Improvement of Air-Swirl ratio in 4-stroke diesel engine to improve performance and emission of an engine

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Abstract - The main thing in a diesel engine is the control of air for achieving good combustion process. In this project, the sole aim is to create the swirl of air for achieving better performance and reduction in harmful emissions. The turbulence of air causes complete combustion of the products and reactants of combustion resulting in reduced emissions of harmful gases like HC, CO & NOx etc.

Key Words: Diesel engine, swirl, performance, Harmful emission, complete combustion

1. INTRODUCTION

Combustion process is the key for an engine to attain great combustion and to cut down emission of health hazardous gases. From the past data excellent combustion results can be obtained by creating swirl and turbulence of air. Various methods are available to create the swirl; in our project we are utilizing the method of masking. Masking is done on the poppet valve. The flow of air in the passage is disrupted by masking. Due to masking done on the poppet valve. The flow of air is disturbed hence swirl will be improved.

1.1 Sub Heading 1

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1.2 Sub Heading 2

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2. POPPET VALVES

2.1 Models of Inlet poppet valve:

Conventional inlet poppet valve is used for single cylinder four stroke diesel engines. Valves are the important elements of a diesel engine. Valves control the Inflow of the fresh charge inside the cylinder and exit the combustion gases out side the engine cylinder. Kirloskar make Diesel engine inlet valve model is shown in the figure. The model shown here is designed in solid works modeling software.

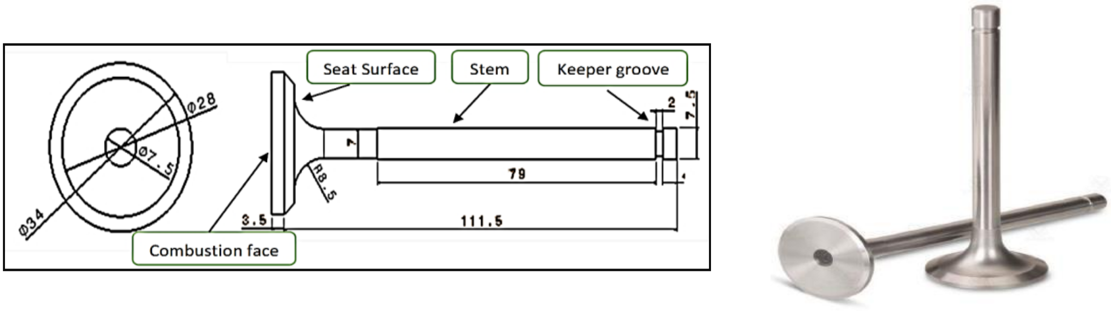
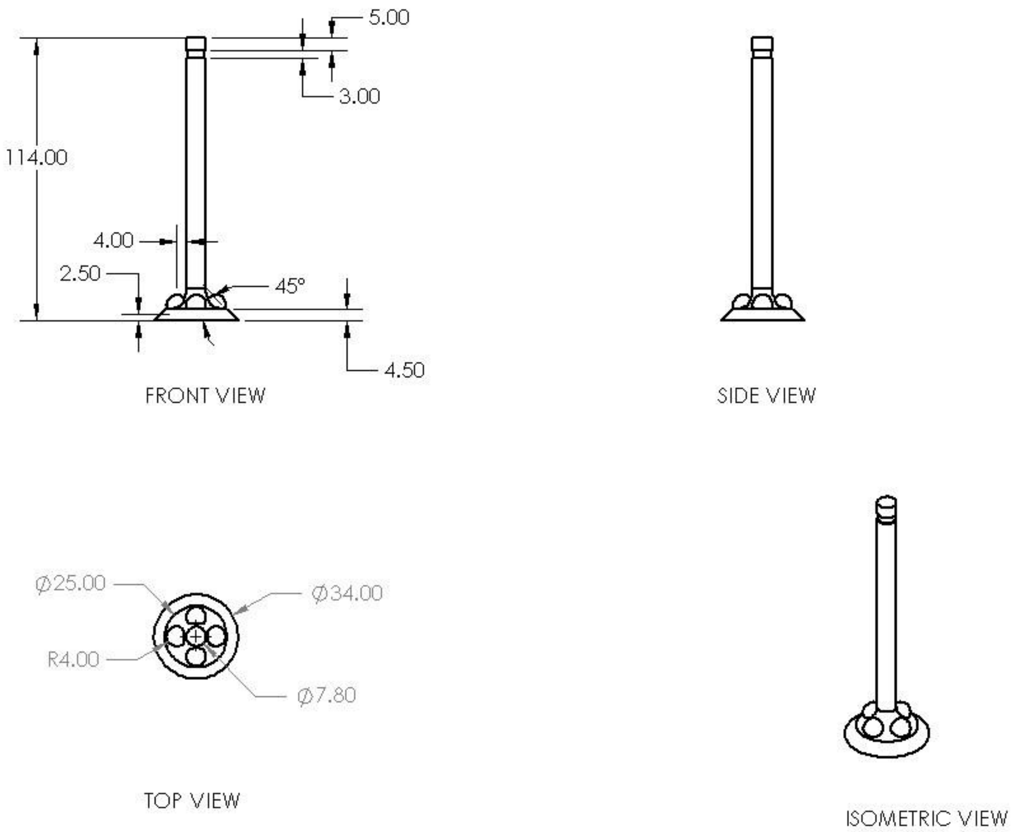


