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Optimization of Engine Parameters using Jatropha Methyl Ester and Pongamia Methyl Ester

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Abstract : Nitrogen dioxide is an irritant gas, which at high concentrations causes inflammation of the airways. Nitrogen dioxide and nitric oxide are referred to together as oxides of nitrogen (NOx). NOx gases react to form smog and acid rain as well as being central to the formation of fine particles (PM) and ground level ozone, both of which are associated with adverse health effects. NOx is produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures. In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere as air pollution can be significant. NOx gases are formed whenever combustion occurs in the presence of nitrogen. Reduction of such pollutants is a major focus for research work. This paper presents the concept of emission reduction using experimental analysis of CI (diesel) engine emission performance using biodiesel (jatropha methyl ester, pongamia methyl ester) compared to that of traditional diesel. Selected natural oils are blended with diesel at various ratio like 10%, 20%, 30% and 40% and tested on a engine test bed. The results shows that biodiesel blends, when compared with the traditional diesel, reduces the emission of harmful gases like CO, CO_2, HC, NOx, and specific fuel consumption and increases the brake thermal efficiency.

Keywords: Jatropha methyl ester, Pongamia methyl ester, Efficiency, Emission.

1. INTRODUCTION

When nitrogen is released during fuel combustion it combines with oxygen atoms to create nitric oxide (NO). This further combines with oxygen to create nitrogen dioxide (NO_2). Nitric oxide is not considered to be hazardous to health at typical ambient concentrations, but nitrogen dioxide can be. We may not be able to completely eliminate the CI engine but we can try to reduce the harmful emission of CI engine of late, petrol is blended with methanol for lowering the CO, NOx, HC etc in exhaust gas. Diesel engine produce more pollution compared to petrol engine because diesel engine can able to produce more power, based on power similar alternate fuel is required so that we choose to use biodiesel (pongamia oil, jatropha oil)[1-3]. The oils cannot be used directly in their natural state in the engine due to their poor calorific value and lower cetane number. In order to obtain similar properties of diesel, the transesterfication process is chosen as it is easy and economical. In this process methanol and potassium hydroxide are used for biodiesel preparation[4, 5]. Based on FTA (fatty acid) value, transesterfication process is selected. The transesterified oil can be blended with diesel upto maximum of 40%, thereby reducing the cost of fuel as well as emission[6-8]. In future we can choose to use the alternate fuels like biodiesel not only to decrease emission but also it increases the efficiency of engine and also act as coolent during combustion[9-11]. After blending it shows high cetane number so that it will makes proper combustion process in the diesel engine. Biodiesels are more suitable for diesel engines owing to emission control according to the government norms[12-14].

1.1 Problem statement

We know that petrol and diesel fuel-based vehicle produce harmful gases like HC, CO, CO_2 and NOx. Diesel vehicles produce far more pollutants than a petrol-based engine[15-17]. Among diesel vehicles, heavy vehicles and marine engines produce far more pollutants than passenger cars. These harmful gases affect humans and causes irreversible damage to the environment[18, 19]. So, controlling the pollution is very important to preserve the nature for future generations.

1.2 Objectives

- To reduce the harmful gases like HC, CO, CO_2 and NOx from exhaust in diesel engine.
- To reduce the specific fuel consumption of engine.
- To increase the brake thermal efficiency of engine.

2. MATERIALS AND METHODS

2.1 Jatropha curcas:

Jatropha is a variety of shrub that grows in dry and semi arid conditions. There are several varieties of Jatropha available. Among all of these types, jatropha curcas is the best oil to extract the methyl ester because it has high fatty acid[20, 21]. In rural areas jatropha oil plays the vital role for cooking and lighting needs and it has higher flash point.[22, 23] Energy extracted from jatropha oil is equal to the energy extracted from diesel. Jatropha oil can be directly used in diesel engine by mixing it with diesel or after converting as a bio diesel fuel by transesterification process[24, 25]. While using a jatropha oil directly in diesel engine, it creates technical issue in the engine and this major challenge needs to be overcome[26, 27]. At the same time preparing biodiesel from jatropha curcas is quite expensive compared to the preparation of diesel fuel.[28, 29] So, a detailed study and analysis is needed for these types of oils. Due to its high centane number it may act as coolant also.

2.2 Pongamia oil:

Pongamia oil has lesser fatty acid value, requires less maintenance for planting and also it requires lower number of transesterfication process steps in comparison with Jatropha curcas[30, 31]. Due to similar cetane number as that of diesel it also easily burned during compression. The various physical properties of diesel, jatropha oil and pongamia oil are shown in Table 1.

PROPERTIES	DIESEL	JATROPA OIL	PONGAMIA OIL
Density (kg m^{-3})	0.840	0.927	0.957
Viscosity (m^2s^{-1})	4.59	48.5	43.7
Calorific value (kJ kg^{-1})	42,390	40,375	9045
Flashpoint °C	75	255	235
Cetane number	45	46	43

Table 1: Various physical properties of diesel, jatropha oil and pongamia oil

PROPERTIES	ASTM method	Instrument
Density (kg m^{-3}) Viscosity (m^2s^{-1}) Calorific value (kJ kg^{-1}) Flashpoint °C	D 1298 D265 D240 D445	Hydrometer Kinematic viscometer Bomb calorimeter Cleveland open cup flash tester

Table 2: Properties measured using applicable ASTM testing method

In order to determine the properties of Jatropha curcas and Pongamia oil hydrometer, kinematic viscometer, Bomb calorimeter and Cleveland open cup flash point testers are used.

2.3 Transesterification:

Transesterification is the process of chemical reaction of any oil with alcohol in the presence of a catalyst[32-34]. Sulphuric acid is used as acid, methanol is used as alcohol and sodium hydroxide is used as a catalyst for the transesterification process[33, 35]. Ester and glycerin are the direct products produced in the transesterification process. Glycerin is a byproduct produced during the transesterification process.

