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EFFECT OF CHANGING ASPECT RATIO, EXPANSION RATIO AND OVALITY PARAMETER ON EXPANSION CHAMBER FOR THE PERFORMANCE OF SOUND TRANSMISSION LOSS

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Abstract
This paper shows the measurement of the Acoustic Transmission Loss of different expansion chamber which is shown by using Finite element Analysis (FEM). For these purpose the evaluation of transmission loss of different cross-sections by keeping constant volume of expansion chamber is explained. To observe the effect of transmission loss of Expansion chamber with changing the L/D ratio of the circular cross-section, effect of transmission loss of expansion chamber with changing the expansion ratio for the circular cross-section and to observe the effect of transmission loss of Expansion chamber with changing ovality parameter for the elliptical cross-sections by designing in FEA Acoustic Module.

Introduction
Exhaust gases repeatedly released from the internal combustion engine at high pressures cause high pressure levels of sound waves. So, designing of an effective acoustical muffler or silencer to attenuate sound pressure levels is becoming a basic requirement [1].There are a lot of noises producing machines which produce noise such as aircrafts, pumps, electrical generators, automotives etc. Exhaust noise of automotive engines is the main component of noise pollution of the urban environment. A muffler is an important noise control element for reduction of machinery exhaust noise, fan noise and other noise sources involving flow of a gas [2]. Basically, muffler is designed for two reasons: 1) High noise attenuation performance, a basic necessity of a muffler. 2) Minimum back pressure, it represents the extra static pressure acted by the muffler on the engine. Mufflers are of two types: the reactive type and absorptive type. Reactive mufflers work on the principle of impedance mismatch by use of sudden changes in the area of cross-section, perforated elements, resonators etc. The reactive or reflective mufflers use the phenomenon of destructive interference to reduce noise. This means that they are designed so that the sound waves produced by an engine partially cancel themselves out in the muffler. For complete destructive interference to occur a reflected pressure wave of equal amplitude and 180 degrees out of phase needs to collide with the transmitted pressure wave. Reflections occur where there is a change in geometry or an area discontinuity [3].
The most basic type of silencing element that may be used for intake and exhaust mufflers is the Expansion chamber muffler. It consists of an inlet tube, an Expansion chamber and an outlet tube.

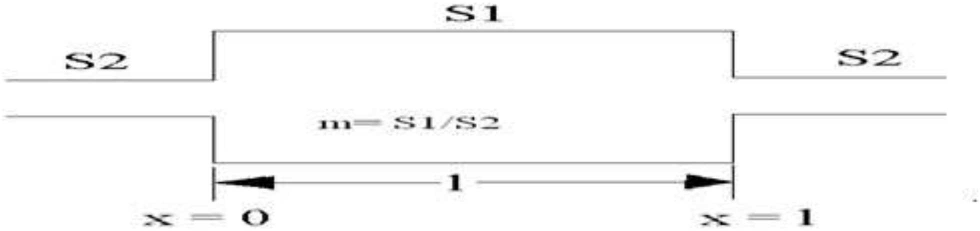


Figure 1: Single Expansion chamber

Where:
S1 = Area of Expansion chamber
S2 = Area of Inlet or Outlet
m = Expansion Ratio (Area Ratio) [2]
L= length of Expansion chamber

Objective & modelling
For evaluation of transmission loss volume of Expansion chamber is keeping constant. Also observe the effect of transmission loss of expansion chamber with changing L/D ratio for the circular cross-sections to observe the effect of transmission loss of

expansion chamber with changing the expansion ratio. Also to observe the effect of transmission loss of expansion chamber with changing the ovality parameter for the elliptical cross-sections.
Following boundary conditions In 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 with increasing the diameter of Expansion chamber by 10 mm to observe the effect of L/D ratio.
3. Modeling of various types of circular Expansion chamber by keeping diameter of Expansion chamber constant as 200mm and with increasing the diameter of tail pipe by 5 mm to observe the effect of expansion ratio
4. Modeling of various types of elliptical Expansion chamber with increasing the ovality ratio of elliptical Expansion chamber by 0.5 to observe the effect of ovality parameter.

