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Experimental Analysis of Backpressure in Exhaust Muffler of Single Cylinder Diesel Engine Using Cod

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Abstract: The important function of a exhaust muffler is to route the exhaust gases from the engine exhaust manifold to the atmosphere while reducing the noise created and back-pressure. Noise reduction is an emerging concern in the automotive industry, and reduction in back-pressure enhances the fuel economy of the engine. In this Study comprehensively analyzes two different models of exhaust muffler and concludes the best possible design for lowest pressure drop. Backpressure is obtained with experimentally on both models. Back pressure was obtained based on the flow field analysis and was also compared with all muffler design. Virtual simulation for back-pressure testing is performed by Computational Fluid Dynamic (CFD) analysis using ANSYS CFD. Finite Element (FE) model generation of the muffler structure is performed using Ansys as the preprocessor. The structural mesh is modeled using 2D shell elements, wherein the internal tubes with fine perforated holes are considered. The CFD fluid meshing is done with tetra elements using Ansys Workbench as the CFD pre-processor.
Keywords: Exhaust muffler; CFD; Backpressure; Emission; Efficiency

I. INTRODUCTION

Using diesel engines as a main driving power element has increased the importance of the technical specification of the diesel engine itself and during and after design specification. The muffler is defined as a system for reducing the amount of noise emitted by an Engine. The muffler is designed as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the diesel engine. Due to increased environmental concerns this requires less noise emissions combined with reduced emission of harmful gases, it is becoming very crucial to carefully design the exhaust system mufflers for automobile applications. Exhaust gas emitted from vehicles contains many components that contribute to air pollution, namely carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NOx).

When the exhaust gases from inlet pipe pass through the perforations inside the shell, the gases get scattered in different directions. After reflection from the inside surface of the shell, the sound cancellation of sound waves occurs. The gases pass through the perforations multiple times and even get reflected from the shell surface multiple times. Due to the combined effect of all these, the level of sound at the muffler outlet is reduced significantly. The flow through the muffler and variation of various parameters such as velocity and pressure along the length of the model can be accurately demonstrated with the help of Experimental analysis or CFD analysis which display accurate results within a short span of time.

Perforated tubes in the muffler as used to escape the hot exhaust gases through the perforation holes in the tube and to deliver to atmosphere. The perforations diameter and number of perforations on the tube and baffle plate are calculated as per the muffler volume and requirement. The perforation need have to proper spacing between the each hole for better performance. Here perforations are closed with the creation of surfaces and it should be in separate collector.After geometry simplification, perforated pipe and baffle plate surfaces are to be meshed with shell elements with minimum element length to have more number of nodes on the surface to achieve proper flow of gases and minimize noise level.Baffle plates have many significant design uses in general in different applications. However, if baffles are created to the pressurized region required within our systems design for proper distribution, and flow rate throughout our system. Many baffles are adjustable and some are fixed. Baffles are used to help reduces the air noise and backpressure during the hot gas passing through the muffler. Perforated baffles are used to expand the exhaust hot gases from one chamber to another chamber through the use of their perforations. Perforated and non perforated baffle plates are merged with muffler shell with the use of trim operation in design modulator.

II. LITERATURE REVIEW

JianminXu and Shuiting Zhou designed a double mode muffler that automatically adjusts exhaust resistance according to the engine speed. The pressure loss and flow inside muffler is analyzed with the CFD software. Pressure loss in double mode muffler is highly influenced by the muffler design.MackliniDalla Nora, Thompson DiórdinisMetzkaLanzanova, Hua Zhao discus the Effects of valve timing, valve lift and exhaust backpressure on performance on engine. Which conclude the higher backpressure will affect the efficiency of engine.Same study is being carried out by Mohammad UzzalHossainJoardder, Md. ShazibUddin and MurariMohon Roy. This study investigated CO reduced with increasing backpressure for all load conditions and NOx emission became little decreased with increasing backpressure.

