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TRANSMISSION LOSS OF CYLINDRICAL MUFFLER WITH DIFFERENT LENGTH TO DIAMETER RATIO BY USING TWO LOAD METHOD AND SIMULATION TOOL

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ABSTRACT
This paper shows the details of measurement of the acoustical transmission loss of single expansion chamber muffler with various lengths to diameter ratios of cylindrical chamber muffler. 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) are compared with experimentally then results are observed with various expansion ratio.

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.

OBJECTIVES AND MODELLING
For evaluation of transmission loss of muffler the volume of Expansion chamber is keeping constant then changing the L/D ratio of muffler [8][9]. Here firstly validate the transmission loss measurement with experimentally and validate with the FEA tool result 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.

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5. Modeling of circular expansion chamber by keeping the length of Inlet tail pipe and Outlet tail pipe as 100 mm.

VALIDATION EXPERIMENTAL AND FEA ACOUSTIC MODULE RESULTS

In our setup sound analyzer consists of two assemblies one for input signal (Green Color) and another for output signal (Red Color) appeared while it will attach with computer system. The differences of FFT of these two signals are analyzed in Matlab based sound spectrum software which is developed by author Dr. Amit Kumar Gupta. This provides Noise (dB) versus frequency plot of different frequency components present in the signal. Our circuit provided the sensitivity, frequency and range selection facility shown in figure 1.

Figure 1: Muffler Transmission loss measurement setup with load

Following boundary condition are applied to muffler [8] [9]:
1. Gas Volume approximately: 6636500 mm^3.
2. Exhaust gas Temperature: 300 K.
3. Exhaust Gas pressure: 1.0 bar.
4. Initial fluid composition: Fresh Air. 5. Upper frequency Limit: 3000 Hz. 6. Lower Frequency Limit: 25 Hz.
Model is prepared on wave build 3D with inlet and outlet boundary condition shown in figure 2.

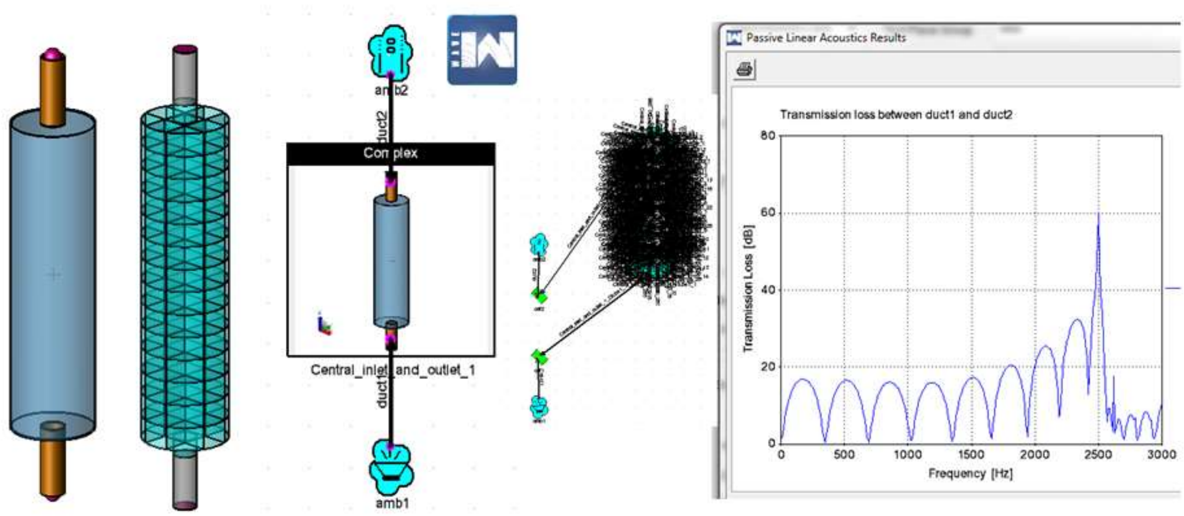

Figure 2: GUI for Post Processing of Wave 1-D.

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COMPARISON OF ALL THE RESULTS

Attenuation curves represent among five observations clearly shows in figure 3 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[10]. 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.