Figure -1: Conventional Inlet poppet valve

2.2 3-D Model of modified inlet poppet valve:

The inlet poppet valve is modified by using 4 balls, which are fabricated at right angles on the seat surface. The 4- ball valve is modeled using solid works software. Radius of the ball is 4 mm and is fabricated upon the seat surface of the poppet at a depth of 2.5 mm. The balls are fabricated on the back of valve radius such that they do not intersect with the valve seating.



FOUR BALL POPPET VALVE

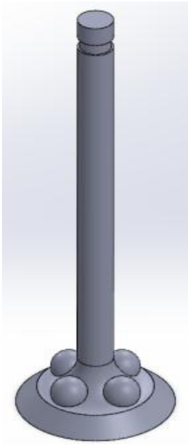


Figure -2. Modified Inlet poppet valve (4-Ball valve)

3. FABRICATION OF MODIFIED MODELS OF INLET POPPET VALVES:

In this type of design there four balls of 8mm diameters which are fastened to the seat surface of the poppet, opposite to each other at right angles. Balls are made up of chrome *steel* with about 1% carbon and 1.5% chrome. Fastening is done by brazing process. This valve is made in such a way that it can withstand high temperature.

Figure -3. Modified Inlet poppet valve (4 Ball valve)

4. DIESEL ENGINE EXPERIMENTAL SETUP

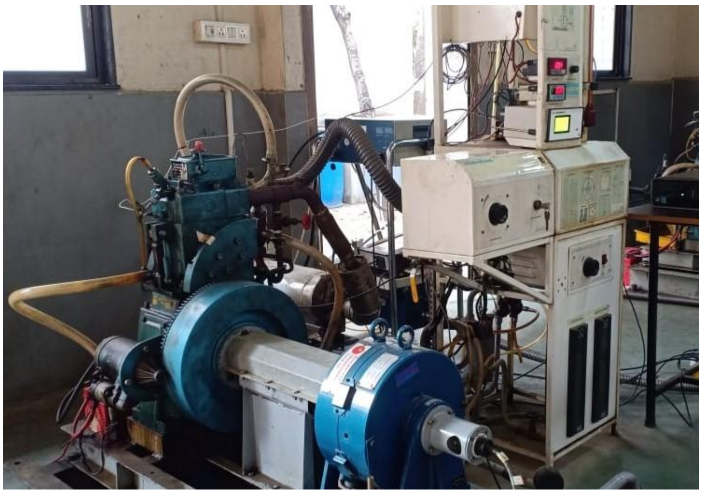


Figure -4. Diesel engine test rig unit

1. Single cylinder four stroke diesel engine test rig which is connected to computer.
2. Dynamometer for increasing and decreasing the load.
3. It has flow measurement unit.
4. Piezo Power unit & proceed indicator
5. Fuel measuring unit.
6. Transmitters are provided for air and fuel flow measurements.
7. AVL 5 smoke measuring unit.

4.1 Specifications of Engine Setup:

1. Engine brand- Kirloskar make
2. Speed-1500 rpm
3. Cylinders & stroke-Single cylinder four stroke.
4. Cooling type-water cooled.
5. Type of fuel used-Diesel.
6. Bore diameter-87.5mm
7. Length of the stroke-110mm

4.2 Emission Test Setup

For measurement of emission AVL 5 gas analyser is used. It indicates level of Carbon monoxide, Hydrocarbons, Nitrogen oxides, Carbon dioxide, Oxygen and smoke etc. It is fitted at the exhaust of an engine.

