International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 8 Issue 11 Series. II || November 2019 || PP 20-30

Experimental Investigation on 4-Stroke C.I. Engine with Different Piston Crown Materials using esterified bio-diesel oils as an alternative fuels

Alagala Harikrishna[1]
[1](*Assistant Professor, Mechanical Engineering Department, KSRM College of Engineering, Kadapa, A.P, India)*

ABSTRACT: *The world energy demand for the last two decades has witnessed uncertainties in two dimensions. Firstly, the price of conventional fossil fuel is too high and has added burden on the economy of the developing and importing nations. Secondly, combustion of fossil fuel is the main culprit in increasing the global warming. The scarcity and depletion of conventional sources are also cases of concern and have prompted research worldwide into alternative energy sources for internal combustion engines. Bio-fuels appear to be potential alternative "greener" energy substitute for fossil fuels. Bio-diesel is a completely natural, renewable fuel made from biological sources such as vegetable oils and animal fats, applicable in any situation where conventional petroleum diesel is used. Numbers of methods are being recommended by several experts and investigators to enhance Engine performance characteristics. Among them, using different piston crown materials on the C.I. Engine to accomplish the best one in terms of performance, emissions and other combustion parameters. The present work was undertaken to study the evaluation of Diesel and Bio-diesel oils such as Jatropha, Karanji, Pamolin as engine fuels along with conventional aluminum piston, aluminum with brass crown piston and aluminum with bronze crown piston and their effects on engine performance. Vegetable oils can be used in Compression Ignition engines and experimental investigations were carried out at a constant speed of 1500 rpm and at different loads between no loads to full load with each variety of fuels. From experiment results it was found that by comparing bio-diesels with pure diesel with aluminum piston, it is observed that diesel & jatropha would give better performance and less emission. Usage of bio-diesels in pure form with brass crown piston may lead to decrease in performance comparing with normal piston crown. It is also observed that emissions are also high with brass crown piston. By comparing bio-diesels with pure diesel with bronze piston, the pure karanji would give good performance, but emissions are just higher than diesel. Usage of Pamolin oil results in lesser concentrations of emissions for all types of pistons but poor in performance parameters and it is concluded that it is not suitable for running engines. Based on the view of cost, the estrified bio-diesel fuels are comparatively high, but the cost can be brought down by mass production. Finally it is concluded that the Karanji oil would give better performance with aluminum piston.*

KEY WORDS: *Bio diesels, compression Ignition (C.I.), aluminum piston, aluminum with brass piston crown and aluminum with bronze piston crown.*

Date of Submission: 27-11-2019 Date of acceptance: 09-12-2019

I. INTRODUCTION

Global oil supplies are reaching the point where demand may outstrip supply. When this occurs, it is expected that oil prices will increase significantly. In addition, combustion of geological oil and derivatives such as petrol releases a greenhouse gas that causes global warming. Bio-diesel is seen as one alternative that can help to reduce the sustainability impacts of these events. However, the production and use of bio-diesel are not without additional impacts - both positive and negative, and countries have their own priorities and vision for growth. Energy however, remains the mainstay for all civilized world and Self-reliance in energy is vital for over all economic development of our country. The priorities may lay in cost economics, environment friendliness, import substitution, or self-sufficiency as strategic objective.

Energy is one of the priority areas for the Nation. The need to search for alternative sources of energy, which are renewable, safe & non-polluting, assumes top priority in view of the uncertain supplies & frequent price hikes fossil fuels in the international market. Among the many species, this can yield oil as source of energy in the form of bio-diesel. All countries of the world, including those with surplus energy are banking upon vegetable oil as alternative source of energy by way of bio-diesel. Developing countries cannot afford to utilize edible vegetable oil or even used vegetable oil. However, many of these countries, like India, have large tracts wastelandsandtropical climate suitable for cultivating a variety of plants that yield non-edible oil. Cultivation for oil in degraded, waste, abandoned and abused lands will provide sustainability, employment generation, and much needed oil to replace fossil fuels. Indian scenario is unique and different from other developed or developing countries.

