Acoustical Transmission Loss Performance By Using Various Absorptive Material

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Abstract: The acoustical performance of duct with the variation of number of baffle plate, with and without of absorptive material, with and without effect of perforation, with the percentage variation of flow area. Transmission loss which is the main acoustic performance parameter is evaluated and determines the reduction in exhaust noise. This is performed in the 3D duct with empty, rock wool, glass wool. Different component are present in the duct for transmission loss like baffle plate, perforated baffle plate, absorptive material etc. by which noise is reduced. Transmission loss using sound absorption material is the main feature. With all combination the rock wool is best in all frequency range but in some frequency range empty duct is best so if we are working in this frequency range the empty duct has maximum transmission loss. Transmission loss of empty duct with all combination has not much change in the performance. But in the certain range of frequency transmission loss increasing very rapidly but also slope of curve very steep so if we are working before that then empty duct with 15% single baffle plate has transmission loss 50 dB. Finally rock wool has maximum transmission loss i.e 65dB in 5% perforation with single baffle plate if we go with same perforation rate i.e 5% with double baffle plate the best combination is 5% perforation and single baffle plate. If we are working at constant frequency i.e 2700 Hz the performance of empty duct is good well but not good for variable frequency.

Index Terms: Transmission loss, Absorptive material, Baffle plate

1. INTRODUCTION
Over the last decade and half the amount of vehicles are increasing and due to this the amount of noise emitted by the exhaust system of vehicles and emission requirement are also getting more and more. Muffler plays an important role in reducing the and intake system noise. So there has been a great deal of research and development in the design and performance of muffler. From designer’s standpoint transmission loss or insertion loss is the main characteristic performance parameter of a muffler. The absorptive muffler consists of a perforated baffle plate covered by noise absorptive glass wool and rock wool[1]. The baffle is perforated so that some part of the pressure wave goes through the perforation through the noise absorbing glass wool. The glass wool is a noise damping material which is fibrous in nature and is protected from the surrounding by an auxiliary cover made of a steel metal sheet. The glass wool can with stand heat more than 950°C thus it is suitable for exhaust application with high temperature. The absorption muffler as the suggested absorbs the noise through its fibrous glass wool where the noises dissipate as heat due to the friction. The heat then transfer to the outer shell and loses its intensity thus reducing the noises of the exhaust[2]. The absorption muffler generally consists of straight through pipes so the exhaust gases will have minimal restriction inside the pipe creating very less back pressure compared to reflection muffler. But the straight through absorption muffler are effective muffler[3,14].

2. LITERATURE REVIEW
In 2015 Amit Kumar Gupta, Ashesh Tiwari presents their paper. The main aim of this paper is to use of FEA as well Experimental Method for Muffler’s Transmission Loss Measurement. FEA is generally used for virtual prototyping. So it saves the substantial amount of time and resources. The acoustic characteristics of single expansion chamber muffler with single central inlet, single central outlet is also investigated in detail by experimental method as well FEA results. Set up of Two Load method is used here for Transmission Loss Measurement. By comparing the Experimental results with FEA results shows the validation of results [4]. In 2015 Amit Kumar Gupta, Ashesh Tiwari told that, Acoustic Muffler’s characteristics are calculated by Transmission Loss and Insertion Loss. Single expansion chamber is generally used as noise reduction elements in exhaust systems. To quantify its effectiveness, transmission loss is commonly used as a parameter comparing the transmitted with incident sound pressure level. Mufflers are typically arranged along the exhaust pipe as the part of the exhaust system of an internal combustion engine to reduce its noise [5,11]. In 2016 Amit Kumar Gupta says that, the measurement of the acoustical transmission loss of extended inlet and extended outlet tube on single expansion chamber for noise reduction with same gas volume. A muffler (silencer) is an important noise control device for reduction of machinery exhaust noises other noise source which involves the flow of gases. Mufflers are typically arranged along the exhaust pipe as the part of the exhaust system of an internal combustion engine to reduce its noise [6,13]. In 2016 Amit Kumar Gupta presents his paper. The main aim of this paper is to use of TMM, FEA (Wave 1-D & Comsol) as well experimental method (two load method) for muffler’s TL measurement for central inlet and side outlet position. Afterword to achieve by proven results analysis is done for convergent and divergent cylindrical duct. Also FEA based tool Comsol Multiphysicsand Wave 1-D is used to validate and comparing the results. FEA tool is used for virtual prototyping which hasalready validated with various case studies [7,9]. In 2015 Amit Kumar Gupta, Ashesh Tiwari told that Muffler acts as noise reduction element on exhaust system. Noise from an automotive application is the major source of noise pollution. Here the transmission loss of central inlet and central outlet muffler of single expansion chamber has been compared and validated in three methods namely transfer matrix method, finite element analysis and an experimental method for this purpose an experimental setup has been built up which is based on two load method. Several researchers have worked in the area of noise attenuation on central inlet by changing the position of outlet as side outlet but no one emphasizes on offset of the central inlet and central outlet position. Thereafter the finite element analysis tool Ricardo wave 1-D and comsol multiphysics is used to evaluate transmission
loss for various offset position of inlet and outlet duct of the muffler. The very purpose to improve the acoustic performance of central inlet with offset outlet pipe by measuring transmission loss of offset inlet with offset outlet with various positions by keeping same space [8,11].

