Experimental investigation of circular stepped dish type combustion chamber (piston top) geometry for four stroke single cylinder di diesel engine fueled with diesel and ramtil oil

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Abstract: In this investigation, the Internal combustion engine is established because of the main power supply to the automobile is internal combustion engine. For this reason, heaps analysis goes on combustion to extend the performance and reduce the emissions. So as to fulfill the tight emission standards, vital efforts are created for the event of isolated I.C engines. During this project work done on the combustion chamber. The new design and modification of the piston bowl is projected to cut back the emissions and improve the engine performance with the assistance of RAMTIL OIL and DIESEL fuels. The circular stepped dish type combustion chamber is to produce higher mixture of fuel with intake air so higher mixture of fuel can result sensible combustion of mixture. This design of the piston could improve the squish of the air fuel mixture, which can end up in higher thermal efficiency and emission reduction of exhaust emissions. It's projected to hold out associate experiment on a four-stroke single cylinder DI Diesel engine by victimization of DIESEL and RAMTIL oil fuel (i.e., within the type of blends B5, B10, B15, B20, B25) as another fuel. Performance parameters like brake thermal efficiency, specific fuel consumption, and overall efficiencies are to be calculated. The Brake Thermal efficiency of the engine is increased compared to diesel fuel with normal piston to the modified (circular dish type combustion chamber) piston with RAMTIL oil blends. The Brake Thermal efficiency (30.77%) of the engine is greatly improved with the comparison of basic piston to changed piston with B15 fuel. The Nox emissions of the B10 and B15 are decreased (min 181 ppm) at full load conditions.

Key words: single cylinder DI diesel engine, Ramtil seed oil alkyl radical Ester, CSDCC piston, Trans esterification method bio diesel, Engine performance and emissions.

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1 INTRODUCTION

Bio-diesel is another fuel source to petroleum-based fuels derived from vegetable oils, animal fats, and used waste vegetable oil as well as triglycerides. Since the crude crises in Nineteen Seventies, the quickly increasing costs and uncertainties regarding crude accessibility, a growing concern of the environmental pollution the fossil fuel gasses greatly damage the ozone layer. And also, it results of greenhouse gases throughout the last decades has revived a lot of researches and a lot of interests within the use of vegetable oils as a substitute of fuel. Vegetable oils or biodiesel fuels are square measure wide accessible from different sources. World faces a dreadful challenge to meet emission standards. Renewable energy sources bio-fuels (like vegetable fuels etc.) is capable of reducing our dependency on foreign import there by increasing the protection of energy offer. The Diesel and biodiesel (Ramtil oil + Diesel) mixture measures the two liquid bio fuels (one is diesel and other one is Ramtil oil at various blends) that may replace substitute of petrol, diesel in the future, in order to meet the fuel necessity of all vehicles. [1-3] initially the primary use of oil in an exceedingly CI diesel engine was first incontestable through Rudolph Diesel. The CI engines were more suitable than the SI engine because of its high compression ratio and its high temperature generating quality. World Health Organization used oil. The long run use of vegetable oils (Ramtil oil) is to appliance in coking and also the thickening of cylinder walls of engine, that resulted in seal projected. Therefore, vegetable oils aren't utilized in SI engines owing to endurance problems. Production and utilization of the bio fuel would generate the new economic opportunities and protection of the setting in Fat economic growth countries like India and wide spread across the globe.

