International Journal of Engineering Research and Modern Education (IJERME)
ISSN (Online): 2455 - 4200
(www.rdmodernresearch.com) Volume I, Issue I, 2016

OBSERVATION FOR TRANSMISSION LOSS BY APPLYING MULTIPLE BAFFLE PLATES ON SINGLE EXPANSION CHAMBER: A SIMULATION APPROACH

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Abstract:

This research paper shows the details of measurement of the Acoustic Transmission Loss of different expansion chamber by using Finite element Analysis (FEA). For this purpose the evaluation of transmission loss of different cross-sections by keeping constant volume of Expansion chamber has been explained explicitly by acoustical simulation tool. Also the design validation has been done with the existing results of same dimensions. To observe the effect of transmission loss of circular cross-section expansion chamber with introduction of baffle plates at various positions by analyzing in FEA Acoustic Module. After the observations the results are compared in order to observe the effect of introduction of baffle plate on muffler.

Key Words: Single Expansion Chamber Muffler, Acoustic Module- Comsol, TMM (Transfer Matrix Method), Transmission Loss & Baffle Plates.

1. Introduction:

Muffler (Silencer) noise is an important research area for automotive industries because of new regulations and standards for noise emission. Silencers are commonly used to reduce noise related with IC engine exhaust, high pressure gas or steam vents, compressors and fans. At present the expansion of automobile industries in India are in increasing trend and also the presence of automobiles in on road has been increasing day-by-day. Now noise pollution has become more major environmental concerns and human concern in present situation. With increasingly strict regulations for controlling noise pollution of automotive vehicles, silencers are important part of engine system and commonly used in exhaust system to minimize noise caused by exhaust gases. [1] [6]

Designing of silencer is a complex function which affects the noise characteristics and fuel efficiency of the vehicle. Basically a muffler of an automobile is characterized by numerous parameters like Insertion Loss (IL), Transmission Loss (TL) and Back Pressure. The best used parameter to evaluate the sound radiation characteristics of muffler is transmission loss (TL). [1][5] The transmission loss gives a value in decibel (dB) that corresponds to the ability of the muffler to dampen the noise. This is one of the most frequently used criteria of muffler performance because it can be predicted very easily from the known physical parameters of the muffler. Many tools are available to simulate the transmission loss characteristics of a muffler. [4]

The transfer matrix method is based on plane wave (1-D) acoustic behavior (at component junctions). Three performance criteria has been considered. These criteria are noise reduction (NR), insertion loss (IL), and transmission loss (TL). TL is the most commonly used parameter to evaluate the performance of simple expansion chamber muffler. Transmission loss is independent of the source and presumes (or requires) an anechoic termination at the downstream end. It is defined as the difference between the power level incident on the muffler proper and that transmitted downstream into an anechoic termination. [2][7]

A baffle plate or mechanical device designed to restrain or regulate the flow of a fluid, the emission of light or sound, or the distribution of sound. Baffles can also be defined as flow-directing or obstructing vanes or panels used in some industrial process vessels (tanks), such as shell and tube heat exchangers, chemical reactors, and static mixers. A baffle is designed to support the muffler and to increase the transmission loss in order to decrease the noise and sound of exhaust system shown in figure 1. [3]

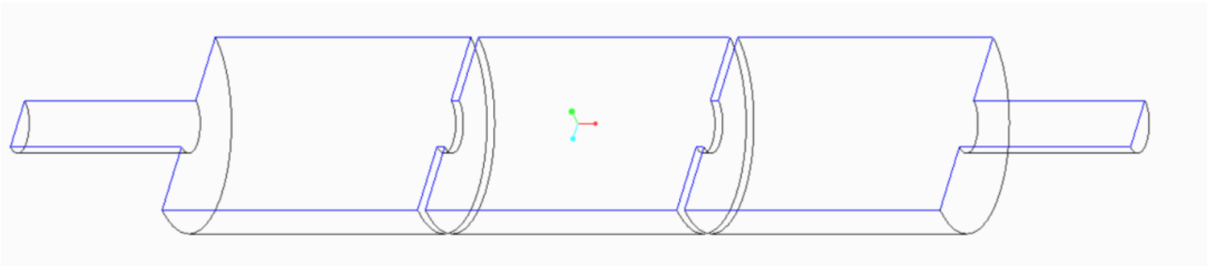


Figure 1: Half Sectional View of Single Expansion chamber with Two Baffle Plates

2. Objectives and Modelling:

For evaluation of transmission loss of muffler the volume of Expansion chamber is keeping constant then applied the baffle plates. To validate the transmission loss measurement with existing system with the FEA result. To observe the effect of transmission loss of circular expansion chamber with and without the introduction of baffle plates shown in figure 2.