3. RESEARCH METHODOLOGY
The methodology used in this work to do the validation, modelling and analysis of all the mufflers is- Model of the various expansion chamber mufflers is prepared in PRO-E software CREO Parametric 2.0. Model is imported in the FEA software into iges format to calculate and predict the transmission loss and acoustic pressure of the various expansion chamber mufflers. FEA software is used to calculate the transmission loss, acoustic pressure and sound pressure level of the various expansion chamber mufflers. Origin Pro-8 software is used to plot the graph to show comparison of the analysed transmission loss and acoustic pressure of the various expansion chamber mufflers. Further to the evaluation of problem, followed by designing of various expansion chamber with various new other dimensions, validation of result of existing system by evaluating the transmission loss, objectives to solve the problem, detailed methodology with well defined set of action is laid down to achieve the goal of calculating, analysing and comparison of transmission loss, acoustic pressure and sound pressure level of the various expansion chamber mufflers.

4. Effect of Perforation
Select the volume of the expansion chamber mufflers, as in this projects volume of the expansion chamber is kept constant i.e., 663661.448 mm³ for all the modelling and processing work. For validation the dimension of the expansion chamber mufflers are taken from the various research papers and kept same for validation of transmission loss measurement with existing system with FEA. Dimension of the expansion chamber mufflers are calculated mathematically by keeping volume constant. Model are prepared in the PTC software wave build 3D with the help of dimension and co-ordinates.

4.1 Transmission Loss With Single Baffle Plate –

Graph detailed analysis-
I. It is observed transmission loss in single baffle plate with perforating size of 2mm with variation of flow percentage area 5%.
II. In case of 5% perforation in empty duct maximum transmission loss occur in the range of frequency (2500-2800Hz) even more than that of glass wool and rock wool.
III. Result with 5% perforation is that rock wool has maximum transmission loss in all range of frequency.

4.2 Transmission Loss With Double Baffle Plate-

Graph detailed analysis-
1. It is observed transmission loss in double baffle plate with perforating size of 2mm with variation of flow percentage area 5%.
2. In case of 5% perforation there is no mean to use glass wool because transmission loss of both empty duct and with glass wool are same.
3. Result with 5% perforation is that rock wool has maximum transmission loss in all range of frequency.
III. With increase perforation from 5 to 10% transmission loss increases in case of glass wool so increase perforation is better for glass wool.

Figure 4.4 Comparison Graph of Transmission loss

4.3 Transmission Loss With Three Baffle Plate -

Graph detailed analysis -
1. It is observed transmission loss in double baffle plate with perforating size of 2mm with variation of flow percentage area 5%.
2. In case of 10% perforation with single baffle plate there is no change occur in case of rock wool.
3. Increase number of baffle plate is good for glass wool and empty duct.
4. In the range of frequency 2000-2500Hz there is transmission loss 30db in double baffle but for three baffle it is 40dB.