Table 1. Modeling of circular expansion chamber for effect of L/D Ratio

S.No	Circular Expansion chamber with Diameter (mm)	Circular Expansion chamber with length (mm)
1	D=200 mm	L = 211 mm
2	D=220 mm	L =174.58 mm
3	D=230 mm	L =159.73 mm
4	D=240 mm	L =146.69 mm

2.1 Effect of L/D ratio on Circular Expansion Chamber :

2.2.1 Circular Expansion chamber with Diameter 200 mm and Length 221 mm

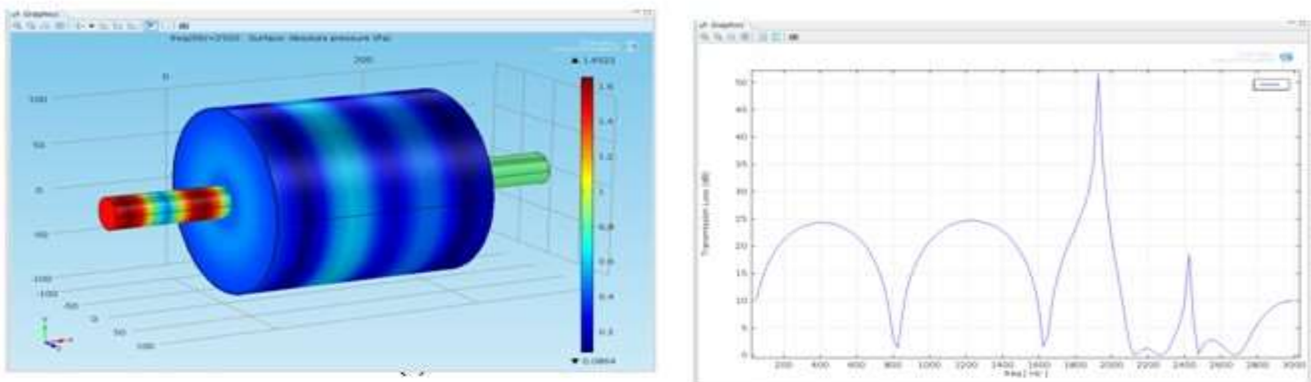
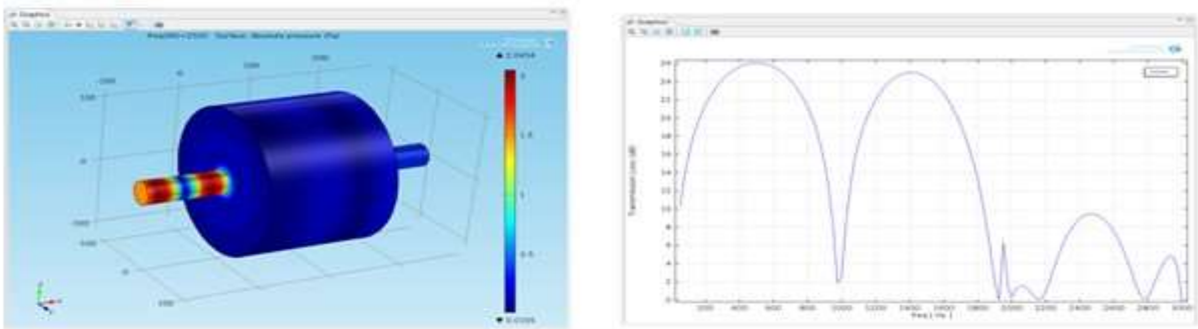


Figure 2: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

2.2.2 Circular Expansion chamber with Diameter 220 mm and Length 174.58 mm.



(a) (b)

Figure 3: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

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2.2.3 Circular Expansion chamber with Diameter 230 mm and Length 159.73 mm

