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Comparative Investigation of Exhaust Emissions of Variable Compression Ratio Engine Utilizing Blends of Linseed Oil Biodiesels, Isopropyl Alcohol, Diethyl Ether with Standard Diesel

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ABSTRACT

Biodiesel is well known substitute fuel for combustion ignition engines. It can diminish the various harmful emissions like carbon monoxide (CO), hydrocarbon (HC) and particulate matter (PM) emissions; however it holds some draw back that includes increase in nitrogen oxides (NO_X) emission as compared with diesel fuel. The present work demonstrates the comparative study of exhaust emissions of a 4-stroke naturally aspirated variable compression ratio compression ignition engine utilizing biodiesel made from linseed oil and sesame oil. Various results of exhaust emissions are obtained through exhaustive experiments at compression ratio 17 and 18. Study showed that the linseed oil displayed the improved emission results in HC emissions and CO emissions whereas blend of isopropyl alcohol and diethyl ether displayed the better emissions of CO_2 and NO_X and standard diesel as well.

***Keywords*:** Variable compression ratio engine, linseed oil, isopropyl alcohol, diethyl ether, exhaust emission, biodiesels

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1. INTRODUCTION

Diesel fuel is the primary role player for a country's industrial economy. Widespread use of conventional fossil fuels give rise to in serious environmental contamination. From the point of view of serious concern for global environmental protection and long-term supply of conventional diesel fuel, it is advisable that extensive research and development should be done with special emphasis on various potential sources of petroleum products. Focus on production and quality of diesel fuel. Alternative diesel fuel should be technically sufficient, economically viable, ecologically acceptable and readily available. Specific researchers examined that the option of biodiesel fuel fuels is a strong challenge for the fuel option, which has led to significant reduction in exhaust emissions. [1-7]. The serious problem of conventional petroleum fuels is the increase in emissions of pollution, such as CO_2, HC, NO_X, SO_X and many other harmful exhaust gases. These gases are injurious to biodiversity with the effect of human health [8]. In recent years, many other social economic aspects have conducted research to develop alternative fuels from renewable resources which are cheap and environmentally suitable [9]. Biodiesel is one of the best choices. Alternative renewable use of vegetable oils in the form of fuel spread in the 1980s such as sunflower, palm, cotton, mustard, soybean, linseed, etc. has been made from oils of different types of oil crops. Biodiesel Fuels (Methanol or processed vegetable oil from ethanol) is a renewable fuel, so it is not poisonous and does not increase CO_2 level in the environment globally. There is absolutely no SO_X in the exhaust, and there is very little NO_X production. [10-14] However, due to the extensive study of waste, food and cooking oils using residues, the researchers were recently attracted to research [15,16].

Consequently, in existing work, the comparison of exhaust emissions of methyl esters of inedible oil (linseed oil) and isopropyl alcohol, diethyl ether blends using a variable compression ratio engine has been studied.

2. LITERATURE REVIEW

In a thorough review of literature, studies on emissions studies using divers alternative fuels were reviewed and the results of the research are concised as follows.

Durbin, T.D. et. al. [2000] utilized 80% California diesel / 20% biodiesel blend to examine the effects on emissions. The results showed the lower THC and CO release and increased NO_x release for biodiesel, the biodiesel blends [17].

M. hvadivu et. al. [2005] investigated discarded cooking oil as a substitute fuel for CI engine. The rise in NO_X release was noticed owing to high viscosity of the Waste cooking oil, while the CO was incremented (without preheating) and decreased with preheating [18].

S. Altun et. al. [2008] utilized similar proportions of blend of biodiesel of sesame oil and standard diesel and found the reduction in CO and NO_X emissions [19].

M.A. Kalam et. al. [2011] evaluated also emission characteristics using discarded cooking oil, experiment showed decline in HC,CO and NO_X emissions [20].

M. M. Roy et. al. [2013] utilized pure and used canola biodiesels (UCB) to investigate the emissions and discovered the higher percentage of the methyl ester in blends of biodiesel–

diesel, results in the lesser emissions of the CO and HC releases while NO_X release was bigger [21].