For the designing of the Expansion chamber following boundary conditions are adopted:-

1. Volume of the Expansion chamber is kept constant i.e., 6636500 mm^3 for all the modeling and designing work.
2. Modeling of various types of circular expansion chamber by keeping the length of expansion chamber as constant i.e., 500 mm.
3. Modeling of various types of circular expansion chamber by keeping the diameter of expansion chamber as constant i.e., 130 mm.

3. Validation of the Existing TMM Results with Fea Acoustic Module:

Author previously used a circular expansion chamber having dimensions of diameter 130 mm, 500 mm and tail pipe diameter 35mm each of inlet and outlet by TMM approach. The dimension and result is shown in figures 5. [2]

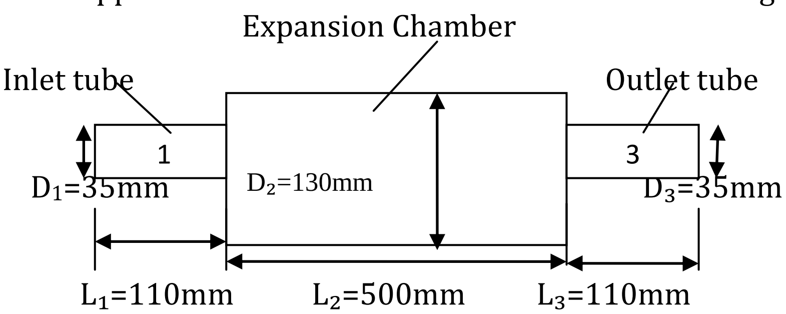


Figure 2: Single Expansion chamber

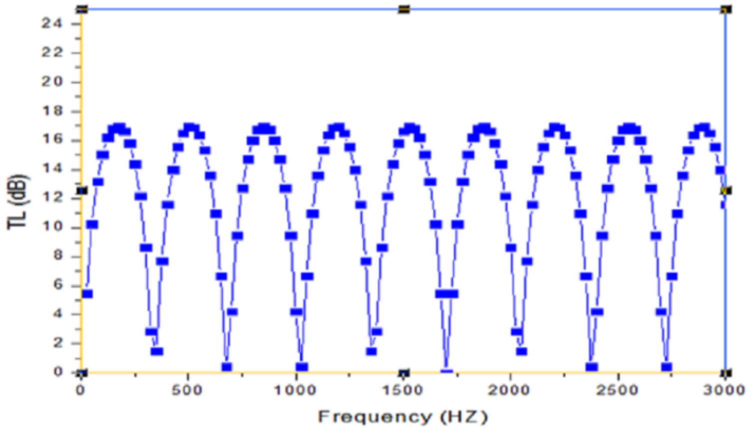


Figure 3: Existing Results of Transmission loss of muffler

Transmission Loss measurement with FEA with same dimensions by using Comsol Tool.