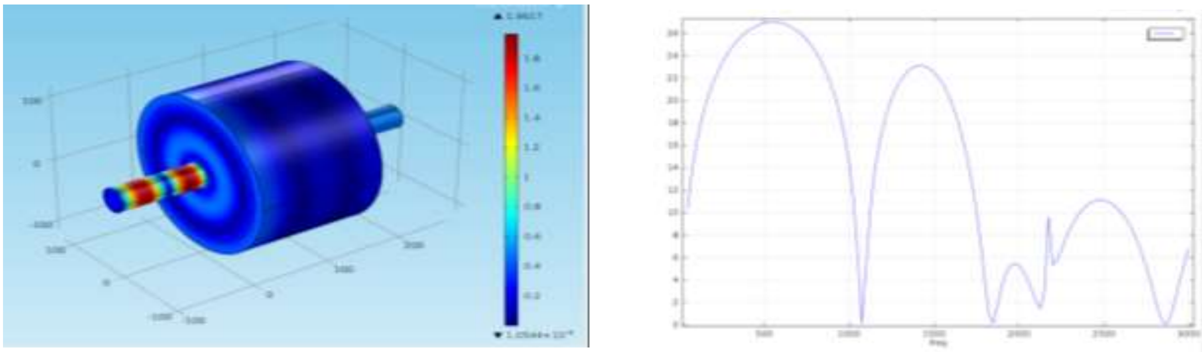

Figure 4: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

2.2.4 Circular Expansion chamber with Diameter 240 mm and Length 146.69 mm

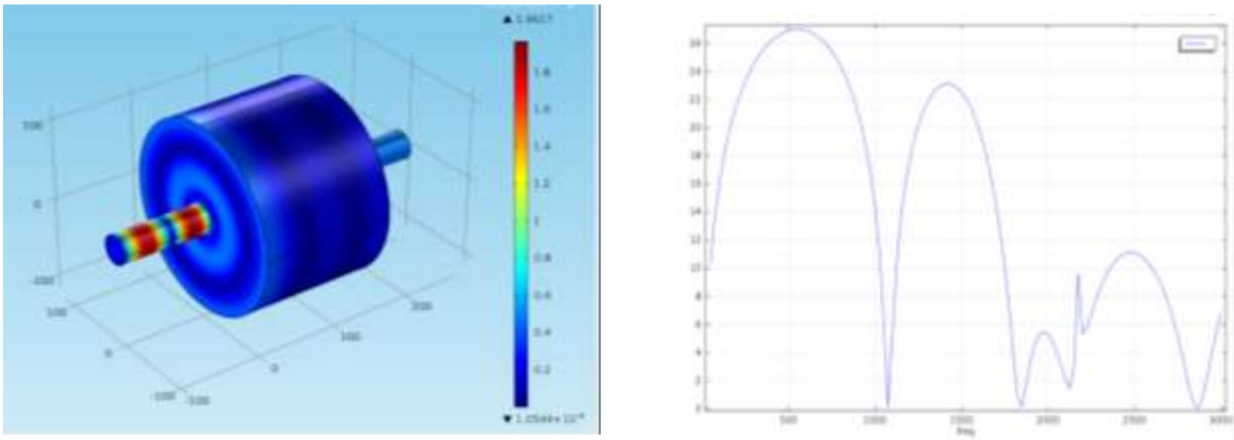

Figure 5: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

Table 2. Modeling of circular Expansion chamber for effect of Expansion Ratio

S.No	Diameter of Tail pipe increasing by 5 mm (mm)	Expansion Ratio (m=D/d)
1	d=25 mm	m=8
2	d=30 mm	m=6.67
3	d=35 mm	m=5.71
4	d=40 mm	m=5

(The diameter of circular Expansion chamber is kept constant i.e.; 200 mm .)

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2.2 Effect of Expansion ratio on Circular Expansion Chamber:

2.2.1 D=200 mm, d=25 mm, m=8

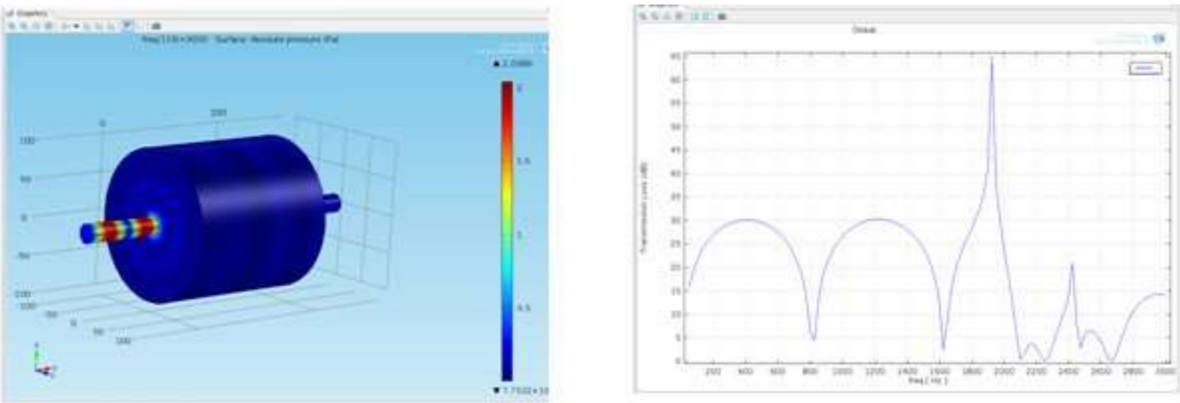
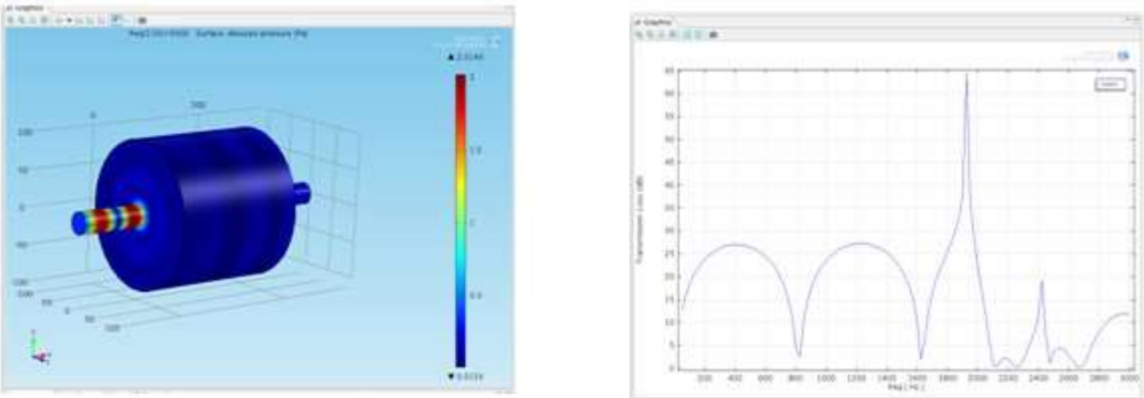


Figure 6: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

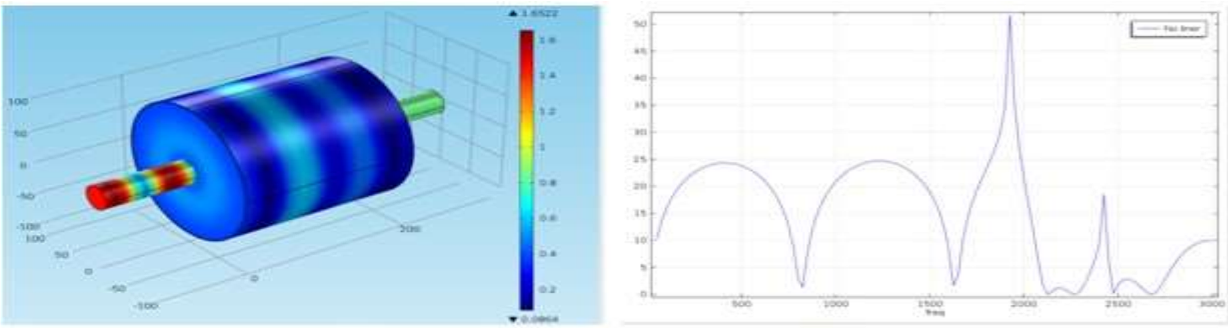
2.2.2 D=200 mm, d=30 mm, m=6.67



(a) (b)

Figure 7: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

2.2.3 D=200 mm, d=35 mm, m=5.71



(a) (b)

Figure 8: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

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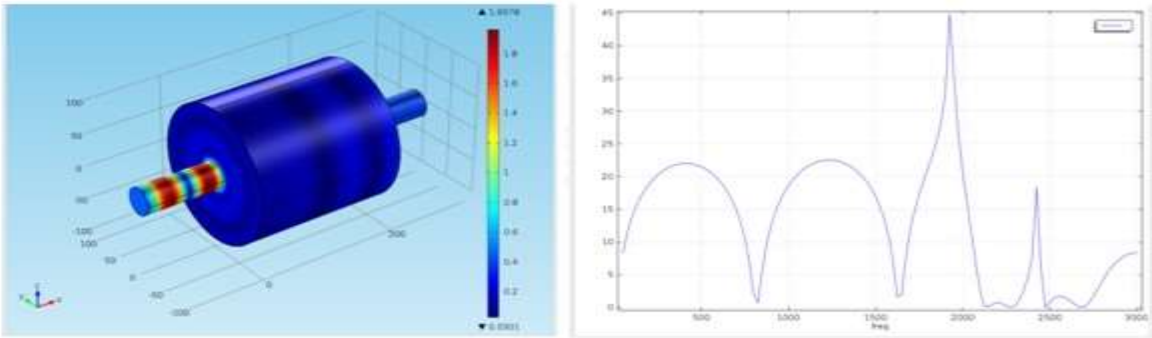
2.2.4 D=200 mm, d=40 mm, m=5