III.EXPERIMENTAL SETUP

The experimental setup consists of four stroke diesel engine. For boundary condition we require values of flow velocity and pressure of the exhaust gases from the cylinder head for this air flow meter and U-tube manometer is used as shown in figure below The diesel fuel used in this study is available in the local market. Loads were measured by electric dynamometer. The arrangement of backpressure measurement is shown in Figure 1. A U-Tube manometer was used to measure the exhaust backpressure in the exhaust line. The fuel consumption rates were measured by taking time for consumption of certain amount of fuel.

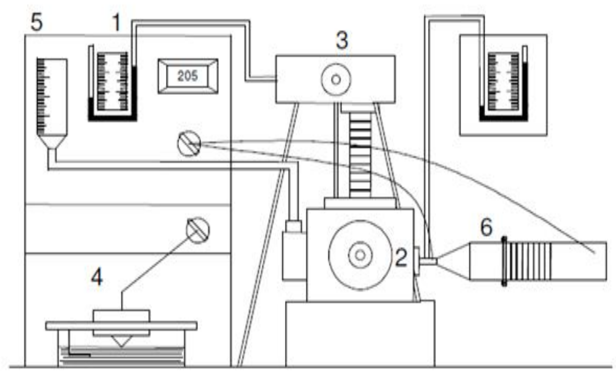

Fig 1 Experimental Setup

IV.METHODOLOGY

Present work has been carried out in following steps

A. Cad Modelling

Base model under study has been modeled using CATIA and some modifications required are done in Ansys. Two different types of muffler have been designed. “Inlet” is the region from which the exhaust gas will enter, muffler pipe allows the exhaust gas to split and pass to another chamber, and outlet carries the gas from muffler chamber to atmosphere.

B. Meshing

Meshing of the base model is done using Ansys.Following are the steps carried out on all the four mufflers cases to get the final meshed models:

Importing and Repairing CAD: In this, the base model modeled using CATIA will be imported to Ansys. The model file will be imported in .stp or .iges Format. After importing into Ansys, check for the free edges, duplicate Surfaces will be carried out. Surface will then be trimmed with proper tolerance and any geometry loss due to importing from design software so that mesh can be easily put on the surface.Meshing the model: The cleaned up model will be meshed with specific Element size.

C. CFD Meshing

Pre-processing methodology using CFD tool Pre-processing for CFD analysis involves the creation of surface mesh, volume mesh and setup of boundary conditions for backpressure study. Meshing is a key step to creating accurate geometric model, correct mesh continuity and mesh density are needed to efficiently compute results and capture the boundary layer effects. The quality of CFD solution is depending on the quality of the underlying volume mesh.

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V. RESULT

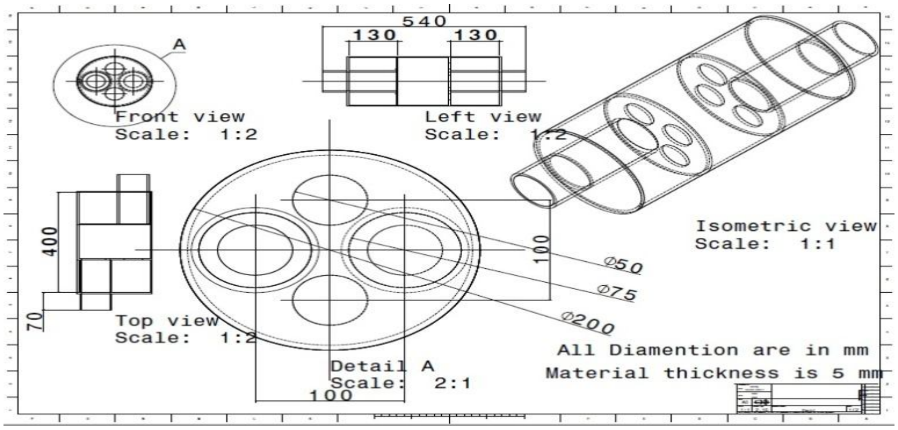

Fig 2 Design without perforation of muffler

Above figure shows the drafting of exhaust muffler. It shows the inside components of the exhaust muffler. It contain pipe and two baffle plates. The pipe does not have perforation and baffle plates have three holes.

