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

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

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

Abstract

In the present electric vehicle scenario, diesel engines are playing a major role in heavy vehicles. This is the motivation for analyzing the influence of air in the combustion chamber of a diesel engine for Bio diesel with a modified engine head. This modified head provides immense excitement for a smooth mixture of air/fuel combustion. This may have an impact on the reduction of emission parameters like HC, CO, and NOx in diesel engines. Based on this, to comprehend engine behavioral patterns of bio diesel influence, along with engine head modification by air swirl. To initiate the swirl inside the combustion chamber, various methods like changing the cylinder head, piston, and inlet manifold system is relevant. We select a diesel engine cylinder to modify in to generate air swirl. The air swirl ratio is assessed with conventional and modified cylinder heads. The performance of modified and conventional cylinder heads is compared in the experimental investigation work. Based on the comparison, the performance parameters for modified cylinder head with Biofuel have increased, like BTE and other efficiencies, BSFC has lowered, and emission levels such as HC, CO, and NOx could indeed be compared. When compared to traditional cylinder heads, modified cylinder heads with biodiesel produce fewer greenhouse gas emissions.

I Introduction

The spark-ignition engine initially invented in 1876 German inventor Nicolaus A. Otto, whereas the compression-ignition engine first invented by Rudolf Diesel in 1892. They investigated internal combustion engines among the first to do so. Diesel engines have been proven to be more attractive to petrol engines because of their lower fuel consumption, lower emissions of carbon monoxide, and higher torques. However, they too are among of the most apparent drivers of air pollution toxins, thus it is crucial to limit their use to a minimum in order to avoid issues from air pollution.

II Engine Specification

Data	Description
Engine Data	1500rpm, CR:18, 4-stroke, Single Cylinder, 220^{o} is valve open and close crank angle
Inlet Boundary	Velocity Inlet 6m/s is given by calculating it from enginerpm
Valve And Piston	Low and High lift approach is used for Valve, full valve lift is 8mm and 110^{o} is the crank angle at that position. Piston position is set correspondingly.

III Modeling

The following methodologies were investigated for studying the flow dynamics within the cylinder using CFD: Cylinder analysis test bench, creating genuine CAD geometry from an existing diesel lab engine for the valves, cylinder head, piston, and cylinder.

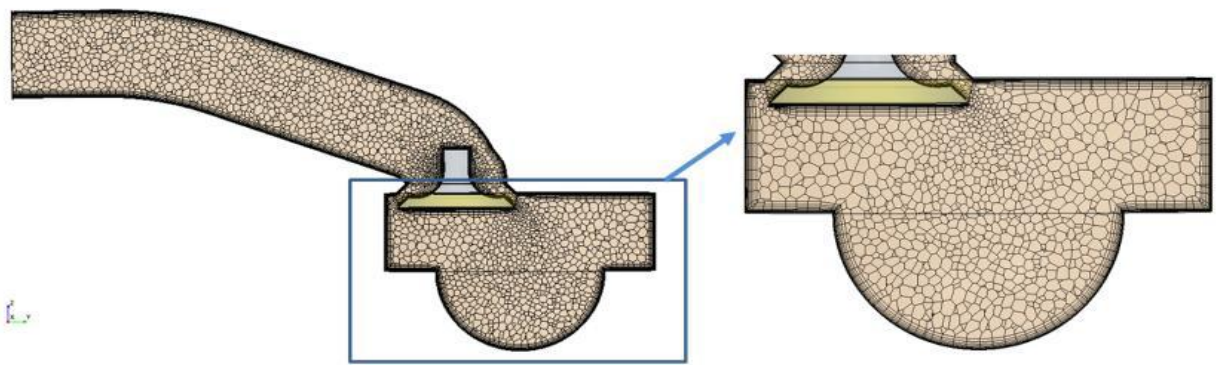
Step-1: Preprocessing

•At this stage, the CAD geometry that will be used for the analysis is imported into the CFD application.

•Only the internal domains in the inlet and cylinders would be evaluated; this is known as fluid domain extraction.

•After extracting the fluid domain, the surface is 2D meshed for later processing; a 3D volume cell is generated inside the domain using the 2D meshing, and the governing equations are solved.

•After developing 3D volume cells, the cells' consistency will be evaluated to confirm that the governing equations are appropriately converging. A polyhedral shape volume cell is employed in this investigation. The figure below depicts the distribution of volume cells in the model.



The fundamental benefit of polyhedral meshes is that each cell has a high number of neighbors, allowing for precise gradient approximation. Furthermore, polyhedrons are less prone to stretching than tetrahedrons, resulting in greater mesh consistency and numerical stability of the system. Furthermore, numerical diffusion is reduced due to mass interchange across several faces. As a result, the answer is more exact with a somewhat lower count.