Figure -5. AVL 5 gas analyser

5. RESULTS AND DISCUSSIONS

5.1 Performance.

1. Load vs Brake thermal efficiency

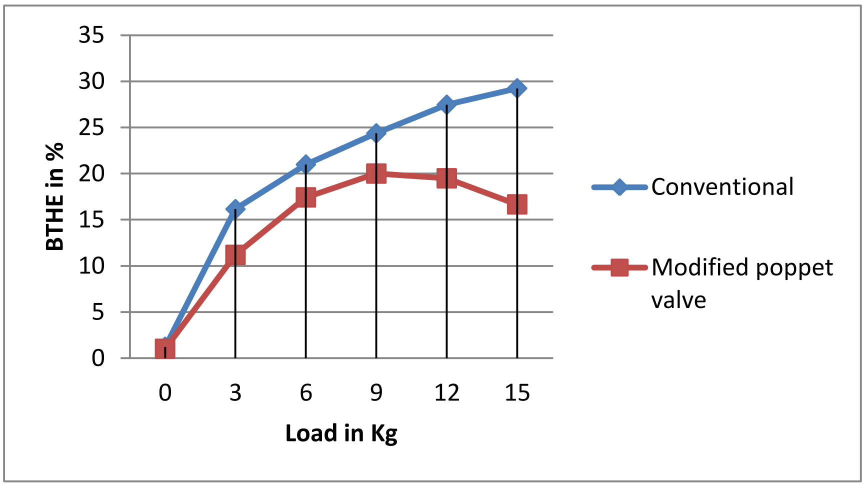


Chart-1: Load vs BTHE

Brake thermal efficiency has the ability to increase with increasing load because of more power developed. Brake thermal efficiency depends upon brake power. The power available at the crank shaft is less in an engine with modified poppet valve hence BTHE is reducing and at higher loads further it is decreasing because of rich equivalence ratio.

2. Load vs indicated thermal efficiency

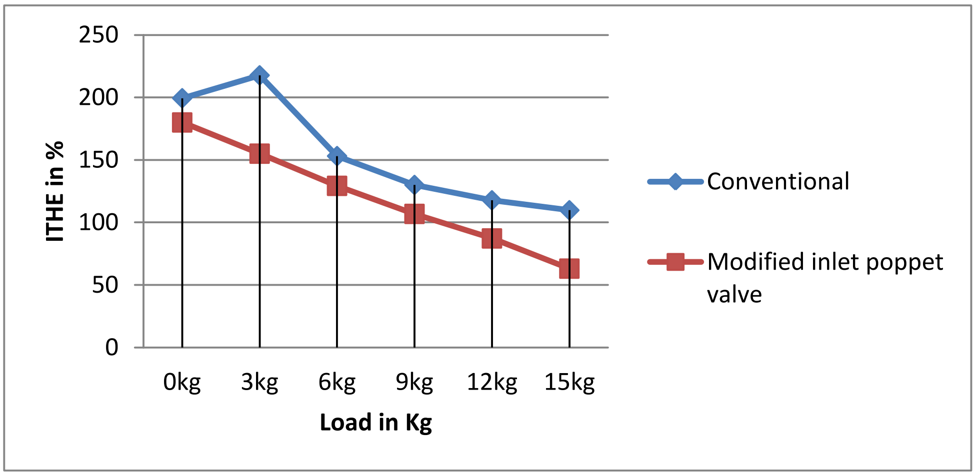


Chart-2: Load vs ITHE

Indicated thermal efficiency depends on indicated mean effective pressure and indicated power. Indicated power is less in an engine with modified inlet poppet valve may be due to the long run of conventional engine so engine oil may have reduced prior to the start of an engine with modified inlet poppet valve, hence friction is generated so indicated power may have reduced. Indicated mean effective pressure is less for an engine with modified inlet poppet valve hence it is slightly decreasing compared to conventional engine.