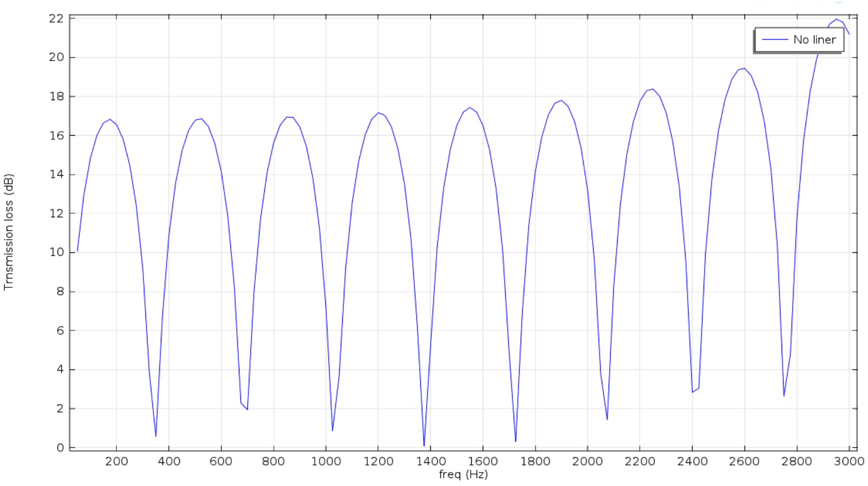


Figure 4: Result comparison for Transmission loss of muffler

The figure 5 shows that Transmission Loss measurement and it compared with FEA with existing same dimensions

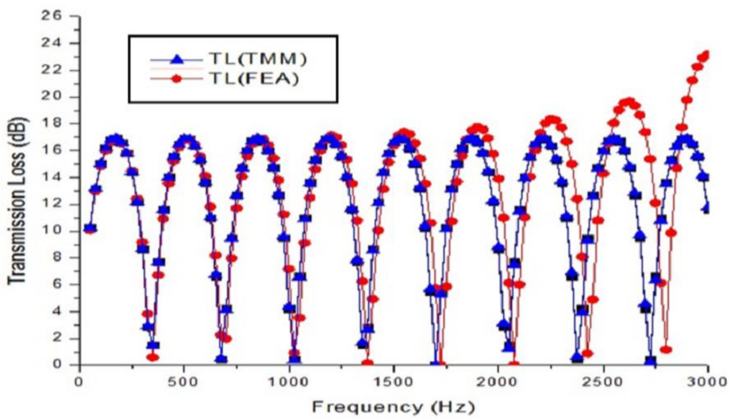


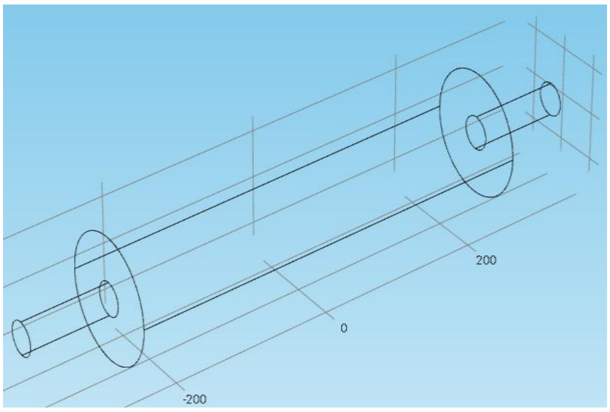
Figure 5: Result comparison for Transmission loss of muffler

Table 1: Modeling of circular expansion chamber for effect of transmission loss with and without introduction of baffle plates:

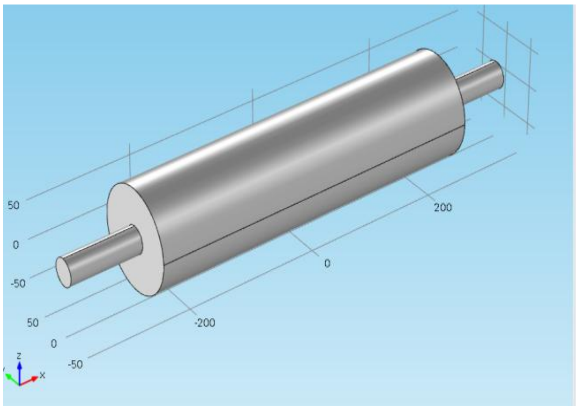
S No.	Circular Expansion chamber length(mm)	Position of Baffle Plate having thickness 5 mm
1	L=500	Without Baffle Plate
2	L=500	Single Baffle at mid position at 250 mm
3	L=500	Two Baffles placed at 166.66mm

