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Design and Analysis of Muffler for 800 cc Car

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Abstract: *Noise pollution is one of the worst outcome of industrial revolution. Automobiles are one of the prime factors for the production of noise. The mufflers are used for attenuation of sound. This paper explores the different designs prepared for 800 cc car and their analysis.*

Introduction:

Noise is one of the undesirable products of technological civilization. Where ever one goes, noise is present. The roar of traffic, the passage of trains and airplanes, the bustle of crowds and the working of industry and the public utilities deafens our ears. Even home is invaded by noise. The noise from whatever source it comes from is undoubtedly, physiologically as well as psychologically harmful. Invading environment in dangerous proportions, it is an invisible but insidious form of pollutant. Noise, as a potentially harmful pollutant, is being recognized as a great nuisance these days affecting the quality of life, particularly, in urban areas.

Cars in 800 cc engine segments are very widely used throughout India. The project was focused on developing the muffler for this segment. For preparing this, Maruti 800 car was taken as bench mark to design a muffler. The relationship between the back pressure and noise is inverse. However, there is a scope for exploring the idea of reducing both which will be good for the life of the engine as well as help in reducing the noise pollution.

The four designs were prepared after benchmarking the car muffler. Then the CFD and Acoustic analysis was carried out for all the designs. After comparing the results, the selection of final design was made for manufacturing.

Alternative Designs for Muffler

This section gives idea about various designs prepared for existing muffler.

Existing Design

The design of existing muffler is as shown in fig 6.6. The details of the muffler are as shown in table 1. There are three chambers, the length of which does not match with the resonance length which is one of the required criteria.

The description of existing model is as follows:

- As mentioned above, there are three chambers:
  - Inlet Chamber: 95 mm
  - Middle Chamber: 40 mm
  - Outlet Chamber: 169 mm
- The inlet pipe, 39 mm outside diameter and 37 mm inside diameter, travels all the way through inlet chamber and middle chamber and terminates on the wall of middle chamber.
- The outlet pipe, 32 mm outside diameter and 30 mm inside diameter, travels all the way through outlet chamber, middle chamber and terminates inside inlet chamber.

- The inlet pipe has 16 holes of 7 mm diameter in the portion lying inside middle chamber. The hot gases come out of this portion
- There is small opening pipe of 29 mm inside diameter, 16 mm length which connects middle chamber with outlet chamber. The gases pass from middle chamber through this pipe and reach outlet chamber.

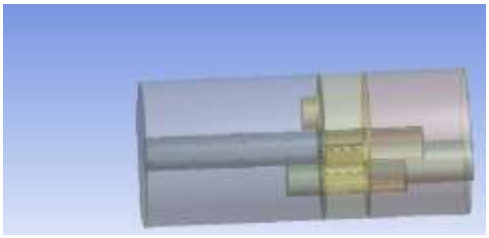

Fig 1: Existing Design

Proposed Design 1

The proposed new design 1 is shown in fig 2 as can be seen from figure, there have been some changes made in this design. Following are the changes incorporated:

- The inlet pipe has 40 holes instead of 16 holes in the middle chamber portion.
- The small pipe connecting middle chamber and outlet chamber is removed. Instead of pipe, 26 holes of 7 mm diameter are introduced so as to facilitate easy passage of gases from middle chamber to outlet chamber.

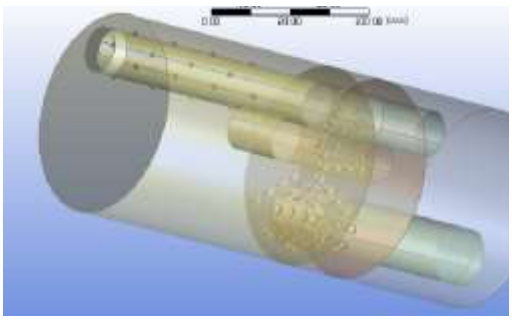

Fig 2: Proposed Design 1

Proposed Design 2:

The proposed new design 2 is shown in fig 3. This design is quite different as compared to the existing design. The differences are as explained below:

- The inlet pipe terminates in inlet chamber.
- There are 80 holes of 7 mm each on the inlet pipe.
- There is not pipe connecting inlet chamber and outlet chamber. Instead 9 holes of 17 mm diameter are provided in the wall separating middle chamber and inlet chamber. Similarly there are 9 holes of 17 mm diameter in the wall separating middle chamber and outlet chamber.
- The outlet pipe does not run through all the chambers. Instead it terminates at middle of outlet chamber itself. Also 56 holes of 7 mm diameter are introduced in the outlet pipe.
- The inlet and out pipes are lying on the same axis.

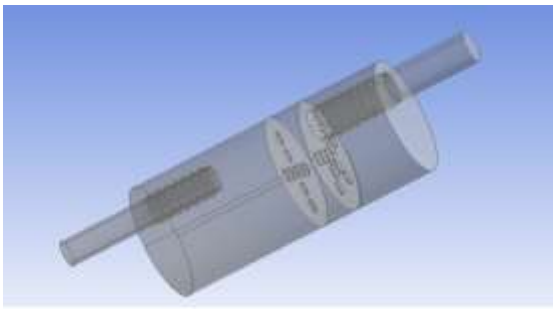

Fig 3: Proposed Design 2

Proposed Design 3:

The proposed design 3 is slight modification of proposed design 2. There is just one difference that both the inlet and outlet pipe are lying on the center of their entrance walls respectively. This is shown in fig 4.

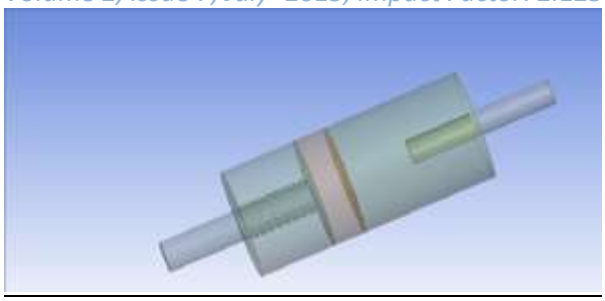

Fig 4: Proposed Design 3

Proposed Design 4:

The proposed design 4 is another modification of proposed design 2. In this design the number of holes introduced in the chamber separating middle chamber and outlet chamber is 17 instead of 9.

Fig 5: Proposed Design 4

CFX Analysis of Alternative Designs

After modelling all the designs, CFX analysis was carried out for the all the designs including the existing one. Fig 6- Fig 9 show the CFX analysis results for all the designs. The analysis of design 3 wasn't carried out because the modifications that need to be done to install this design in the existing car are more and hence have to be justifiable. This can be justified only if it has lowest transmission loss. This would be clear only after carrying out acoustic analysis. CFX analysis was carried out for all the rest of designs. The back pressure was lowest amongst design 2 and design 4. The acoustic analysis will give further clear understanding.

