Design & Development of Reactive Muffler for Diesel Engine

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Abstract— Now a days the environmental norms for noise pollution are strictly taken in to consideration. Muffler is important part of the engine system used in exhaust system to reduce noise level. The objective of this study is to reduce exhaust gas noise level. The performance of the muffler is assessed by analysing pressure variation, exhaust gas flow pattern using CFD, length of expansion chamber, transmission loss. The K-epsilon method is used to obtain desired outputs by inputting sinusoidal nature of pressure wave. The modeling of muffler is done by using modeling software and performance parameters are estimated using Star CCM+ software.

Key words: Muffler, CFD, Expansion Chamber, Transmission Loss, Pressure Distribution

I. Introduction

Muffler design is an important research area for automotive companies because of new regulations and standards for noise emission. To examine the performance of any muffler, certain parameters are used. These parameters are transmission loss and back pressure. The transmission loss gives a value in decibel (dB) that corresponds to the ability of the muffler to dampen the noise. Transmission loss is independent from the noise source, thus this property of muffler does not vary with respect to noise source. New designs to improve the acoustical properties of a muffler cause a resistance against the flow of exhaust gases and this resistance stems the flow. For the actual complex muffler, the internal flow is three-dimensional and unsteady. Reports on the distribution of flow field, velocity, pressure and temperature of complex muffler is rare. So is significant to have numerical simulation on the internal air flow, pressure and temperature distribution of automobile exhaust muffler.

II. Methodology

Muffler is one of the major exhaust system components and it is broadly classified into two types based upon its operating mechanism:

A. *Reactive Muffler*

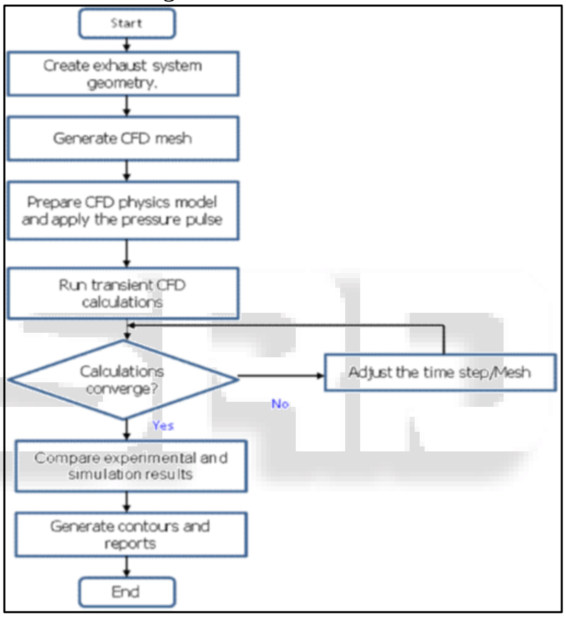
The reactive or reflective muffler uses the phenomenon of destructive interference to reduce the noise. This means that they are designed so that the sound Waves produced by an engine partially cancel themselves out in the muffler. For complete destructive interference to occur, a reflected pressure wave of equal amplitude and 180 degree out of phase needs to collide with the transmitted pressure wave. Reflections occur when there is a change in geometry or an area discontinuity.

B. *Absorptive Muffler*

Absorptive silencers contain either fibrous or porous material, and depending upon their absorptive properties they reduce the noise levels. Sound energy is reduced as their energy is converted into heat in their absorptive material. It is based on the use of flow resistive materials, again normally in the form of porous acoustic linings. In hybrid type, Sound is attenuated by reflection and cancellation as well as absorption and in active noise control method; they used the noise cancellation method to attenuate the sound.

During the design process of the muffler the design targets need to be achieved. Some of the design targets are as follows

- Transmission loss
- Insertion loss
- Tail pipe noise
- Backpressure
- Model Building



Flow Chart 1: Model Building

To estimate performance parameters i.e. transmission loss, pressure variation, flow pattern CAD model is created in CATIA to carry out analysis in star CCM+ software. CAD model is import in Star CCM+ software and trimmer meshing is applied on that.

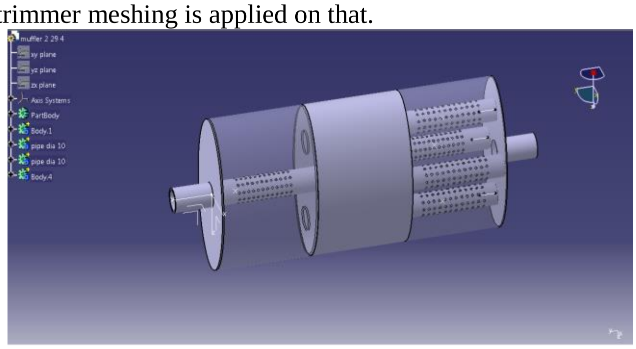


Fig.1- 3D CAD model of reactive muffler geometry 01

Solid model of muffler is created by using CATIA software. Total length of geometry of muffler is 360 mm. It has baffle1 with holes on it and baffle2, also pipes has perforations on it.

Geometry 01 has 2 holes on baffle 1 and it has 4 perforated pipes in third chamber. The diameter of pipe is 20mm and diameter of perforation is 2mm.