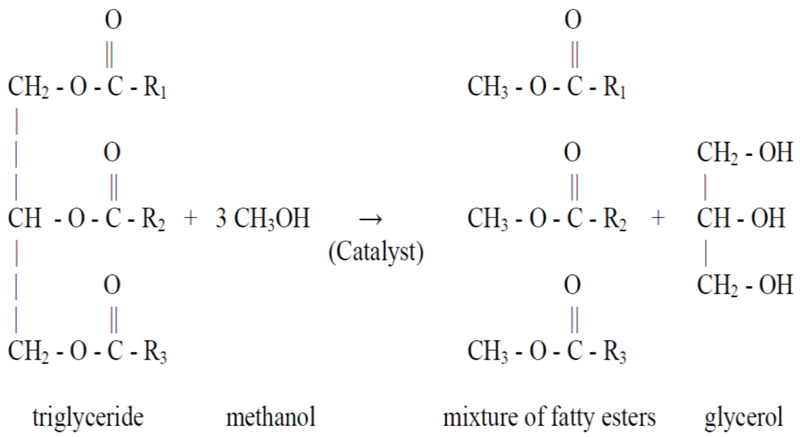

Fig 1: Transesterification reaction

2.4 Neutralization:

In nature nearly 5 to10 percentage of free fatty acid is generally present in vegetable oils. Such fatty acids must be removed from the vegetable oil by heating the oil at 100 °C before taking into the conversion process of vegetable oil to biodiesel[36, 37]. Fatty acid presence is nearly 8.29% in jatropha curcas and 4.25% in pongamia oil which is unsuitable for biofuel production in industry[38, 39]. Since both the oils has more percentage of fatty acid content we cannot use them directly to produce biodiesel or blend it with diesel. So, it needs two step esterification process and one transesterification process before it becomes suitable for diesel engines for jatropha oil but for pongamia it requires only one esterfication process and one transesterfication process because it has lesser fatty acid content[40, 41]. After the process while blending with diesel it shows similar characteristics of diesel so that it can be used as an alternate fuel.

2.5 Ester production:

In this present work biodiesel is produced from jatropha curcasby transesterification process. Batch reactor is used to carry out the transesterification reaction process.[42, 43] During the transesterification process, it is heated to eliminate the moisture content present. During esterification process 120 mL of methanol and 0.6 g sulphuric acid is vigorously mixed up to 60 minutes at 60 °C but due to its high free fatty acid content, it requires esterification process to be carried again to get jatropha methyl ester[43].

2.6 Transesterification:

After esterification process the transesterification process will be carried out by treating it with 100 mL of sodium methoxide for 90 minutes at 60 °C and jatropha methyl ester is produced[25, 43].

After synthesizing the biodiesel,various tests are carried out like measurement of density, calorific value, viscosity, flash point. Multiple readings and observation are done to check its feasibility.

2.7 Experimental setup:

The engine used to test the synthesized biodiesel is the Kirloskar, single-cylinder four-stroke water-cooled diesel engine, which is capable of developing 3.5 kW at 1500 rpm. There are five temperature sensors to measuring the temperature in exhaust[44, 45]. Apex software is used for measuring the brake thermal efficiency, mechanical efficiency etc. and also to ensure proper air fuel ratio in the engine[46]. The engine has been tested in the compression ratio of 17.8 and injection pressure of 200 bar. These parameters are fixed for the entire testing process of bio diesel named B10, B20, B30 (jatropha methyl ester blended with diesel), B10,B20 (pongamia methyl ester with diesel). An AVL gas analyzer is used to measure the proportion of various gases CO, HC, CO_2, NOx, O_2 in the exhaust gas[47].

Figure 2:Engine setup

3. RESULTS AND DISCUSSION

Various blends of jatropha methyl ester were used to run the Kirloskar diesel engine and various physical, chemical and thermal properties were collected. The analysis of these findings compared to diesel is as shown below.

3.1 Diesel

Speed (rpm)	**Load (kg)**	**Torque (N**	**Mechanical Efficiency (%)**	**Volumetric efficiency (%)**
1521	0	0.08	0.33	76.81
1503	3	4.68	15.89	75.92
1482	6	10.68	29.60	75.71
1472	9	15.69	38.71	74.91
1453	12	21.40	45.27	74.08
1453	14	23.10	47.21	74.01

Table 3: Experiment carried for diesel (CR -17.4) (IP -200 BAR)

From Table 3 it is clear that while increasing the load from 0 to 12 kg, the speed of the output shaft gradually reduces from (1521 rpm to 1453 rpm). Additional increase in load beyond has no effect on the speed. Also, increasing the load from 0 to 12 kg, results in the torque increasing from 0 to 21 Nm, and with further load increae, gradual torque increase is observed. Increasing the load from 0 to 12 kg, results in the mechanical efficiency going up from (0.3 to 45.22), beyond which knocking is observed. Similarly, while increasing the load from 0 to 12 kg the volumetric efficiency efficiency is decreased from (76.8 to 74).[48]