A. Dhar et. al. [2014] considered the influence of blends of biodiesel made from Karanja oil for exhaust emissions and investigated the reduction in CO and BSHC at higher engine speeds and loads [22].

Luka L. et. al. [2016] investigated that use of rapeseed oil gives decline in formatted CO and NO_x releases due to better oxidation [23].

V. Perumal et. al. [2017] examined that the use of pongamia methyl ester (PME) may definitely reduce the greenhouse gases at the same time the employability in the agricultural field. It was observed that the use of PME as fuel reduces CO and HC emissions whereas there is considerable reduction in NO_X emission [24].

3. MATERIALS AND METHODS

In the present work the various blends of fuel were prepared utilizing Isopropyl alcohol and diethyl ether with standard diesel fuel. All blends of the fuel samples were prepared (%by volume) in addition with standard diesel fuel. Proportions of Isopropyl alcohol were varied as 10%, 15% and 20% by volume while content of DEE kept constant as 5% by volume for all fuel samples. The various proportions of LME fuel were taken as 15%, 20% and 25% and blends were prepared as (LME15), (LME20) and (LME25) respectively by volume with respect to neat standard diesel. The other fuel samples were prepared using 5% diethyl ether, 10% Isopropyl alcohol by volume (IPD15), 5% diethyl ether 15% Isopropyl alcohol by volume (IPD20) and 5% diethyl ether 20% Isopropyl alcohol by volume (IPD25) with neat standard diesel.

Table 1. The fuel properties.

Fuel Properties	Density (kg/m3)	Viscosity (mm2/s)	Calorific (MJ/kg)	Cetane Number
LME15	832.8	3.156	45.781	48
LME20	833.1	3.214	45.521	48
LME25	833.7	3.271	44.981	48
LME100	835.8	4.256	38.17	47
IPD15	822.9	2.718	45.243	48
IPD20	818.95	2.498	43.971	46
IPD25	816.3	2.426	42.134	45
IPA100	781	1.3311	24.04	13
Diesel	832.6	2.946	47.231	48

On increasing quantity of diethyl ether in the blend, the oxygen content and cetane number of the fuel blend is increased accordingly whereas the kinematic viscosity and density of the fuel decreases. Furthermore the high volatility of diethyl ether may result in to vapor lock in fuel line associated with some instability and fluctuations in engine speed and power output.

These factors effect adversely on the engine performance. Blend consistency and stability were examined comprehensively. The main fuel properties of various blends and standard diesel fuel are shown in Table 1.

In the present experimental investigation a single cylinder, naturally aspirated, 4-stroke diesel engine was used to perform experiment. The engine was run at rated speed of 1500 rpm and compression ratio was varied at 17 and 18 under diverse load conditions. Fig. 1 shows the congfiguration of the engine set up. The engine specification is displayed in Table 2.

Table 2. Engine Specification

S.N.	Parameter	Specification
1	Make	Kirloskar, India
2	Product	VCR Engine Setup
3	Rated Brake Power (kw)	3.5
4	Rated Speed(rpm)	1500
5	Number of Cylinder	One
6	Bore (mm)	87.5
7	Stroke (mm)	110
8	Connecting Rod length (mm)	234
9	Swept volume (cc)	661.45
10	Compression Ratio(variable)	18
11	Fuel injection starts before TDC	230
12	Cooling System	Water Cooled
13	Lubrication System	Forced Feed