Research on vegetable oils as diesel fuel was conducted at least 100 years ago but interest lagged because of cheap and plentiful supplies of petroleum fuels. Periodic increase in petroleum prices due to more demand, stringent emission norms, and feared shortages of petroleum fuels due to rapid depletion and net production of carbon dioxide from combustion sources have rekindled interest in renewable vegetable oil fuels. Bio-diesel is now recognized as one alternative to petroleum-based diesel. It is renewable and has significantly lower greenhouse emissions - effectively zero if renewable energy is used in its production. It has a number of additional advantages including creation of rural employment and development, improved air quality, and decreased reliance on external sources of oil.

Experimentation

Make : Kirloskar
Bore : 80 mm
Stroke: 110 mm
Speed: 1500 rpm
Brake horse power: 5h.p.
Number of cylinders: 1
Compression ratio: 16.5: 1
Orifice diameter: 20.46 mm
Coefficient of discharge (cd): 0.6
Effective diameter of brake drum: 15.3 cm
Type of ignition:Compression ignition
Method of loading :Rope brake dynamometer Method of starting: Manual cranking
Method of cooing provided: Water cooing

Experiments are conducted on the standard Engine with Diesel in different combinations of insulated parts. The Engine is tested under no load for the first 20 minutes and for each load the Engine is operated long enough to stabilize the condition. All the tests are conducted at the rated speed of 1500 rpm. From the observed readings, the parameters of performance, emissions are evaluated.

Preparation Of Piston Crowns:

A brass crown was turned out of brass rod of 85 mm diameter. The hemispherical shape of standard piston crown was turned using the concave and convex turning tool.

End milling provided the recess for the valve clearance. The brass crown was fixed to the aluminum piston with the help of studs at 90^0 of orientation because the high speed reciprocating movement of piston demands a very secure method of fastening the crown to the piston. The overall weight of the piston with brass crown was 100 gm more than the standard piston.

Because brass has high thermal conductivity and good thermal capacity it acts as a heat barrier piston crown with air gap insulation and this case air used as the insulating medium in addition to the brass crown. The thickness of the air gap had been optimized at 2mm for best performance. It was decided to maintain the same value. Thus it increases the rate of heat transfer from the hot combustion gases to the crown using the expansion stroke and from the crown to fresh charge during suction and compression stroke of the next cycle. The crown thus acts as a heat regenerator, thus it acts as a reservoir of heat.

About Esterification

While adding the base, a slight excess is factored into provide the catalyst for the esterification.

The calculated quantity of base (usually sodium hydroxide) is added slowly to the alcohol and it is stirred until it dissolves. Sufficient alcohol is added to make up three full equivalents of the triglyceride, and excess is added to drive the reaction to completion.

The solution of sodium hydroxide in the alcohol is then added to a warm solution of the waste oil, and the mixture is heated (typically 50 ° C) for several hours (4 to 8 typically) to allow the esterification to proceed. A condenser may be used to prevent the evaporative losses of the alcohol. Care must be taken not to create a closed system, which can explode.

Fig.1Experimental Setup for the Production of Esterified Oils Fig.2 Separator Funnel

II. Instrumentation

1.LOADING SYSTEM

A rope brake dynamometer is used for measuring the load. It has simple mechanism and capable of measuring optimum loads at normal speeds. Increases, heat generated at the interface of rope and pulley increases rapidly and leads to decrease in efficiency.

The brake drum dynamometer consists of a pulley at one end of the crankshaft, which is fixed firmly with a key. A rope is wound from the bottom and is attached to the frame at the top with adjustable nuts. These nuts are used for increasing &decreasing the load over engine. One spring balance is arranged at the one end of cotton ropes. The reading of balance will give the load on engine. Water is circulated through their arrangement and by regulating changing of load by varying weights on the platform connected to the rope.

2. FUEL CONSUMPTION

The fuel tank is attached with a graduated burette. The valve at the bottom of the tank is closed when the consumption rate is to be measured so that fuel is consumed only from the burette. The time taken for certain amount of fuel (20cc) consumption is recorded by the stopwatch to measure the fuel consumption rate.

3. AIR SUPPLY SYSTEM

An air box equal to the twenty times the volume of the engine cylinder is fixed to the stand. The air enters into the air box passing through an orifice plate and one leg is connected of U-tube manometer is connected to orifice plate and other leg is opened to atmosphere and it is filled with the water. The difference in water column in two legs of u-tube manometer gives the pressure drop across the orifice plates. This pressure drop is to calculate the mass flow rate of air.