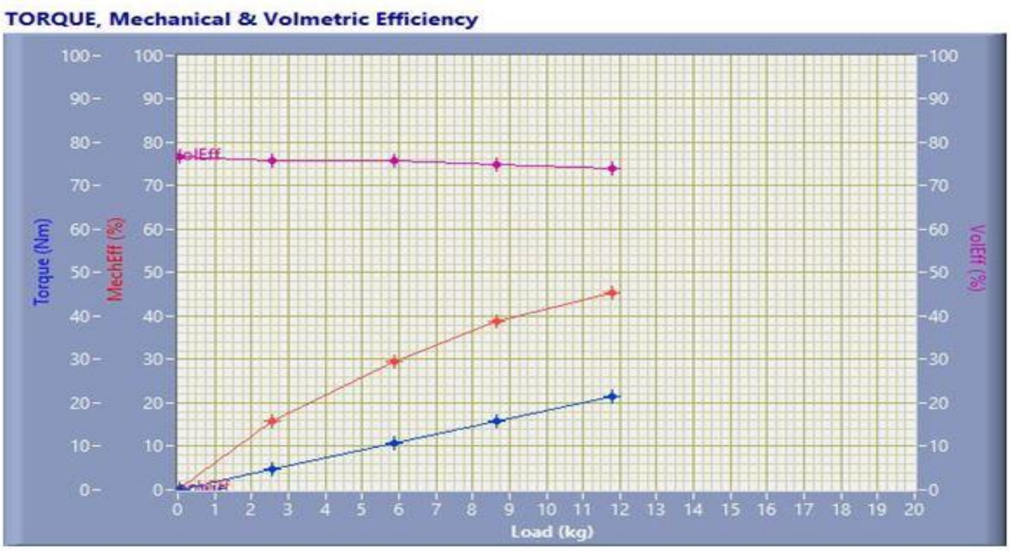

Figure 3: Output of experiment carried for diesel (CR -17.4) (IP -200 BAR)

3.1 Emission test

Load (Kg)	CO (%V)	HC (ppm)	CO_2 (%V)	O_2 (%V)	NOx (ppm)
0	0.04	6	0.50	20.80	27
3	0.02	1	0.40	20.30	46
6	0.01	1	0.20	20.57	43
9	0.01	1	0.30	20.44	52
12	0.01	0	0.10	20.76	36

Table 4: Emission test for diesel

While increasing the load from 0 to 12 kg the value has gradually decreased from (0.04 to 0.01 %v). Load vs (HC) while increasing the load from 0 to 12 kg the value suddenly drops from (6 to 1 ppm), beyond which it is maintained till 9 kg, and then decrease. While increasing the load from 0 to 12 kg the value has gradually decreased from (0.5 to 0.1 %v). While increasing the load from 0 to 12 kg the value gradually decreased from (20.8 to 20.76 %v). While increasing the load from 0 to 12 kg the value has decreased from (27 to 16 ppm) when it attain 9 kg maximum NOx is produced then it suddenly decreases when the load incearses at certain point NOx increases then it decreases. The higher NOx emission is attributed to the longer ignition delay period, due to the large premixed air-fuel charge[49, 50].

3.2 Jatropha Methyl Ester - JME10

Speed (rpm)	Load (Kg)	Torque (N	Mechanical Efficiency (%)	Volumetric efficiency (%)
1521.00	0	0.27	1.03	76.36
1508.00	3	4.98	15.39	76.14
1489.00	6	10.24	26.89	75.68
1470.00	9	16.00	37.17	74.90
1458.00	12	20.78	43.61	74.06

Table 5: Experiment carried for JME 10 (CR -17.4) (IP -200 BAR)

While increasing the load from 0 to 12 kg the speed of the output shaft reduces from (1521 rpm to 1458 rpm). After 12 kg, constant speed is maintained and when compared to diesel it has more speed. While increasing the load from 0 to 12 kg the torque is also increasing from 0 to 21 Nm, and further based on load, gradual torque increase is observed like a diesel. While increasing the load from 0 to 12 kg the mechanical efficiency is increased from (1 to 43.61) if load increases after 12 kg then knocking is observed, compared to diesel during initial condition it has higher efficiency. While increasing the load from 0 to 12 kg the volumetric efficiency is decreased from (76.3 to 74 %) compared to diesel it has same volumetric efficiency. In comparison with diesel the jatropha methyl ester has 1.66 % lesser mechanical efficiency.[48, 51]

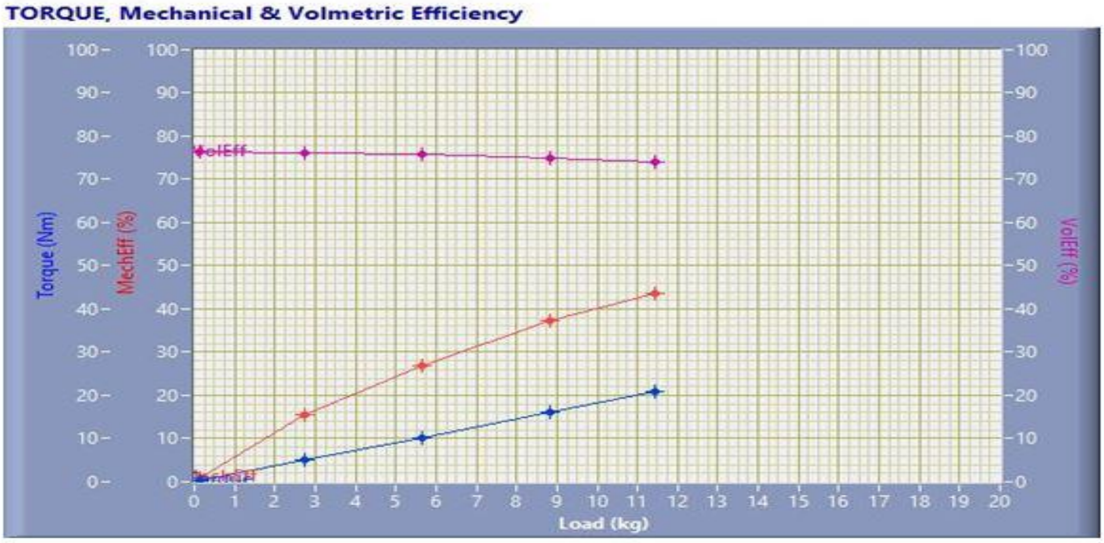

Figure 4: Output of Experiment carried for JME 10 (CR -17.4) (IP -200 BAR)