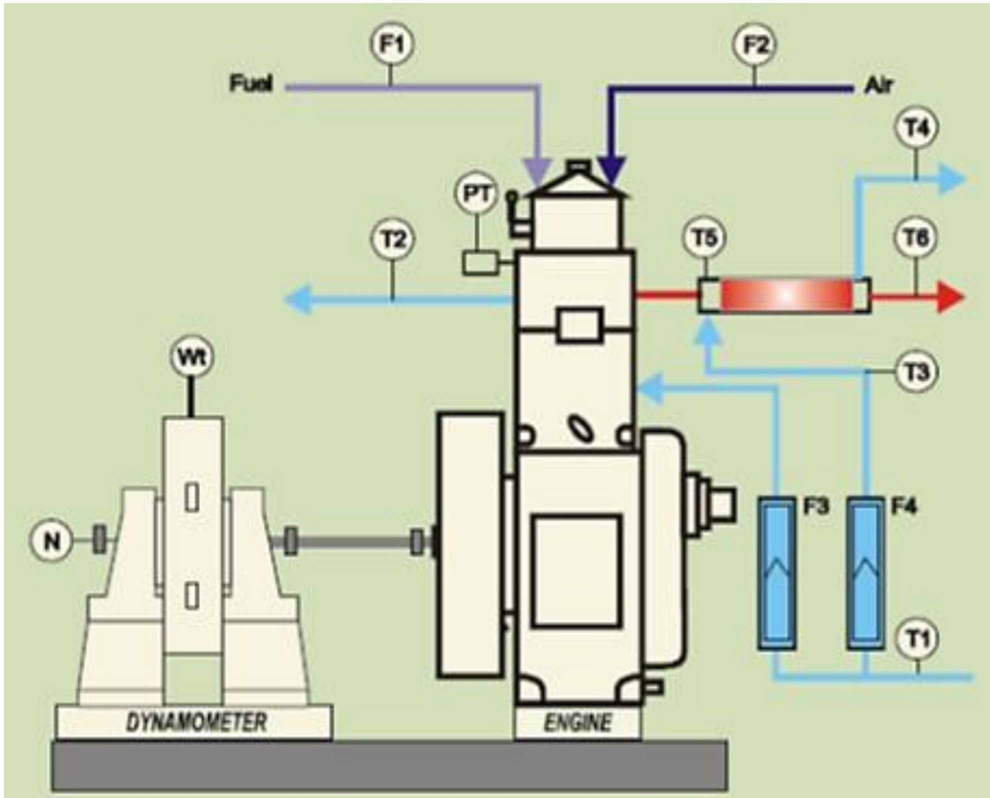

Figure 1. Engine Set Up

4. RESULTS AND DISCUSSION

4. 1. Exhaust gas emissions

Emission of exhaust gases is an outcome of the combustion process of variety of fuels viz. natural gas, petrol, petroleum diesel fuel and blends of biodiesel etc. This is a key element of stationary internal combustion engines of automobile emissions. The characteristics of exhaust gas emissions viz. un burnt hydrocarbons (HC), carbon mono oxide (CO), carbon dioxide (CO_2) and Oxides of nitrogen (NO_x) with respect to no load to full load condition of engine.

4. 2. Emission of hydrocarbon (HC)

The Fig. 2 and Fig. 3 show the hydrocarbon (HC) emission in a great extent that is an sign of poor ignition of fuel. The exhaust emissions of Hydrocarbon (HC) for all blends of IPD and LME fuels with respect to standard diesel at compression ratio 17 and 18.

The test fuels of linseed methyl ester (LME) showed that the emission of unburnt hydrocarbons was decreased by 3%, 10% and 10.5% respectively at CR17 while increase in HC emissions was exhibited by blends of IPD as 3% 7% and 11.4% respectively at maximum load whereas standard diesel fuel presented highest HC emission of 70 ppm. Even though for test samples of LME; the hydrocarbon emissions were decreased as 3%, 6.8%, 12.3% respectively at CR18; however blends of IPD; it was increased by 3.4%, 5.5% and 9.5%

respectively at maximum load condition. The combustion process is critically influenced by viscosity of the higher concentration blends of biodiesel and produced increased emissions of hydrocarbon caused by inadequate combustion. Conversely it was acknowledged that exhaust emissions of HC for IPD blends were obtained to be increased when amount of isopropyl alcohol is increased in the blends. Results of experiment demonstrated that the viscosity of the blends of higher concentration of biodiesel, disturbs the process of combustion thereby inadequate combustion caused increment in hydrocarbon emissions.

