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Design and Fabrication of Muffler for Four Stroke Diesel Engine

S.Balamurugan, N.Jeyaprakash, K.Manikandan
prakash84gct@gmail.com, mechstarmani@gmail.com

Abstract— The main aim of our research is to design a Muffler for four stroke diesel engine. Muffler is a device which is used for reducing the amount of noise emitted by the exhaust of an internal combustion engine.

In this research baffle arrangement are used to resist the flow of the exhaust from the engine. An exhaust pipe must be carefully designed to carry toxic and/or noxious gases away from the users of the machine .Indoor generators and furnaces can quickly fill an enclosed space with carbon monoxide or other poisonous exhaust gases if they are not properly vented to the outdoors. Also, the gases from most types of machine are very hot; the pipe must be heat resistant and it must not pass through or near anything that can burn or damaged by the heat. A chimney serves as an exhaust pipe in a stationary structure. For the internal combustion engine it is important to have the exhaust system "tuned" optimal efficiency.

Mufflers are installed within the exhaust system of most internal combustion engines, although the muffler is not designed to serve any primary exhaust function. The muffler is engineered as an acoustic soundproofing device designed to reduce the loudness of the sound pressure created by the engine by way of acoustic quieting. The majority of the sound pressure produced by the engine is emanated out of the vehicle using the same piping used by the silent exhaust gases absorbed by a series of passages. And chambers lined with roving fibre glass insulation and/or resonating chambers harmonically tuned to cause destructive interference where in opposite sound waves cancel each other out. An unavoidable side effect of muffler use is an increase of back pressure which decreases engine efficiency. This is because the engine exhaust must share the same complex exit pathway built inside the muffler as the sound pressure that the muffler is designed to mitigate.

Keywords: Muffler, Diesel Engine, Auto CAD, Pro-E

I. Introduction

1.1 Muffler

If you've ever heard a car engine running without a muffler, you know what a huge difference a muffler can make to the noise level. Inside a muffler, you'll find a deceptively simple set of tubes with some holes in them. These tubes and chambers are actually as finely tuned as a musical instrument. They are designed to reflect the sound waves produced by the engine in such a way that they partially cancel themselves out.

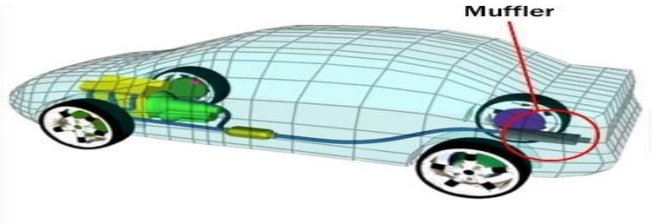

Figure 1 Arrangement of muffler in a car

Mufflers use some pretty neat technology to cancel out the noise. In this article, we'll take a look inside a real car muffler and learn about the principles that make it work.

II. Literature Survey

This is focused on the development and implementation of effective methods for acoustic design and modelling of the exhaust line of internal combustion engines, and specifically for two relevant components, from the standpoint of noise control, such as mufflers and catalytic converters. Therefore, a literature review of the one-dimensional models and their approach has been performed also a review of the existing literature regarding the characterization of perforated elements, absorbent materials and monoliths has been carried out. The limitation and deficiencies of the plane wave models show the need of multidimensional modelling tools, which are valid for high frequencies and more general muffler and catalytic converter geometries.

The finite element method is applied to solve the convective wave equation in dissipative silencers using the pressure formulation. The coupling between connected sub domains by means of perforated elements inside the muffler is studied in detail. In addition, the effect of the mean flow on the acoustic impedance is analyzed, paying particular attention to different perforated boundary conditions. The continuity condition of velocity and displacement are applied and the obtained results are compared with experimental results.

Two different modelling techniques are considered:

(1) First, the procedure described in previous works, 3D ducts/3D monolith, in which the finite element method leads to the calculation of the three-dimensional acoustic field inside the complete catalytic converter.

(2) On the other hand, the proposed technique in thesis,3D ducts/1D monolith, in which the monolith is replaced by a plane wave transfer matrix, that is, only one-dimensional acoustic behaviour is allowed within the capillary ducts. The results provided by both approaches are compared with experimental measurements, showing that the latter technique exhibits a better arrangement.

2.1 About Sound

Sound is a pressure wave formed from pulses of alternating high and low air pressure. These pulses makes their way through the air at -- you guessed it -- the speed of sound.

In an engine, pulses are created when an exhaust valve opens and a burst of high-pressure gas suddenly enters the exhaust system. The molecules in this gas collide with the lower-pressure molecules in the pipe, causing them to stack up on each other. They in turn stack up on the molecules a little further down the pipe, leaving an area of low pressure behind. In this way, the sound wave makes its way down the pipe much faster than the actual gases do.

2.2 Sound wave frequency

A higher wave frequency simply means that the air pressure fluctuates faster. The faster an engine runs, the higher the pitch we hear. Slower fluctuations sound like a lower pitch.