3. Load vs mechanical efficiency

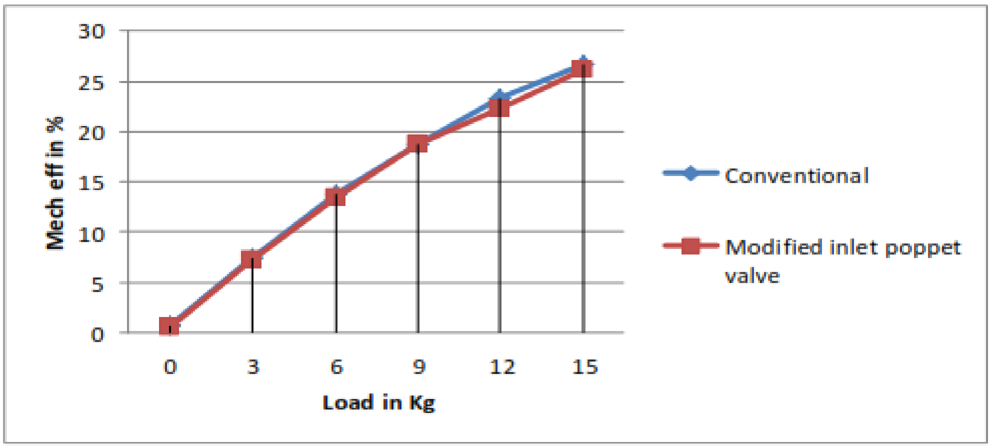


Chart-3: Load vs Mech eff

Mechanical efficiency is the ratio of BP to IP. Mechanical efficiency is almost same for both the setups.

4. Load vs specific fuel consumption

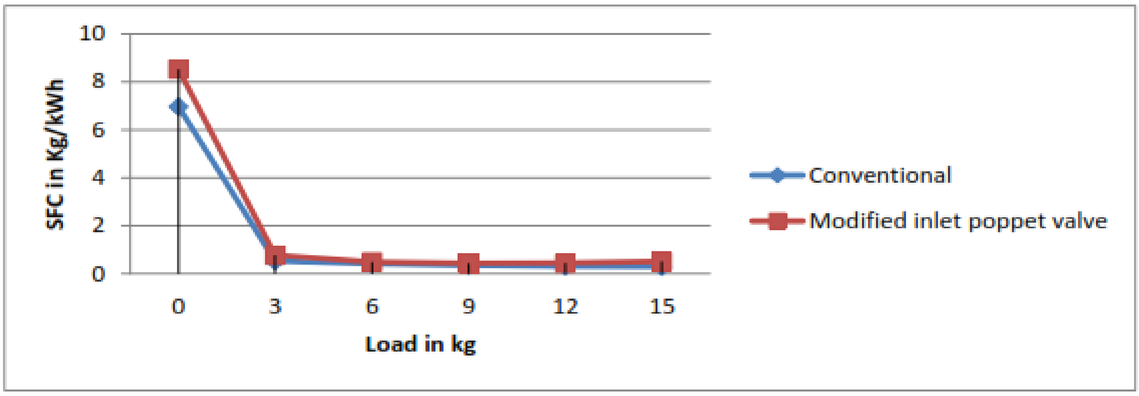


Chart-4: Load vs SFC

SFC is increasing in modified engine compared to conventional engine because of combustion of rich mixture. As there is reduced air flow in the engine cylinder because of modifications causing fuel rich mixture.

5. Load vs A/F Ratio

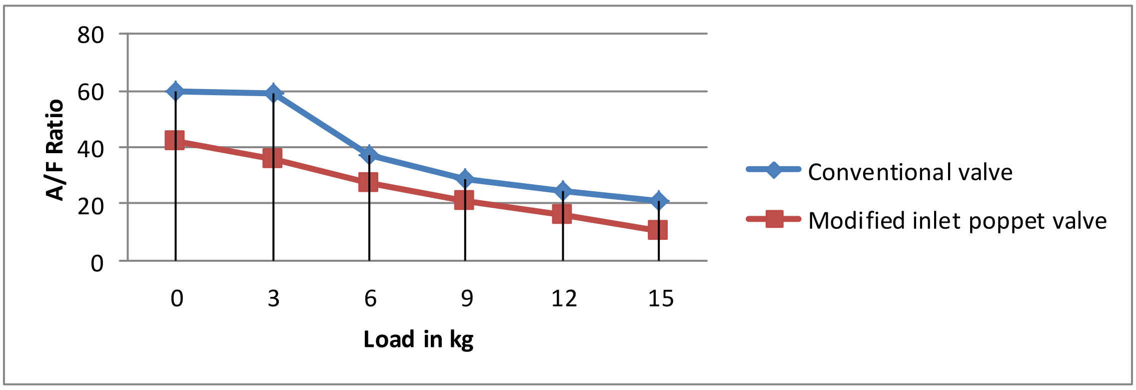


Chart-5: Load vs A/F Ratio

As there is a rich equivalence ratio because of modifications A/F ratio is decreasing in an engine with modified inlet manifold.