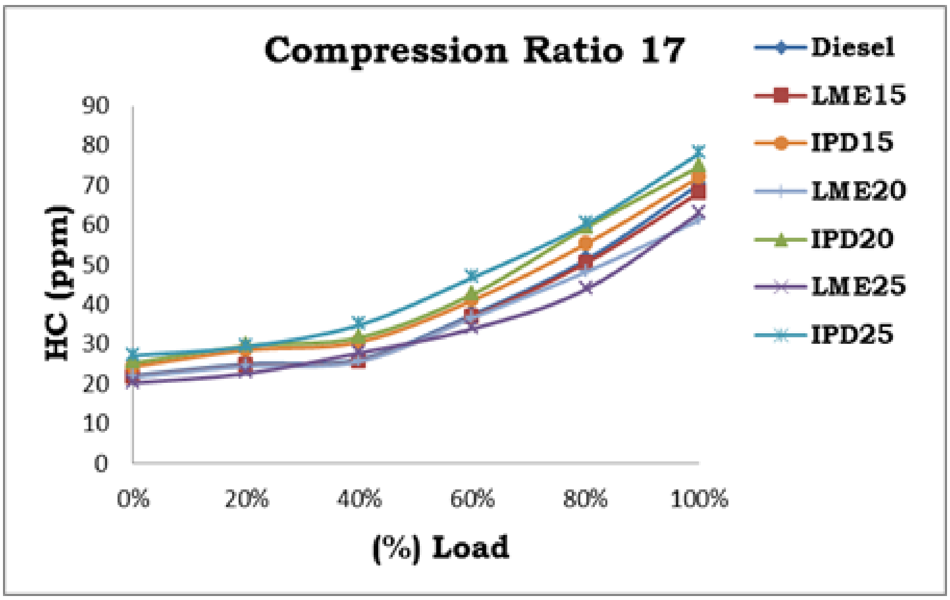

Figure 2

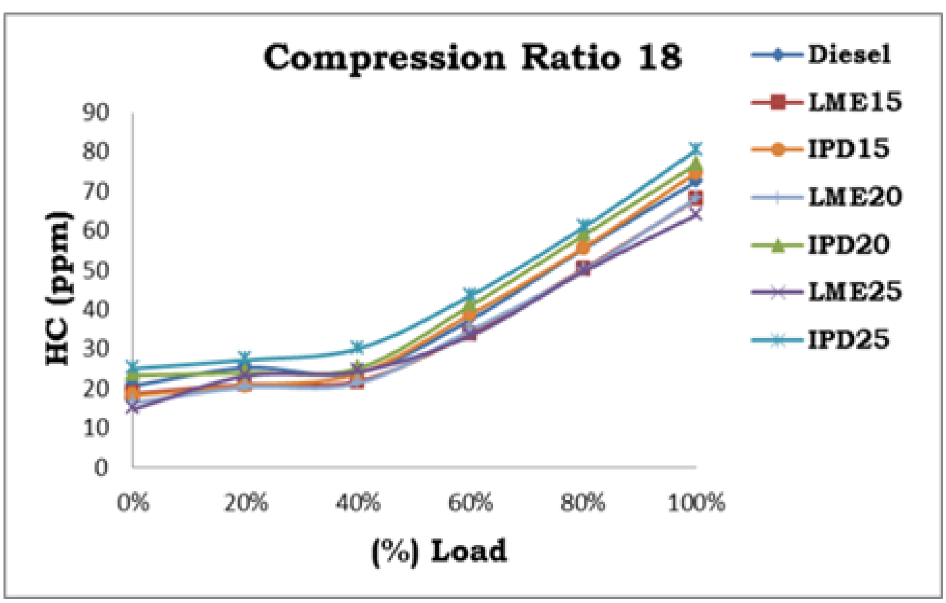

Figure 3

4. 3. Emissions of carbon dioxide (CO_2)

The emission of Carbon dioxide (CO_2) is prime source of greenhouse effect. CO_2 is the key aspect that causing change in environment. Emissions of CO_2 for different alternative fuel samples IPD15, LME15, IPD20, LME20, IPD25, LME25 and standard diesel for compression ratio 17 and 18 are illustrated by characteristics curves in Fig. 4 and Fig. 5.

