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AN EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION CHARACTERISTICS OF TOROIDAL SHAPE CI ENGINE SYSTEM FUELED WITH PONGAMIA PINNATA OIL-DIESEL BLEND

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ABSTRACT

The present work investigates on performance and emission characteristics of toroidal shape combustion ignition engine system fueled with pongamia pinnata oil-diesel blend in terms of brake specific fuel consumption, brake thermal efficiency, mechanical efficiency and indicated thermal efficiency CO, HC , NOx emissions.

Key words - Toroidal, Bio Diesel, Pongomia Pinnata

1. INTRODUCTION

Diesel engines provide a major power source for transportation in the world and contribute to the prosperity of the worldwide economy. However, recent concerns over the environment, increasing fuel prices and the scarcity of fuel supplies have promoted considerable interest in searching for alternatives to petroleum based fuels. An experimental investigation will perform on a four-stroke, one-cylinder water-cooled direct injection diesel engine to study the performance and emissions of an engine operated using the pongamia pinnata oil diesel blended fuels. The effect of the pongamia pinnata oil diesel blended fuel on the engine brake thermal efficiency, brake specific fuel consumption, specific energy consumption and exhaust emissions will be investigated. Oxygen content in biodiesel is high which leads emission of NOx which is a harmful air pollutant. To reduce this obstacle complete combustion is needed. However in flat piston diesel engine combustion process is incomplete. Thus to avoid the problem toroidal shape piston is selected to replace flat piston in the diesel engine.

The test results showed that brake thermal efficiency for toroidal combustion chamber is higher than normal flat shape combustion chamber and also increases the combustion rate higher than normal engine rate.

2. MATERIALS AND METHODS

The required materials and methods for this work will be discussed in details as follows

Pongomia Pinnata Bio Diesel

For the present work pongomia pinnata is chosen as the alternate source for diesel. Pongamia Pinnata, an excellent shrub having natural spread across the globe, is one of the promising bio fuel crops ideally suitable for growing in the wastelands. Greater potential exists in India for bringing millions of hectares of wasteland under extensive plantation of pongamia, virtually converting unproductive lands into green oil fields. Pongamia seeds contain 30–40% oil.

To prepare pongomia bio diesel, the transesterification reaction was performed on raw pongamia oil. Transesterification is a chemical process of transforming large, branched, triglyceride molecules of vegetable oils and fats into smaller, straight chain molecules, almost similar to diesel fuel. The process takes place by the reaction of raw pongamia oil with methyl alcohol in the presence of catalyst. The properties of the raw pongamia oil were experimentally evaluated.

Extraction method

The first stage (acid catalyzed) of the process is to reduce the free fatty acids content in karanja oil by esterification with methanol (99% pure) and acid catalyst sulfuric acid (98% pure) in one hour time at 57ºC in a closed reactor vessel. The karanja crude oil is first heated to 50 ºC and 0.5% sulfuric acid is to be added to oil then methyl alcohol about 13% added. Methyl alcohol is added in excess amount top speed up the reaction. This reaction proceeding with stirring at 700 rpm and temperature was controlled at 55-57 degree for 90 min with regular analysis of free fatty acid every after 25-30 min.

Transesterification

The catalyst used is typically sodium hydroxide (NaOH) with 1% of total quantity of oil mass. It is dissolved in the 13% of distilled methanol (CH3OH) using a standard agitator at 700-rpm speed for 20 minutes .The alcohol -catalyst solution was prepared freshly in order to maintain the catalytic activity and prevent the moisture absorbance. After completion, it has slowly charged into preheated esterified oil.

Transesterification Reaction

When the meth oxide was added to oil, the system was closed to prevent the loss of alcohol as well as to prevent the moisture. The temperature of reaction mix was maintained at 60 to 65ºC (that is near to the boiling point of methyl alcohol) to speed up the reaction. The recommended reaction time is 70 min. The stirring speed is should be maintained at 560-700rpm. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. The reaction mixture should take for each 20 min.

Pretreatment

In this method, the karanja oil is first filtered tore move solid material then it is preheated at 110 degree for 30 min tore move moisture (presence of moisture responsible for saponification in the reaction).After this de moisturisation of Oil we removed available wax, carbon residue, saponificable matter and fiber.