3.2.1 Emission Test

Load (Kg)	CO (%V)	HC (ppm)	CO_2 (%V)	O_2 (%V)	NOx (ppm)
0	0.05	6	0.60	20.03	28
3	0.03	3	0.60	20.11	62
6	0.02	1	0.50	20.25	79
9	0.00	1	0.10	20.89	29
12	0.00	0	0.10	20.76	14

Table 6: Emission test for JME 10

While increasing the load from 0 to 12 kg the value has gradually decreased from (0.05 to 0.00 %v). No CO emission is seen from 8 to 12 kg. While increasing the load from 0 to 12 kg the value of its suddenly decreased from (6 to 1 ppm), after which it is maintained constant and decreases as compared to diesel. While increasing the load from 0 to 12 kg the value of CO_2 has gradually decreased from (0.5 to 0.1 %v) similar to diesel. While increasing the load from 0 to 12 kg the value has gradually increased from (20 to 20.8 %v). While increasing the load from 0 to 12 kg the value has decreased from (27 to 14 ppm). When it attains 9 kg maximum amount of NOx is produced then it suddenly decreased as compared to diesel it produces less NOx. [51]

3.3 Jatropha Methyl Ester - JME20

Speed (rpm)	Load (Kg)	Torque (N	Mechanical Efficiency (%)	Volumetric efficiency (%)
1509.00	0	0.45	1.54	75.69
1498.00	3	5.00	14.77	75.09
1481.00	6	10.39	29.10	74.54
1466.00	9	15.44	42.99	73.98

1451.00	12	20.75	48.92	73.14

Table 7: Experiment carried for JME 20 (CR -17.4) (IP -200 BAR)

While increasing the load from 0 to 12 kg the speed of the output shaft is gradually reduced from (1521 to 1451) after 12 kg it look like constant speed is maintained when compared to diesel it has more speed. While increasing the load from 0 to 12 kg the torque is also increasing from 0 to 21 nm further based on load is increased gradual torque is increased like as disesel. While increasing the load from 0 to 12 kg the mechanical efficiency is increased from (1 to 48.92) after 12 kg if load increases then knocking will produced ,compared to diesel during initial condition it has high efficiency. While increasing the load from 0 to 12 kg the volumetric efficiency efficiency is decreased from (75.69 to 73.14) compared to diesel it has same volumetric efficiency.Compartively with diesel the JME20 3.65 % mechanical efficiency has increased.[52]

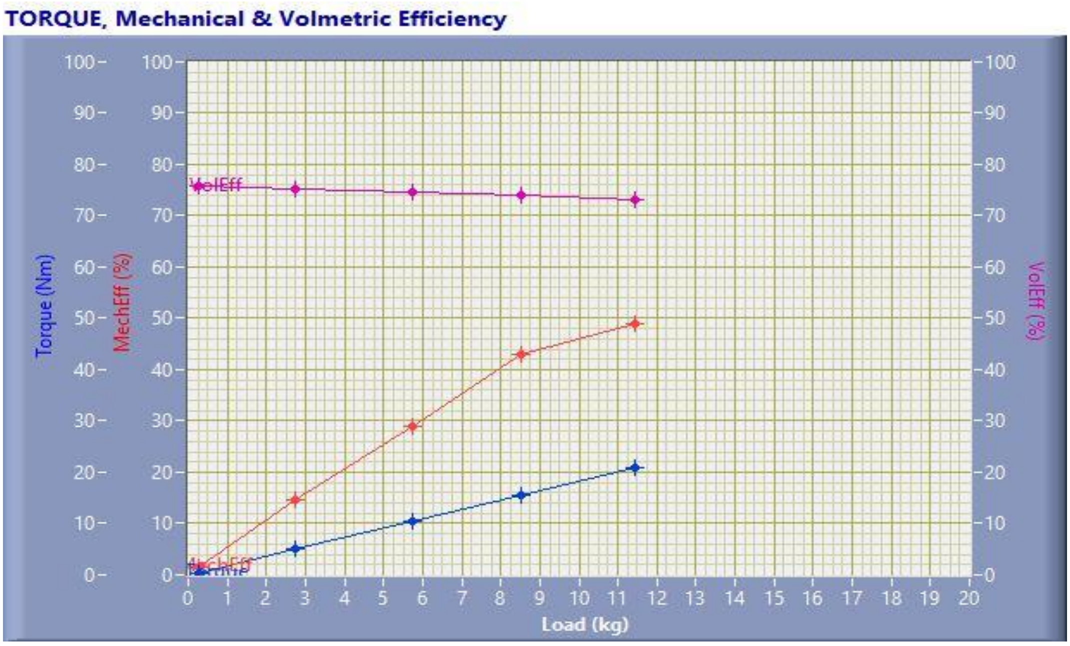

Figure 5: Output of Experiment carried for JME 20 (CR -17.4) (IP -200 BAR)

3.3.1.Emission Test

Load (Kg)	CO (%V)	HC (ppm)	CO_2 (%V)	O_2 (%V)	NOx (ppm)
0	0.03	6	0.40	20.33	31
3	0.02	1	0.40	20.40	56
6	0.02	2	0.40	20.51	63
9	0.01	1	0.20	20.76	32
12	0.00	1	0.10	20.91	13

Table 8: Emission test for JME 20

While increasing the load from 0 to 12 kg the value has gradually decreased from (0.03 to 0.00 %v). No CO is occurred at 12 kg. While increasing the load from 0 to 12 kg the value has suddenly decreased from (6 to 1 ppm) then it maintain constant and then it will decreases same compared to diesel. While increasing the load from 0 to 12 kg the value has gradually decreased from (0.4 to

0.1 %v) similar to diesel. While increasing the load from 0 to 12 kg the value has gradually increased from (20.3 to 20.9 %v). While increasing the load from 0 to 12 kg the value has decreased from (31to 13 ppm) when it attain 6 kg maximum NOx is produced then it suddenly decreased compared to diesel it produces less NOx. [51]