In this investigation, 62 cells with diameters smaller than 1mm were selected because the bulk of in cylinder experiments employ this number.

The solver configuration is complete after the preprocessing processes mentioned below are done.

Step-2: Solver Setup

In this phase, the models required to solve the fluid flow are chosen, and boundary conditions are applied at the intake and outflow. Reports and contour sceneries are also generated as needed. Additional information is provided in the table below.

Parameters	**Model**	**Description**
Air	Ideal Gas	Air flow in cylinder modeled as airmedium using Ideal gas approach
Time	Transient State	Transient approach is approach is used in which flow field will vary with respect to time.
Turbulence	K-Epsilon	To capture Turbulence in the model K- Epsilon model is used where K is turbulent kinetic energy and Epsilon is turbulent dissipation
Flow Nature	Turbulent Flow	Reynolds number of this study is Re>3000

Table 3.1: Models for addressing flow field problems.

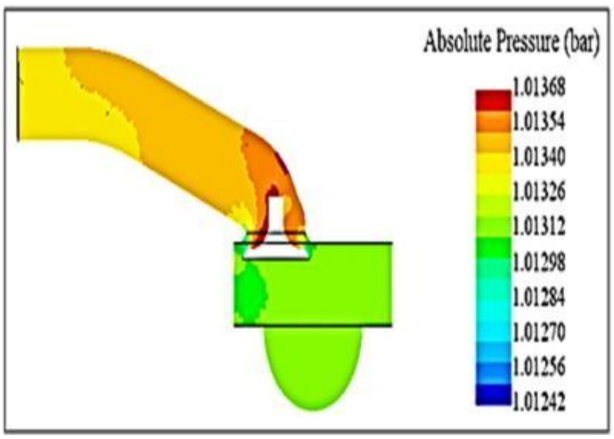
Data	Description
Engine Data	1500rpm, CR:18, 4-stroke, Single Cylinder, 220° is valveopen and close crank angle
Inlet Boundary	Velocity Inlet 6m/s is given by calculating it from enginerpm
Valve And Piston	Low and High lift approach is used for Valve, full valve lift is 8mm and 110° is the crank angle at that position. Piston position is set correspondingly.

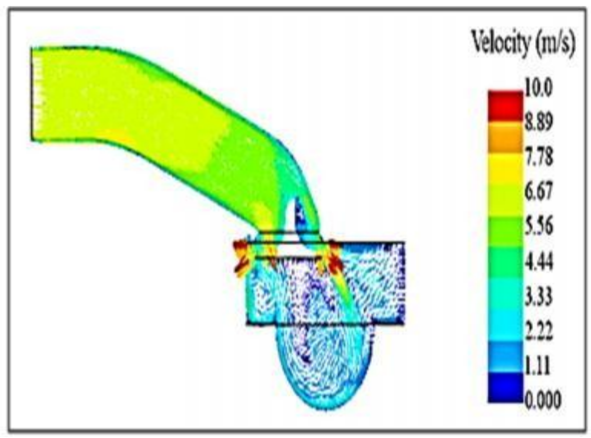
Table 3.2: The model introduces a boundary condition.

Contours and report generation: Prior to executing the event, reports are created to measure swirl, tumble, and TKE, and contours can be generated either during or after this step.

Step-3: Post Processing

At this point, the simulation will provide results, and the next step will be to test the convergence of documents and flow variables. Report variables and contour information will be retrieved if all convergence requirements are satisfied.





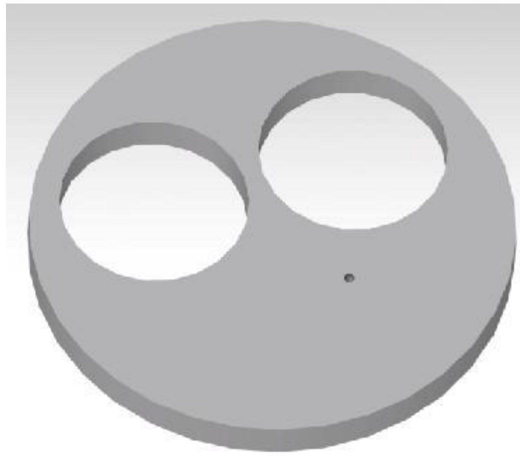
The first image illustrates strain, the second exhibits vector plots indicating flow direction, and the third depicts the vector plot itself but in the form of line linking vectors; tiny fluctuations in the flow field are seen in this plot.