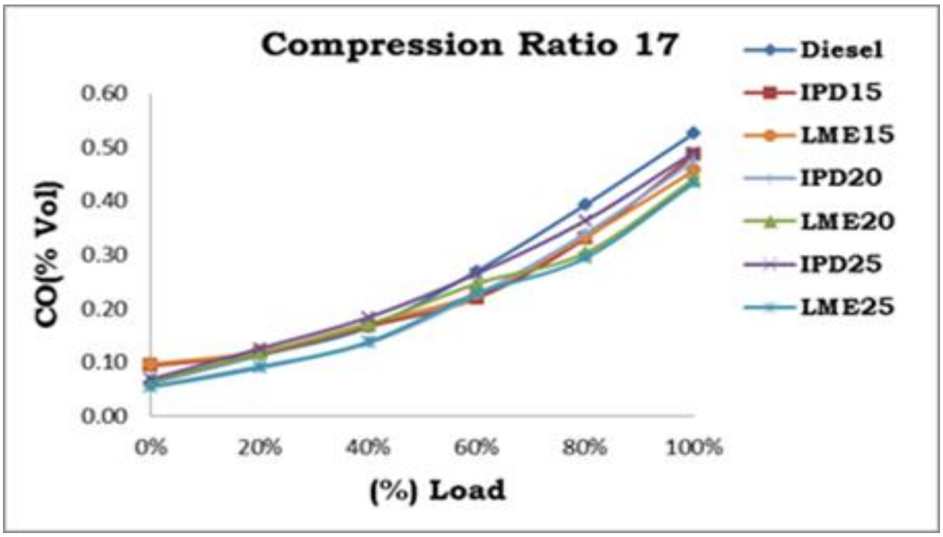

Figure 4

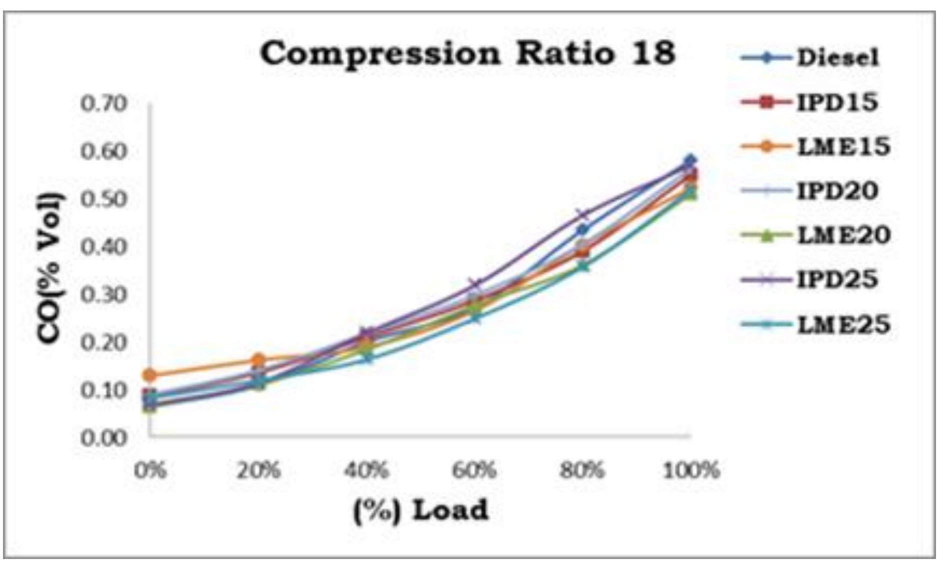

Figure 5

It was indication from results that the all substitute fuel blends of linseed oil (LME) displayed the increment in emissions of CO_2 as 9.3%, 8.7% and 10.6% respectively at CR17 although blends of isopropyl alcohol (IPD) exhibited considerably a smaller amount of CO_2 emissions as compared to conventional diesel at peak load. However, at CR18; all fuel blends of linseed oil (LME) exist with escalation in exhaust of CO_2 by 7.6%, 8.3% and 13.7% respectively, even though blends of isopropyl alcohol (IPD) presented yet again noticeable decrease in CO_2 emissions.