3.4 Jatropha Methyl Ester - JME30

Speed (rpm)	Load (Kg)	Torque (N	Mechanical Efficiency (%)	Volumetric efficiency (%)
1515.00	0	0.58	1.41	75.75
1507.00	3	4.99	10.66	75.44
1485.00	6	10.64	21.58	74.03
1476.00	9	15.27	27.35	73.33
1452.00	12	21.16	36.15	73.35

Table 7: Experiment carried for JME 30 (CR -17.4) (IP -200 BAR)

While increasing the load from 0 to 12 kg the speed of the output shaft is gradually reduced from(1515 rpm to 1452 rpm). After 12 kg, constant speed is maintained and when compared to diesel it has more speed. While increasing the load from 0 to 12 kg the torque is also increasing from 0 to 21 Nm, and further based on load, gradual increase is observed like a disesel. While increasing the load from 0 to 12 kg the mechanical efficiency is increased from (1.41to 36.15) if load increases after 12 kg then knocking is observed, compared to diesel during initial condition it has high efficiency. While increasing the load from 0 to 12 kg the volumetric efficiency efficiency is decreased from (75.75 to 73.35) compared to diesel it has more or less same volumetric efficiency. Compartively with diesel the JME30 8.65 % mechanical efficiency has decreased.[53]

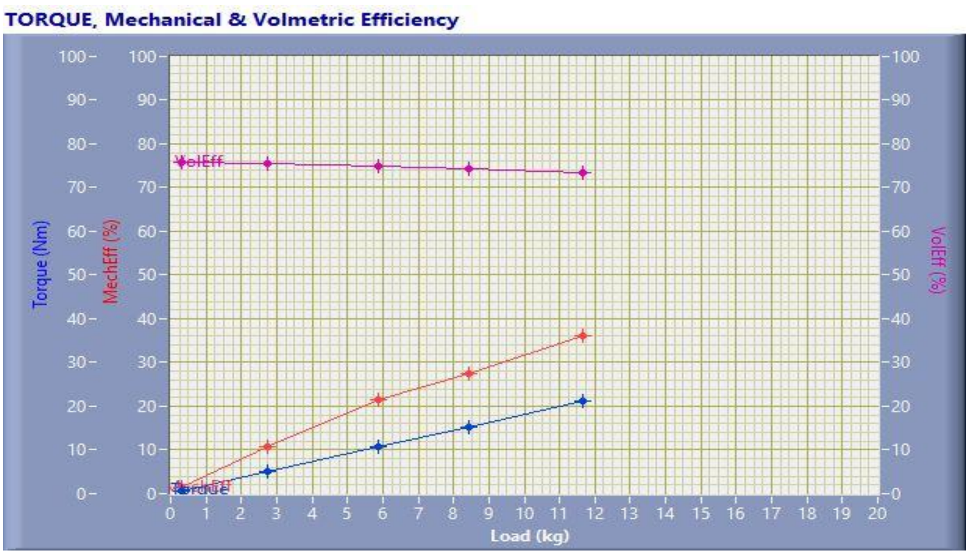

Figure 6: Output of Experiment carried for JME 30 (CR -17.4) (IP -200 BAR)

3.4.1.Emission Test

Load (Kg)	CO (%V)	HC (ppm)	CO_2 (%V)	O_2 (%V)	NOx (ppm)

0	0.05	10	0.50	20.18	29
3	0.03	7	0.50	20.19	62
6	0.01	6	0.30	20.50	59
9	0.01	7	0.30	20.62	45
12	0.01	6	0.10	20.90	12

Table 8: Emission test for JME 30

While increasing the oad from 0 to 12kg the value has gradually decreased from (0.05 to 0.01 %v). No CO is occurred at 12 kg. While increasing the load from 0 to 12 kg the value has suddenly decreased from (10 to 6 ppm)then it maintain constant and then it will decreases same compared to diesel. While increasing the load from 0 to 12 kg the value has gradually decreased from (0.5 to 0.1 %v) similar to diesel. While increasing the load from 0 to 12 kg the value has gradually increased from (20.18 to 20.9%v). While increasing the load from 0 to 12 kg the value has decreased from (29 to 12 ppm)when it attain 3 kg maximum NOx is produced then it suddenly decreased compared to diesel it produces less NOx. Compartively with diesel the NOx (4ppm) has reduced while using JME 30.[54]

3.5 Pongamia Methyl Ester - PME10

Speed (rpm)	**Load (Kg)**	**Torque (N**	**Mechanical Efficiency (%)**	**Volumetric efficiency (%)**
1508.00	0.15	0.28	0.72	75.66
1494.00	2.59	4.70	10.82	75.37
1480.00	5.66	10.28	20.48	75.10
1468.00	8.53	15.48	28.82	74.58
1457.00	11.41	20.72	37.57	74.02

Table 9: Experiment carried for PME 10 (CR -17.4) (IP -200 BAR)

While increasing the load from 0 to 12 kg the speed of the output shaft reduces from (1508 rpm to 1457 rpm). After 12 kg, constant speed is maintained when compared to diesel it has more speed. While increasing the load from 0 to 12 kg the torque is also increasing from 0 to 21 Nm, and further based on load, gradual torque increase observed like a disesel.[55]