Esterification

Karanja oil contains 6%- 20% free fatty acid 26-29. The methyl ester is produced by chemically reacting karanja oil with an alcohol (methyl), in the presence of catalyst heating was stopped and the products were cooled and transferred to separating funnel.

Settling and Separation

Once the reaction is complete, it allowed for settling to take 8-10 hours in separating funnel. At the stage, two major products were obtained they are glycerin and biodiesel. Each has a substantial amount of the excess methanol that has used in the reaction. The glycerin phase is much denser than biodiesel phase and settled down while biodiesel floated up. The two can be gravity separated with glycerin simply drawn off the bottom of the settling vessel.

Alcohol Removal

Once the glycerin and biodiesel phases were been separated, the excess alcohol in each phase was remove by distillation. In either case, the alcohol is recovered using distillation equipment and is re-used. Care must be taken ensure no water accumulates in the recovered alcohol stream.

Drying Of Biodiesel

This is normally the end of the production process to remove water present in the biodiesel that results in a clear amber-yellow liquid with a viscosity similar to petro diesel

Properties of Bio Diesel Blends

The properties of diesel such as density, viscosity, calorific value and its properties during blend with bio diesel in different ratios such as B20, B40, B60, B100 has been found out and tabulated is shown in table 2.1.

TABLE 1 PROPERTIES OF BIO DIESEL BLENDS

Property	Diesel	B20	B40	B60	B100
Density (kg/m3)	0.85	0.8596	0.8692	0.8788	0.898
Viscosity (ns/m2)	2.9	3.412	3.924	4.436	5.46
Calorific Value	44.12	43.126	42.132	41.138	39.15

Experimental setup

The test engine used for this purpose was the Kirloskar, single cylinder four-stroke water cooled diesel engine developing 5.2 kW at 1500 rpm. The detailed technical specifications of the standard diesel engine are given in Table 2.2 as shown.

Table 2 Engine Specifications

MAKE	KIRLOSKAR TV1
Engine type	Vertical diesel engine, four stroke, water cooled, single cylinder
Displacement	661 cc
Bore and stroke	87.5 mm and 110mm
Compression ratio	17.5:1
Fuel	Diesel
Rated brake power	5.2kW @ 1500 rpm
Ignition system	Compression ignition
Injection pressure	200 bar
Combustion chamber	toroidal combustion chamber

Engine Modification

Development of biodiesel fuelled direct-injection diesel engine requires modifications to fuel injection system and to the combustion chamber, since they strongly influence both the engine performance and the pollutant emissions. Mixture formation within the engine cylinder mainly depends upon shape of the combustion chamber in a direct injected diesel engine. In direct injection diesel engines a single combustion chamber with different piston bowl shapes such as cylindrical, square, hemispherical, shallow depth, and toroidal have been used. In the present investigation, to investigate the effects of combustion chamber geometry on performance, combustion and emission characteristics of biodiesel fuelled direct injection diesel engine the piston bowl geometry was modified to have Toroidal Combustion Chamber The three dimensional view of the toroidal shape piston is as sown in the fig .1.the various dimensions with exact ratio should be carried out for better performance.

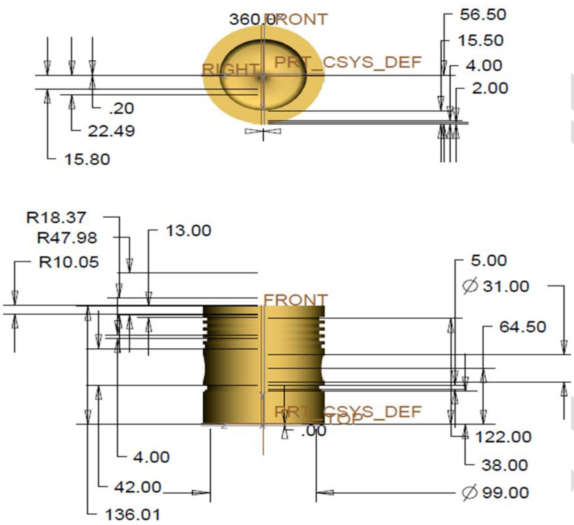


Figure .1 3D diagram of toroidal piston

Using the specified dimensions the machining has been done on the piston which was shown in the figure 2

