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EXPERIMENTAL INVESTIGATION ON PERFORMANCE AND EMISSION ANALYSIS OF SINGLE CYLINDER 4-STROKE DIESEL ENGINE WITH MODIFIED PISTON ALONG WITH BIO-DIESELS

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Abstract - *Experimentally, the effect of piston shape and swirl intensity on the performance of a direct injection (DI) diesel engine was explored and also use of Biofuels. To create optimal swirl for better fuel-air mixing, changes in piston geometry have been recommended. The shape of the combustion chamber, as well as the fuel spraying and mixing process, has a big impact on diesel engine combustion and emissions. For diesel engines, in-cylinder air motion governs both air–fuel mixing and combustion, which is characterized by swirl and turbulence. A modified piston was used to assess the overall performance of a DI diesel engine. Furthermore, the engine's performance was compared for modified piston with convectional diesel & Biofuels. When compared to a regular piston, the modified piston enhanced brake thermal efficiency and brake specific fuel consumption for the same operating conditions. Both standard and modified pistons have their HC, CO, and NOx emissions measured.*

Key Words**: Engine piston modification, Bio-diesel, Mahua oil, Karanja oil, 20% blend with diesel**

1.INTRODUCTION

Internal combustion engines (ICE) are the most common form of heat engines, as they are used in vehicles, boats, ships, airplanes, and trains. They are named as such because the fuel is ignited in order to do work inside the engine.[1] The same fuel and air mixture is then emitted as exhaust. This can be done using a piston (called a reciprocating engine), or with a turbine.

1.1 Bio Fuel

Biofuel is a renewable and clean-burning fuel that is made from waste vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles. Biodiesel produces less toxic pollutants and greenhouse gases than petroleum diesel. It can be used in pure form (B100) or can be blended with petro-diesel in the form of B2 (2% biodiesel, 98% petroleum diesel), B5 (5% biodiesel, 95% petroleum diesel), B20 (20% biodiesel, 80% petroleum diesel) and B100 (pure biodiesel).

1.2 Objectives and Methodology

This project introduces a modification in piston and use of different non edible biodiesel blends

Here Mahua biodiesel and karanja Biodiesel each blended with raw diesel in B20 form (20% biodiesel and 80% diesel) are used.

The main objective of using biodiesel in this project is to reduce the emissions from the engine and also it can be used as an alternative fuel in the upcoming days.

Finally, comparison is done between the different fuels used.

1.3 Oil Specifications:

Sl No.	Parameter	Specification
1	Ash, max	0.01%
2	Carbon Residue (Ramsbottom) on 10% residue, max[a]	0.3%
3	Cetane Number (CN), min	48[b]
4	Cetane Index (CI), min	46[b]

5	Distillation 95% vol. Recovery at °C, max	–
6	Flash point Abel, min	35 °C
7	Kinematic Viscosity at 40 °C	2.0–5.0 cst
8	Density at 15 °C	820–860 (820–870)[b] Kg/m^3
9	Total Sulfur, max	500 mg/Kg
10	Water content, max	0.05% vol mg/Kg
11	Cold filter plugging point (CFPP) a) Summer, max b) Winter, max	18 °C 6 °C
12	Total contaminations, max	–
13	Oxidation stability, max	–
14	Polycylic Aromatic Hydrocarbon (PAH), max	–
15	Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C, max	460 microns
16	Copper Strip corrosion for 3 hrs at 50 °C	Not worse than No. 1

Table -1: Diesel Oil Specification

Sl No.	Parameter	Specification
1	Moisture and insoluble impurities	0.10%
2	Refractive Index at 400C	1.459
3	Specific Gravity at 300C	0.862
4	Saponification Value	187-196
5	Iodine Value	58-70
6	Unsaponifiable matter	2 %
7	Acid Value max.	0.5
8	Titre	400C
9	Flash Point	2500C

Table -2: Mahua Oil Specification

S.No	Parameter	Specification Ranges
1	Karanjan Content	< 20,000
2	Specific Gravity	0.925-0940
3	Refractive index	1.4734 - 1.4790
4	Acid Value	20
5	Saponification Value	186-196
6	Iodine Value	80-90
7	Unsaponifiable matter	Max 1.5%

Table -3: Karanjan Oil Specification

2. ENGINE SPECIFICATION

Engine Details:

IC Engine set up under test is Research Diesel having power 3.50 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 18.00, Swept volume 661.45 (cc)

Combustion Parameters:

Specific Gas Const (kJ/kgK) : 1.00, Air Density (kg/m^3) : 1.17, Adiabatic Index : 1.41, Polytrophic Index : 1.20, Number Of Cycles : 10, Cylinder Pressure Referance : 5, Smoothing 2, TDC Reference : 0

Performance Parameters:

Orifice Diameter (mm) : 20.00, Orifice Coeff. Of Discharge : 0.60, Dynamometer Arm Legnth (mm) : 185, Fuel Pipe dia (mm) : 12.40, Ambient Temp. (Deg C) : 27, Pulses Per revolution : 360, Fuel Type : Diesel, Fuel Density (Kg/m^3) : 830, Calorific Value Of Fuel (kj/kg) : 42000

3. DESIGN AND MODIFICATION

Piston Details:

Piston Dimensions Piston diameter: 87.5mm Piston bowl diameter: 52mm Piston length: 100mm.

3.1 Modified 3D models:

The piston is a critical component in internal combustion engines. It turns heat energy into mechanical power through a reciprocating motion. When the engine produces power, it goes up and down inside the cylinder. The piston's job is to stop gases from expanding and sending them to the crankshaft. The force of the explosion is transferred to the crankshaft, which rotates as a result.

Fig.1-Modified piston of 2 cutouts and 2 protrusions on piston and piston bowl

4. EXPERIMENTATION SETUP

Fig.2-Experimental setup

4.1 The Testing set-up consists of:

1. Four stroke diesel engine with single cylinder.
2. Eddy current injection kit for current loading.
3. Transmitters are used for measuring fuel flow and air flow.
4. Rotameters are used for measuring cooling.
5. Fuel measurement unit and fuel tank.
6. A device for emission testing.

4.2 Procedure for Testing:

1. Fill the fuel tank with diesel.
2. Check flow of cooling water to the engine.
3. Keep load of engine at 0 Kg.
4. Put ON the main supply.
5. For initial condition, run the engine at 0 kg and tabulate the readings.
6. Gradually increase the load in steps of 2Kgs and tabulate the readings

5. EXPERIMENTAL ANALYSIS

5.1 Performance

5.1.1 Load vs Brake thermal efficiency

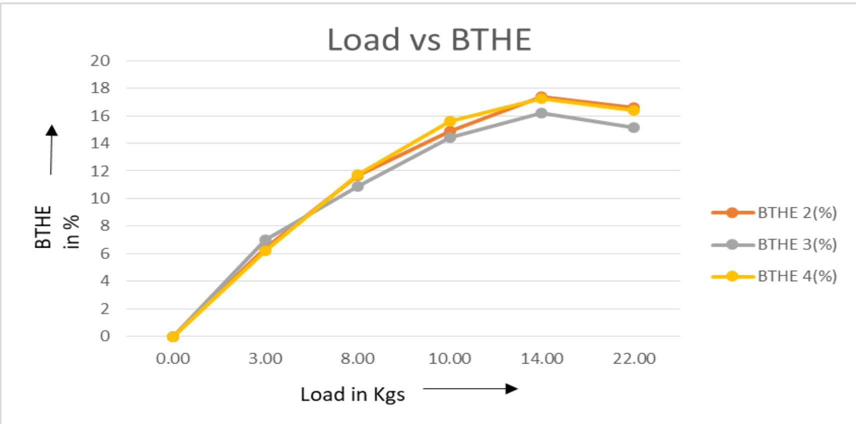

Chart -1: Load vs BTHE

Inference: Brake thermal efficiency depends on Brake power and specific fuel consumption. Here Specific fuel consumption is increasing in an engine with modified piston with biodiesel as the flow of fuel is more than air. Hence brake thermal efficiency is increasing with increasing load. Brake thermal efficiency of Biodiesel will be same as that of diesel at low load.