It was analysed that CO_2 exaust emissions were in increased amount on increasing quantity of biodiesel combinations at compression ratio 17; this might be primarily due to more large amount of oxygen present in these fuels that produced improved combustion when compared to standard diesel.

Conversely, at compression ratio 17; the pressure and temperature inside the cylinder have been improved, resulting in increased CO_2 emissions for all substitute fuels and standard diesel in the same way as defined above.

4. 4. Emissions of carbon monoxide (CO)

CO exhaust emissions are very dangerous and poisonous, it is exposed because of unsatisfactory combustion of hydrocarbons. CO emission characteristics for a number of alternative fuels, i.e. IPD15, LME15, IPD20, LME20, IPD25, LME25, CR17 and CR18 compared to mineral diesel are described in Fig. 6 and Fig. 7. At CR17 the all test substitute fuel blends of linseed oil (LME) shown 13.2%, 9.6% and 18.8% decrement in CO emissions respectively while all blends of isopropyl alcohol (IPD) shown the reduction by 7.5%, 11.3% and 7.5% correspondingly. Even though test fuels blends (LME) presented decrease in CO exhaust emissions by 10.3%, 12.1% and 13.8% correspondingly at CR18 while all blends of (IPD) indicated decrement in CO emissions by 5.2%, 3.4% and 1.7% respectively.

All fuels have generated CO emissions to a lesser magnitude, at partial load and produce more emissions while the engine load is higher. This is basically due to a reducing air-fuel ratio during the increased load on the engine while the temperature decrement in the cylinder chamber as well as the delay in the process of combustion also interrupts the CO emissions.