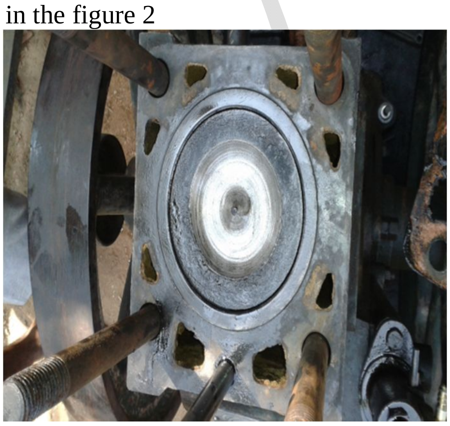


Figure 2 photographic view of employed toroidal combustion chamber

Test method

In this work, performance characteristics such brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency, mechanical efficiency and emission characteristics such as CO,HC, NOx for diesel and blends with pongomia pinnata in the ratio B20, B40, B60, B100 are calculated.

The variation of performance for each bio diesel blend is used and these tests are taken for all blends as well diesel by replacing the toroidal piston with the normal piston.

The results of the performance and emission characteristics of pongomia pinnta oil-diesel blend was compared with normal piton and toroidal and also the bio diesel performance with diesel.

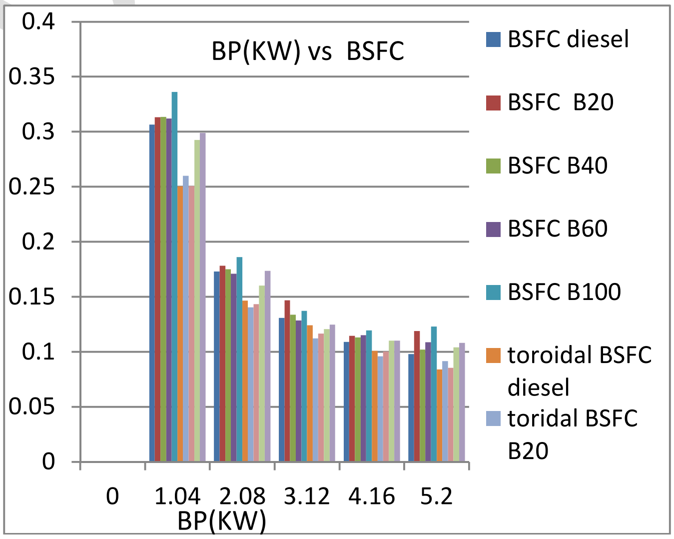
3. RESULTS AND DISCUSSION

The performance and emission characteristics of toroidal shape combustion ignition system fuelled with pongomia pinnata oil diesel blend were discussed below.

Performance Analysis

The various performance analyses such as brake specific fuel consumption (BSFC), brake thermal efficiency (BT), indicated thermal efficiency (IT), mechanical efficiency (MECH) are calculated and shown as follows.

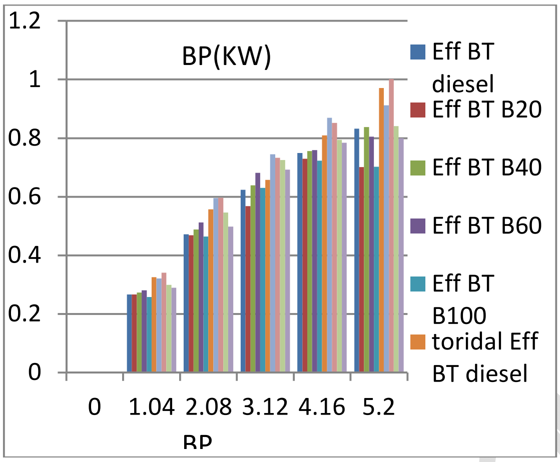
Brake specific fuel consumption



Graph 3.1 Brake Specific Fuel Consumption

BSFC vs. Brake Power for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 and for same blends toroidal shape piston is also calculated are shown in graph 3.1. These results show that B40 is almost equal to performance of diesel in normal flat piston diesel engine. But the tests on toroidal piston shows overall improvement in all four blends when compared to normal flat piston engine and here to B40 shows performance higher than other blends.

