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

[1]Dr HIREGOUDAR YERRENAGOUDARU, [2]SHADAB KHAN, [3] SUHAS BHAT, [4]MOHAMMED SAIFUDDIN.

[1,2,3,4] *Rao Bahadur Y Mahaballeswarappa Engineering Collage Ballari 583104*

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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. 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. 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, 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.

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

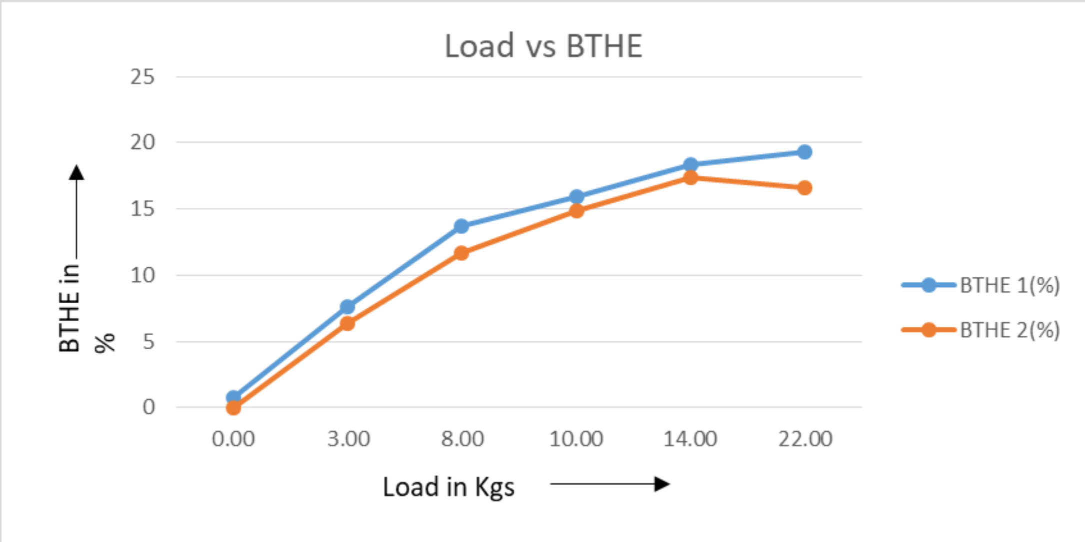

Chart -1: Load vs BTHE

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

5.1.2 Load vs Specific fuel consumption

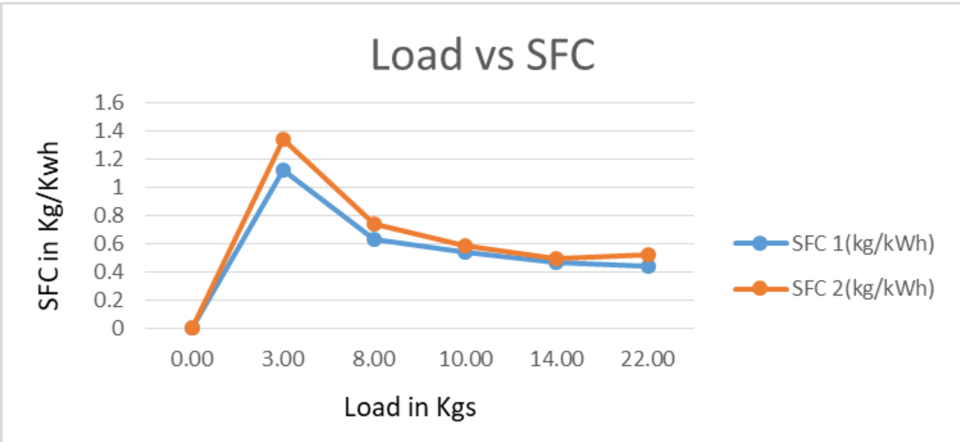

Chart2 -: Load vs SFC

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

5.1.3 Load vs Indicated thermal efficiency

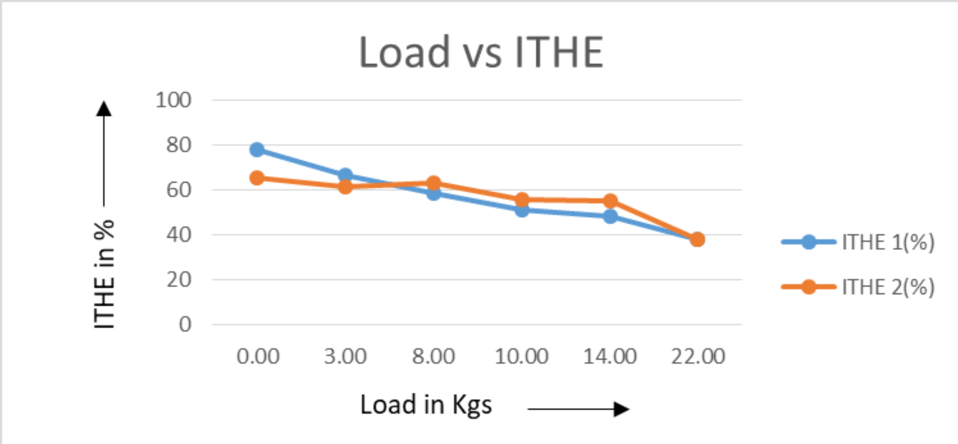

Chart -3: Load vs ITHE

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 more for diesel engine with modified piston indicated thermal efficiency at low load & more as load increases.