The performance and emissions characteristic of the diesel fuel engine for various biodiesel fuel and vegetable-based fuels have been presented in various publication by the authors across the globe, and they have been shown that the bio fuels (Jetropha oil, Neem oil, vegetable oil and waste cooking oil etc.) are supportive to the fossil fuels in order to control the emission that have been omitted by the industrial engines and transportation vehicles. Study shows that the mass content of the biofuels is lesser than petroleum-based diesel fuel, it reduces Un-burnt hydro carbons, and carbon monoxide and NOx are moderate temperature. The Jetropha blend i.e., B5, B10, B15, B20 and B25 are running abnormal load condition during the testing of diesel engine performance test. B15 showed very nearer performance of the diesel fuel. A few experimental investigations of fuel blends with additives shows that the properties of the fuel improved hence it leads to increase the higher thermal efficiency and lower the harmful emissions [4-9]. Generally, the vibration occur in diesel engine is more than the petrol-based engine because of its heavy rigid body and high compression ratio, variable compression ratios of the engines cause different range of temperature extractions from the engine cylinder walls. [10]

At present scenario there will be different types of techniques carried out to improve the performance those are pre-combustion, post combustion, piston bowl modifications are employed (i.e., piston crown is changed to different shapes) in the present investigation on piston bowl modification i.e., circular stepped dish type combustion chamber (CSDCC) is used in the present research work. The test is conducted with Ramtil blends of B5, B10, B15, B20, and B25 with diesel fuel for both Normal piston and modified piston with mechanical loaded Kirloskar diesel engine test rig equipment. [12-18] On the face of the upcoming energy crisis, vegetable oils have come up as a promising source of engine fuels. They are being researched widely because of their huge availability, renewable in nature and better performance when used in the diesel engines. There are so many vegetable oils have been investigated in compression ignition engine by fuel modification or engine modifications.

2 Materials and Methods

Niger is understood as Ramtil or Niger seed oil in India and Noog in African nation it's very important minor oil seeds crop of Tropical system like India   Ramtil oil is edible oil, scientifically referred to as GUIZOTIA ABYSSINICA. It is obtained from the seeds of Niger seed plant that belongs to the composite. The Niger seed plant is associate erect, stout, branched annual herb, grownup for its edible seeds and oil. It’s typically cultivated in Mysore, Madhya Pradesh states, geographic region etc. In India south Gujarat zone wherever the cultivation of Ramtil is high and it's in the main for the exports purpose and as a bird feeding purpose. Ramtil oil additionally considers as a minor oil seed crop is incredibly vital in terms of quality and style of its oil and export potential. This social group crop is additionally facing up to the adverse climate and poor soil conditions.

Fig.2.1Ramtil biodiesel

Table 2.1 Properties of fuel

S.No	Parameters	Units	D100	R100
1	Density at 15 ^0C	kg/m3	844	885
2	Kinematic Viscosity at 40 ^0C	cst	2.95	4
3	Flash point	^0C	66	140
4	Water content	%w/v	0.005	0.19
5	Acid value	mg KOH / gm	-	0.5
6	Calorific value	kJ/kg	44,120	40,000
7	Cetane Number	-	49.7	45

3 OBJECTIVES

The objective of this investigation is to effectively utilized the ramtil oil as a substitute fuel for diesel engine and there by greatly reducing environmental harms caused by engine emissions

1. To find out the characteristics of ramtil oil and its blends, the engine fueled with ramtil biodiesel to study the performance and its effects of modified circular stepped combustion chamber.
2. To improve turbulence and quality of fuel mixture the circular steps on piston crown are employed.
3. To experimentally evaluate the effects of modified combustion chamber on single cylinder diesel engine fueled with ramtil oil.
4. To reduce exhaust emissions by employing biodiesel fuel with rich content of oxygen in biodiesel fuel compared to diesel fuel.
5. To reduce NOx and HC emissions by using swirl and squish with the help of modified crown and appropriate biodiesel blend.

