ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Issue 4, April 2016

Simulation and Experimental Validation of Sound Transmission Loss of Pure Reactive Muffler with Different Expansion Ratio

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Abstract*:* This paper shows the details of measurement of the acoustical transmission loss of single expansion chamber muffler with various expansion ratios. A muffler is an important noise control element for reduction of machinery exhaust noise, fan noise, and other noise sources involving 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. Firstly simulation tool results (Comsol, wave 1-D) are compared with experimentally then results are observed with various expansion ratio.

Keyword: Reactive Muffler, FEA Acoustic Module- Comsol, wave 1-D, Sound Transmission loss.

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I. INTRODUCTION

Mufflers are mostly used to reduce noise related with internal combustion engine exhausts, high pressure gas or steam vents, compressors and fans. These examples lead to the conclusion that a Muffler allows the passage of fluid while at the same time restricting the free passage of sound.[1] Mufflers might also be used where it is directly access to the interior of a noise containing enclosure is required, but through which no steady flow of gas is necessarily to be maintained. For example, an acoustically treated entry way between a noisy and a quiet area in a building or factory might be considered as a muffling device. [6] [7] Muffler may function in any one or any combination of three ways: they may suppress the generation of noise; they may attenuate noise already generated; and they may carry or redirect noise away from sensitive areas.

Sound waves propagating along a pipe can be attenuated using either a dissipative or a reactive muffler. A dissipative muffler uses sound absorbing material to take energy out of the acoustic motion in the wave, as it propagates through the muffler. Reactive silencers, which are commonly used in automotive applications, reflect the sound waves back towards the source and prevent sound from being transmitted along the pipe. Reactive silencer design is based either on the principle of a helmholtz resonator or an expansion chamber, and requires the use of acoustic transmission line theory [2] [3]. There are several parameters that describe the acoustic performance of a muffler and it is associated piping. These include the noise reduction (NR), the insertion loss (IL), and the transmission loss (TL) [4][5]. The Noise Reduction is the sound pressure level difference across the muffler.

II. OBJECTIVES AND MODELLING

For evaluation of transmission loss of muffler the volume of Expansion chamber is keeping constant then changing the expansion ratio of muffler. Here firstly validate the transmission loss measurement with experimentally and validate with the FEA result by using acoustical simulation tool which proves the compatibility of software.

Following design conditions are applied to analyzing the transmission loss of the simple expansion chamber:

1. Volume of the Expansion chamber is kept constant for all the modeling and designing work.
2. Modeling of circular expansion chamber by keeping the length of expansion chamber as constant i.e., 500 mm.
3. Modeling of circular expansion chamber by keeping the diameter of expansion chamber as constant i.e., 130 mm.
4. Modeling of circular expansion chamber by keeping the diameter of central inlet and central outlet tail pipe as constant i.e., 35 mm.
5. Modeling of circular expansion chamber by keeping the length of Inlet tail pipe and Outlet tail pipe as 100 mm.

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III. VALIDATION EXPERIMENTAL AND FEA ACOUSTIC MODULE RESULTS

Figure 1: Muffler Transmission loss measurement setup with load

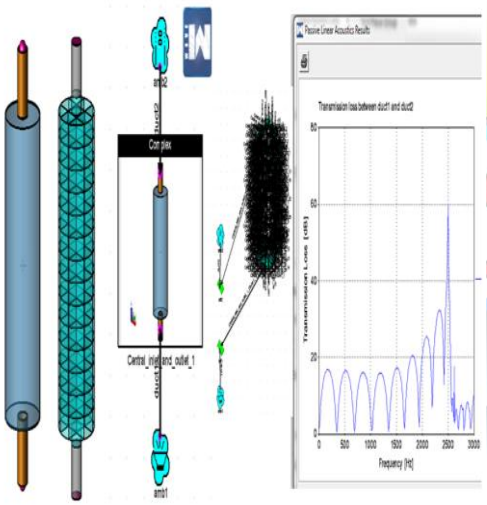
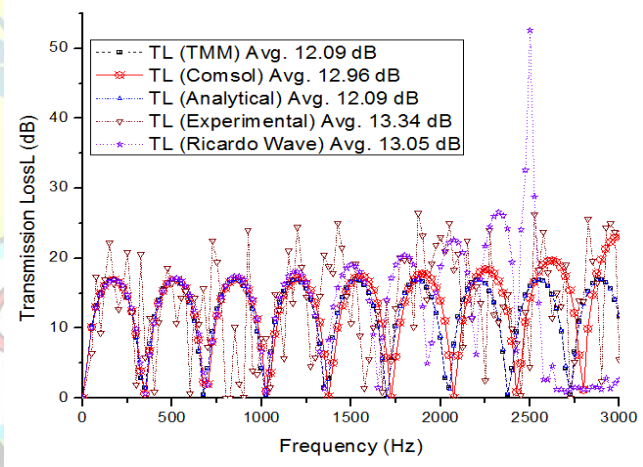


Figure 2: GUI for Post Processing of Wave 1-D.