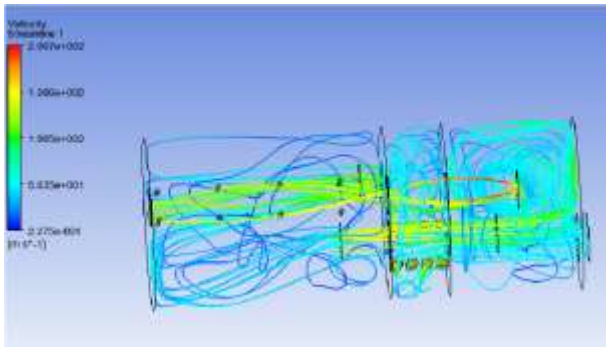

Fig 6: CFX analysis of existing muffler

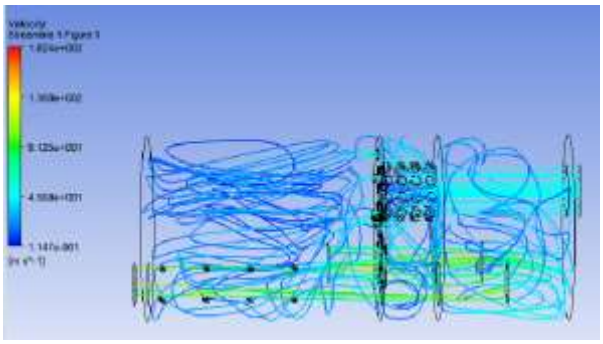

Fig 7: CFX Analysis of Proposed Design 1

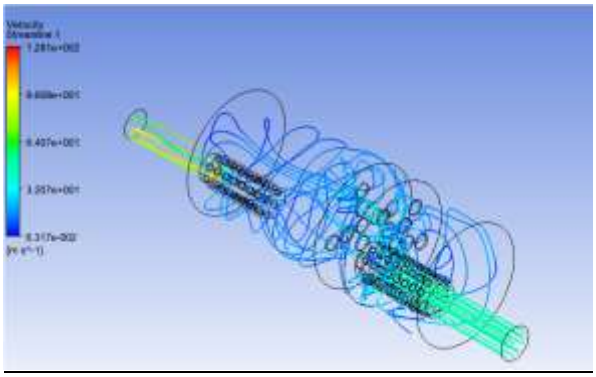

Fig 8: CFX Analysis of Proposed Design 2

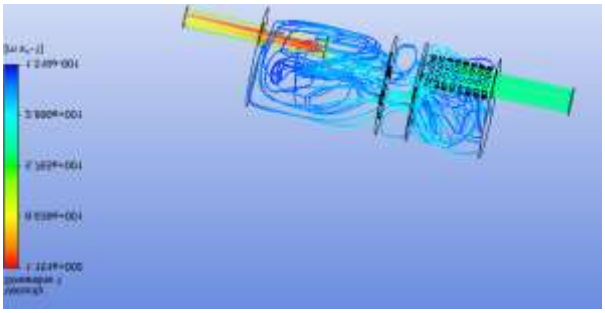

Fig 9: CFX Analysis of Proposed Design 4

Acoustic Analysis of Alternative Designs:

The acoustic analysis was carried out using commands for all the designs. Fig 10 to fig 14 show the transmission loss graphs for all the designs. It is evident from the graphs that design 2 is best alternatives amongst all the designs.