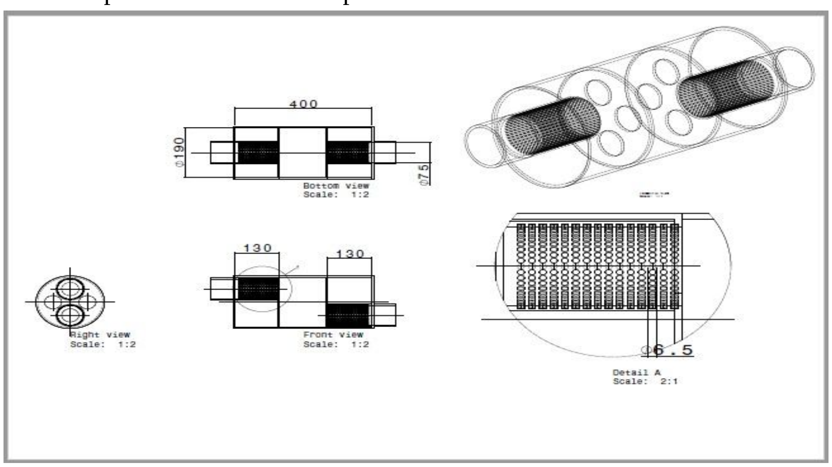

Fig 3 Design with perforation of muffler

Above figure shows the drafting of muffler with perforation on pipe while the other dimensions remain the same.
In this study, inlet and outlet boundary conditions are specified in below table

Table 1.Inlet Boundary Conditions

Gas Temperature	633 k
Mass flow rate of gas	18.5 kg/hr

Table 2.Outlet Boundary Conditions

Outlet pressure	Atmospheric pressure

Table 3.Engine Specification

Specification	Values
Bore x stroke	87.5 x 110 mm
engine	Single cylinder diesel engine
Compression ratio	16:1
Calorific value of the fuel	45500kj/kg
Density of the fuel	850kg/m3
Sump capacity	2.70 liter
Connecting rod length	234 mm
Overall dimension	617 x 504 x 877

After carrying out detailed experiment and studying the manufacturing feasibility of exhaust muffler design following results are drawn:

Table 4.Muffler pressure drop

Muffler designs	Total pressure drop(kPa)
Design1	4.55
Design2	4.85

VI. CONCLUSIONS

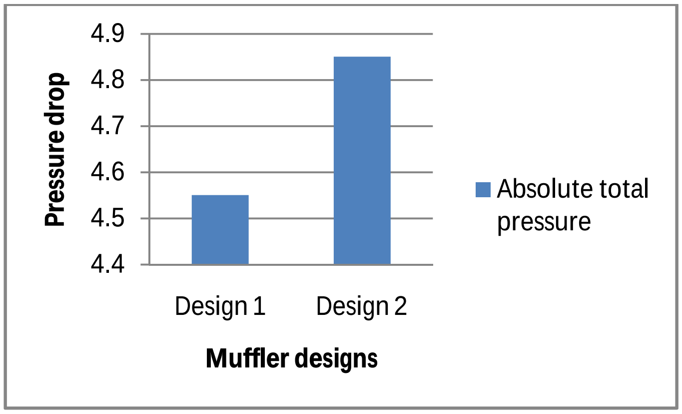

Fig 4 Total pressure drop chart

The chart shows total pressure drop across different muffler design. From the study it is concluded that the design 1 of exhaust muffler gives low pressure drop. If the two designs are compared, muffler design 1 gives better result with low pressure drop, and also easy to manufacture.