5.1.2 Load vs Specific fuel consumption

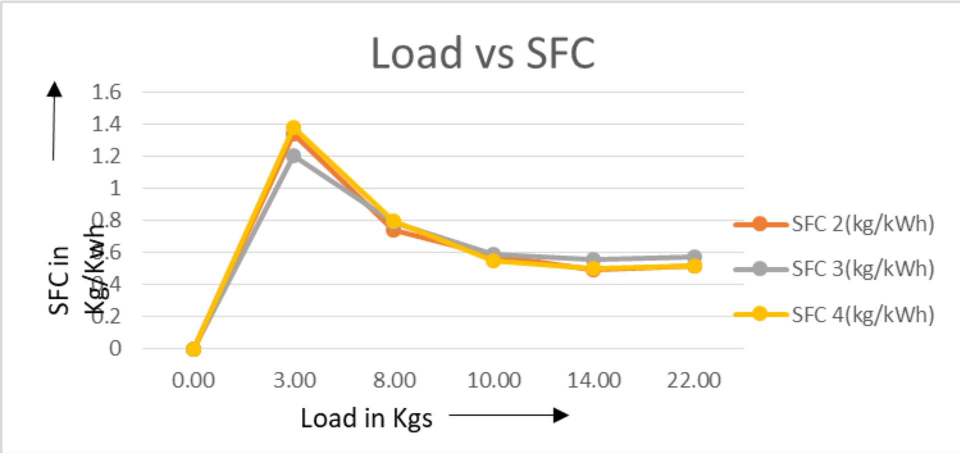

Chart2 -: Load vs SFC

Inference: The specific fuel consumption of conventional diesel engine is lower than that of engine with modified piston with biodiesel This is because of the higher viscosity and poor mixture formation of biodiesel.

5.1.3 Load vs Indicated thermal efficiency

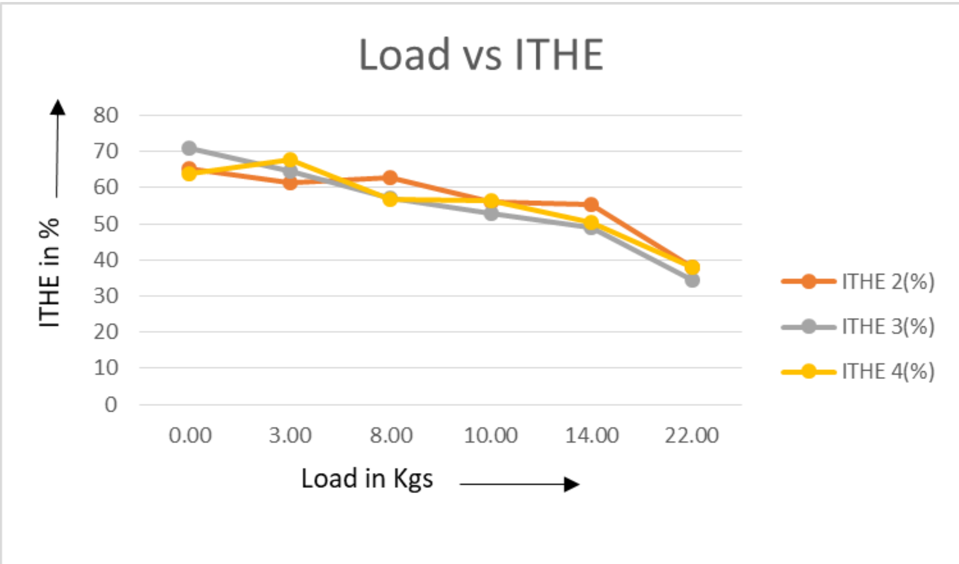

Chart -3: Load vs ITHE

Inference: Indicated thermal efficiency depends on the indicated power which in turn depends on the indicated mean effective pressure. Indicated mean effective pressure is the average pressure in the cylinder for a complete engine cycle. As indicated mean effective pressure is increasing for diesel engine with modified piston with biodiesel indicated thermal efficiency is also increasing by using biofuels