5.1.4 Load vs Mechanical efficiency

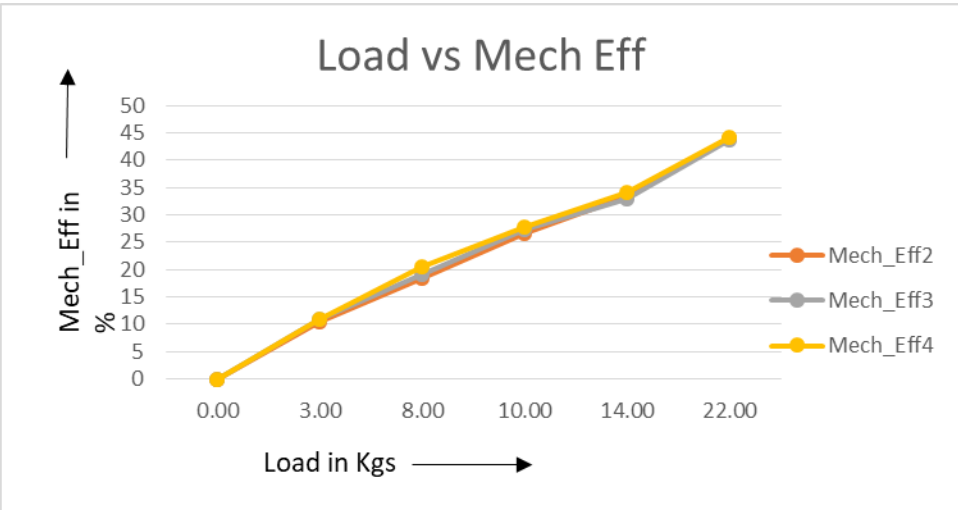

Chart -4: Load vs Mech_Eff

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

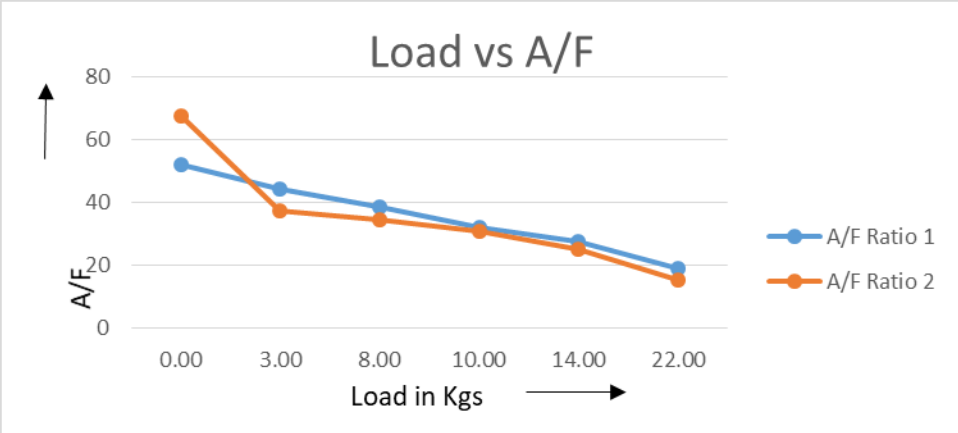

Chart -5: Load vs A/F ratio

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