All three phases of modeling are completed using STAR CCM+ V12.02 technology. It is a CFD software industry leader, with applications spanning from aviation to electronic cooling.

The name Star CCM+ stands for Simulation of turbulent flow in any region using continuum computational mechanics.

CAD Model of Head modification:

Circular cut cylinder head: Dimension for circular cut 3x3 mm.



IV Experimentation

Methodology

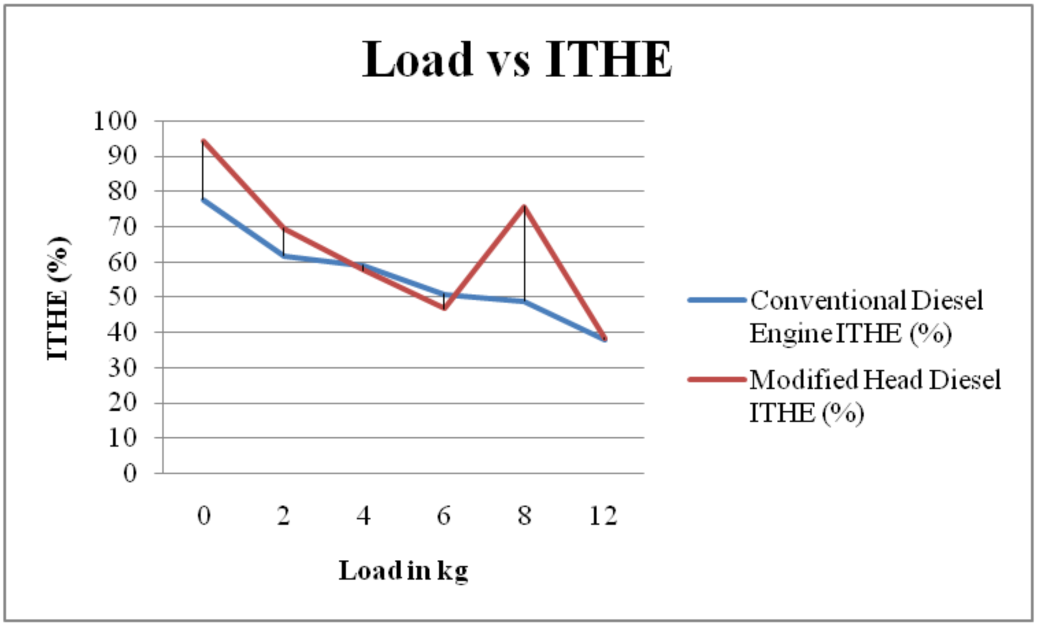
1. Diesel engine with a single cylinder.
2. A loaded eddy current dynamo.
3. A system for measuring fluid flow.
4. A method of water cooling.
5. Motor oil.
6. ALV5 Emission Testing Kit.