IV. COMPARISON OF ALL THE RESULTS

Attenuation curves represent among five observations clearly shows that by the comparison with five results transfer matrix method, analytical, experimental (two load method) and FEA tools like Ricardo wave 1-D & cosmol multiphysics the transmission loss are equally are comparable. Small deviation is appeared with FEA tool is due to meshing parameter. Comparison of additional FEA tools like wave 1-D and comsol results shows the good agreement between existing TMM and analytical method. It also describes the experimental two load method which is used for result comparison. Now any shape of muffler can be modeled to predict the TL measurement. In recent scenario so many complicated geometry where the practical analysis proves too expensive and complicated. Therefore the FEA Tool can be the best approach to achieve the expected outcomes regarding the transmission loss of Muffler.

Figure 3: Result comparison of TL for all method



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Modelling and simulation of muffler for expansion diameter (D=200) mm , Tube diameter (d) = 25 mm i.e., Expansion Ratio = 8

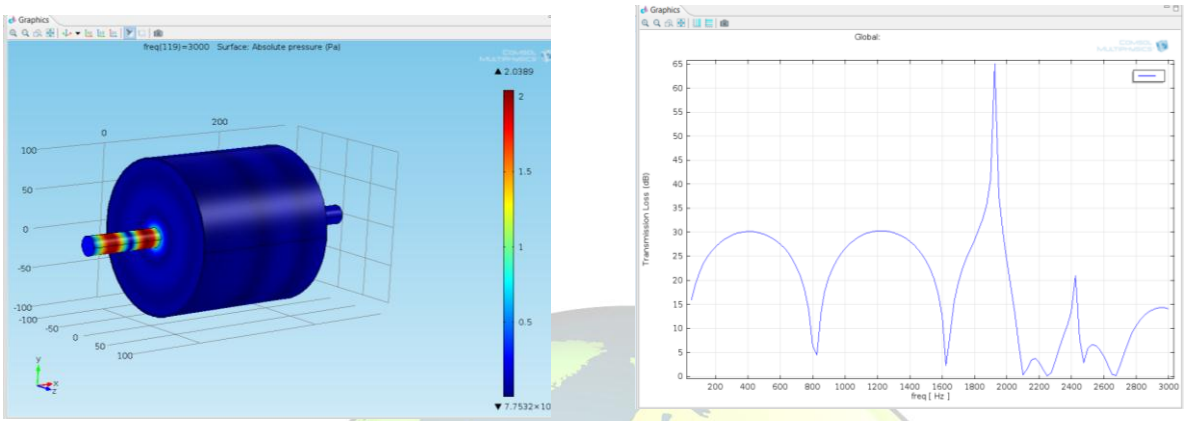

Figure 4: Transmission Loss of Circular Expansion chamber with expansion ratio of 8

Table 1: TL results of circular expansion chamber with different expansion ratio

S No.	Tail pipe Diameter (mm)	Expansion Ratio	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
1	D=25 mm	m=8	19.59	2.03
2	D=30 mm	m=6.67	16.09	2.01
3	D=35 mm	m=5.71	15.02	1.98
4	D=40 mm	m=5	13.38	1.95

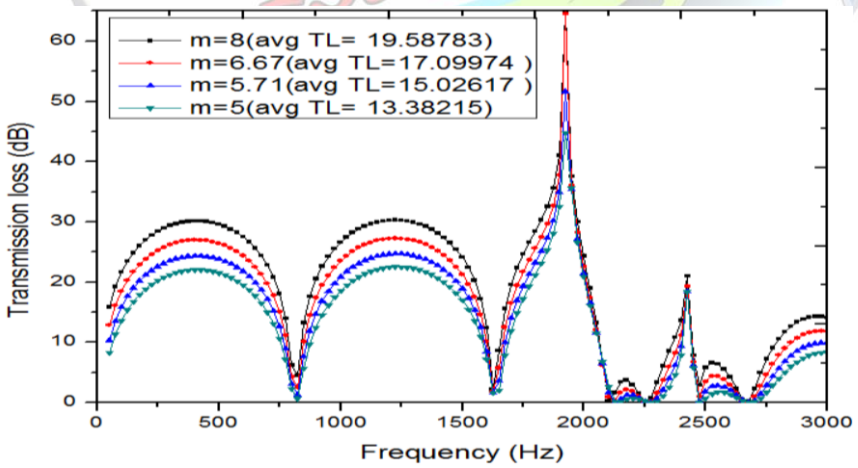

Figure 5: Transmission Loss for various circular Expansion chamber for effect of Expansion Ratio

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V. RESULTS AND DISCUSSION

The effect of transmission loss by changing expansion ratio for circular cross-section chamber the FEA results shows that for D=25 mm, m=8 has maximum Transmission Loss of 19.59 dB and acoustic pressure of 2.03 Pa as compared with other cross section having same volume. Attenuation curve shows clearly that the requirement for high attenuation is that the muffler has a large expansion ratio.

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