4. Effect of Transmission Loss with and Without of Baffle Plates:

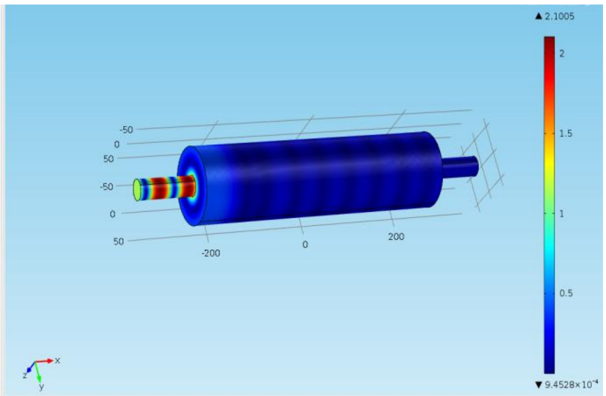
4.1 Without Baffle Plate:



(a)



(b)



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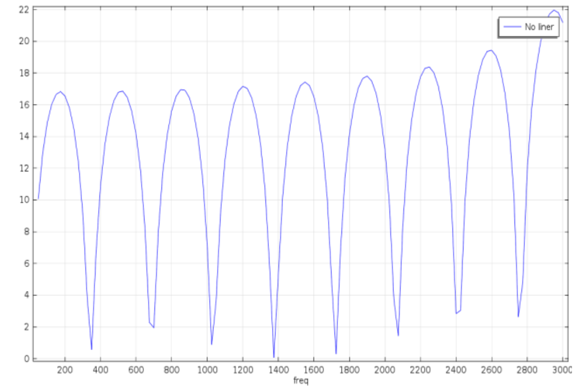
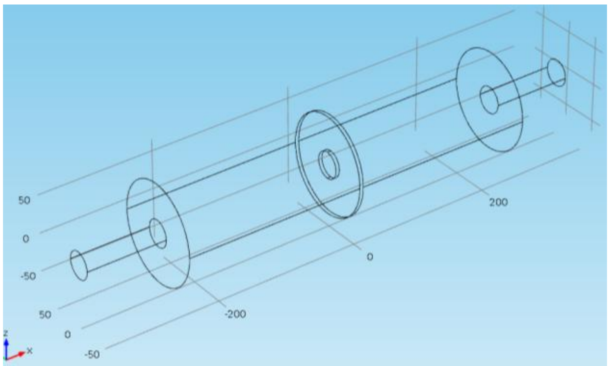


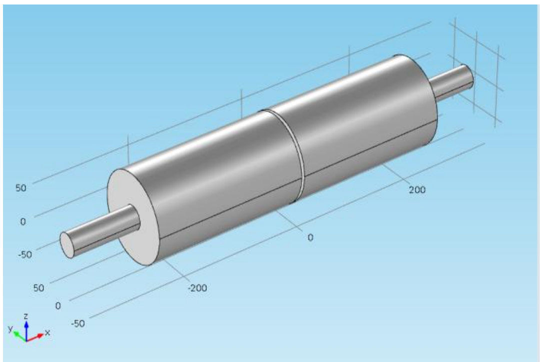
(d)

Figure 6: Modeling and Analysis of circular Expansion chamber without baffle plates (a) Wireframe (b) Modeling (c) Absolute pressure (d) Transmission loss

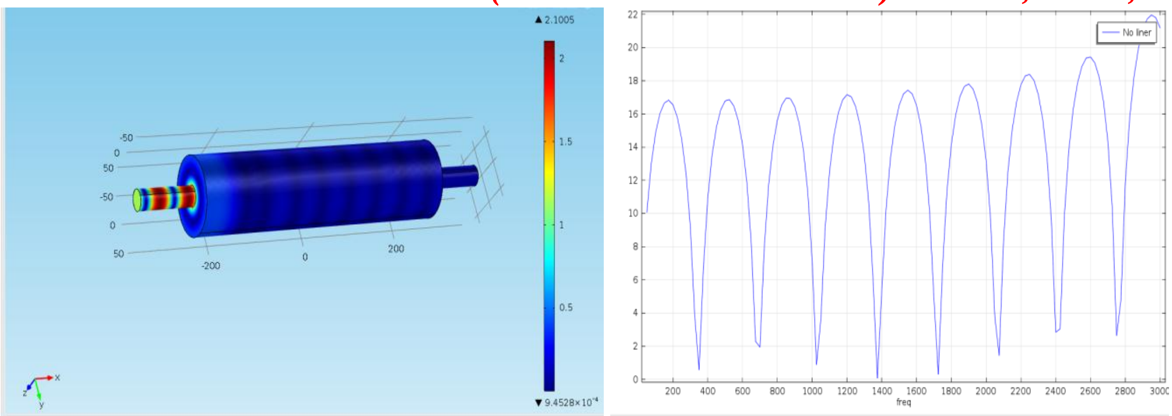
4.2 Single Baffle Plate at 250 mm Equal Distances:



(a)



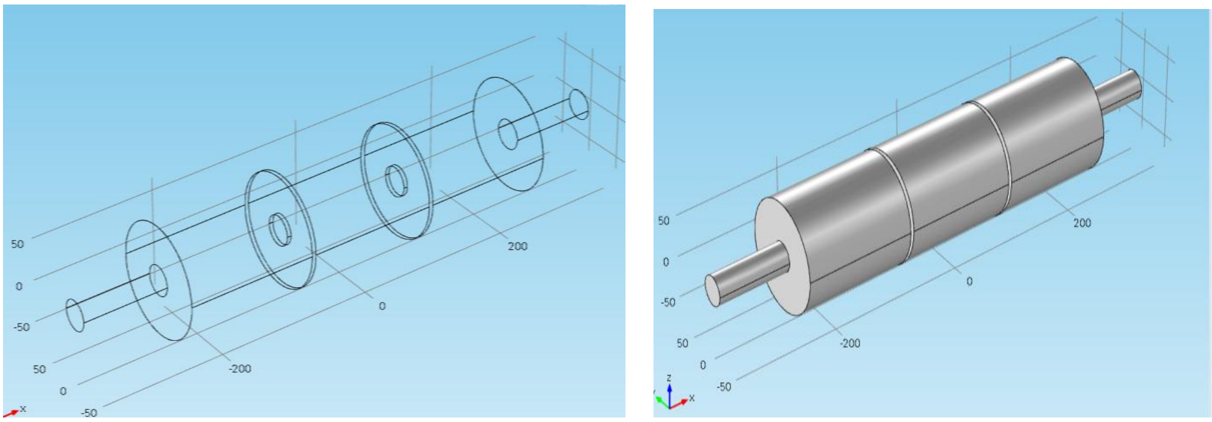
(b)



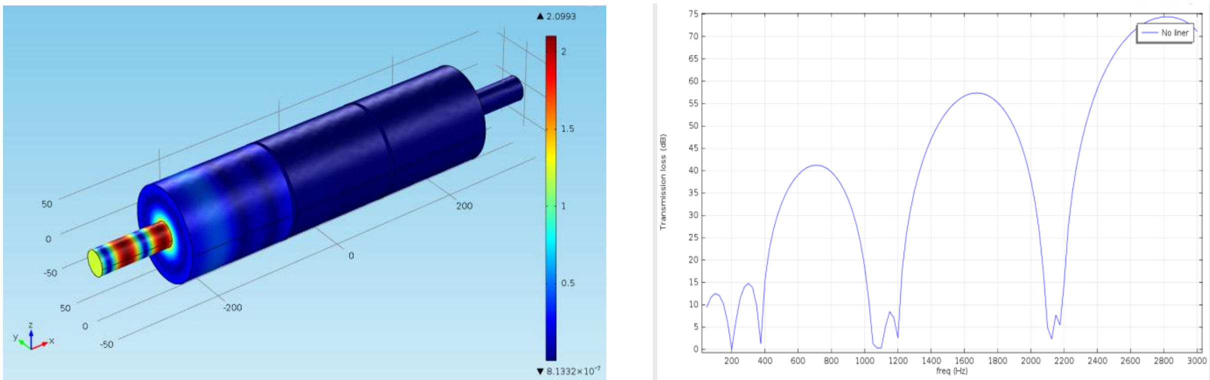
(c) **(d)**

Figure 7: Modeling and Analysis of circular Expansion chamber with Single Baffle Plate (a) Wireframe (b) Modeling (c) Absolute pressure (d) Transmission loss

4.3 Double Baffle Plate at 166.66 mm Equal Distance :



(a) **(b)**



(c) **(d)**

Figure 8: Modeling and Analysis of circular Expansion chamber with Double Baffle Plate (a) Wireframe (b) Modeling (c) Absolute pressure (d) Transmission loss

5. Results and Discussion:

The following results were observed by using with and without baffles plates. The maximum transmission loss achieved in case of double baffle plate shown table 2.