4 EXPERIMENTAL SETUP

4.1 Engine Set Up

In the present research work the investigation of engine performance by using single cylinder DI diesel engine with Ramtil oil as blend and circular stepped dish type combustion chamber used in this research work. The experiments were conducted on single cylinder Kirloskar make direct injection four stroke cycle diesel engine. The specifications of the Kirloskar engine are given in the table 4.1. Naturally aspirated, water cooled eddy current dynamometer was used for this experimental test rig. The engine was coupled with Piezo type cylinder pressure sensor, electromagnetic pick up, thermo couples to measure the temperatures of outlets like, water, air and gas, Rota meter to measure the water flow rate and manometer is used to air flow and fuel rates. The smoke meter and gas analyzers are situated to measure the smoke density. In this research work Bosch smoke meter is used to find out the smoke density. An attempt is made in this work with circular steps on the piston crown of the aluminum alloyed piston with finished machining of the piston head.

The circular stepped bowl shape on the piston head shown in the fig.4.2.the experiments are conducted on single cylinder DI diesel engine by varying loads and blends (loads are 0 to 15 kg applied gradually) and the blends are B5, B10, B15, B20, B25 (Ramtil oil + Diesel fuel) the results of the different blends of performance of the circular stepped dish type combustion chamber were compared with normal piston engine.

4.2 Test Procedure

The procedure for performance analysis of single cylinder DI diesel engine is in two phases. At firstthe experimental investigation of performance test is carried out with normal piston fueled with diesel in order to get standard values to compare with the modified piston values. In the second stage the experimental investigation is conducted by using Ramtil oil and it blended fuels (i.e., B5, B10, B15, B20 and B25). Before conducting these steps firstly need to check the lubrication system of the engine, fuel tank level and permit the water to flow into the engine. In this investigated experiment different type of instruments are used to measure the different engine parameters. After that, apply the load (using rope dynamo meter) on the engine and note down the all required readings of Engine i.e., speed of the engine, time taken for ten 10cc of fuel consumption and brake load placed on the engine. Repeat the same procedure for various masse of the fuels. Finally stop the engine by removing the load on the engine, then cut off the fuel supply and Continue the experimentation for different load trials.

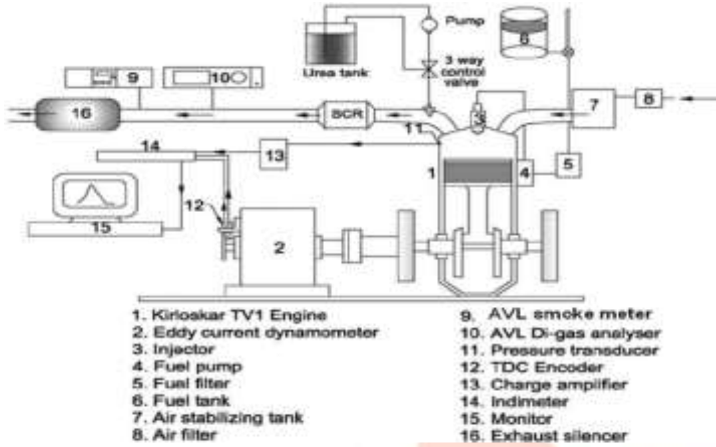

Fig.4.1 Schematic Diagram of Experimental setup

Fig.4.2 Experimental Engine setup

Table 4.1Specification of Test Engine:

S.No	Parameters	Specifications
1	Type	Naturally aspirated
2	No. of Cylinders	Single
3	No. of strokes	Four
4	Fuel	Diesel
5	Make	Kirloskar
6	Rated Speed	1500Rpm
7	Cylinder bore	80mm
8	Cylinder stroke	110mm
9	Cooling method	Water cooled engine

4.3 Engine Modifications

In this present research work the piston crown of the standard engine combustion chamber is changed to evaluate the performance, combustion and exhaust emissions characteristics of Ramtil bio fuel on single cylinder Di diesel engine. The standard spherical combustion chamber was designed for single cylinder DI diesel engine, but when it comes to biofuel application the engine need for modification in the combustion chamber shape has to be taken into consideration to evaluate its characteristics and performance. The greatly improved fluid motion in the combustion chamber by its design of geometry applicable the mixture formation biofuel with air particles therefore stoichiometric mixture leads to complete combustion it leads to improving BTE and lower the SFC. Squish and squill enhancement by circular steps are provided on piston top to improve the efficiency of biodiesel air particle mixing by improving the speed swirling motion of the mixture with the fabricated circular stepped dish type combustion chamber piston and schematic representation of piston are shown in fig. 4.1 & 4.2.