4. EXHAUSTTEMPERATURE MEASURMENT

Exhaust temperature is measured by an iron-constantan thermocouple fitted very near the cylinder head in the exhaust manifold and is measured directly from a dial type indicator, that is already calibrated.

5. COOLING WATER FLOW RATE

Coolant water flow rate is measured by collecting the water into the 2 liters pan and time is measured to fill it with help of stopwatch. The outlet temperature and the inlet temperature of the cooling water is measured using a inbuilt thermocouple arrangement.

6. MEASURING OF FLUE GAS PROPORTIONS

The proportions of exhaust gases are measured by inserting the probe of the flue gas analyzer into adjustment made in the exhaust manifold. The manufacturing company of the instrument is TECH-ED EQUIPMENT COMPANY BANGLORE the cost of equipment Rs 2, 69,000. By using these measure the proportions of five gases C0, CO_2, HC, O_2, and NOX.

III. Experimental Procedure

The various fuels that are used during investigation are diesel, Jatropha fuel, Pamolin fuel.

❖ **To find the performance of any engine with any fuel, the following procedure is followed**:

a. Measure the diameter of brake drum and diameter of rope with the inelastic thread and measure the length with the help of long scale.
b. The engine is provided with proper supply of cooling water and check the availability of lubricating oil in the crankcase and fuel level in the fuel tank by measuring the burette level.

c. There should be no load on the engine while starting, the decompression lever is relieved and by sufficient cranking and engage the decompression lever to get the engine started.

d. The running engine is left idle for some time to attain steady state conditions.

e. At this no load condition, the following readings are noted.

1. Time for 20 cc fuel consumption.
2. Exhaust gas temperature.
3. Cooling water exhaust Temperature.
4. Manometer reading.
5. Speed of the engine and
6. Time for 2 lit water collections.

f. Later the load is increased from no load to full load in steps of 20% and at every load the above-mentioned parameters are noted. The engine is made to run10 minutes at every load before taking the above readings.

g. Finally the load is completely removed and stopping the fuel supply stops the engine

Fig.3 EXPERIMENTAL SET UP OF 5 HP KIRLOSKAR ENGINE

Fig.4 EXHAUST GAS ANALYZER

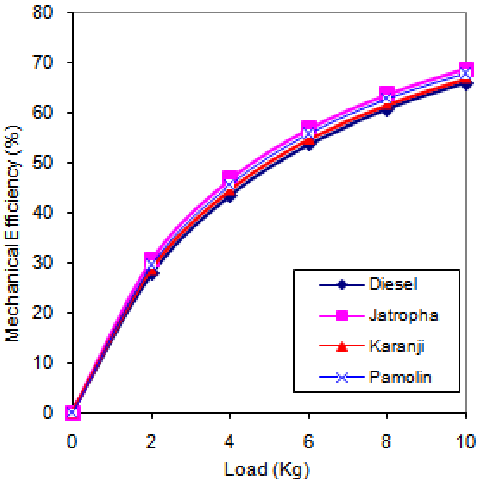
Fig.5 TOP VIEW OF THE PISTON

Fig.6ALUMINUM PISTON WITH BRONZE CROWN

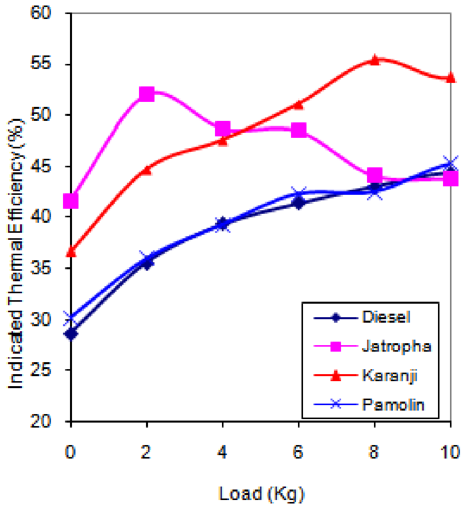
Fig.7 ARRANGEMENT OF PISTON INTO THE ENGINE CYLINDER

IV. Results

Experiments have been conducted on an engine test rig with different bio-diesel oils and performance curves, are drawn for different types of pistons and following results are drawn.