5.2 Emissions

5.2.1 Load vs CO Emission

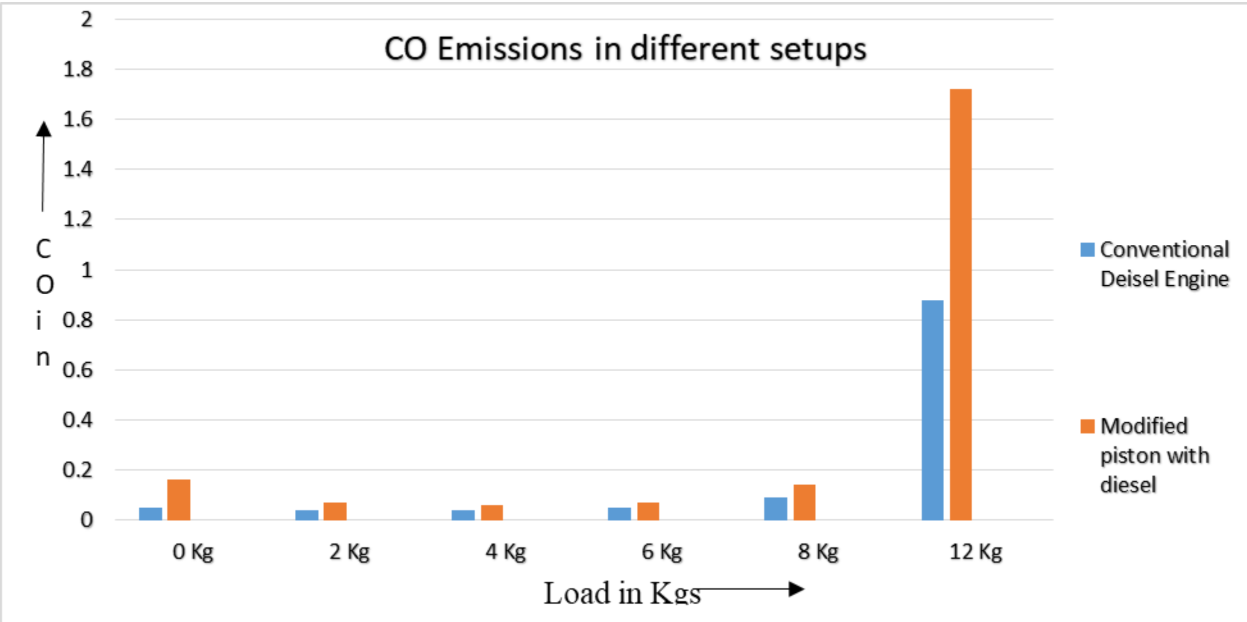

Chart -6: CO Emissions

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

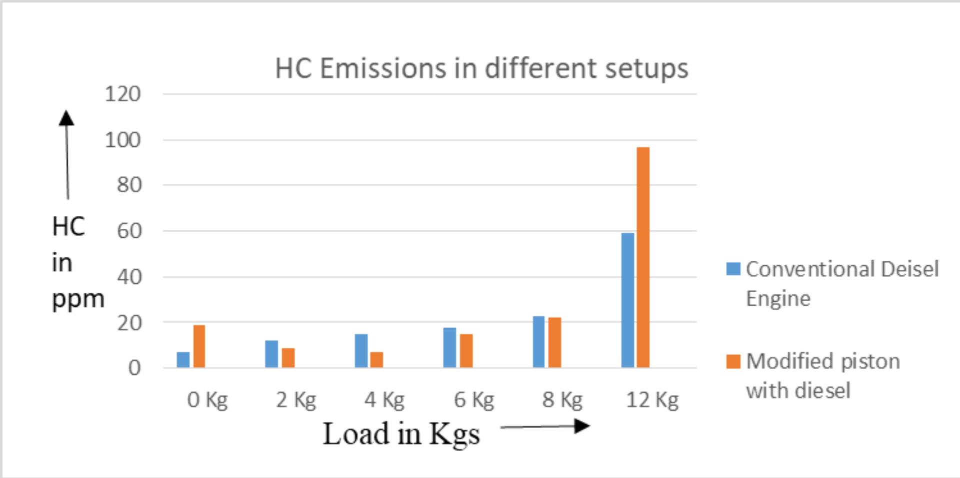

Chart -7: HC Emissions

