, CO2, NOx, HC, and smoke are measured and compared with diesel oil. It was observed that CO emission decreased with the increase in of engine load at part load. Lower CO2 emissions were noticed for all examined biodiesel blends Jatropha, palm and algae as compared to diesel oil. The reduction in CO2 emission was explained in terms of the higher oxygen content in biodiesel blends Jatropha, algae, and palmas compared to diesel oil. The increase in CO2 emission was due to the higher oxygen content in waste cooking oil biodiesel blends compared to diesel oil. CO, HC, CO2, and smoke emissions are lower for biodiesel blends B10 and B20 (Jatropha, algae and palm) thought about ''to diesel fuel''. CO2 emissions from biodiesel mixes B10 and B20 created from squander cooking oil are higher contrasted with diesel fuel. NOX emissions from all biodiesel mixtures B10 and B20 increases than diesel fuel for all biodiesel blend B10 and B20.NOx emissions for all biodiesel blends were higher than diesel oil **[4].**

A.M. Liaquat, H.H. Masjuki, M.A. Kalam, M. Varman, M.A. Hazrat, M. Shahabuddin, M. Mofijur (2012) Science direct

In this study, the engine performance and emissions characteristics of the diesel engine with Jatropha biodiesel and its blends such as JB5, JB10, and J5W5 were investigated and compared with diesel fuel. The torque of the motor fuelled with DF is higher than that of mix energizes. Over the whole speed run, the normal torque decrease contrasted with DF is found as 0.63% for JB5, 1.63% for JB10 and 1.44% for J5W5. Motor torque and brake control for mix energizes were diminished when contrasted with diesel fuel, principally because of their particular lower warming qualities. Nonetheless, J5W5 indicated a lower decrease contrasted with JB10. The bsfc for the tried energizes is found somewhat higher than that for DF. The bsfc values for mix powers were higher than that of DF because of lower warming qualities and higher densities. It is likewise noticed that at some lower motor speeds, the bsfc values for mix fills were discovered lower than that of DF on account of the improved burning due to the innately oxygen-containing.In the instance of motor fumes gas emissions, decrease in HC, CO, and CO2 were found for JB5, JB10 and J5W5 when contrasted with DF at both motor working conditions. While, NOx emanation for all mix energizes was expanded when contrasted with DF. However, J5W5 was found to be comparable with JB10 and produced better results except for NOx **[5].**

Ashok Kumar Yadav, Mohd Emran Khan, Alok Manas Dubey, Amit Pal (2016) Science direct

Studied the performance and emission of a four-cylinder, four-stroke, water-cooled engine fuelled with a blend of methyl esters of Oleander, Kusum and Bitter. They prepared biodiesel from different non-edible oils Such as Oleander, Kusum, and Bitter Groundnut were prepared by the transesterification process. The biodiesels Oleander oil methyl esters (OOME), Kusum oil methyl esters (KOME) and bitter Groundnut Oil Methyl Esters (BGOME) Showed poor performance compared to diesel fuel. Results demonstrated that the brake thermal efficiency of OOME is found higher and brake specific fuel utilization lower contrasted with KOME and BGOME. BGOME shows less consumption. Among the tested biodiesels, KOME showed the least BTE (19.7%), while OOME the maximum efficiency (20.20%) at a speed of 2900 rpm. compared to diesel (22.5%). Further increase in rpm decreases the brake thermal efficiency for a wide range of engine rpm **[6].**

R. El-Araby, Ashraf Amin , A.K. El Morsi, N.N. El-Ibiari , G.I. El-Diwani (2018) Science direct

This study has discussed the study of Palm oil/palm oil methyl esters are blended with diesel fuel as an alternative fuels for diesel engines. Palm oil/palm oil methyl ester was added in volume percentages of 5%, 10%, 15%, 20%, and 30%. This paper provides an experimental determination of density, viscosity, and flashpoint for palm oil, palm oil biodiesel and their blends with diesel fuel.