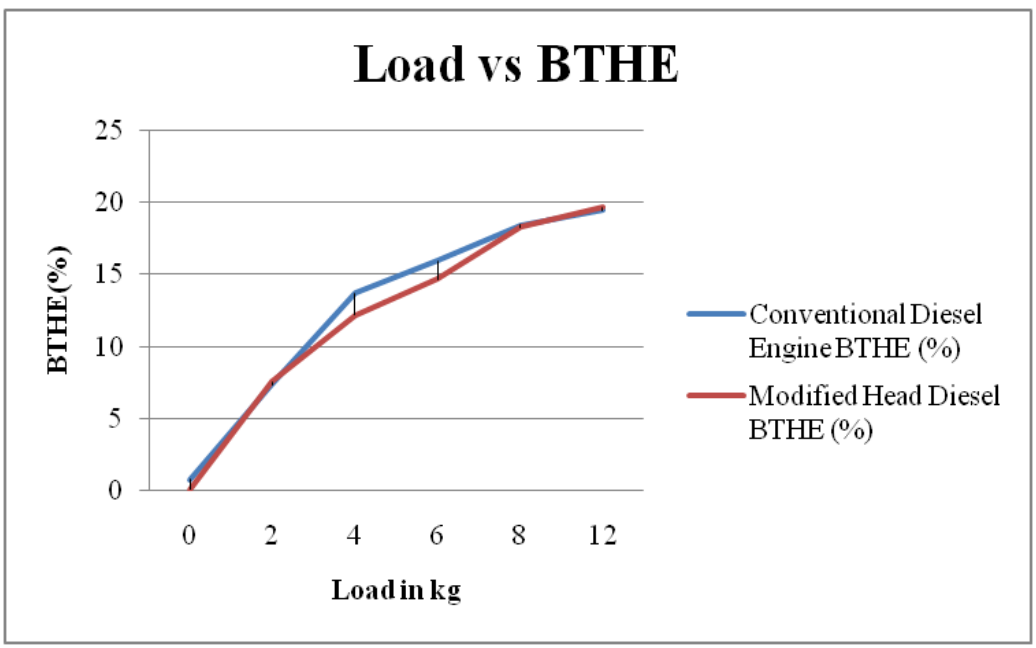
Procedure

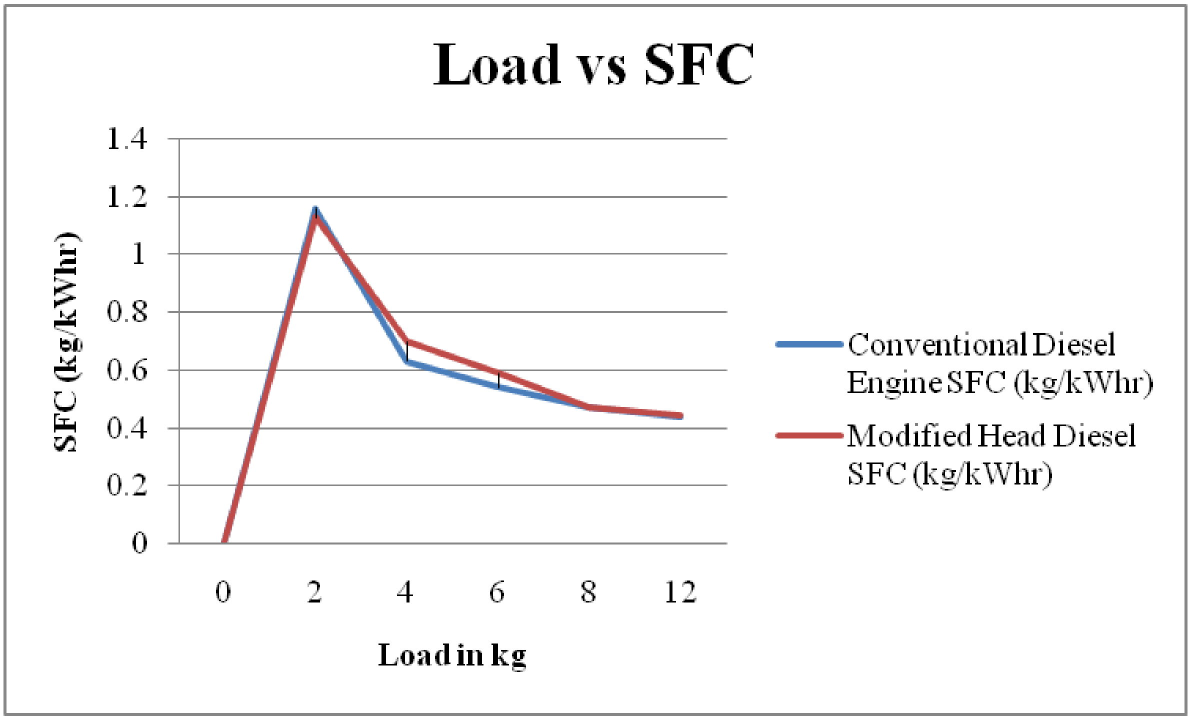
1. Verify there is enough fuel for the experiment.
2. On water with a flow rate suitable for cooling jackets.
3. Before commencing the experiment, remove the burden.
4. Take the necessary readings at certain intervals and gradually raise the load.
5. Repeat the experiment after 15-minute intervals.
6. Calculate data obtained in a table.