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

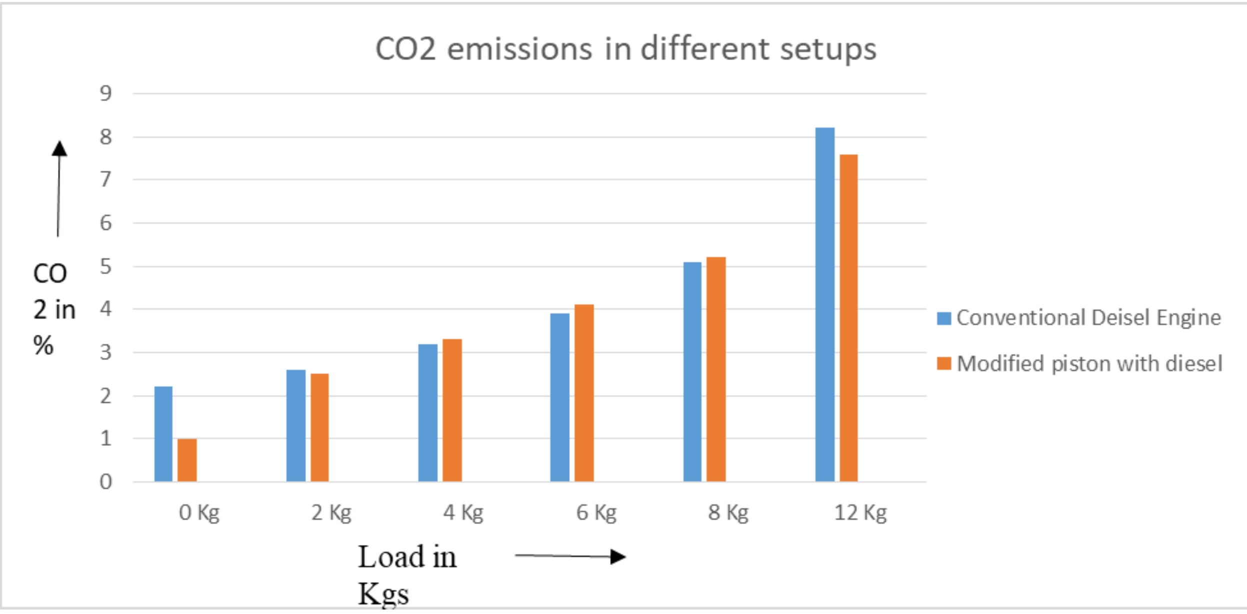

Chart -8: CO2 Emissions

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

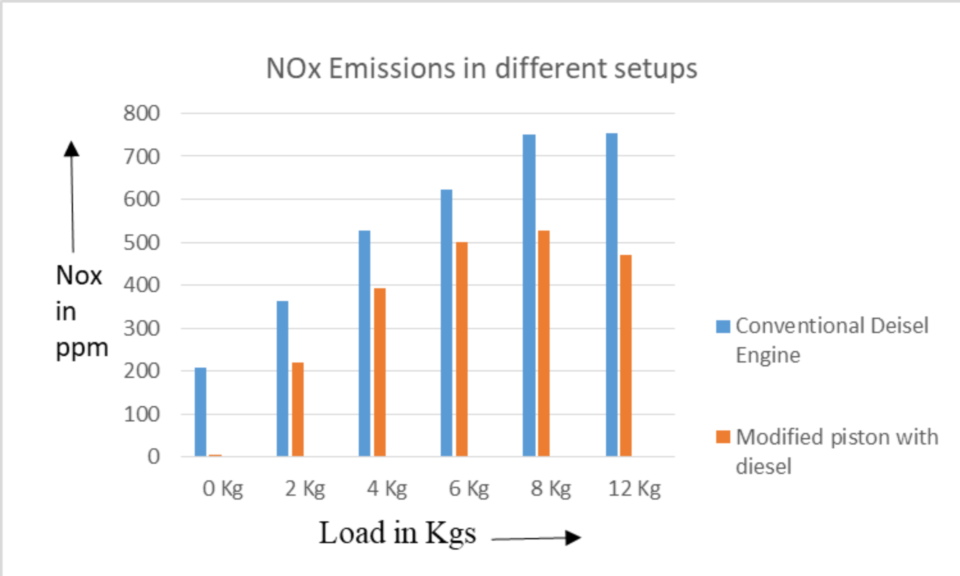

Chart -9: NOx Emissions