5.1.4 Load vs Mechanical efficiency

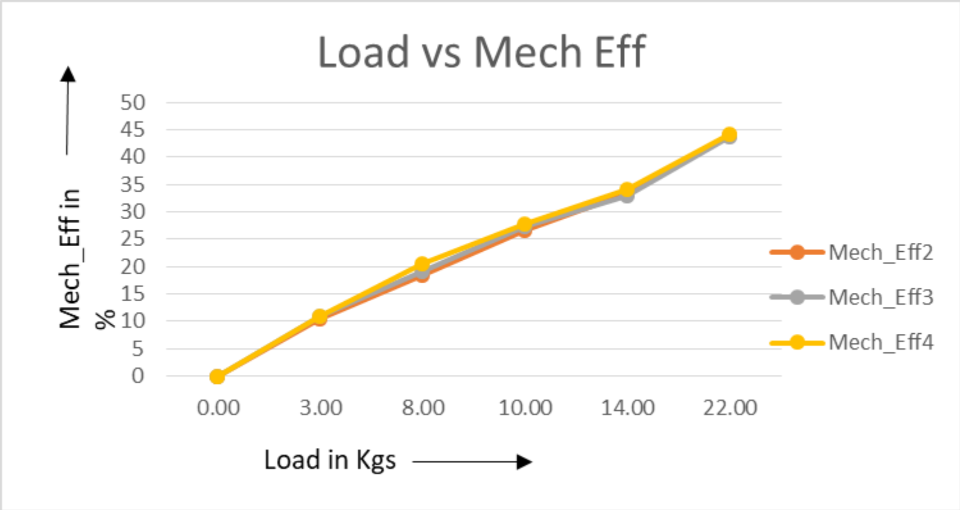

Chart -4: Load vs Mech_Eff

Inference: Mechanical efficiency is obtained by the ratio of brake power to the indicated power. As the indicated power is increasing in an engine with modified piston with biodiesel hence mechanical efficiency is decreasing.

5.1.5 Load vs A/F Ratio

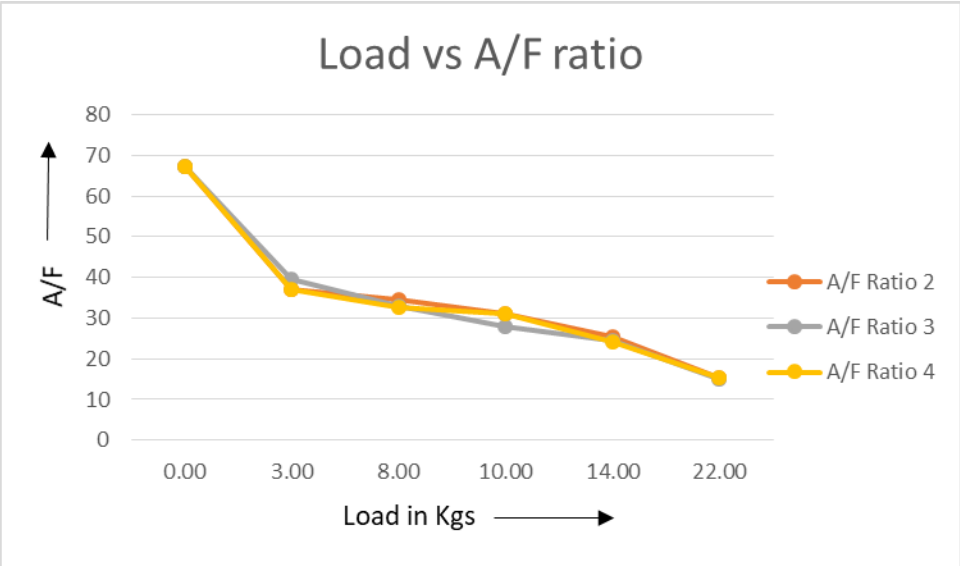

Chart -5: Load vs A/F ratio

Inference: The air fuel ratio is less in conventional diesel engine and it is increasing in an engine with modified piston with biodiesel because of less air flow resulting in rich mixture.