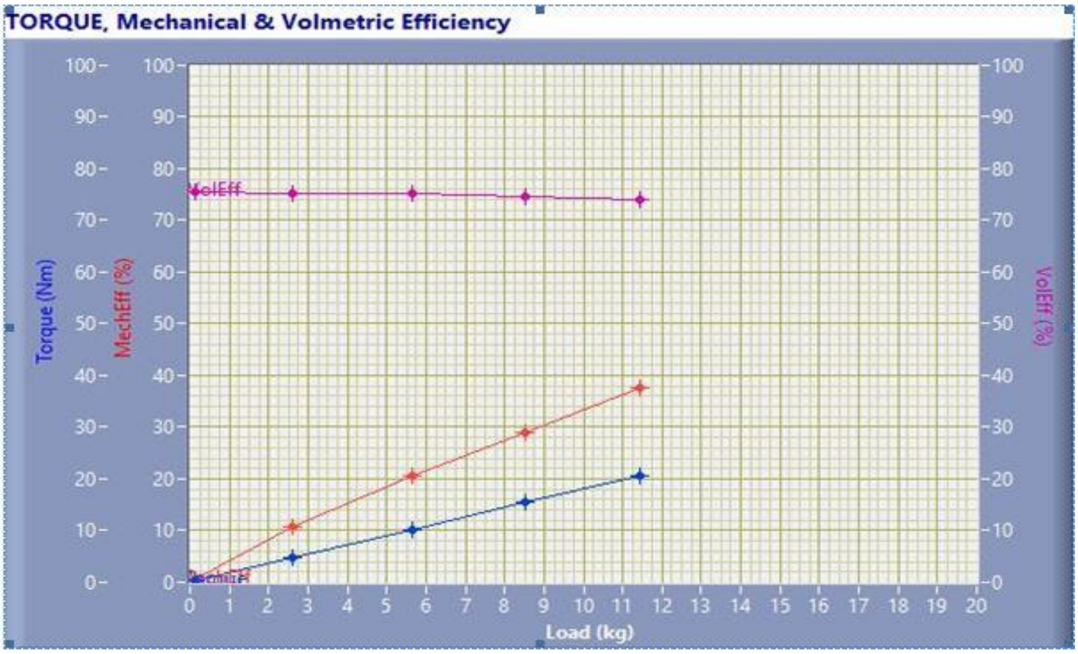

Figure 6: Output of Experiment carried for PME 10 (CR -17.4) (IP -200 BAR)

While increasing the load from 0 to 12 kg the mechanical efficiency is increased from (0.72 to 37.57) after 12 kg then knocking is observed, compared to diesel during initial condition it has higher efficiency. While increasing the load from 0 to 12 kg the volumetric efficiency efficiency is decreased from (75.66 to 74.02) compared to diesel it has more or less same volumetric efficiency.[51]

3.5.1 Emission Test

Load (Kg)	CO (%V)	HC (ppm)	CO_2 (%V)	O_2 (%V)	NOx (ppm)
0	0.02	4	0.60	20.02	107
3	0.02	3	0.60	20.01	114
6	0.01	1	0.50	20.18	145
9	0.01	2	0.30	20.49	86
12	0.01	0	0.10	20.84	21

Table 10: Emission test for PME 10

While increasing the load from 0 to 12 kg the value has gradually decreased from (0.02 to 0.01 %v). While increasing the load from 0 to 12 kg the value has suddenly decreased from (4 to 0 ppm). While increasing the load from 0 to 12 kg the value has gradually decreased from (0.6 to 0.1 %v) similar to diesel. While increasing the load from 0 to 12 kg the value has gradually increased from (20.02 to 20.84%v). While increasing the load from 0 to 12 kg the value has decreased from (107 to 21 ppm) when it attain 3 kg maximum NOx is produced then it suddenly increased compared to diesel it produces high NOx.[56]

3.6 Pongamia Methyl Ester - PME 20

Speed (rpm)	Load (Kg)	Torque (Nm)	Mechanical Efficiency (%)	Volumetric efficiency (%)
1509.00	0.16	0.28	0.78	75.70
1496.00	2.69	4.88	11.99	75.45
1487.00	5.73	10.41	21.41	75.11
1469.00	8.67	15.74	30.26	74.02
1458.00	11.58	21.01	35.58	73.05

Table 11: Experiment carried for PME 20 (CR -17.4) (IP -200 BAR)

While increasing the load from 0 to 12 kg the value has gradually decreased from (0.02 to 0 %v). No CO is occurred at 12 kg. While increasing the load from 0 to 12 kg the value has suddenly decreased from (5 to 2 ppm). While increasing the load from 0 to 12 kg the value has gradually decreased from (0.5 to 0.2 %v) similar to diesel. While increasing the load from 0 to 12 kg the value has gradually increased from (20.22 to 20.77%v). While increasing the load from 0 to 12 kg the value has decreased from (90 to 40 ppm) when it attain 3 kg maximum NOx is produced then it suddenly increased compared to diesel it produces high NOx.