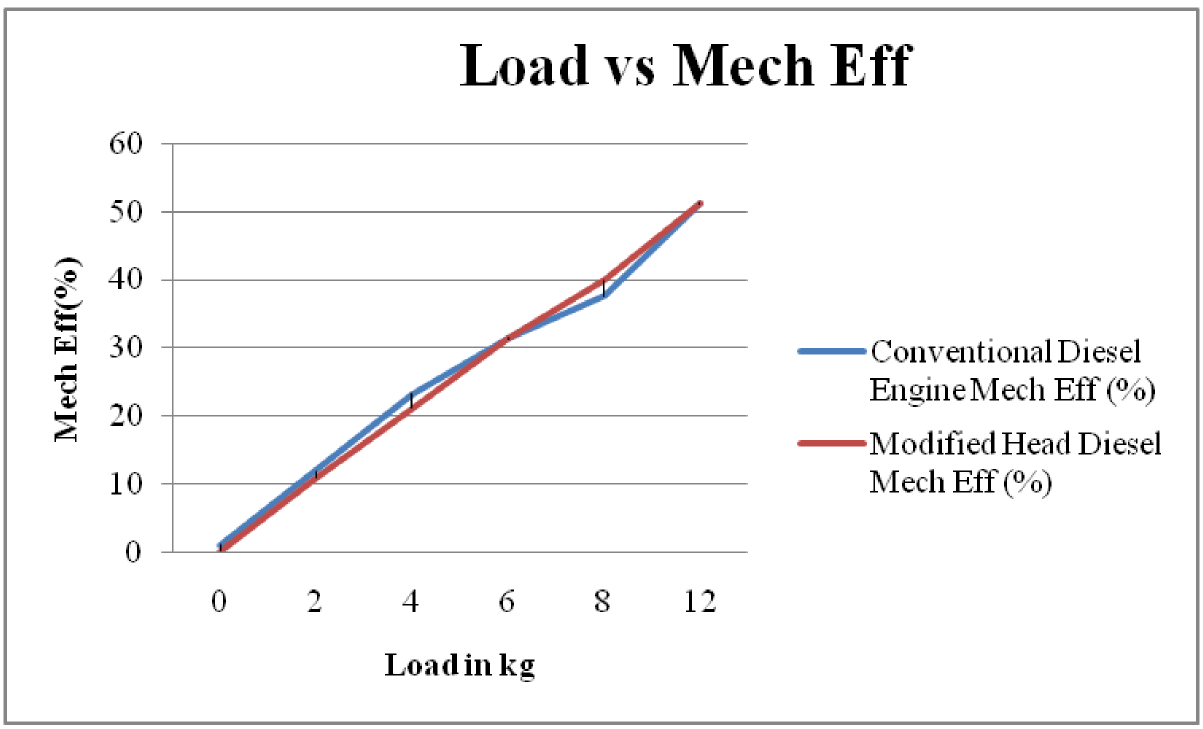
V Analysis

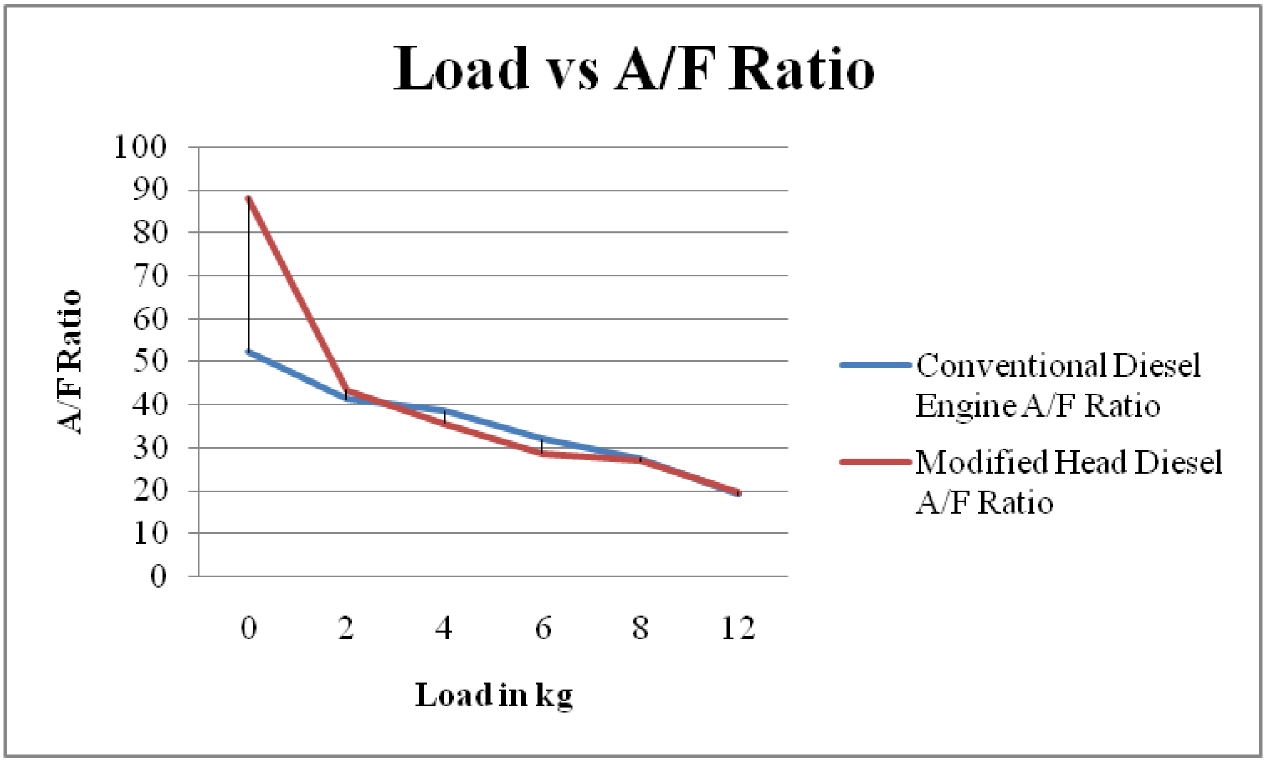
Performance





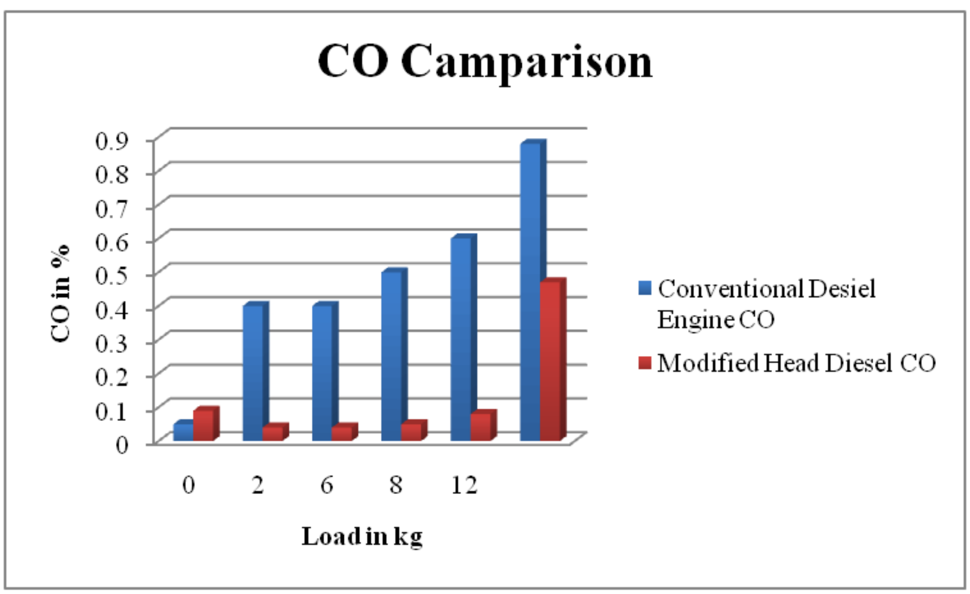

Load vs SFC
SFC (kg/kWhr)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
12
Load in kg
Conventional Diesel Engine SFC (kg/kWhr)
Modified Head Diesel SFC (kg/kWhr)


Load vs Mech Eff
Mech Eff(%)
60
50
40
30
20
10
0
0
2
4
6
8
12
Load in kg
Conventional Diesel Engine Mech Eff (%)
Modified Head Diesel Mech Eff (%)