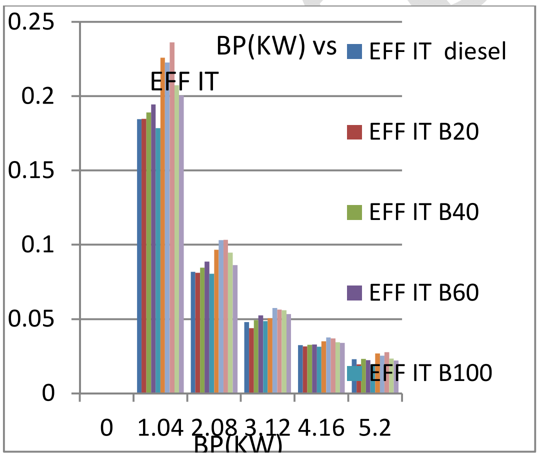
Brake thermal efficiency



Graph 3.2 Brake Thermal Efficiency

Brake thermal efficiency vs. Brake Power for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 and for same blends toroidal shape piston is also calculated are shown in graph 3.2. These results show that B40 is almost equal to performance of diesel in normal flat piston diesel engine. But the tests on toroidal piston shows overall improvement in all four blends when compared to normal flat piston engine and here to B40 shows performance higher than other blends.

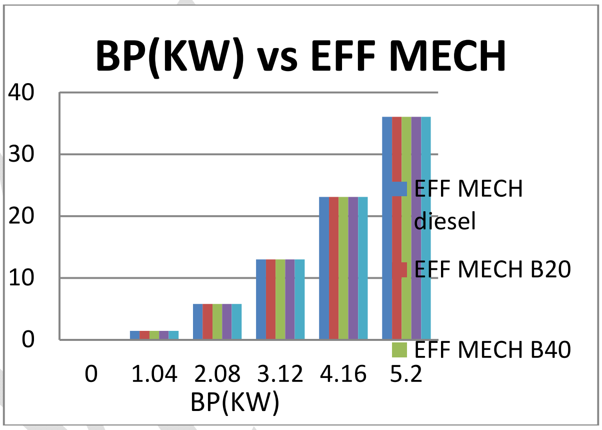
Indicated thermal efficiency



Graph 3.3 Indicated Thermal Efficiency

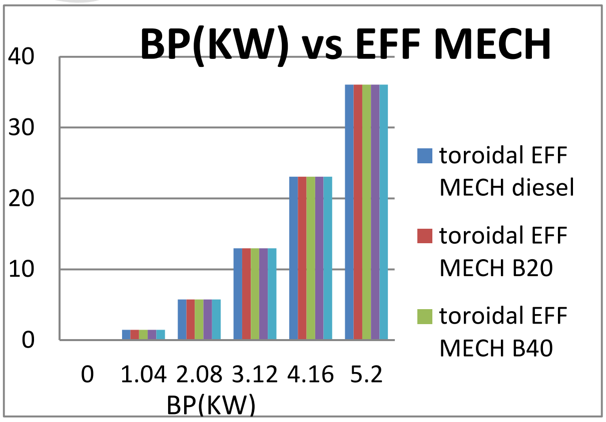
Indicated thermal efficiency vs. Brake Power for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 and for same blends toroidal shape piston is also calculated are shown in graph 3.3. These results show that B40 is almost equal to performance of diesel in normal flat piston diesel engine. But the tests on toroidal piston shows overall improvement in all four blends when compared to normal flat piston engine and here to B40 shows performance higher than other blends.

Mechanical efficiency



Graph 3.4 Mechanical Efficiency

Mechanical efficiency vs. Brake Power for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 are shown in graph 3.4. Above results show that mechanical efficiency remains constant in all blends. But increases with increase in brake power which is shown in graph clearly.