Graph.1



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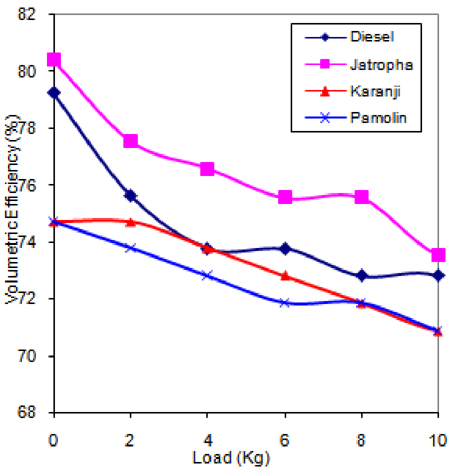

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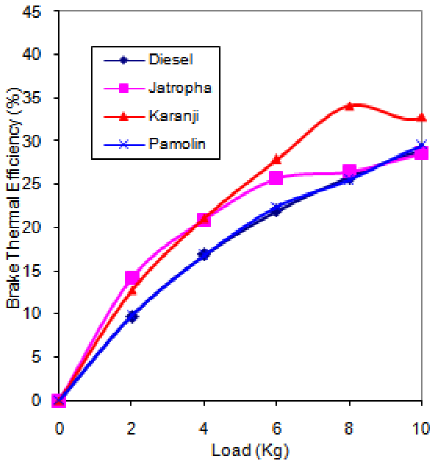

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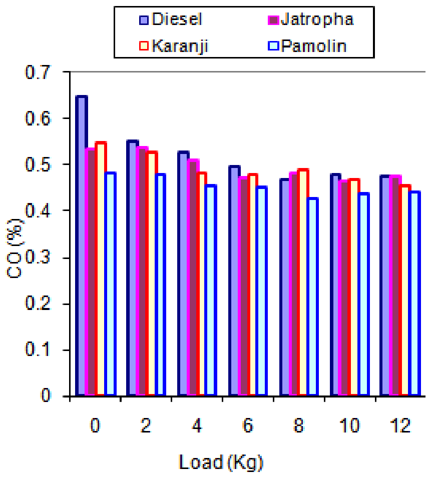

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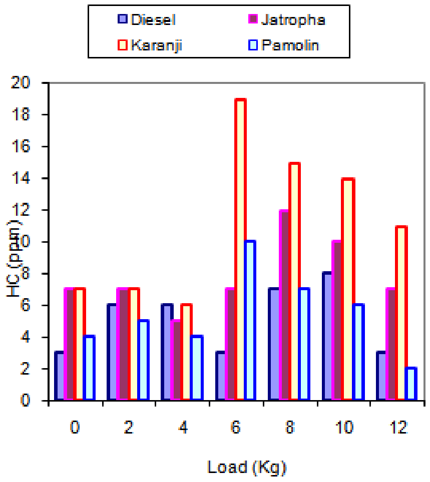

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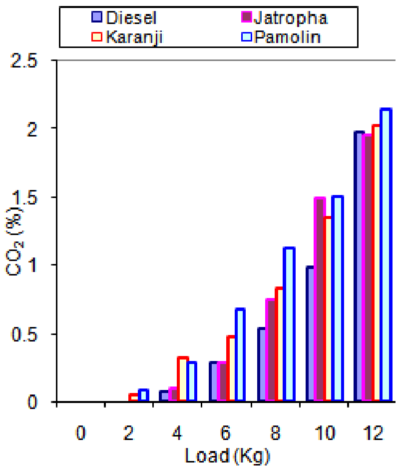

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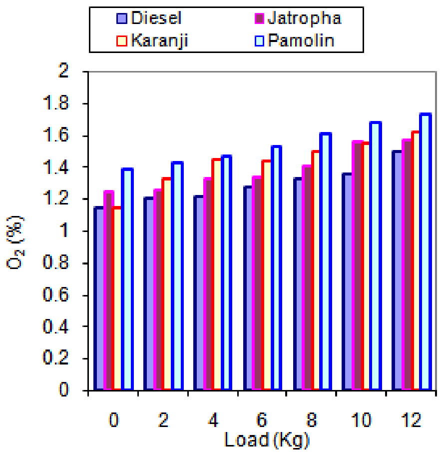