5.2 Emissions

5.2.1 Load vs CO Emission

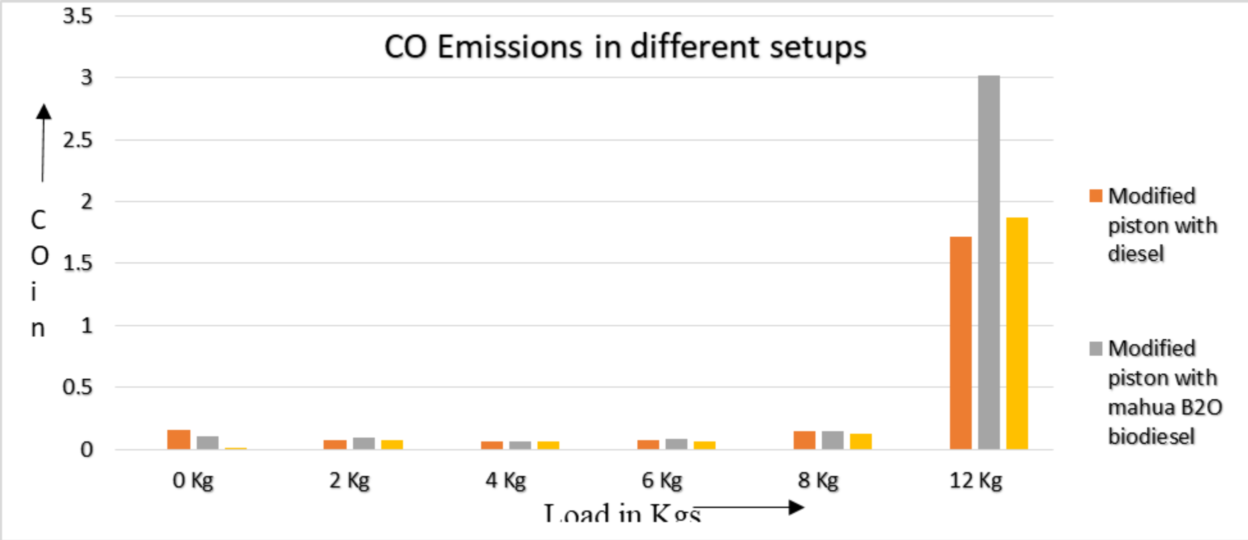

Chart -6: CO Emissions

Inference: Higher fuel/air ratio causes the emission of CO. During the initial loads the CO emissions are comparatively small and there is slight difference between difference setups. But at higher loads it is increasing because with increase in the load the fuel/air ration increases This causes rich fuel/air mixture hence resulting in Carbon monoxide emissions.

5.2.2 Load vs HC Emission

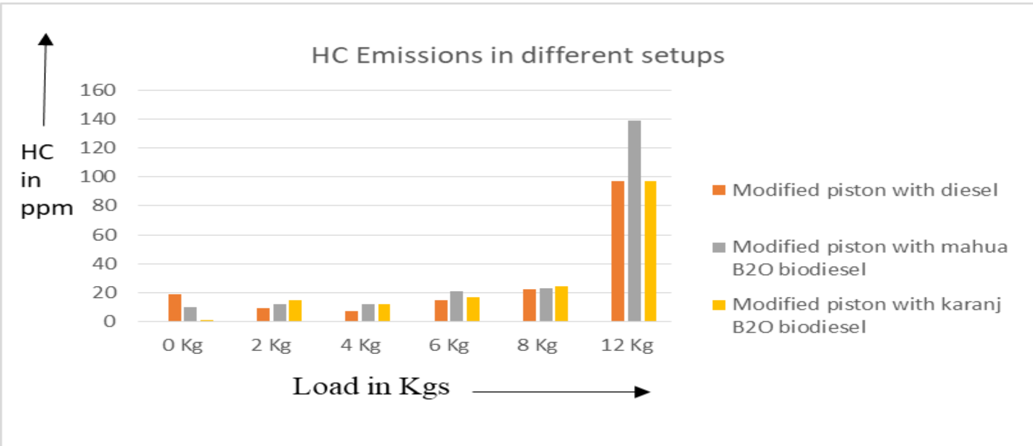

Chart -7: HC Emissions

Inference: Higher fuel/air ratio causes the emission of HC. During the initial loads the HC emissions are comparatively small and there is slight difference between difference setups. But at higher loads it is increasing because with increase in the load the fuel/air ration increases This causes rich fuel/air mixture hence resulting in hydrocarbon emissions.