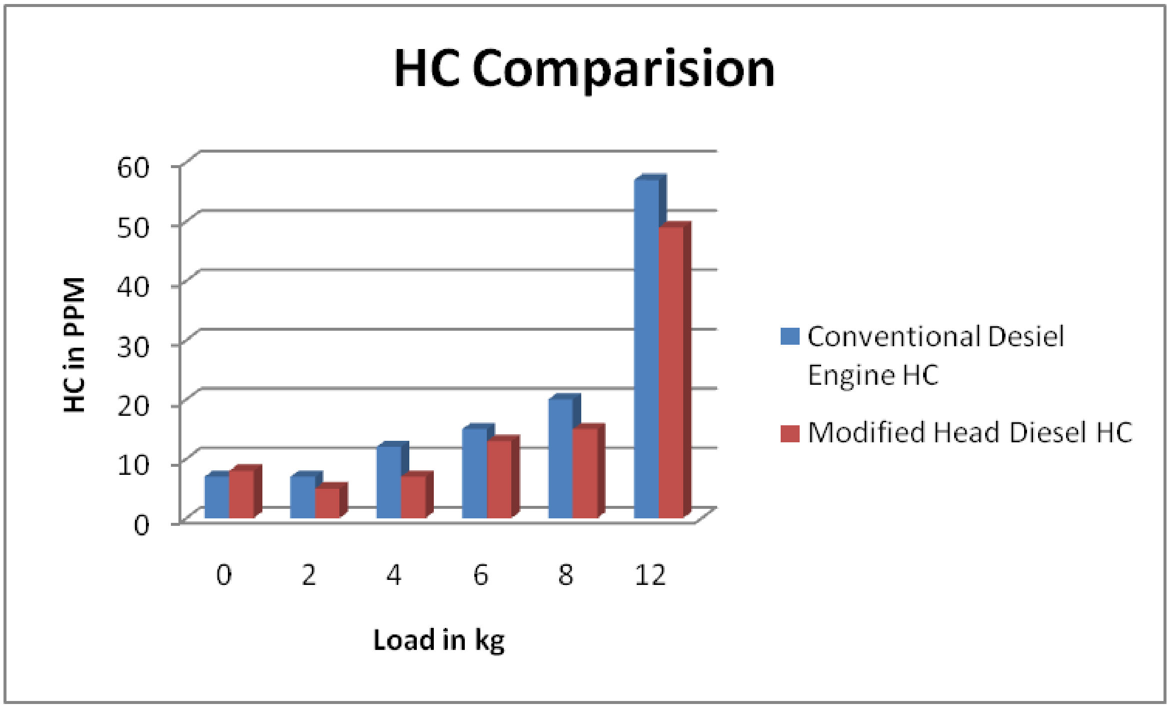


As the results shows that there is no change in the performance even after the modification of head, this is due to that we are concentrating only on the emission.