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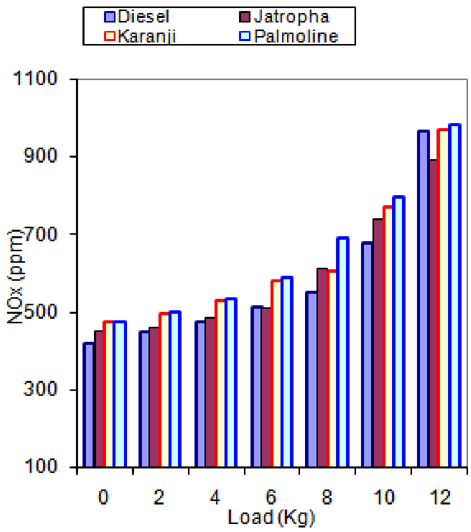
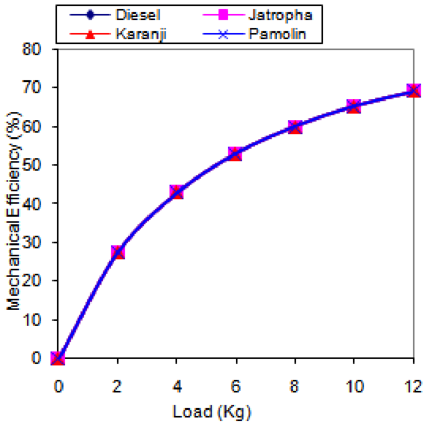


Graph.9

PISTON CROWN MATERIAL:BRASS



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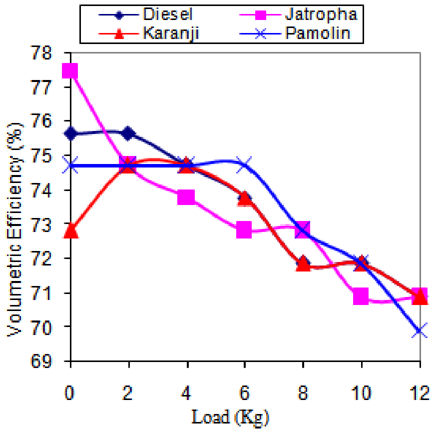

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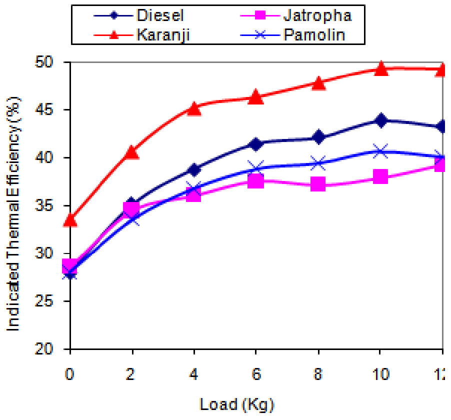

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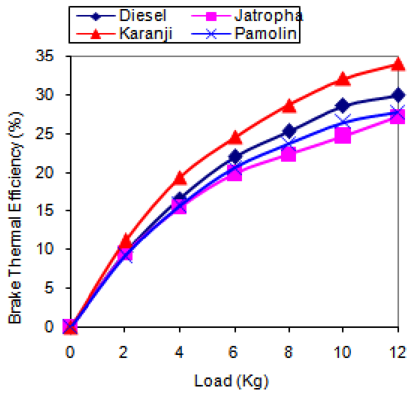

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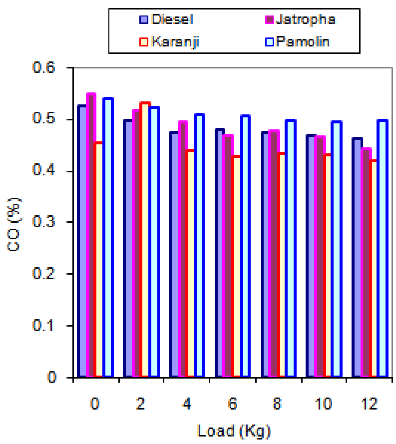