Inference: NOx emissions are less compared to convection diesel engine at various loads for with modified piston because of rich mixture burning.

5.2.5 Load vs O_2 Emission

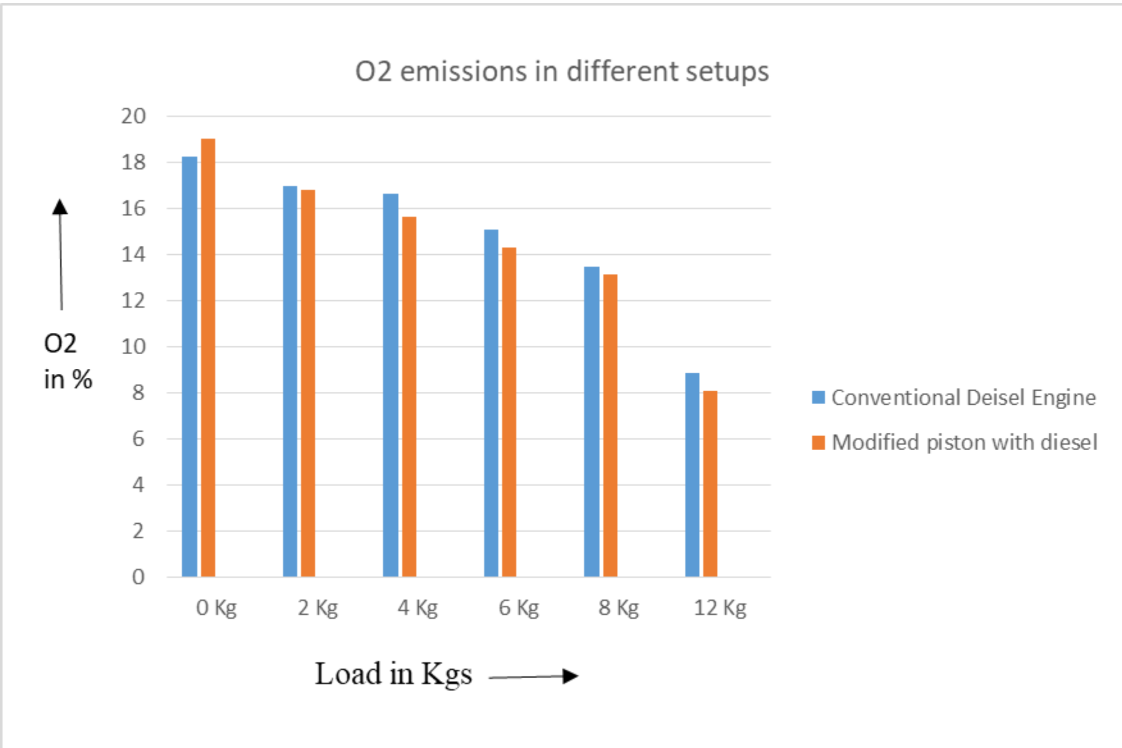

Chart -10: O2 Emissions

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.