This paper provides an experimental determination of density, viscosity and flash point for palm oil, palm oil biodiesel and their blends with diesel fuel. Diesel was blended with Palm oil and palm oil biodiesel. The properties of both blends were estimated. The results showed that the fuel properties of the blends were very close to that of diesel till 30% unless other characteristics are within the limits **[7].**

Table 2.1

Comparison of fuel properties according to ASTM

Fuel Property	Diesel	Biodiesel
Fuel composition	C_{10}-C_{21} HC	C_{12}-C_{22} FAME
Density @ 15 °C, g/ml	0.848	0.978
Kin. viscosity @40 °C, mm²/s	1.3-4.1	1.9-6
Flash point, °C	60–80	100–170

Table 2.2

Properties of diesel fuel, palm oil and palm oil biodiesel.

Property	Palm oil	Palm oil Methyl ester	Diesel
Density @15 °C, g/ml	0.925	0.877	0.827
Kin. viscosity @40 °C, mm²/s	41	4.56	2.28
Flash point, °C	260	196	64

Table 2.3

Properties of palm oil with different blends and diesel.

Fuel	Density @15 "Cg/ ml	Kinematic viscosity @40 "C mm²/s	Flash point, "C
Diesel	0.827	2.28	64
B5	0.827	2.48	66
B10	0.835	2.73	69
B15	0.84	3.06	70
B20	0.845	3.33	72
B30	0.8553	3.4	74
B100	0.925	41	260

Table 2.4

Properties of palm oil methyl esters (Biodiesel) with different blends and diesel.

Fuel	Density @15 "Cg/ ml	Kinematic viscosity @40 "C, mm²/s	Flash point, "C
Diesel	0.827	2.28	64
B5	0.83	2.34	66
B10	0.833	2.49	69
B15	0.834	2.67	70.5
B20	0.835	2.82	71.5
B30	0.841	2.85	82.0
B100	0.877	4.56	196

Siddharth Jain, M.P. Sharma (2010) Science direct

Reported that the research on the production of biodiesel from Jatropha in India. JOME produced from jatropha oil was blended with diesel at various loads. A study has dealt with AHEC, IIT Roorkee with the production of biodiesel from Jatropha oil and performance evaluation of 2 kVA DG set on blends of biodiesel and diesel at various loads.

The brake thermal efficiency is discovered higher up to B30 in contrast with diesel while BTE of B100 (24%) nearly rose to diesel (24.5%) for JOME.

While the brake specific fuel consumption for B100 was 14.8% higher than diesel for biodiesel from Jatropha oil at full load. The brake thermal efficiency for B10 (25.8%), B20 (25.2%) and B30 (24.6%) was found about 1.3%, 0.7% and 0.1% higher than diesel, respectively. Results showed that B30 has the higher performance to diesel and B100 has almost equal to diesel **[8].**

Piyush M Patel, Prof. Gaurav P Rathod,Prof. Tushar M Patel (2014)

This paper show the performance of four-Stroke diesel engine performance and emissions measure first without magnet situation and then with magnet situation, and results are compared. The experimental results show that the fuel consumption of engine is less when the engine with magnet reduction in fuel consumption is about 8% at higher load.The Brake Thermal Efficiency of engine is less when the engine with magnetizer than that without fuel magnetizer at higher load. The percentage reduction in HC and NOX is about 30% and 27.7 % respectively. The percentage reduction in CO2 emissions is reduced about 9.72% at average of all loads with the effect of magnetic field. Here the magnetic field shows adverse effect **[9].**

Mayur S. Raut, Siddharth S. Uparwat , Prof. Chandradeep Nagaralere (2017).

This paper shows the effects of the magnetic field on fuel consumption in single-Stroke Diesel Engine at the normal conditions when fuel is exposed to a magnetic field. The incomplete combustion affects the engine performance is due to the improper mixing of hydrocarbon and oxygen molecules. In this work to improve the combustion efficiency, the magnet is used by adopting a magnetic fuel ionization method in which the fuel is ionized due to the magnetic field. From the experimental results, the brake specific fuel consumption gets decreased with magnet, fuel and thermal efficiency of the engine get increased with the use of magnet **[10] .**

Ali S. Faris, Saadi K. Al-Naseri, Nather Jamal, Raed Isse, Mezher Abed, Zainab Fouad, Akeel Kazim, Nihad Reheem, Ali Chaloob, Hazim Mohammad, Hayder Jasim, Jaafar Sadeq, Ali Salim, Aws Abas (2012)