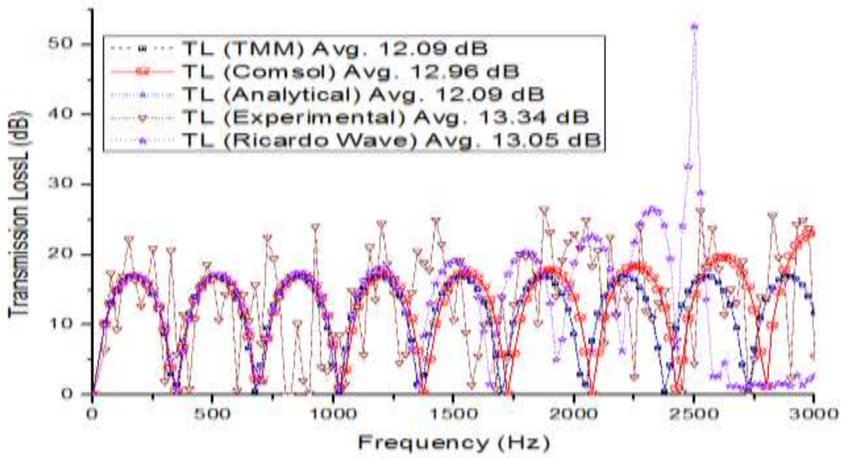


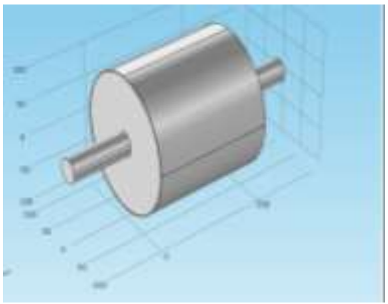
Figure 3: Result comparison of TL for all method

MODELING OF CIRCULAR EXPANSION CHAMBER WITH DIFFERENT L/D RATIO

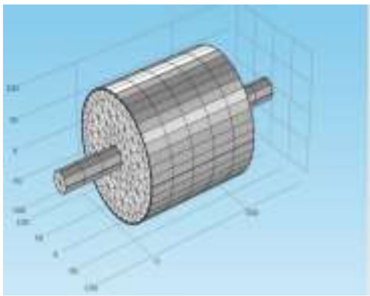
Table 1: TL measurement of circular expansion chamber with different expansion ratio

Case	Circular Expansion Chamber with Diameter (mm)	Circular Expansion Chamber of length (mm)
I	D=200 mm	L = 211 mm
II	D=220 mm	L =174.58 mm
III	D=230 mm	L =159.73 mm
IV	D=240 mm	L =146.69 mm

Case 1: D=200 mm, L = 211 mm



(a)



(b)

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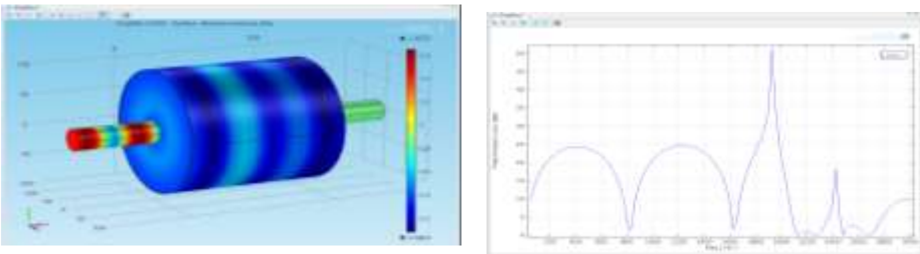
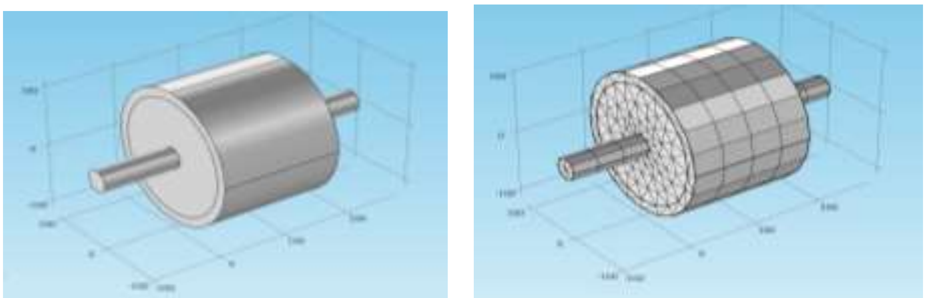


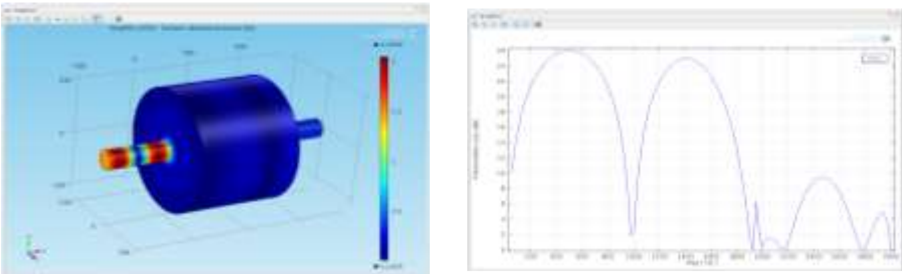
(c) *(d)*

Figure 4: Analysis of Circular Expansion chamber Case I :(a) Modeling (b) Meshing (c) Absolute pressure (d) Transmission loss