Table 2: Result of circular Expansion chamber for effect of Transmission Loss with and without introduction of baffle plates

S. No.	Circular Expansion chamber length (mm)	Baffle Plate of 5 mm position at length (mm)	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
1	L=500	Without Baffle	13.23	2.00
2	L=500	L =250 (Single Baffle)	36.27	2.09
3	L=500	L =166.66 (Two Baffle)	39.85	2.10

Graph of Transmission Loss with and without introduction of baffle plates is shown in figure 9. Which shows that the higher attenuation is achieved in case of using double baffles?

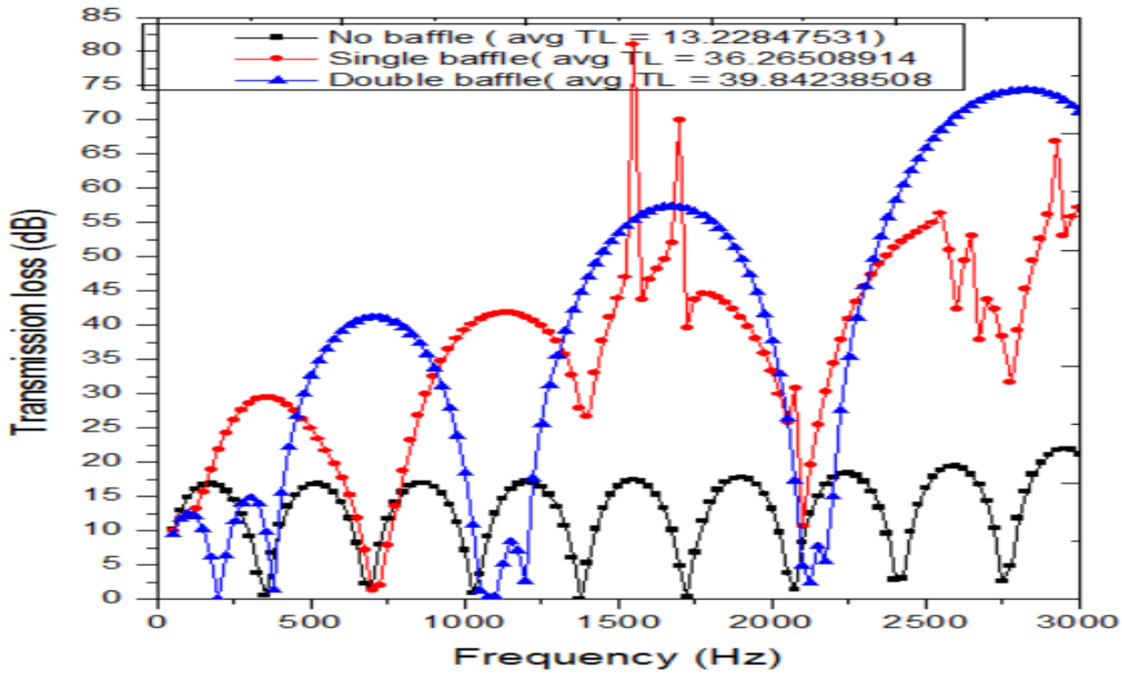


Figure 9: Transmission Loss for various circular Expansion chamber for effect of Baffle Plates

6. Conclusions:

The following conclusions are made with FEA results:

1. The analysis result is matched and validated with existing result.
2. By introduction of Baffle Plates to the muffler FEA results shows that the Transmission Loss for muffler with double baffle plates is showing maximum attenuation level of 39.84 dB as compared with other circular cross-section muffler having same volume.
3. Two baffle plates attenuate the more noise. Single baffle attenuate the sound in Low frequency while two baffles attenuate the sound in mid to high frequency zone. By the introduction of Single baffle plate shows that it can attenuate the noise level in lower to medium frequency zone.

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