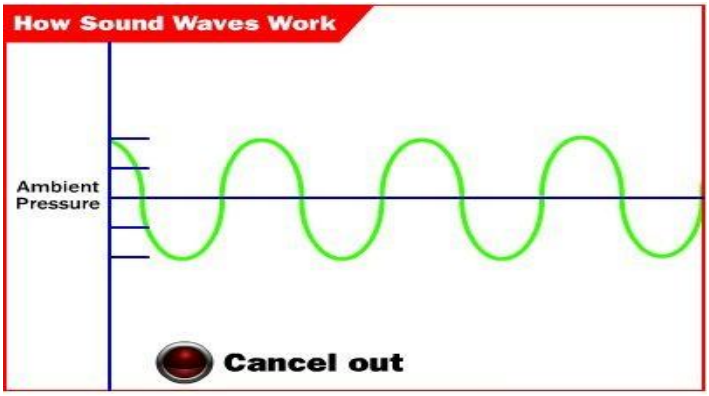

Figure 2 Sound wave frequency

2.3 Air pressure level

The wave's amplitude determines how loud the sound is. Sound waves with greater amplitudes move our eardrums more, and we register this sensation as a higher volume.

2.4 Sound Reducers

The key thing about sound waves is that the result at your ear is the sum of all the sound waves hitting your ear at that time. If you are listening to a band, even though you may hear several distinct sources of sound, the pressure waves hitting your ear drum all add together, so your ear drum only feels one pressure at any given moment.

2.5 Inside a Muffler

Located inside the muffler is a set of tubes. These tubes are designed to create reflected waves that interfere with each other or cancel each other out. Take a look at the inside of this muffler: The exhaust gases and the sound waves enter through the centre tube. They bounce off the back wall of the muffler and are reflected through a hole into the main body of the muffler. They pass through a set of holes into another chamber, where they turn and go out the last pipe and leave the muffler.

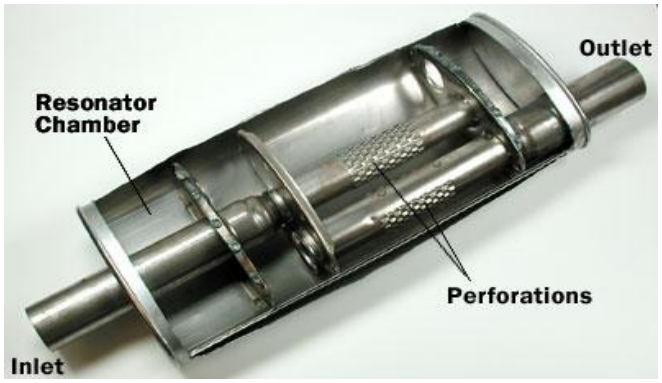

Figure 3 Inside a muffler

2.6 Backpressure and Other Types Of Mufflers

One important characteristic of mufflers is how much **backpressure** they produce. Because of all of the turns and holes the exhaust has to go through, mufflers like those in the previous section produce a fairly high backpressure. This subtracts a little from the power of the engine.

Figure 4 Nascar muffler

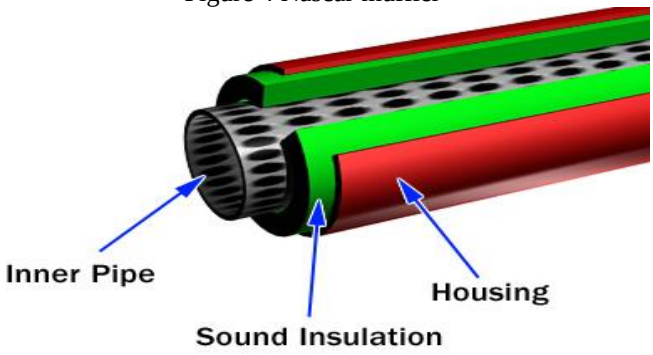

Figure 5 Glass pack Muffler

2.7 Glass pack muffler

These mufflers produce much less restriction, but don't reduce the sound level as much as conventional mufflers.

III. Design of Muffler

3.1 Design consideration

The muffler is to be designed on the following requirements.

- The muffler should reduce the noise of the exhaust.
- The muffler should make free flow of the exhaust.

- The muffler should improve the performance.
- The muffler should stack the combustion product.

3.2 Design used in engine

Figure 6 Four Stroke Diesel Engine

3.3 Design of muffler using Auto cad

The muffler is designed with the aid of Auto cad package. The 2-D view of muffler is drawn in Auto cad. The dimension of the muffler is represented in the 2-D diagram.