In the suction stroke, outside air which is entering in to the engine barrel was compacted to higher weight and temperature, which is not adequate to blend with the fuel injector and a portion of the fuel particles are not consumed in this procedure and leaves in to air from exhaust stroke, because of this there is loss of fuel and furthermore delivers less power than the required power generated. Piston features include the piston head, bore, piston pin, piston skirt, piston rings, and lands. The piston head is the top surface (closest to the cylinder head) of the piston which is subjected to tremendous forces and heat during normal engine operation. The circular stepped dish type combustion chamber (piston head) was replaced to check the performance of it. The main advantage of this new design is increasing the thermal efficiency with the perfect combination of ramtil oil blend at full load. The piston head will effectively use to form squish and swirl by its circular stepped shape, so that a rich stochiometric fuel mixture will cause the high compression ratio. The reason behind the circular stepped piston combustion chamber piston of cylinder is to make the turbulence to get an appropriate air fuel ratio. Mainly in the new MPFI frameworks since there is no carburetors utilized, however different piston bowl shapes were utilized. This is yet predominant in old DI diesel engine as well. Turbulence and squish will enable the air and fuel to blend appropriate mixture. The fluid motion inside the single cylinder diesel engine cylinder plays a vital role, and the mixture has a significant impact on the combustion quality of the fuel (Ramtil oil + Diesel).

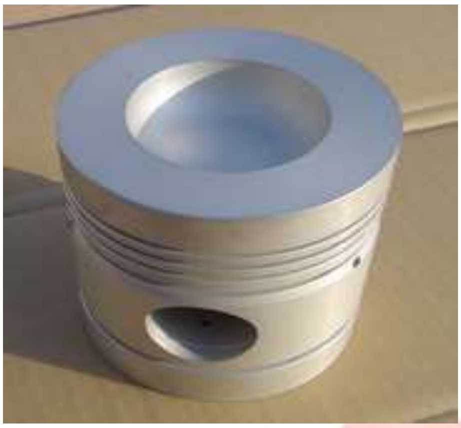

Fig.4.3 standard piston

Fig.4.4 Fabricated circular stepped type piston.

5 RESULTS AND DISCUSSIONS

***a.* Performance Analysis**:

LOAD vs BSFC:

The variation of brake specific fuel consumption with Load is shown in figure 5.1. The graph itself reveals that as the Load increases Brake specific fuel consumption decreases. It can be observed that the BSFC of 0.412 kg/kW-hr were obtained for diesel and 0.36 kg/kW-hr for B10 at full load. It was observed that BSFC decreased compared to other blends.