VII. ACKNOWLEDGMENT

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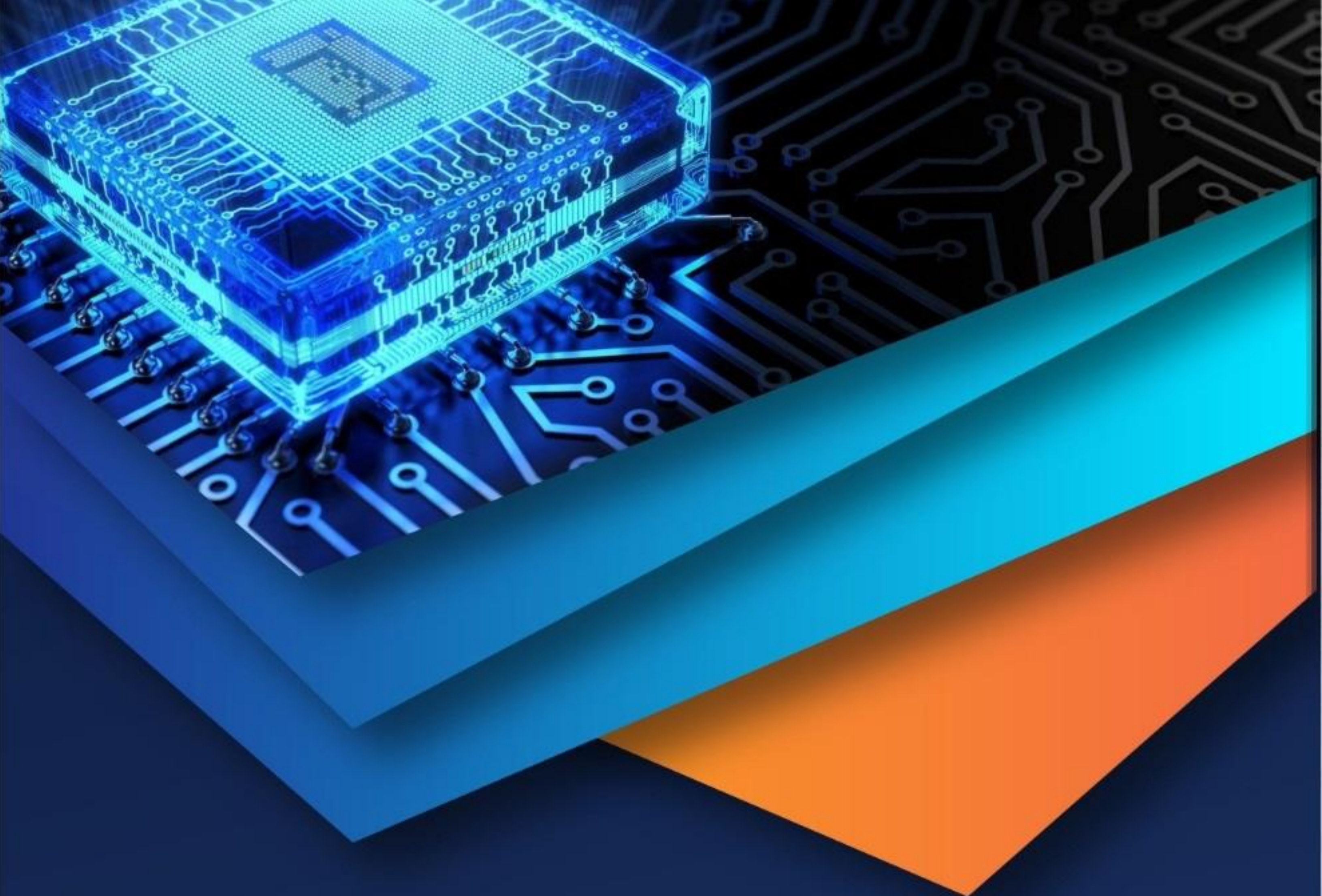

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