5.2.3 Load vs CO_2 emission

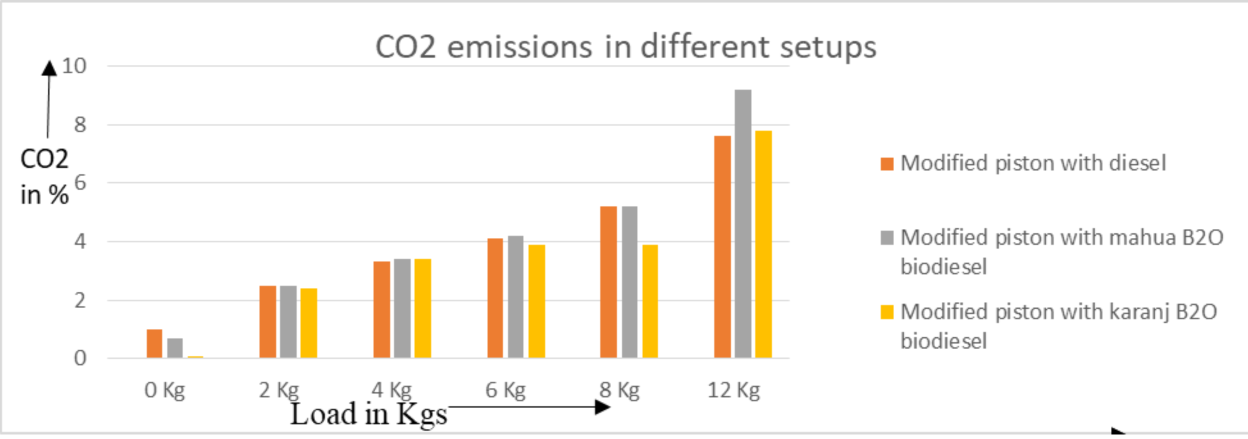

Chart -8: CO2 Emissions

Inference: The combustion process causes a mixing of carbon with oxygen in air resulting in the formation of carbon dioxide. The change of CO2 emission is almost same in all the setups

5.2.4 Load vs NOx emission

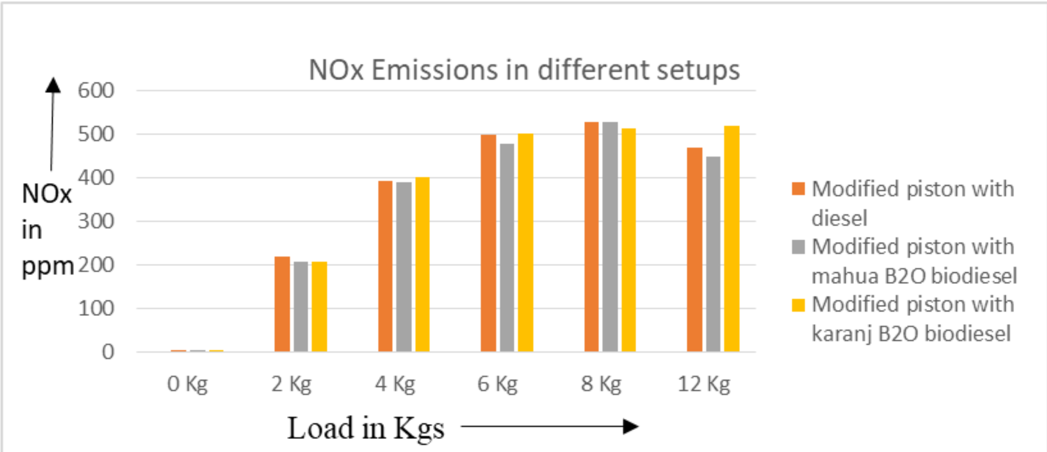

Chart -9: NOx Emissions

Inference: NOx emissions are less compared to convection diesel engine at various loads for Mahua & Karanj Biodiesel with modified piston because of rich mixture burning, lower combustion temperature inside the cylinder and lower Calorific value of the biodiesel.