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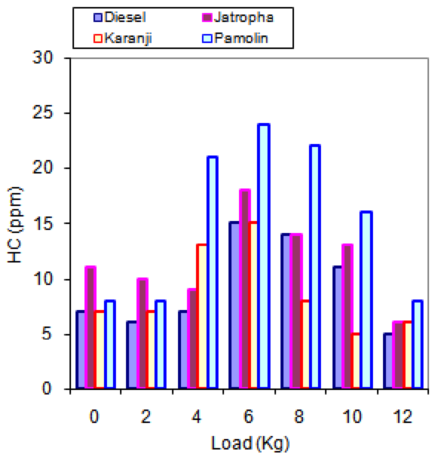

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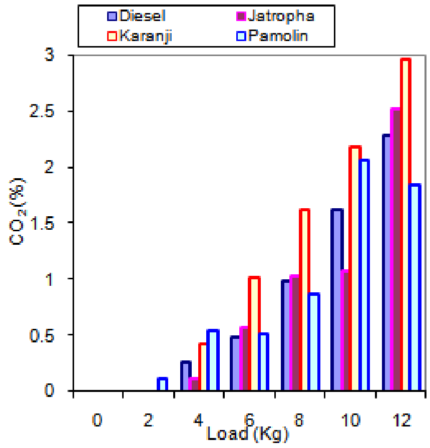

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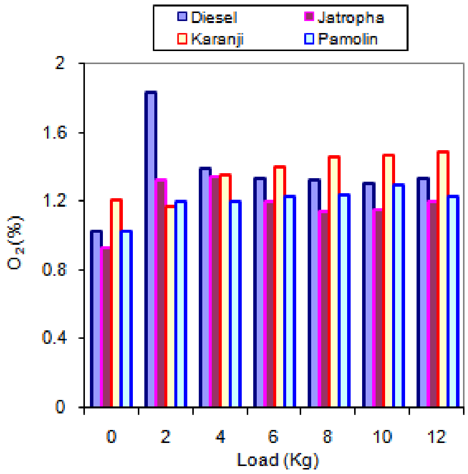

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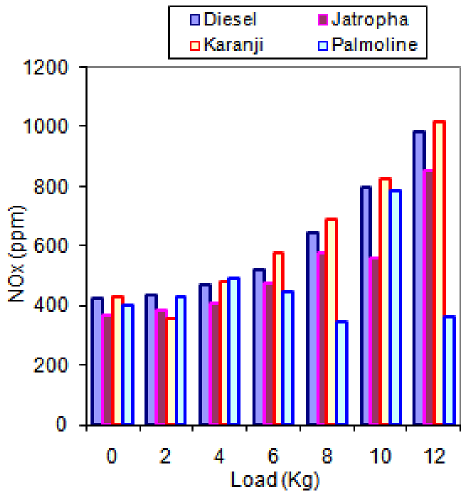
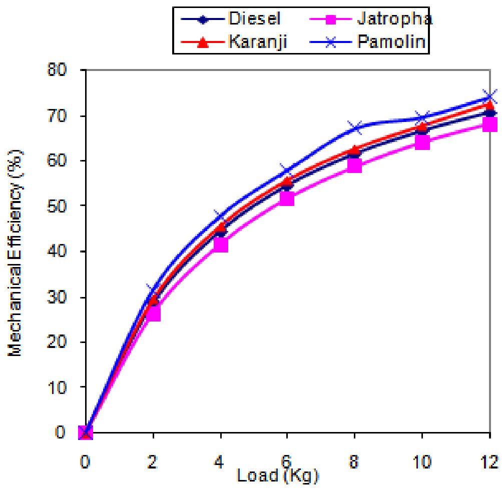