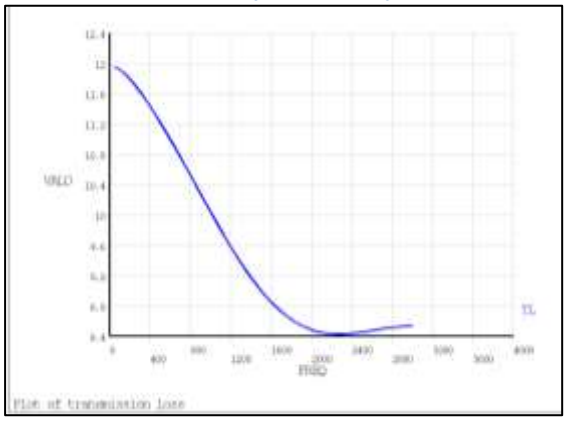

Fig 10: Acoustic Analysis for Existing Muffler

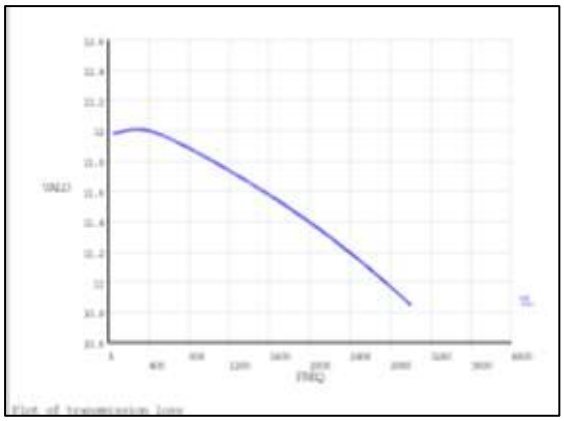

Fig 11: Acoustic Analysis of Proposed Design 1

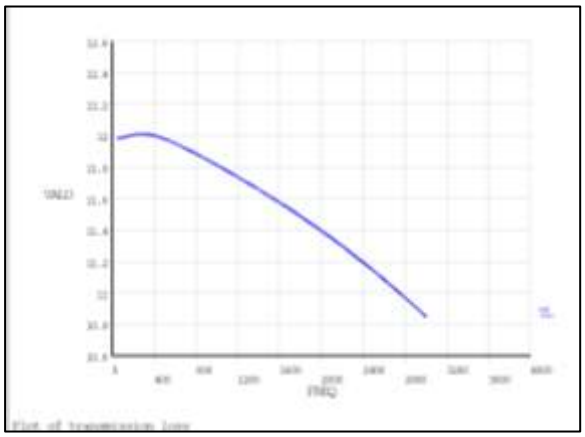

Fig 12: Acoustic Analysis of Proposed Design 2

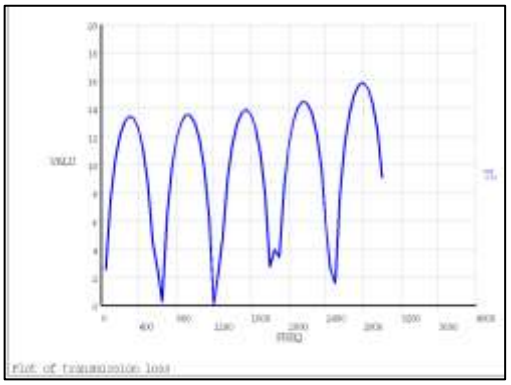

Fig 13: Acoustic Analysis of Proposed Design 3

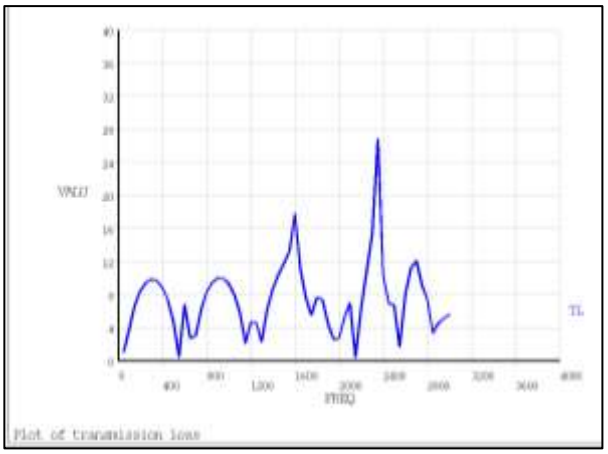

Fig 14: Acoustic Analysis of Proposed Design 4

Selection of final Design:

As is evident from the both the analysis, the design 2 is having best results amongst all. The table 1 shows the comparison of analytical results for all the proposed designs. Based on this the proposed design 2 was selected for manufacturing.

Table 1: Analytical Results for Muffler Designs

Muffler	Back Pressure (kPa)	Transmission Loss (dB)
Original	67.7	11.9
Design 1	24	12.1
Design 2	9.045	less than 8 except at frequency > 2500
Design 3	-	15.8
Design 4	8.9	> 8

Conclusion:

The modelling and analysis of different designs were carried out. This was done in order to select the best alternative available for manufacturing. Accordingly, the best design was selected which was proposed design 2. This design was manufactured and tested experimentally to compare the results with existing one. This was found to be superior design in actual working as well.

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