Case II: D=220 mm, L =174.58 mm



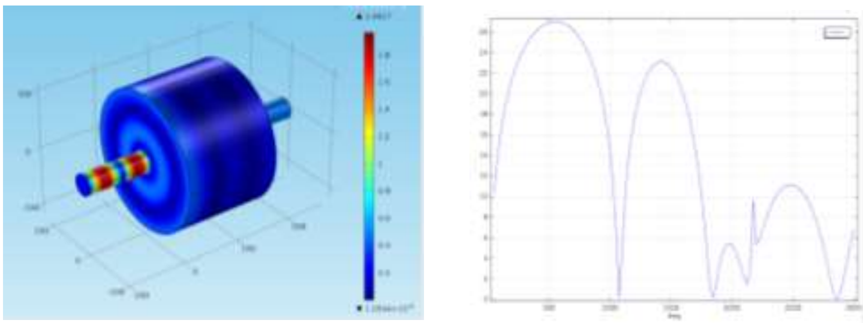
(a) *(b)*



(c) *(d)*

Figure 5: Analysis of Circular Expansion chamber Case II :(a) Modeling (b) Meshing (c) Absolute pressure (d) Transmission loss

Case III: D=230 mm, L =159.73 mm



(a) *(b)*

Figure 6: Analysis of Circular Expansion chamber Case III: (a) Absolute pressure (b) Transmission loss

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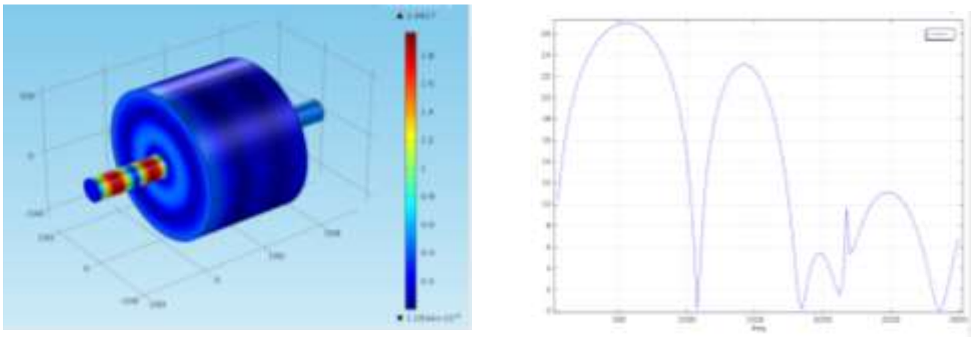
Case IV: D=240 mm, L =146.69 mm



(a) *(b)*

Figure 6: Analysis of Circular Expansion chamber Case IV: (a) Absolute pressure (b) Transmission loss

RESULTS AND DISCUSSION

The effect of transmission loss by changing aspect ratio of circular cross-section chamber the FEA results shows that for Case IV: D=200 mm, L =211 mm has maximum Transmission Loss of 15.02 dB shown in figure 7. Also with low acoustic pressure of 1.65 Pa as compared with other L/D ratio having same volume shown in table 1.

Table 2: TL results of circular expansion chamber with different expansion ratio

Case	Circular Expansion Chamber with Diameter (mm)	Circular Expansion Chamber with length (mm)	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
I	D=200 mm	L = 211 mm	15.02	1.65
II	D=220 mm	L =174.58 mm	14.14	2.04
III	D=230 mm	L =159.73 mm	14.41	1.96
IV	D=240 mm	L =146.69 mm	14.35	1.56

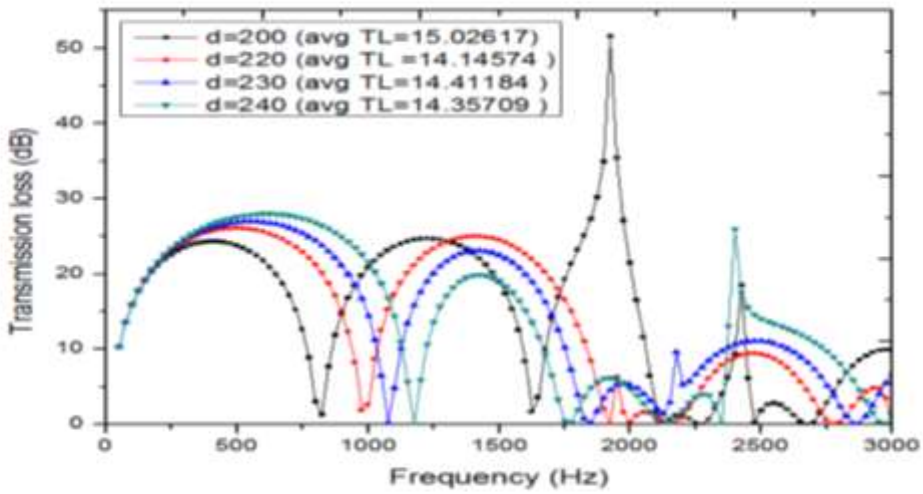


Figure 7: TL Analysis of Circular Expansion chamber

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