5.2 Emission.

1. Hydrocarbons (HC):

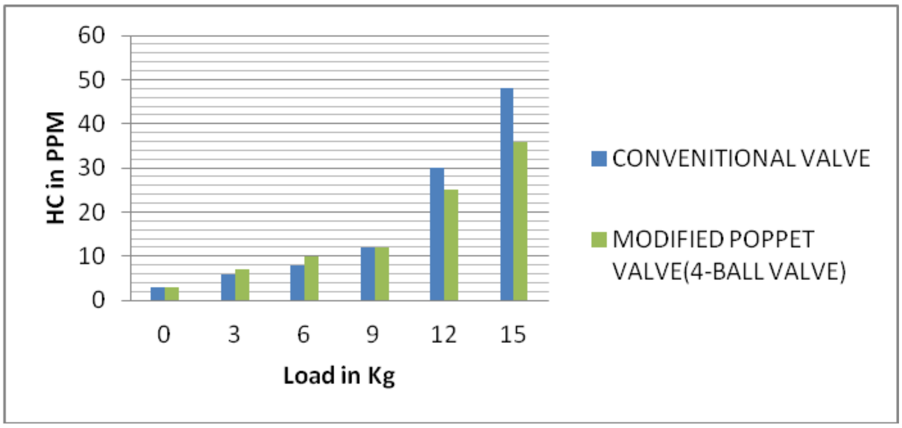


Chart-6: Load vs. HC for Conventional Fuel.

Because of not enough temperature near the cylinder wall hydrocarbon emissions are due to the unburned fuels. HC emissions are also caused due to rich Air fuel ratio. It is observed that in the chart- 6, 25.00 % of HC is reduced for Modified (4-ball valve) inlet poppet valve when compare to conventional inlet poppet valve at maximum loading condition. For 100% loading the percentage of unburnt fuel is less for modified valve (4 ball valve) than conventional valve, due proper mixture of air and fuel.

2. Carbon monoxide (CO):

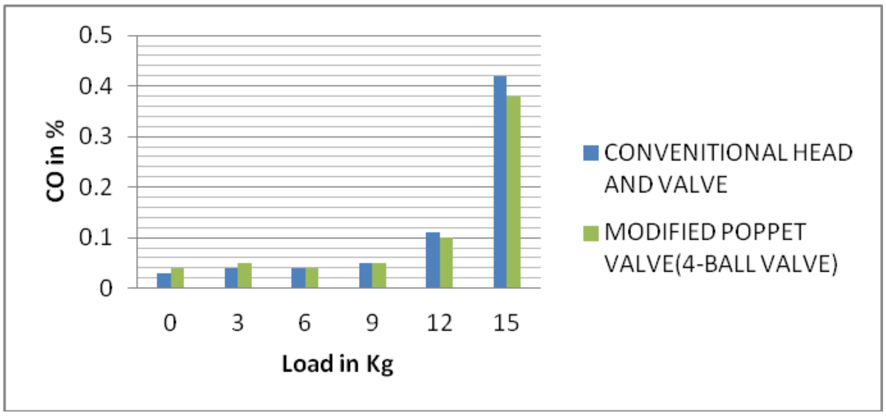


Chart-7: Load vs. CO% for Conventional Fuel.

Carbon monoxide is produced by incomplete combustion; Swirling of air has very good impact on combustion hence CO is reduced in an engine with modified poppet valve. It is observed that in the above chart-7, 19.04 % of CO is reduced for Modified Inlet poppet valve (4 ball valve) when compare to conventional inlet poppet valve at maximum loading condition. During 100% loading, the percentage of incomplete combustion is less for modified Valve (4 ball valve) than conventional valve that is because of more oxidation process occurred.