5.2.5 Load vs O_2 Emission

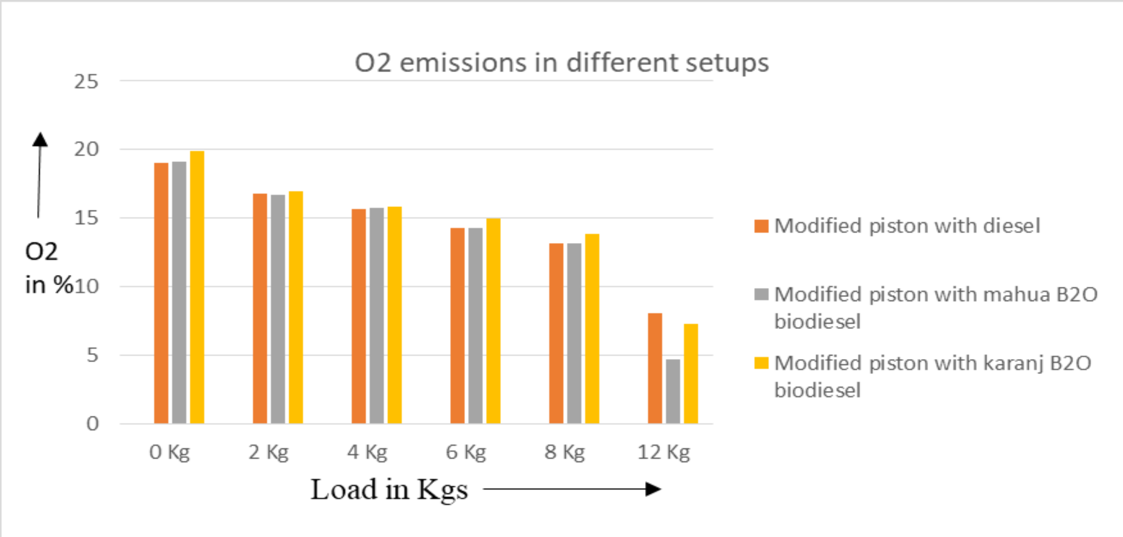

Chart -10: O2 Emissions

Inference: With increasing load oxygen emission is reducing in different setups which results in good combustion of fuel. O2 emission is also nearly same for different setups and fuels.

5.2.6 Load vs smoke

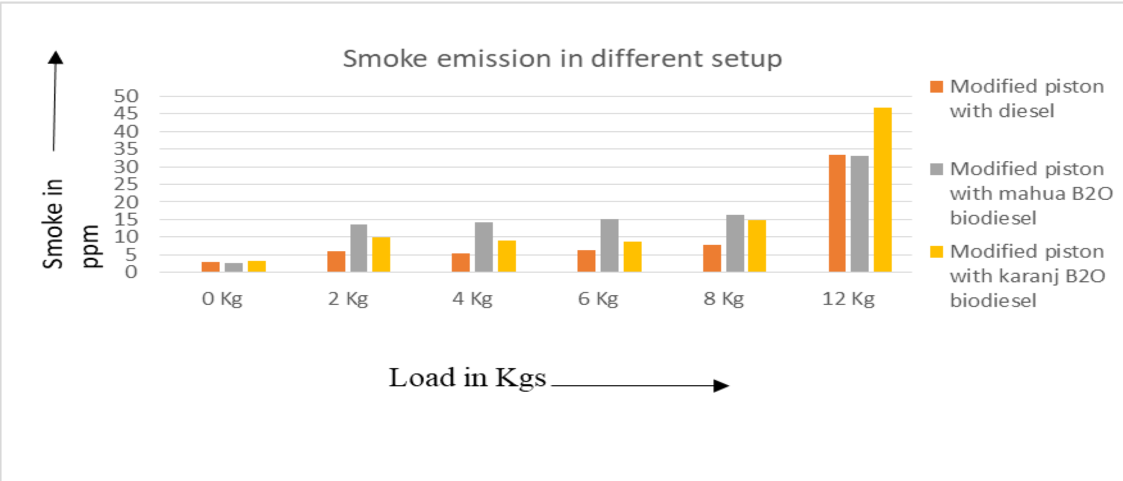

Chart -11: Smoke Emissions

Inference: Smoke emission is the part of combustion process. Smoke is increasing with increasing load because of rich air/fuel mixture and also due to the biodiesel blend.

6. CONCLUSIONS

- The experimental results show the improvement in emission parameters of single cylinder four stroke diesel engine with modified piston by using Mahua B20 and Karanja B20 Biodiesel.
- The modified piston with biodiesel has good impact on NOx & O2 emission.
- The modified piston with biodiesel has good impact on CO2, HC & CO Emissions at less loads compared with convection diesel

- Brake thermal efficiency, Indicated thermal efficiency and Specific fuel consumption of Biodiesel is nearly same compared to Diesel

7. FUTURE SCOPE

- Biofuel percentage in diesel to be varied and checked.
- Similar experiment can be conducted by using different non edible bio fuels.
- CFD analysis can be done.
- Swirl ratio can be checked by swirl test rig.
- Geometry can be varied depending upon the required parameters.

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