Graph.18

PISTON CROWN MATERIAL: BRONZE



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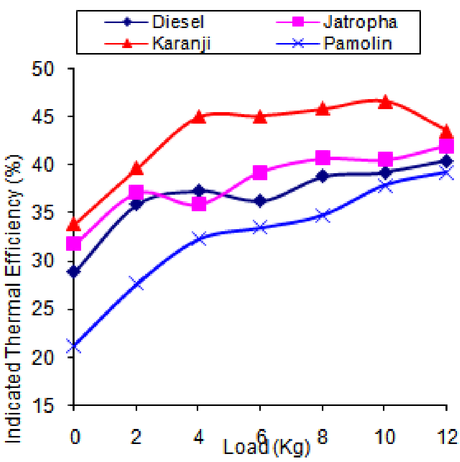

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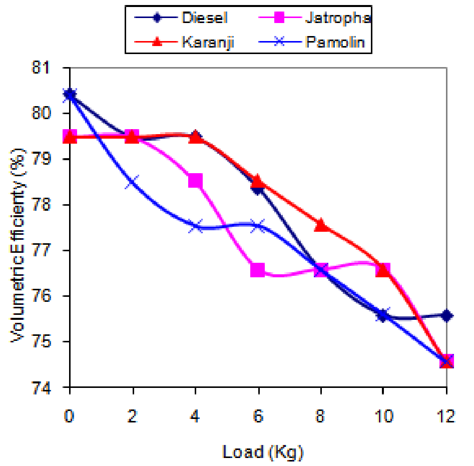

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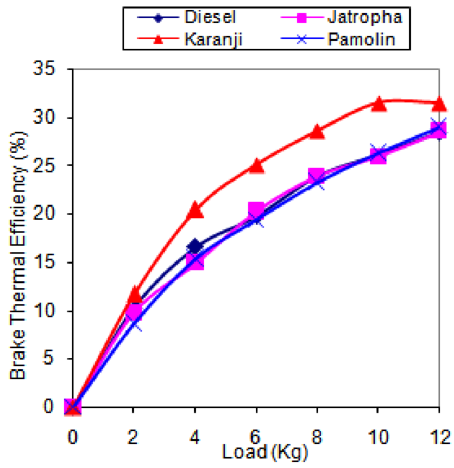

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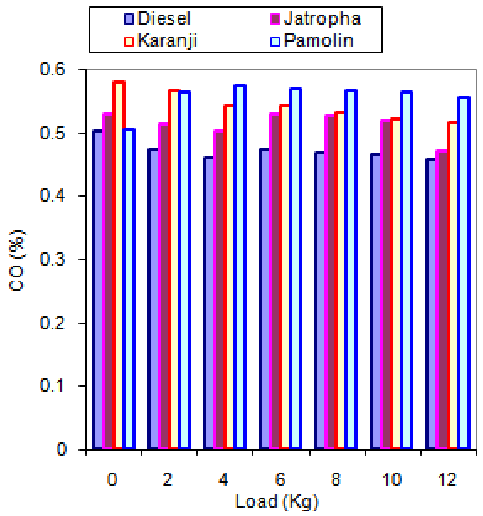

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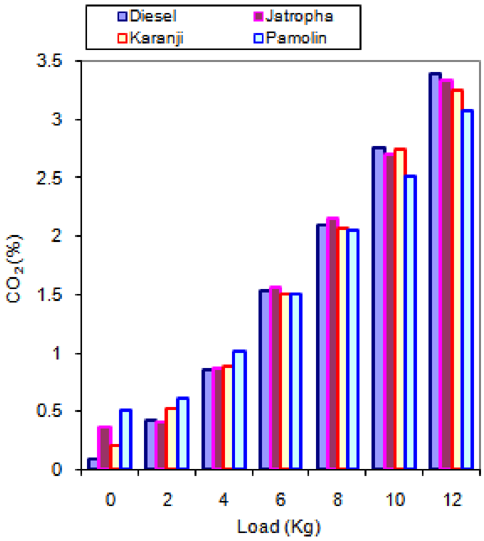

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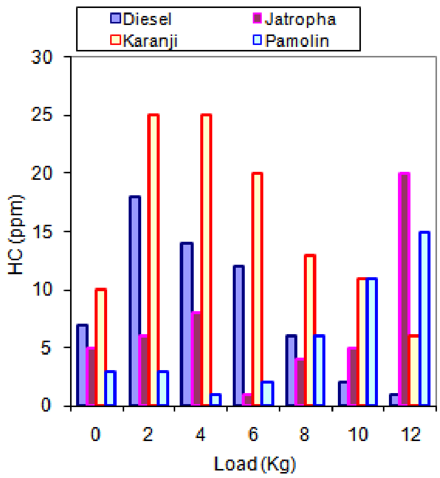