5.2.6 Load vs smoke

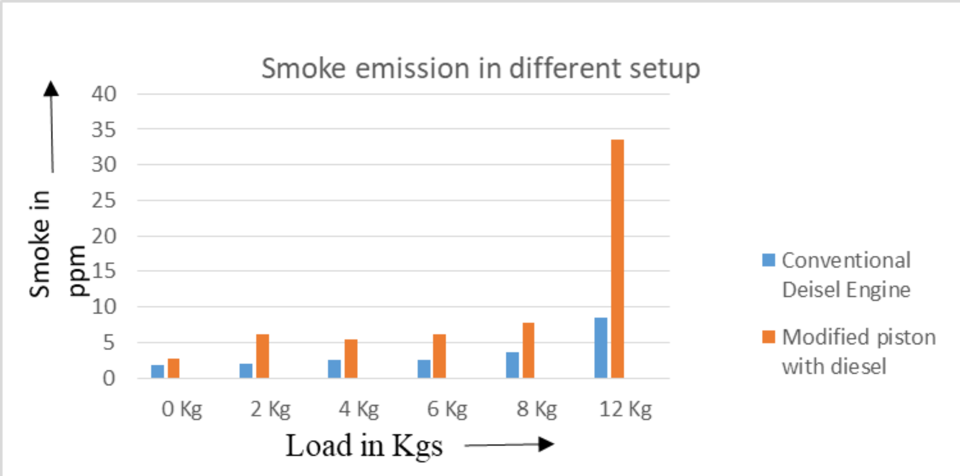

Chart -11: Smoke Emissions

Inference: Smoke emission is the part of combustion process. Smoke is increasing with increasing load because of rich air/fuel mixture.

6. CONCLUSIONS

- The experimental results show the improvement in emission parameters of single cylinder four stroke diesel engine with modified piston
- The modified piston with biodiesel has good impact on NOx & O2 emission.
- The modified piston 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

- CFD analysis can be done.
- Swirl ratio can be checked by swirl test rig.
- Geometry can be varied depending upon the required parameters.

REFERENCES

1. Alan C. Hansen, Qin Zhang and Peter W. L. Lyne, "Ethanol–diesel fuel blends a review", *Bioresource Technology, Volume 96*, Issue 3, February 2005, Pages 277-285.
2. Hanbey Hazar, "Effects of biodiesel on a low heat loss diesel engine", *Renewable Energy 34* (2009) 1533–1537.
3. Neven Voca,Boris Varga,Tajana Kricka, Duska Curic, Vanja Jurisic and Ana Matin, "Progress in ethanol production from corn kernel by applying cooking pre-treatment" Bioresource Technology Volume 100, Issue 10, May 2009, Pages 2712-2718.
4. Avinash Kumar Agarwal, "Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines" *Renewable Energy,* 27 November 2006.
5. Hakan, Bayraktar. "Experimental and theoretical investigation of using gasoline–ethanol blends in spark-ignition engines", *Renewable Energy*, 2005; *Volume 30, Issue 11:pp1733-1747.*

6. Jason J, Daniel Marc, Rosen A, "Exergetic Environmental Assessment of Life Cycle Emissions for various Automobiles and Fuels, Energy 2 (2002) 283-294

7. Hwanam Kima, Byungchul Choi, "Effect of ethanol–diesel blend fuels on emission and particle size distribution in a common-rail direct injection diesel engine with warm-up catalytic converter", R*enewable Energy 33* (2008) 2222–2228.

8. Baker, Q. A., "Use of Alcohol-in-Diesel Fuel Emulsions and Solutions in a Medium-Speed Diesel Engine", *SAE Paper No. 810254*.

9. Internal combustion engines by V ganesan 4th edition.

10. Internal combustion engines fundamentals by John B Heywood.