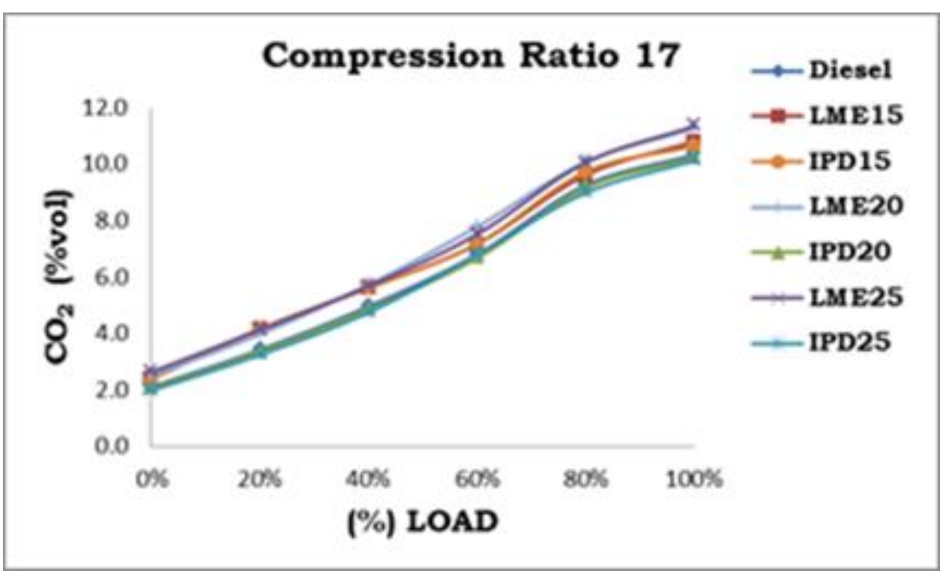

Figure 6

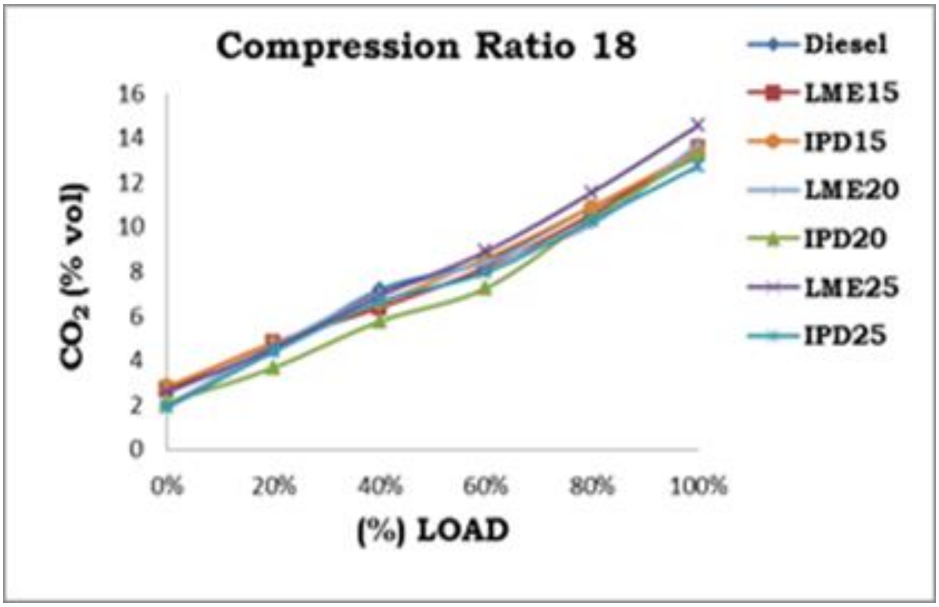

Figure 7

4. 5. Emissions of nitrogen oxides (NO_X)

Formation of oxides of nitrogen (NO_X) is typically resulting from the reaction of nitrogen and oxygen during combustion of fuels containing hydrocarbons at higher temperature. The emissions of NO_X for fuel samples IPD15, LME15, IPD20, LME20, IPD25, LME25 and standard diesel for compression ratio 17 and 18 are shown in fig. 8 and fig. 9.