Figure 4.5 Comparison Graph of Transmission loss with 5% perforation

4.4 Transmission Loss With Single Baffle Plate -

Graph detailed analysis -
1. It is observed transmission loss in single baffle plate with perforating size of 2mm with variation of flow percentage area 10%.
2. In case of 10% perforation with single baffle plate there is no change occur in case of rock wool and empty duct.
4.11 Transmission Loss With Three Baffle Plate-

Graph detailed analysis-
1. It is observed transmission loss in three baffle plate with perforating size of 2mm with variation of flow percentage area 10%.
2. Transmission loss in case of three baffle plate for glass wool has increased up to 50dB from 30dB in case of 10% double baffle plate.
3. So for same perforation increase number of baffle plate is good for glass wool only.
4. There is no effect of increase number of baffle with same percentage area flow but it is good for

![Figure 4.8 Comparison Graph of Transmission loss with three baffle plate](image)

4.13 Transmission Loss With Single Baffle Plate-

Graph detailed analysis-
1. It is observed transmission loss in double baffle plate with perforating size of 2mm with variation of flow percentage area 15%.
2. Compare to double baffle plate with 10% perforation rate transmission loss of empty duct has more transmission loss in the range of 2500-2700 HZ.
3. At particular point of frequency the transmission loss of empty duct has more than that of rock wool. But rock wool transmission loss increases over ahead of empty duct.

![Figure 4.9 Comparison Graph of Transmission loss in single baffle plate](image)

4.15 Transmission Loss With Double Baffle Plate-

Graph detailed analysis-
1. I observed transmission loss in double baffle plate with perforating size of 2mm with variation of flow percentage 15%.
2. In case of double baffle plate with 15% perforation the performance of glass wool is not good compare to empty duct at some point of frequency empty duct has more transmission loss.
3. Rockwool has more transmission loss in all.

![Figure 4.10 Comparison Graph of Transmission loss with double baffle plate](image)

4.17 Transmission Loss With Three Baffle Plate-

Graph detailed analysis-
1. It is observed transmission loss in three baffle plate with perforating size of 2mm with variation of flow percentage area 15%.
2. Increase perforation rate has no effect on the performance of rock wool but on glass wool has large change in transmission loss, in 15% double
baffle plate it is near 20dB, after adding one more baffle it value near 55dB.

**Figure 4.11 Comparison Graph of Transmission loss with three baffle**

### 4.19 RESULTS

<table>
<thead>
<tr>
<th>PERFORATION RATE</th>
<th>SINGLE BAFFLE PLATE (Avg. TL in dB)</th>
<th>DOUBLE BAFFLE PLATE (Avg. TL in dB)</th>
<th>THREE BAFFLE PLATE (Avg.TL in dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With 5%</td>
<td>23.99</td>
<td>26.02</td>
<td>35.02</td>
</tr>
<tr>
<td>With 10%</td>
<td>27.05</td>
<td>31.26</td>
<td>40.08</td>
</tr>
<tr>
<td>With 15%</td>
<td>30.28</td>
<td>39.56</td>
<td>45.83</td>
</tr>
</tbody>
</table>

### CONCLUSIONS

An experimental method and wave 1-D simulation for transmission loss (TL) measurement in central outlet muffler with packing density of glass wool and rock wool with packing density 60kg/m² shows the validation result. With the comparison of rock wool and glass wool as absorptive material shows the maximum transmission loss can be achieved with rock wool with respect to all packing density. Attenuation curve under four design observation i.e. empty expansion chamber, expansion chamber with single baffle plate, Expansion chamber with double baffle plate, Expansion chamber with triple plate. The average transmission loss performance in single plate (empty, rock wool, glass wool) is 17dB, 29dB, 21dB. In double baffle plate the average transmission loss is 23.99dB, 32.02dB, 26.62dB. In triple baffle plate the average transmission loss is 27.23dB, 35.32dB, 29.23dB. So design of expansion chamber with three baffle plate is more suitable to achieve high transmission loss. The proposed work has done with glass wool and rock wool to evaluate the transmission loss performance of the muffler. First it is observed that the increasing perforation rate increasing transmission loss only up to certain range of frequency. Performance of rock wool is well in all the combination but has no effect of increasing number of baffle plate with perforation rate 5%, 10%, 15%. So in case of rock wool 5% perforation rate with double baffle plate has maximum transmission loss i.e 65dB. Transmission loss of glass wool increases with increases perforation rate and number of baffle plate so in case of glass wool 15% perforation rate and three baffle plate has maximum transmission loss i.e 55dB. Transmission loss of empty duct with all combination has not much change in the performance. But in the certain range of frequency transmission loss increasing very rapidly but also slope of curve very steep so if we are working before that then empty duct with 15% single baffle plate has transmission loss 50dB. Finally rock wool has maximum transmission loss i.e 65db in 5% perforation with single baffle plate if we go with same perforation rate i.e 5% with double baffle plate the best combination is 5% perforation and single baffle plate. If we are working at constant frequency i.e 2700Hz the performance of empty duct is good well but not good for variable frequency.

### REFERENCES