Graph 3.5 Mechanical Efficiency toroidal

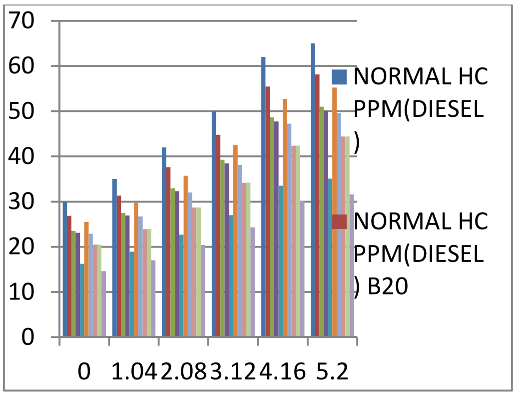
Mechanical efficiency vs. Brake Power for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 for toroidal combustion chamber is shown in graph 3.5. Above results show that mechanical efficiency remains constant in all blends. But increases with increase in brake power

Thus mechanical efficiency remains constant for both normal flat piston and toroidal piston.

Emission Characteristics

Various emission characteristics such as CO, HC and NOx are calculated and results are shown below

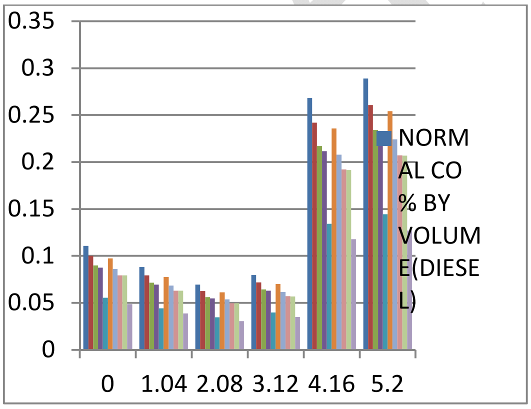
HC Emission



Graph 3.6 HC emission

Hydro carbon emission for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 are calculated and for same blends replacing toroidal shape piston is also calculated and results are shown in graph 3.6. HC emission is high when it was tested on diesel and it is gradually decreasing with blend on biodiesel here B60 blend shows lesser HC emissions and test was carried out on toroidal piston which shows lesser emission rate compared to normal blend. It shows reduction about 10-15 % when compared to normal flat piston.

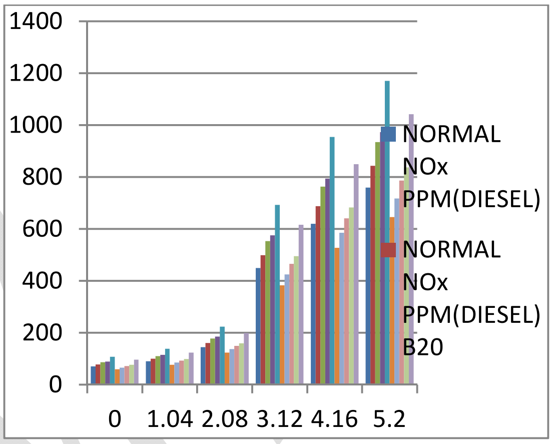
CO Emission



Graph 3.7 CO emission

Carbon monoxide(CO) emission for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 are calculated and for same blends replacing toroidal shape piston is also calculated and results are shown in graph 3.7. CO emission is high when it was tested on diesel And it is gradually decreasing with blend on biodiesel here B60 blend shows lesser CO emissions and test was carried out on toroidal piston which shows lesser emission rate compared to normal blend. It shows reduction about 10-15 % when compared to normal flat piston.

NOx Emission



Graph 3.8 NOx emission

NOx emission for diesel and blend with pongomia bio diesel in ratio B20, B40, B60, and B100 are calculated and for same blends replacing toroidal shape piston is also calculated are shown in graph 3.6. NOx emission is low when it was tested on diesel it is gradually increasing with blend on biodiesel .test was carried out on toroidal piston which shows lesser emission rate compared to normal blend with diesel. Due to the fact that combustion rate is increased in toroidal shape piston.diesel shows less emission compared to other blends yet replacing toroidal piston shows reduction in NOx about 9-10 % when compared to diesel performance in normal flat piston.

4. CONCLUSION

The present work analysis the performance, emission and characteristics of pongamia oil-diesel blend. The test results revealed that the blend B40 shows better increase in performance when compared to other blend such as B20, B60, B100.this B40 blend shows equal in performance to normal diesel but emission of NOx is high thus to reduce this obstacle toroidal shape piston is used to increase the combustion rate. The replacement of toroidal shape piston instead of normal piston not only show reduction in emission rate, it also increases the performance characteristics such as brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency of engine as well.

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