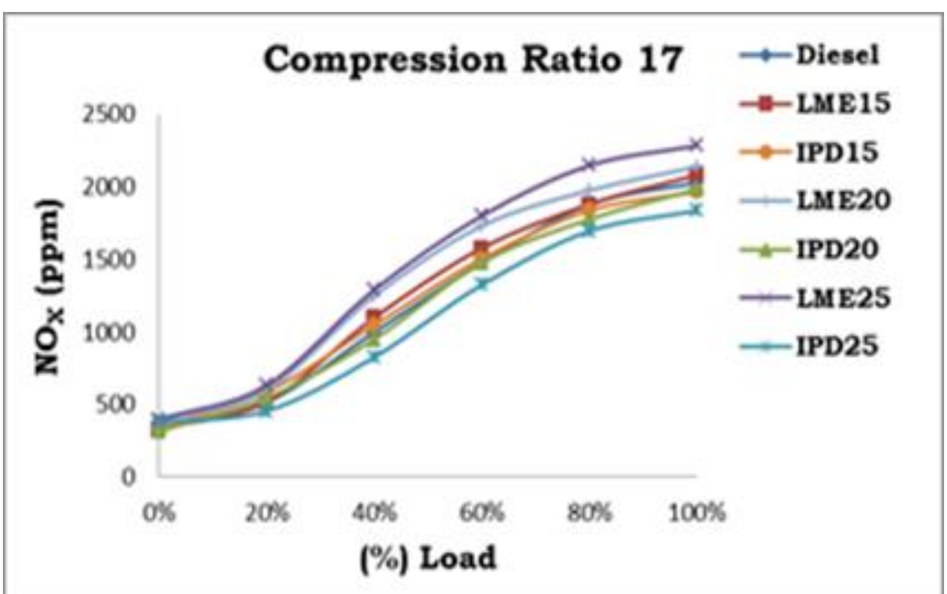

Figure 8

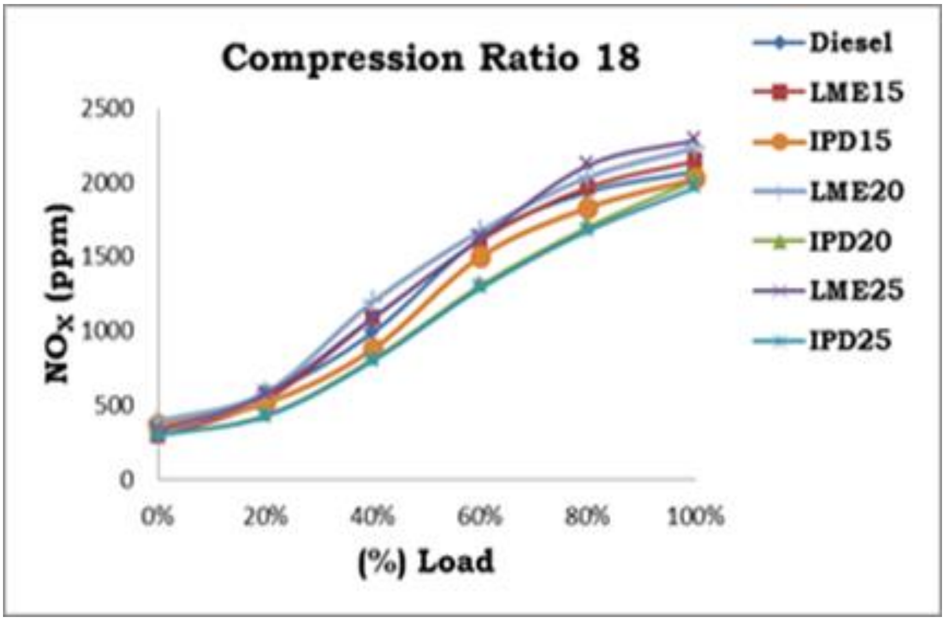

Figure 9

At CR17 fuels LME15, LME20 and LME25 showed the emission of NO_X emissions was reported increased by 2.5%, 5.4% and 12.5% respectively while IPD15, IPD20 and IPD25 showed 4.5%, 2.3% and 9.5% decrement in NO_X exhaust emissions at full load. Whereas at CR18; test fuels LME15, LME20 and LME25 showed the emission of unburnt hydrocarbons was reported increased by 5.6%, 9.6%, and 12.9% respectively while IPD15, IPD20 and IPD25 showed 2.4%, 2.8% and 5.3% increment in emissions of NO_X. It has been observed that as load increases the NO_X emissions of the diesel fuel and different fuel increased significantly due to high combustion temperature at highest load. On increasing the load on engine, the formation of NO_X may be attributed to fact that increases in overall fuel air ratio origins the increment in combustion chamber temperature.

4. CONCLUSIONS

The aim of the existing study is to identify the findings of the comparative study of exhaust emissions obtained from a standard diesel engine utilizing the blends of methyl ester of linseed oil, isopropyl alcohol and diethyl ether with respect to neat diesel. According to the results of the test, the subsequent conclusions may be discovered from the present investigation.

i. Test fuels LME25 exhibited the maximum reduction in hydrocarbon (HC) emissions as 12.3% at compression ratio 18% with respect to standard diesel fuel. However at compression ratio 17; The test fuels IPD25 displayed the maximum increment of 11.4% in (HC) emissions with respect to diesel.

ii. The fuels LME25 showed the peak increase in CO_2 emissions by 13.7 % at CR18 whereas all samples IPD15, IPD20 and IPD25 showed significant decrement in CO_2 emissions with respect to all samples and standard diesel.

iii. The fuel LME25 exhibited highest reduction in CO emissions as 18.8% at compression ratio 17, though fuel IPD20 exhibited maximum reduction of 11.3% in CO emissions at compression ratio 17,

iv. It has been perceived that test fuel LME25 showed the increase in emissions of NO_X 13% respectively and at highest load and compression ratio 17. However IPD25 displayed the decrease in emissions of NO_X as 9.5% with respect to standard diesel at compression ratio 17.

In general due to higher oxygen content of diethyl ether in blends; lower percentage of blends of IPD and linseed oil methyl ester may be suitable as alternative fuel to unmodified diesel engine considering the different aspect of exhaust emissions.

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