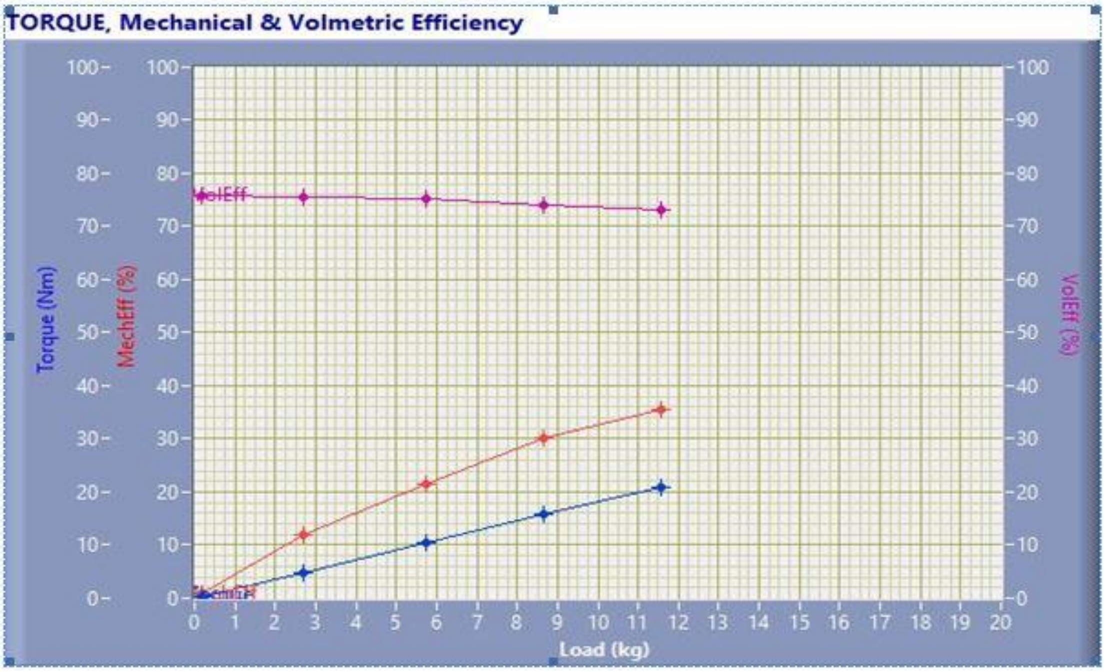

Figure 6: Output of Experiment carried for PME 20 (CR -17.4) (IP -200 BAR)

3.6.1 Emission Test

Load (Kg)	CO (%V)	HC (ppm)	CO_2 (%V)	O_2 (%V)	NOx (ppm)
0	0.02	5	0.50	20.22	90
3	0.01	5	0.50	20.18	122
6	0.01	4	0.50	20.27	140
9	0.01	1	0.20	20.66	68

12	0.00	2	0.20	20.77	40

Table 12: Emission test for PME 10

While increasing the load from 0 to 12 kg the value has gradually decreased from (0.02 to 0 %v). No CO is occurred at 12 kg. While increasing the load from 0 to 12 kg the value has suddenly decreased from (5 to 2 ppm). While increasing the load from 0 to 12 kg the value has gradually decreased from (0.5 to 0.2 %v) similar to diesel. While increasing the load from 0 to 12 kg the value has gradually increased from (20.22 to 20.77%v). While increasing the load from 0 to 12 kg the value has decreased from (90 to 40 ppm) when it attain 3 kg maximum NOx is produced then it suddenly increased compared to diesel it produces high NOx.

3.7 Efficiency (Diesel Vs JME)

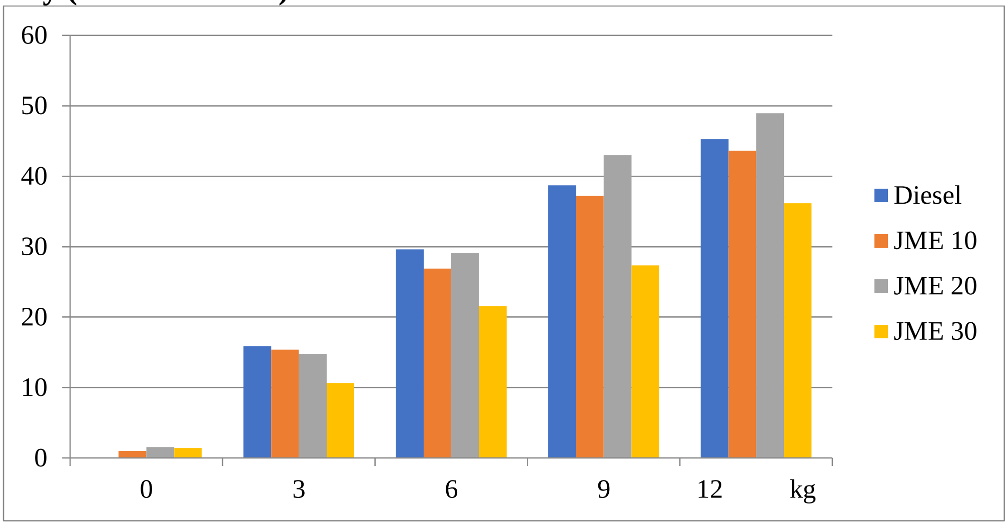

Figure 7: Efficiency comparison chart between diesel and different percentage of JME

The chart shows the efficiency of diesel and jatropha methyl ester and in which JME 20 shows high efficiency compared to diesel. Hence jatropha methyl ester 20 can be used as alternate fuel blended with diesel.

3.8 Efficiency (Diesel Vs PME)

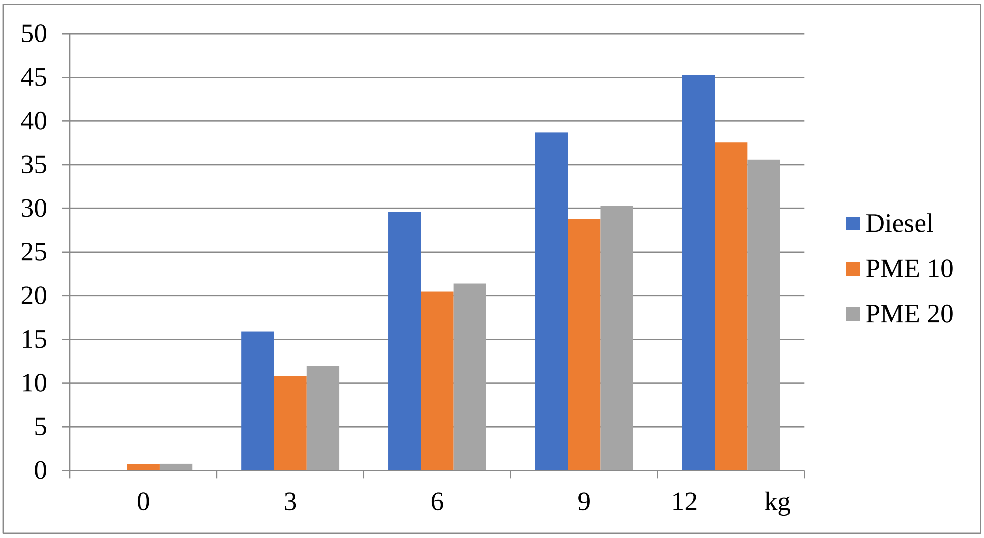

Figure 8: Efficiency comparison chart between diesel and different percentage of PME

While compared to diesel and Jatropha methyl ester the pongamia methyl ester shows less in efficiency because of its lower calorific value, cetane number.