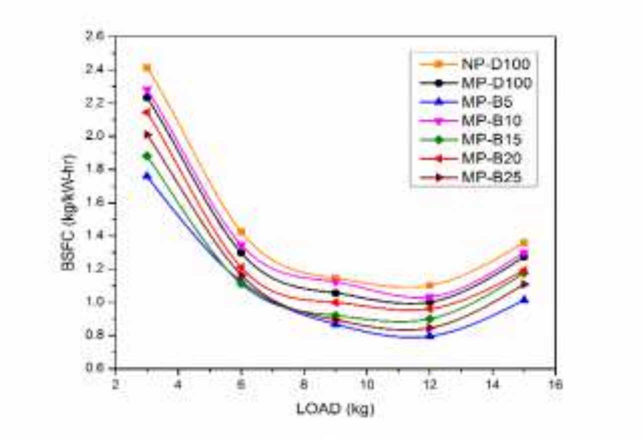

Fig.5.1: Load vs Brake Specific Fuel Consumption

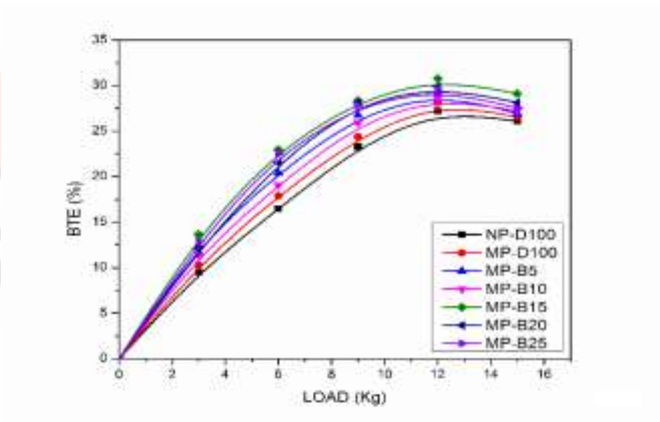

Fig.5.2: Load vs Brake Thermal Efficiency

LOAD vs BTE:

The variation of brake thermal efficiency with Load is shown in figure 5.2. The above graph is reveals that, as the Load increases the brake thermal efficiency increases. The maximum thermal efficiency is occurred at B15 with modified piston, at full load (30.77%) was higher than that of diesel with modified piston (26.58%).

LOAD vs BMEP:

The variation of brake mean effective pressure with Load is shown in below figure 5.3. The graph is reveals that, the highest BMEP of the modified piston with diesel is higher than all remaining blends (diesel and remaining blends) i.e., 319.26 kN/m^2 noted at full load condition.

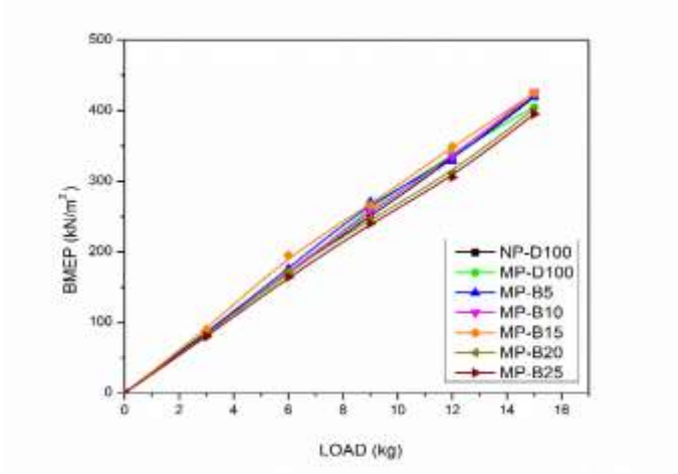

Fig.5.3: Load vs Brake Mean Effective Pressure

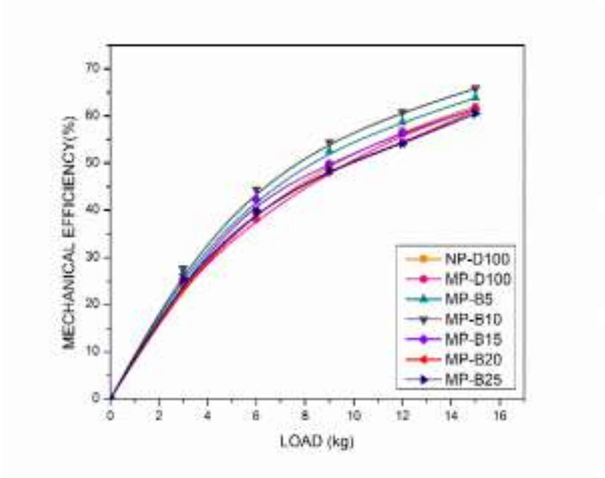

Fig.5.4: Load vs Mechanical Efficiency

LOAD vs ME:

The variation of mechanical efficiency with load is shown in the above figure 5.4. The plot show that the brake mean effective pressure is slightly varies with respect to the load. The highest brake mean effective pressure is obtained at full load with B10 (426.01 kN/m^2) was higher than that of diesel with modified piston (405.16 kN/m^2). So, it is evident that the brake mean effective pressure is higher with modified piston with B15.

b. Emission Analysis:

LOAD vs HC:

The variation of hydro carbons with load is shown in figure 5.5. The plot itself reveals as the load increases hydro carbons also increases i.e., the HC of the engine with blends (B5, B10, B15.B20, and B25) are slightly higher than the NP with diesel fuel. Generally, the hydro carbon emissions are high when there are dust particles in the fuels, and density of the fuels is high. The minimum HC emissions are noted at NP piston with diesel i.e., 12.25 ppm.

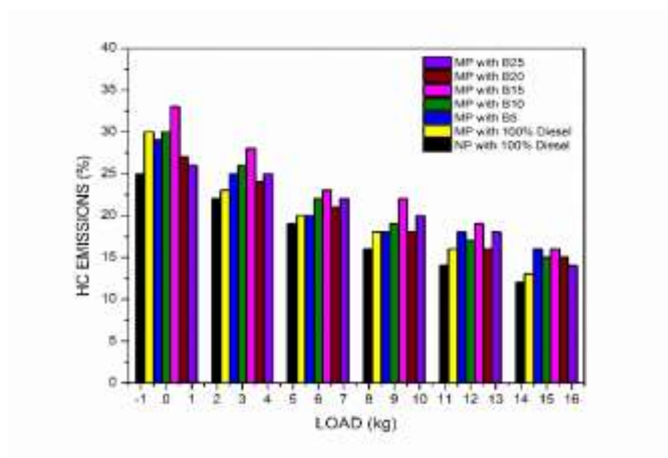

Fig.5.5: Load vs Hydro Carbon Emissions.

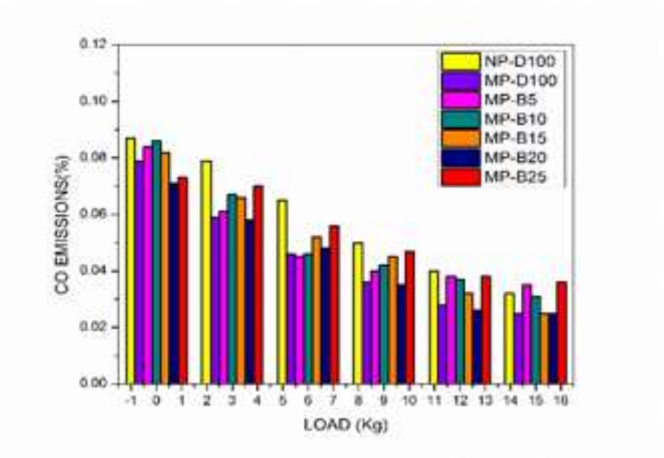

Fig.5.6: Load vs Carbon Monoxide Emissions

Load vs CO:

The variation of carbon monoxide with normal piston and modified piston with different blends is plotted in the above graph 5.6. The amount of carbon monoxide is caused due to improper burning and temperature variation. With the comparison of diesel (both normal and modified piston) the carbon emissions of blended fuel is comparatively low. The B5 is slightly nearer to the diesel fuel. The maximum CO emissions are noted at normal piston at no load condition (0.089 ppm) and the minimum CO emissions are noted at B25 at ¾ of the full load condition (0.0289 ppm).

LOAD vs NOx:

The variation of N0x with the load is shown in the below figure. The plot is reveals that as the load increases N0x will increases. The amount of NOx produced by the engine at diesel (at both normal piston and modified piston) is comparatively low. B10 is 254 ppm, where as in case of Diesel fuel is 320 ppm for diesel fuel. The N0x of Ramtil oil blend B10 decreased when compared to the diesel at full load condition.