1) Computational Meshing

In this study, the exhaust system was modelled from the tail pipe to model the exhaust system. The three dimensional wireframe CAD modelling data were imported in an STL format. Geometry of muffler is divided for better meshing of muffler. Boundary condition is selected as wall for geometry.

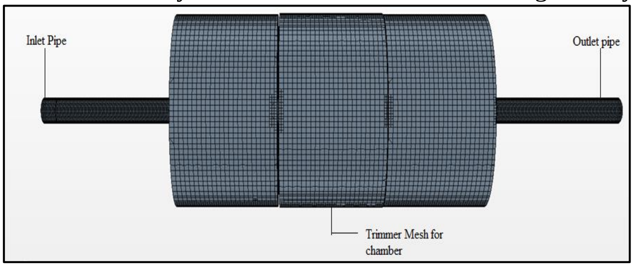


Fig. 3: Turbulent Model

All physical phenomena involved in the exhaust flow are highly coupled with the turbulent flow nature of very fast change of turbulent kinetic energy generation and dissipated energy. Therefore, it is very significant to select suitable turbulence model for the simulation of the flow patterns in exhaust system. In the current study K-epsilon all Y+ model is used. Navier- Stokes equation is used for solution Geometry of muffler is divided into number of parts for mesh to obtain better mesh quality. Hexahedra trimmer volume mesh type of meshing is used for analysis because it provides better analysis results by comparing to other and hexahedra trimmer meshing reduced number of elements. Reduction in number of meshing elements causes reduction in analysis time of software. So it is preferable type of meshing for muffler. Total number of elements in volume mesh are 439990 and meshing size is 4 mm are used.

2) Mach number

Mach number is the ratio of velocity of medium to the velocity of sound in that medium. Figure shows the velocity distribution of exhaust gas inside the muffler.

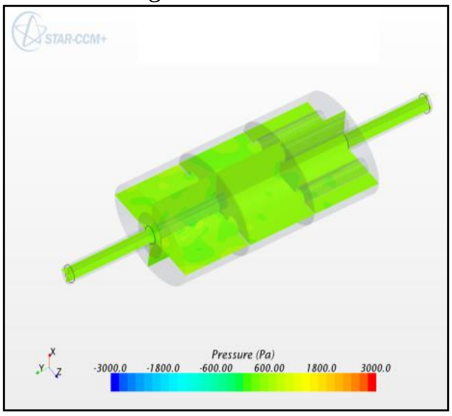


Fig. 4: Pressure distribution inside the muffler geometry 01

As shown in fig when gas enters through input the pressure at the input is -400 pa that means vacuum region is created at muffler but when it reaches to first pipe to the baffle no. 1 it shows more pressure variation as per baffles.

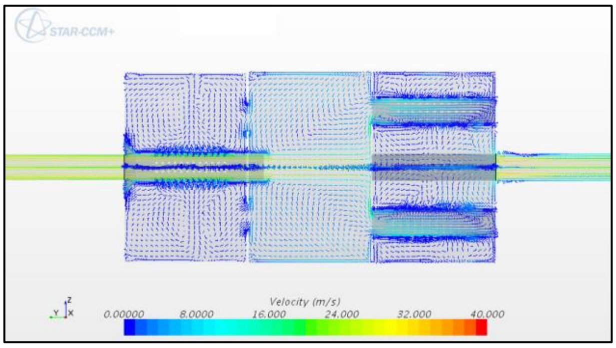


Fig. 5: Velocity distribution inside the muffler geometry 01

As shown in figure 5 when the gas enters through input the Mach number at the input is 0.02 which increases at the baffle.1 which is varied through 2 and 3 chambers respectively.

III. TRANSMISSION LOSS ANALYSIS

Transmission loss is a characteristic parameter which shows the performance of muffler. Selection of suitable muffler is based on transmission loss because transmission loss does not depend on the source of noise. Graph is plotted for frequency verses transmission loss. Transmission loss is vary w.r.t. change in geometry parameters such as number of holes, diameter of pipe, number of pipes.

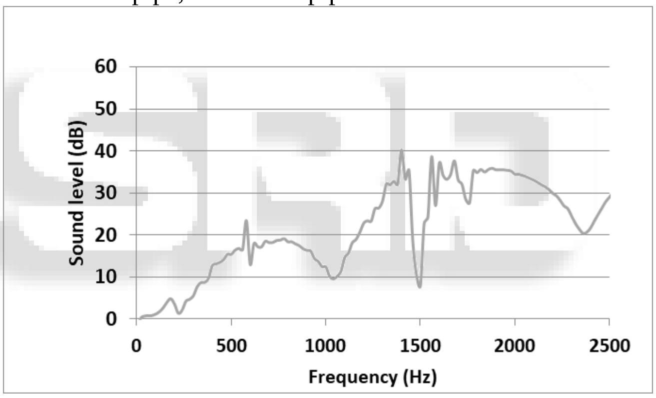


Fig. 4: Transmission Loss of Geometry

IV. CONCLUSIONS

Above muffler is best suited for the frequencies between 1000 to 1500 HZ.4 pipes reduces the back pressure.

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