This paper shows that emissions in the Two-Stroke Engine when fuel is exposed to a magnetic field. Magnetic treatment needn't bother with vitality and consequently be economically feasible. From the experimental investigation, it is found that the brake specific fuel consumption reduce up to 14%, and the thermal efficiency of the engine gets increased with use of the magnet. It was found that the percentages of exhaust gas components (CO, HC) were decreased by 30%, 40% respectively, but CO2 percentage increased up to 10% **[11].**

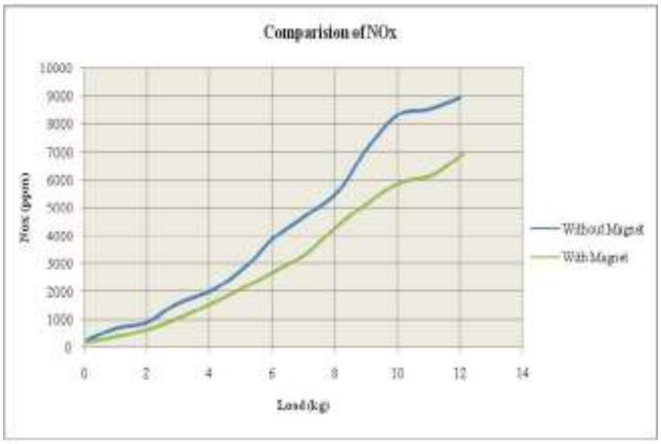

Figure 2.1 Variation of NO X (ppm) with load **[9]**

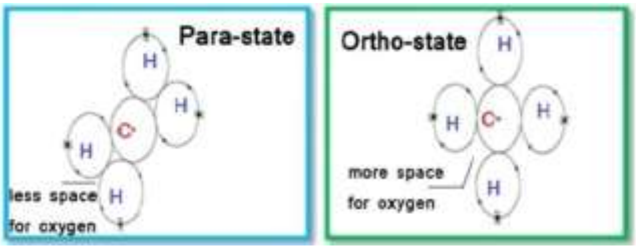

Figure 2.2 State of diesel molecule **[10]**

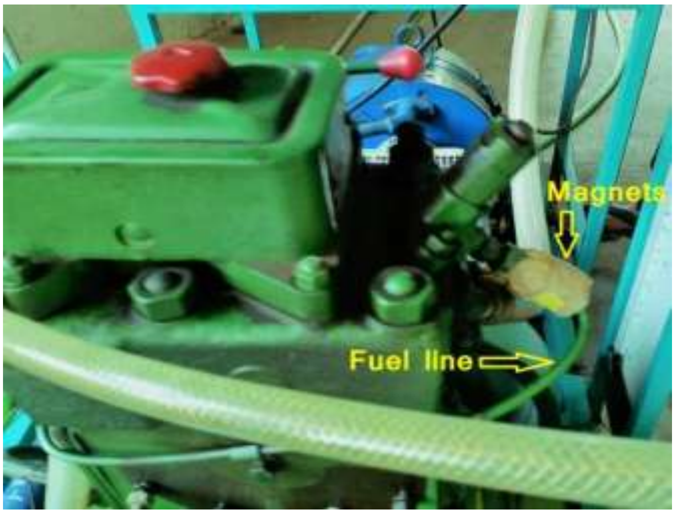

Figure 2.3 Experimental setup [**10]**

Chia-Yang Chen, Wen-Jhy Lee, John Kennedy Mwangi1, Lin-Chi Wang, Jau-Huai Lu (2017)

In this paper study, the impact of the magnetic tube on pollutant emissions from the diesel engine, the magnetic tube is set up at the fuel intake of a diesel generator at the ideal condition with a constant speed of 1800 rpm, 50% and 25% loads. From experimental, it is found that the brake specific fuel consumption and fuel consumption were decreased by an average of 3.5% and 15%, respectively, while the brake thermal efficiency was improved by approximately 3.5%.