3.9 Emission At 12kg Load (JME)

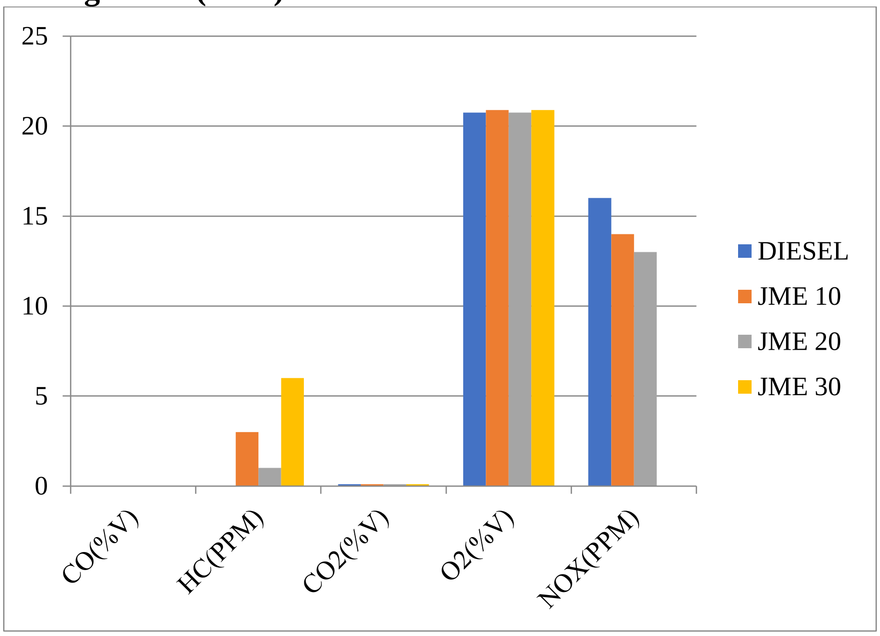

Figure 9: Emission comparison chart between diesel and different percentage of JME

While emission chart shows that Jatropha methyl ester 20 has less emission compared to diesel it shows that jatropha act as well as coollent in the in the internal section.

3.10 Emission At 12kg Load (PME)

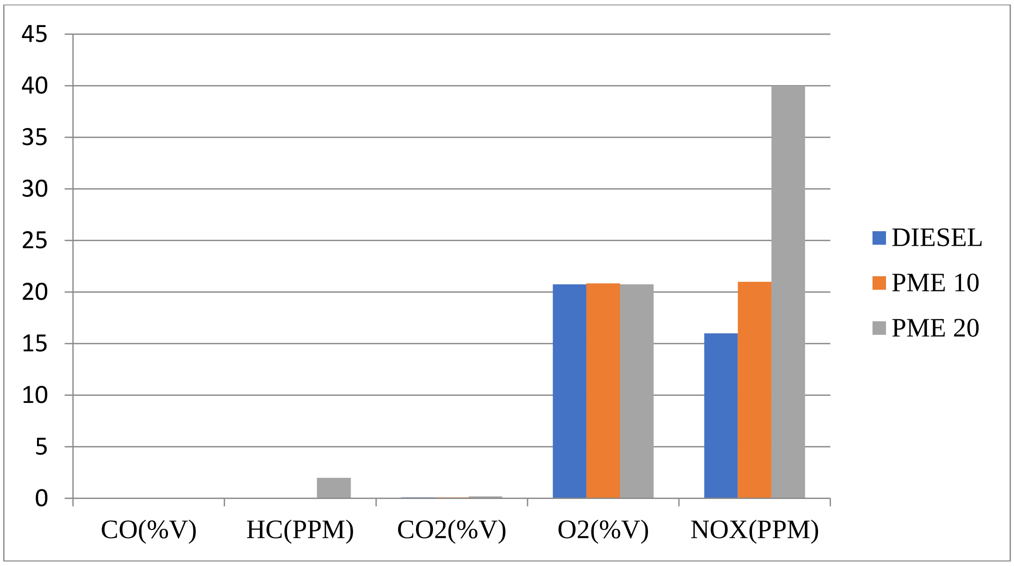

Figure 10: Emission comparison chart between diesel and different percentage of PME

While emission chart shows that PME has high emission compared to diesel and jatropha methyl ester so that it does not act as collant and its not useful for diesel engine.

4. CONCLUSION

A Kirloskar single cylinder compression ignition engine was operated successfully using jatropha methyl ester and pongamia methyl ester blends as the source fuel. The following conclusions were made based on the experimental results.

- Engine works smoothly on Jatropha methyl ester blends with performance comparable that of pure diesel operation.
- Methyl ester of Jatropha oil results in a slightly increased thermal efficiency as compared to that of diesel and efficiency reduces in pongamia methyl ester.
- The exhaust gas temperature is decreased with the methyl ester of Jatropha oil as compared to diesel.
- CO_2 emission is low with the methyl ester of Jatropha oil.
- CO emission is low at higher loads when compared with the methyl ester of Jatropha oil.
- NOx emission is decreased with methyl ester of Jatropha oil compared to diesel.
- There is significant decrease in smoke emissions when the methyl ester of Jatropha oil is used.

This methyl ester of Jatropha oil along with diesel may reduce the environmental impacts of transportation, the dependency on crude oil imports, and may offer business possibilities to agricultural enterprises for periods of excess agricultural production. On the whole, it is concluded that the methyl ester of Jatropha oil will be a good alternative fuel for diesel engine for agricultural applications. Pongamia oil cannot be used because it reduces the efficiency and also increases the emission.

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