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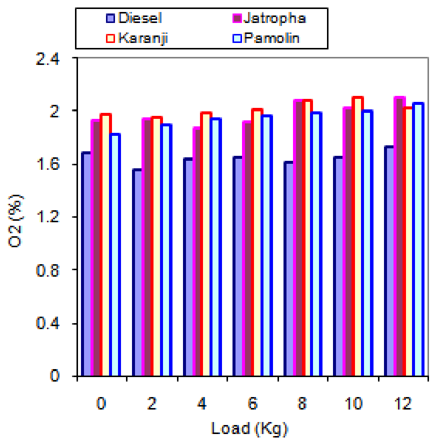

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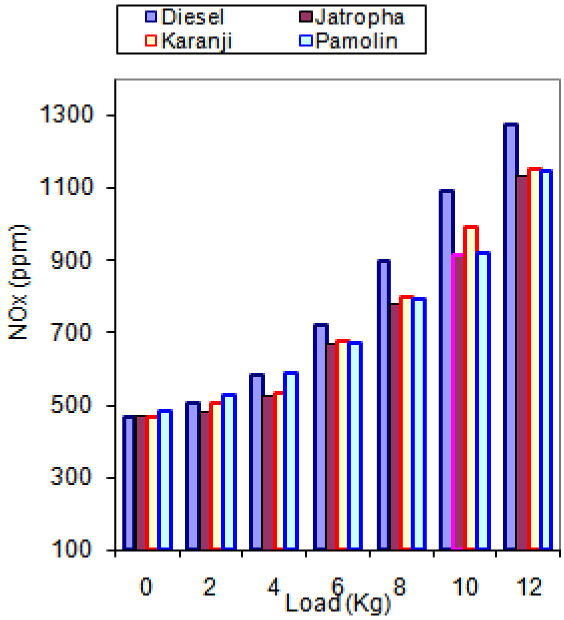

Graph.27

V. Conclusions

An existing 4-stroke diesel engine was selected for experimentation and number of experiments has been carried out on it by using both diesel and esterified bio-diesel oils in pure form. The original aluminum piston crown was replaced with brass and bronze material for testing and comparing with different fuels.
All the performance characteristics were observed and heat balance sheets were prepared for different pistons and oils.

Analysis of exhaust gas compounds like CO, HC, CO_2, O_2 and NO_x was carried out and comparison has been made between the various oils and also between the pistons.

The conclusions drawn are:

1) For the diesel fuel, η_{mech} is almost similar to all types of pistons. But η_{ith} & η_{bth} are high for the aluminum piston than brass and bronze pistons. η_{vol} is high for bronze piston.
2) For Jatropha fuel, η_{mech}, η_{ith} & η_{bth} are high for aluminum piston than brass and bronze pistons and η_{vol} is high for bronze piston.
3) For Karanji fuel, η_{mech} is almost similar to all types of pistons. But η_{indi} & η_{bth} are high for aluminum and η_{vol} is high for bronze piston.
4) For Pamolin fuel, η_{vol} and η_{mech} is high for bronze piston. But η_{ith} & η_{bth} are high for aluminum piston.

On comparing bio-diesels with pure diesel with aluminum piston, it is observed that diesel & jatropha would give better performance and less emission.

Usage of bio-diesels in pure form with brass crown piston may lead to decrease in performance comparing with normal piston crown. It is also observed that emissions are also high with brass crown piston.
On comparing bio-diesels with pure diesel with bronze piston, the pure karanji would give good performance, but emissions are just higher than diesel.

Usage of Pamolin oil results in lesser concentrations of emissions for all types of pistons but poor in performance parameters and it is concluded that it is not suitable for running engines.
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Alagala Harikrishna "Experimental Investigation on 4-Stroke C.I. Engine with Different Piston Crown Materials using esterified bio-diesel oils as an alternative fuels" International Journal of Engineering Science Invention (IJESI), Vol. 08, No.11, 2019, PP 20-30