The particulate matter, carbon monoxide, hydrocarbons and carbon dioxide emissions decreased in the scope of 21.9–33.3%, 5.4–11.3%, 29.4–64.7% and 2.68–4.18%, individually [12].

3. RESEARCH GAP

From the literature review it's determined that additional analysis is needed on optimizing the blend and analyzing the performance and emission characteristics of biodiesel.

This project is basically about how to reduce diesel and biodiesel consumption in diesel engines with the use of magnets. Other than fuel consumption, magnet also helps in reducing unburned hydrocarbon in the emission. The magnet device clamped on the fuel line connected before the fuel injector and run the engine that helps in reducing the emission & gives proper combustion.

4. OBJECTIVES

- To choose Best bio-diesel that having nearly same properties as Diesel have.
- To investigate result of various mix on the performance of 4 stroke single cylinder internal-combustion engine.

- To analyse the Presence of NOx, CO2, ,CO from exhaust gas emission by using bio-diesel.
- To understand the effect of magnet on the performance of I.C.engine by attaching it in fuel line pipe. in pipe pipe.

5. FUTURE SCOPE

Based on the literature survey, the subsequent suggestions are made for future intervention in the field of Biodiesel creation.

Acknowledgment of the Kyoto convention and clean improvement instrument (CDM) will prompt more biodiesel creation around the globe. Generation of biodiesel is growing quickly, determined by vitality security and other ecological concerns. Given geographic differences among request and supply potential and supply cost, extended exchange biodiesel bodes well. The worldwide potential for biodiesel creation isn't clear, however it could supply a considerable level of transport fuel request. With the expansion in worldwide human populace, progressively agrarian land will be expected to create nourishment for human utilization. In this manner, the insufficient grounds could build the generation cost of biodiesel feedstock. These issues are previously being knowledgeable about Asia where vegetable oil costs are generally high. A similar pattern will inevitably happen in the remainder of the world. In this manner, non-eatable oil, hereditarily designed plants, and microalgae feedstock are potential answers for this issue and can guarantee the manageability of biodiesel generation in what's to come. Supporting approaches are critical to advance biodiesel research and make their costs focused with other traditional wellsprings of vitality. Further advancements in the utilization of side-effects will improve the financial practicality of the biodiesel generation process generally speaking.

Further research is required to decrease the NOx emissions by using different fuel additives or different types of fuel magnetizers.

6. CONCLUSIONS

Biodiesel received much more attention because of its environmental benefits and economic as well as its availability in the form of natural resources.

Biodiesel delivered from non-consumable oil normal assets can recognize the utilization of eatable oil for the generation of biodiesel.

The emission of sulfur dioxide SO2 is reduced by using palm oil methyl ester. CO and HC emissions are highest for diesel and lowest for biodiesel because of higher oxygen content. Most researchers resulted that the brake specific fuel consumption is highest for biodiesel at loads and exhaust gas temperature is found higher for biodiesel. Palm - biodiesel having a high cetane number is crucial to ensure the biodiesel fuelled engine will operate smoothly with less noise. The Fuel magnetizer saves fuel by increasing combustion efficiency, less CO is being emitted; thereby, less fuel is being used. One of the main concerns for magnetizer is to lower CO, HC and NOx levels. Using a magnetic field increasing the engine thermal efficiency due to rise combustion efficiency within the combustion chamber. Using the magnetic field increased CO2 emissions as a result of improving combustion efficiency. Hence magnetic treatment of fuel on a very large scale will help to save fuel and to reduce environmental pollution.

REFERENCES

[1] V. Mamilla, M. Mallikarjun and G. Lakshmi Narayana Rao, "Effect of Combustion Chamber Design on a DI Diesel Engine Fuelled with Jatropha Methyl Esters Blends with Diesel", Procedia Engineering, vol. 64, pp. 479-490, 2013. Available: 10.1016/j.proeng.2013.09.122.

[2] S. Nayak and B. Pattanaik, "Experimental Investigation on Performance and Emission Characteristics of a Diesel Engine Fuelled with Mahua Biodiesel Using Additive", Energy Procedia, vol. 54, pp. 569-579, 2014. Available: 10.1016/j.egypro.2014.07.298.