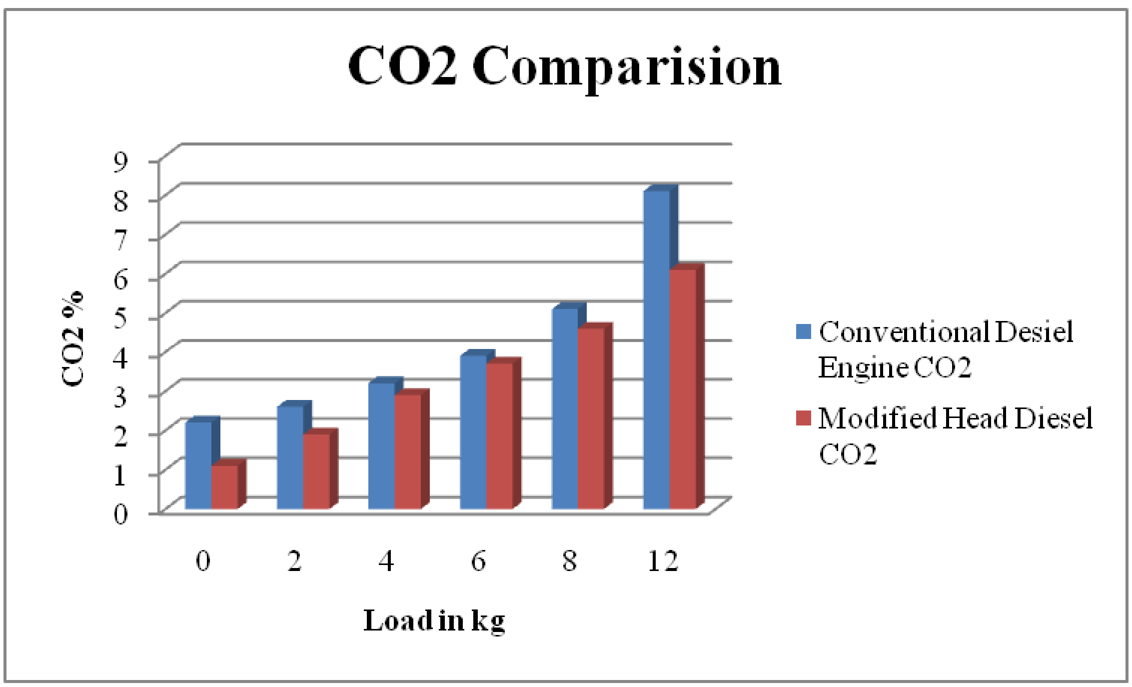
Emission



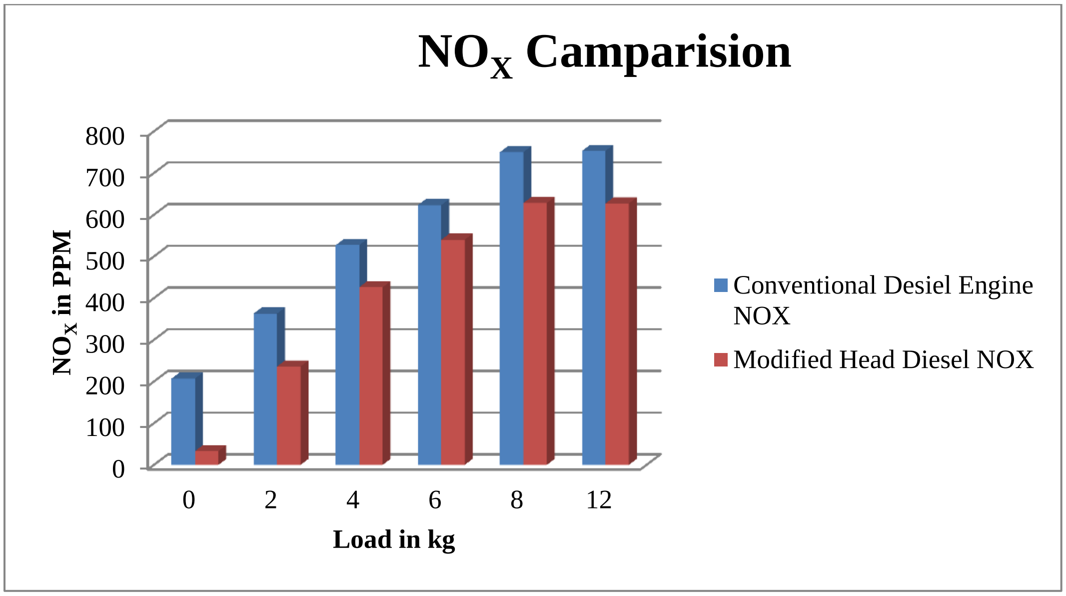
As compared CO emission is reduced significantly due to the complete combustion occurring inside the combustion chamber.



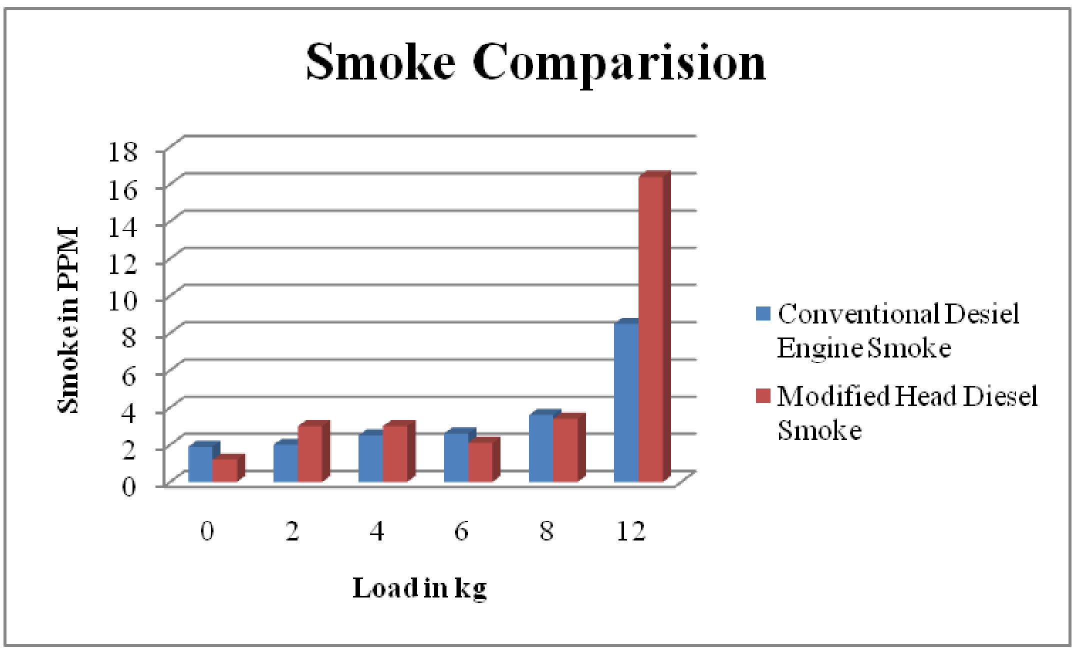
As compared HC emission is reduced slightly due to the complete combustion occurring inside the combustion chamber.



As compared CO_2 emission is reduced slightly due to the complete combustion occurring inside the combustion chamber.



As compared NO_X emission is reduced due to the complete combustion and also sufficient air is passed for burning which also act as cooling agent that reduces the internal temperature of the combustion chamber.



Due to combustion of rich fuel in the modified engine head smoke is slightly increased with load.

VI Conclusion

1. Due to the modification of engine head the performance is not affected, but emission parameter is drastically reduced.
2. There is a slightly decreases in BTHE and a small increase in SFC.
3. CO and HC emission is drastically reduced in modified head.

4. NO_X and CO_2 are reduced in modified head.

VII Future Scope

1. Head modification to improve performance as well as emission parameter.
2. Use of proper fuel injector to maintain A/F ratio.
3. Use of alternative fuel to be done.

VIII Reference

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