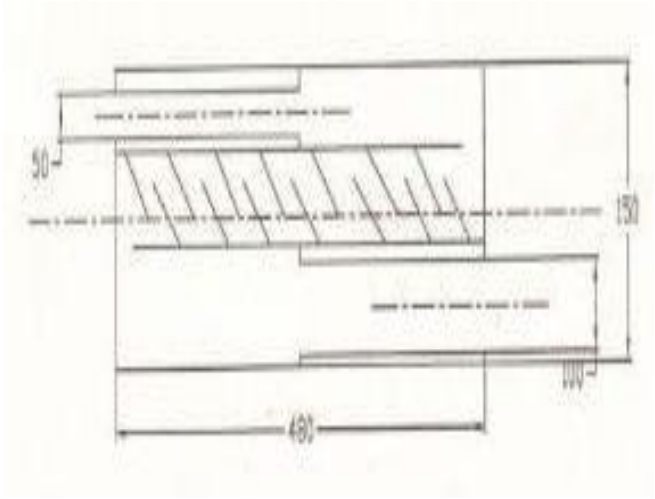

Figure 7 Dimensions of Muffler (All dimensions are in mm)

3.4 Design of muffler using PRO-E

The 3-D view of the muffler is drawn using pro-engineer package.

Figure 8 Inner View

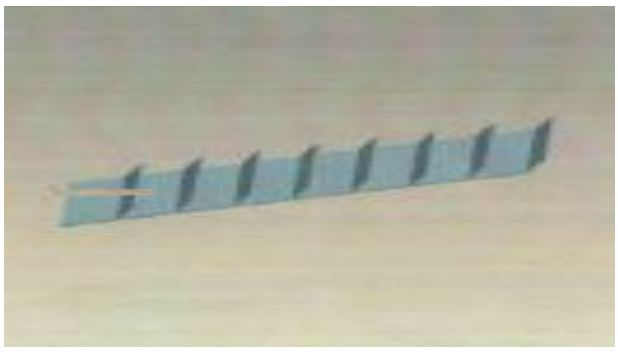

Figure 9 Baffle design

Figure 10 Baffle arrangement design

Figure 11 Inner assembly

Figure 12 Pipe assembly

Figure 13 Total assembly view 1

Figure 14 Total assembly view 2

IV. Part Fabrication

4.1 Baffle arrangement:

Figure 15 Baffle arrangement

Figure 16 Baffle side view

The baffle arrangement which is used inside the muffler is shown here.

Figure 17 Cylindrical shell

Figure 18 Finishing of muffler view 1

V. Working of Muffler

5.1 Working:

First, we need to know a little about sound. The sound is a pressure wave formed from pulses of alternating high and low air pressure. In an engine, pulses are created when an exhaust valve opens and a burst of high pressure gas suddenly enters the exhaust system. The molecules in this gas collide with the lower-pressure molecules in the pipe, causing them to stack up on each other.

They in turn stack up on the molecules a little further down the pipe, leaving an area of low pressure behind. In this way, the sound wave makes its way down the pipe much faster than the actual gases do. Two main characteristics of the wave determine how we perceive the sound wave frequency – A higher wave frequency simply means that the air pressure fluctuates faster. The faster an engine runs, the higher the pitch we hear. Slower fluctuations sound like a lower pitch .air pressure level-The wave's amplitude determines how loud the sound is. Sound waves with greater amplitudes move our ear drums more, and we register this sensation as a higher volume. It turns out that it is possible to add two or more sound waves together and get less sound. How can you cancel out sound? The key thing about the sound waves is that the result at your ear is the sum of all the sound waves hitting your ear at that time. If you are listening to a band, even though you may hear several distinct sources of sound, the pressure waves hitting your ear drum all add together, so your ear drum only feels one pressure at any given moment. It is possible to produce a sound wave that is exactly the opposite of another wave. This is the basic for those noise-cancelling headphones you may have seen.

5.2 Application:

5.2.1 For IC engine:

- Stationary engine.
- Laboratory engine.

5.2.2 For power stations:

- Used in generators.
- Used in diesel engine power plant.

5.2.3 For automobile:

- Cars
- Buses
- Trucks

5.2.4 Other applications:

- Used in hoists.
- Used in cranes.

5.3 Advantages:

- By using an active muffler the exhaust noise can be easily tuned, amplified, or nearly eliminated and the backpressure can be essentially eliminated, thus increasing engine performance and efficiency.
- By increasing engine efficiency and performance, less fuel will be used and the emissions will be reduced.
- The exhaust flow can be reduced.
- The exhaust noise can be reduced.
- The muffler should stack the combustion product.
- The muffler should reduce the backpressure also.

Muffler can also help to reduce wear on engine components

VI. Result

Thus, by running the muffler system continuously for about three hours of 800 rpm diesel engine we finally got the result as the following table,

Parameter	Regulation Limit	Actual
CO (% by vol.)	3.5	2.81
CO_2%	4500	3620

Table 1

The above table shows that the designed and fabricated muffler for diesel engine gives an expected result which can be used in every domestic vehicle.

VII. Conclusion

Thus, by using this kind of muffler we can eliminate the enormous amount of toxic exhaust that are all released from an engine which leads the way towards the eco-friendly vehicle production. It reduces the usage of fuel about 0.5%, also reduces the back pressure of the exhaust flow, and thus increases the range of continuous exhaust flow than a normal conventional engine. It also reduces the wear on engine component which, shows the life of a component will be increased to a certain level. With these factors concern, this project will be a successful one.

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