[3] M. Mofijur, M. Rasul, N. Hassan and M. Uddin, "Investigation of exhaust emissions from a stationary diesel engine fuelled with biodiesel", Energy Procedia, vol. 160, pp. 791-797, 2019. Available: 10.1016/j.egypro.2019.02.159.

[4] K. Abed, M. Gad, A. El Morsi, M. Sayed and S. Elyazeed, "Effect of biodiesel fuels on diesel engine emissions", Egyptian Journal of Petroleum, vol. 28, no. 2, pp. 183-188, 2019. Available: 10.1016/j.ejpe.2019.03.001.

[5] A. Liaquat et al., "Application of blend fuels in a diesel engine", Energy Procedia, vol. 14, pp. 1124-1133, 2012. Available: 10.1016/j.egypro.2011.12.1065.

[6] A. Yadav, M. Khan, A. Dubey and A. Pal, "Performance and emission characteristics of a transportation diesel engine operated with non-edible vegetable oils biodiesel", Case Studies in Thermal Engineering, vol. 8, pp. 236-244, 2016. Available: 10.1016/j.csite.2016.08.001.

[7] R. El-Araby, A. Amin, A. El Morsi, N. El-Ibiari and G. El-Diwani, "Study on the characteristics of palm oil–biodiesel–diesel fuel blend", Egyptian Journal of Petroleum, vol. 27, no. 2, pp. 187-194, 2018. Available: 10.1016/j.ejpe.2017.03.002.

[8] S. Jain and M. Sharma, "Prospects of biodiesel from Jatropha in India: A review", Renewable and Sustainable Energy Reviews, vol. 14, no. 2, pp. 763-771, 2010. Available: 10.1016/j.rser.2009.10.005.

[9] P. M Patel, "Effect of magnetic field on performance and emission of single cylinder four stroke diesel engine", IOSR Journal of Engineering, vol. 4, no. 5, pp. 28-34, 2014. Available: 10.9790/3021-04552834.

[10] Mayur S. Raut, " Experimental Inspection by using the Effect of Magnetic Field on the Performance of Diesel Engine" International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 03 | Mar - 2017 Available: e-ISSN: 2395 -0056

[11] A. Faris et al., "Effects of Magnetic Field on Fuel Consumption and Exhaust Emissions in Two-Stroke Engine", Energy Procedia, vol. 18, pp. 327-338, 2012. Available: 10.1016/j.egypro.2012.05.044.

[12] C. Chen, W. Lee, J. Mwangi, L. Wang and J. Lu, "Impact of Magnetic Tube on Pollutant Emissions from the Diesel Engine", Aerosol and Air Quality Research, vol. 17, no. 4, pp. 1097-1104, 2017. Available: 10.4209/aaqr.2016.11.0478.

[13] N. Acharya, P. Nanda, S. Panda, and S. Acharya, "Analysis of properties and estimation of optimum blending ratio of blended mahua biodiesel," Eng. Sci. Technol. an Int. J., vol. 20, no. 2, pp. 511–517, 2017.

[14] E. Sadeghinezhad et al., "A comprehensive literature review of bio-fuel performance in internal combustion engine and relevant costs involvement," Renew. Sustain. Energy Rev., vol. 30, pp. 29–44, 2014.

[15] M. Mofijur, A. E. Atabani, H. H. Masjuki, M. A. Kalam, and B. M. Masum, "A study on the effects of promising edible and non-edible biodiesel eedstocks on engine performance and emissions production: A comparative evaluation," Renew. Sustain. Energy Rev., vol. 23, pp. 391–404, 2013.

[16] Teresa L. Alleman and Robert L. McCormick, "biodiesel handling use guide" National Renewable Energy Laboratory,November 2016.

[17] T Fuels. "Better Choice for Our Children-BIODIESEL." National Biodiesel Board - Www.biodiesel.org - Www.nbb.org. Web. 11 May 2010. <http://www.biodiesel.org>.

Abbreviations

ASTM American Society for Testing and Materials

FAME Fatty Acid Methyl Ester

FFA Free Fatty Acid

B0 Pure Diesel

B100 Pue biodiesel

NOx Nitrogen oxides

HC Hydro carbon