3. Nitrogen oxides (NOx):

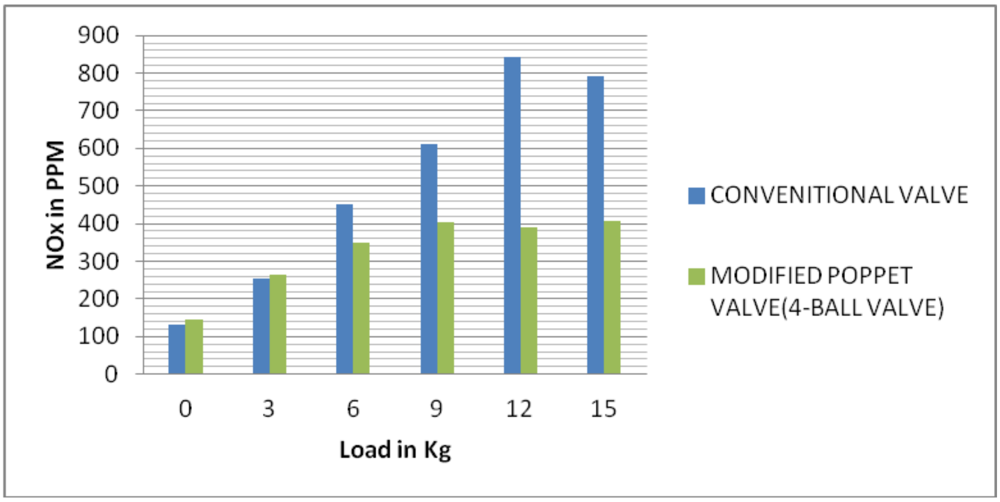


Chart-8: Load vs. NO_X for Conventional Fuel

Air, mainly composed of oxygen and nitrogen, is initially drawn into the combustion chamber, then, it is compressed. Nitrogen oxides results from the engine cylinder temperature. As the cylinder temperature increases reflects an increase in NOx.

It is observed from above chart that 48.6 % of NO_X is reduced for Modified Inlet poppet valve (4 ball valve) when compare to conventional inlet poppet valve at maximum loading condition, due to increase in surrounding cylinder temperature for conventional valve.

4. Carbon dioxide (CO2):

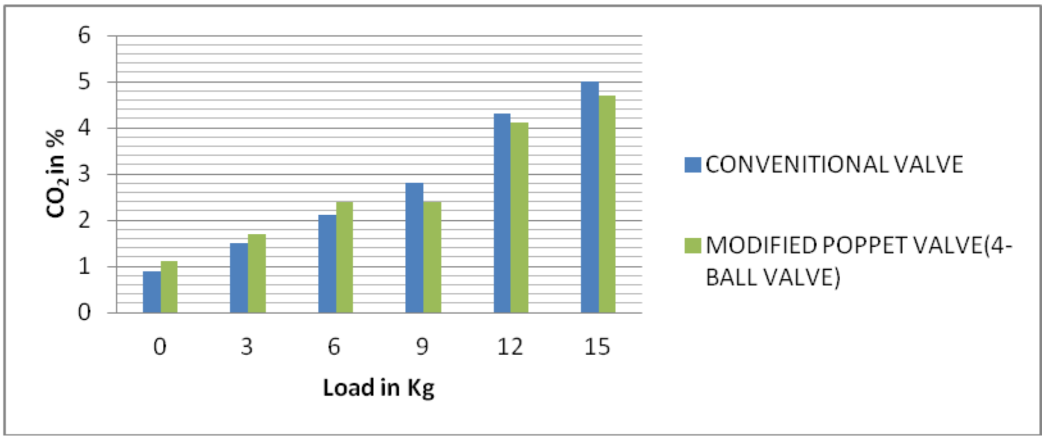


Chart-9: Load vs. CO_2% for Conventional Fuel.

As CO_2 increases, that indicates the complete combustion taken place. It is the product of CO which gives to CO_2.

It is observed from chart-9 that 4.00 % of CO_2 is reduced for Modified Inlet poppet valve (4 ball valve) when compare to conventional inlet poppet valve at maximum loading condition.

5. CONCLUSION:

The final conclusions for the study are taken from the investigation on the use of inlet poppet valves in diesel engines with modified inlet poppet valve designs.

1.Advancement of inlet air to the engine can be done by means of inlet poppet valves.

2.Brake thermal efficiency is decreasing in an engine with modified poppet valve due to less brake power and indicated thermal efficiencies are slightly decreasing due to lower indicated mean effective pressure and friction.

3.Specific fuel consumption is slightly increasing in an engine with modified poppet valve because of rich equivalence ratio

4.Based on the experiment the emission levels are greatly decreased in an engine with modified inlet poppet valves when compared to conventional valve.

5.Manufacturing cost of 4 ball valve is less and can easily be prepared.

Future Recommendations

1. The size and number of balls can be changed and to be checked.
2. The inlet valve rotation during process can be made static to enhance good swirl rates.
3. The engine valves can be modified to generate air swirl at the entrance for better performances.
4. Engine size can be made compact for same capacities with use of less air, i.e., with lower volumetric efficiencies and at high swirl rates for the same capacity, the engine can be made compact in size

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