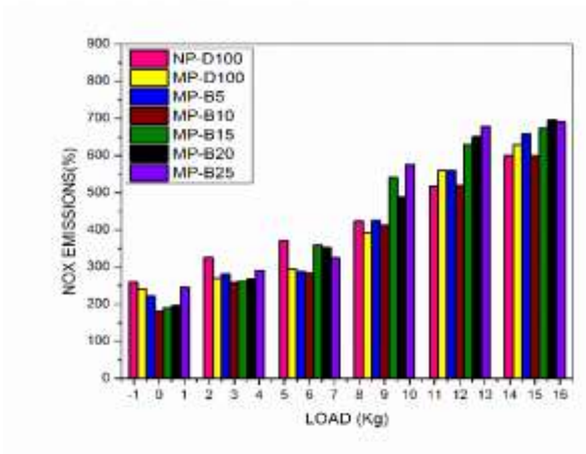

Fig.5.7: Load vs NOx Emissions

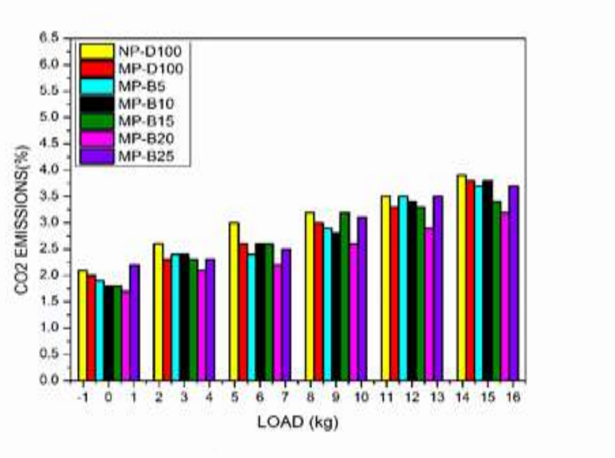

Fig.5.8: Load vs CO_2 Emissions

LOAD vs CO_2 EMISSIONS:

The variation of the NOx with normal piston and modified piston with various blends is ploted in the listed graph. The amount of NOx is extracted due to high temperature of the engine cylinder. The NOx emission of the B10 and B15(181 ppm is notes as min.) of the engine is comparivetly lower than remainig blends.

6 CONCLUSION

1. The experiments were conducted on single cylinder DI diesel engine with varying loads with diesel and different proportion of blends of Ramtil oil (also known as Niger seed oil) like B5, B10, B15, and B20 and B25 with the both normal piston and modified piston.
2. The graph of Brake Thermal Efficiency vs Load will show that, the Brake Thermal Efficiency of the engine will greatly improve B15(30.77%) fuel with modified piston bowl.
3. The BSFC of the modified piston was decreased with B15 and B10 with modified piston bowl. lower than the modified piston with diesel fuel.
4. The CO Emissions of B10 and B15 of the engine was comparatively lower (0.031) than the all the blends with modified piston bowl. (Max. CO is 0.087)
5. The CO_2 emissions of the engine with B20 is comparatively lower (1.7% at no load condition) than the diesel fuel with modified piston. (max CO_2 is 3.9 ppm at NP with diesel)
6. The NOx emissions of the B10 and B15 fuel were recorded equal or lower (181 ppm) than the diesel fuel. i.e., the circular stepped dish type bowl will improve the combustion quality, it leads to complete combustion.
7. The experimental results shown that B15 blend emissions characteristics such as CO, HC and NOxare decreased, and observed that B15 blend gives energetic results in performance parameter with greater thermal efficiency and lesser specific fuel consumption when compared to Diesel at both normal and modified pistons.
8. Hence the B15 of Ramtil oil blend was giving best performance than other blends and diesel at both normal and modified piston.
9.

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