(a) (b)

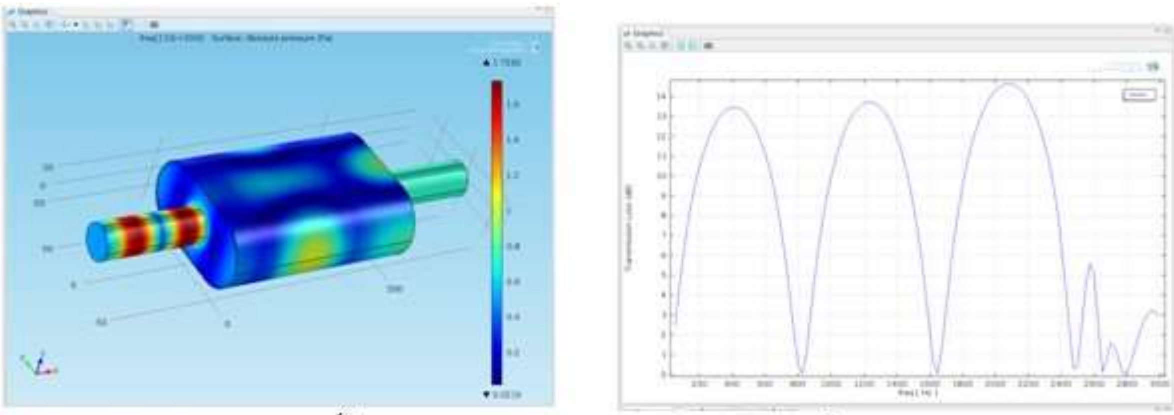
Figure 9: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

Table 3. Modeling of elliptical Expansion chamber for effect of Ovality Ratio

S. No.	Elliptical Expansion chamber with major radius a in mm	Elliptical Expansion chamber with minor radius b in mm	OVALITY RATIO (a/b)
1	141.4	70.74	2
2	158.20	63.28	2.5
3	177.30	57.6	3
4	187	53.4	3.5

2.2 Effect of L/D ratio on Circular Expansion Chamber :

2.3.1 a=141.4 mm b=70.74 mm i.e., a/b = 2



(a) (b)

Figure10 : Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

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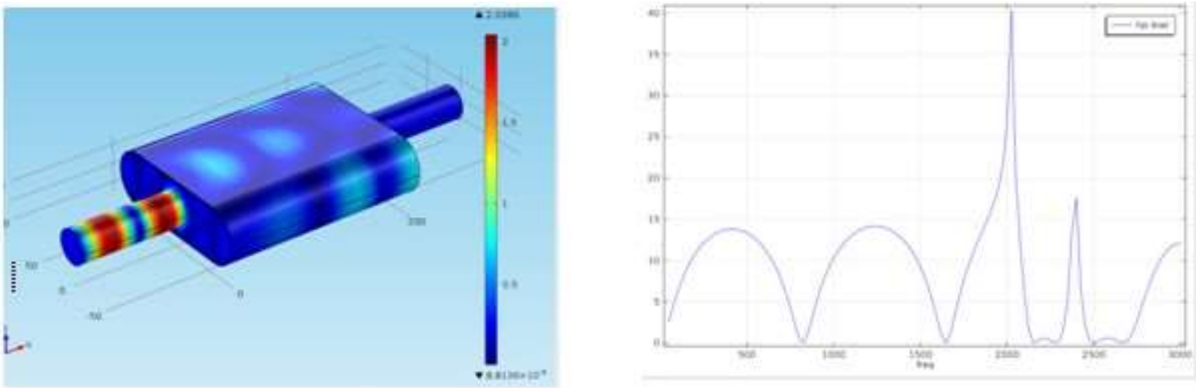
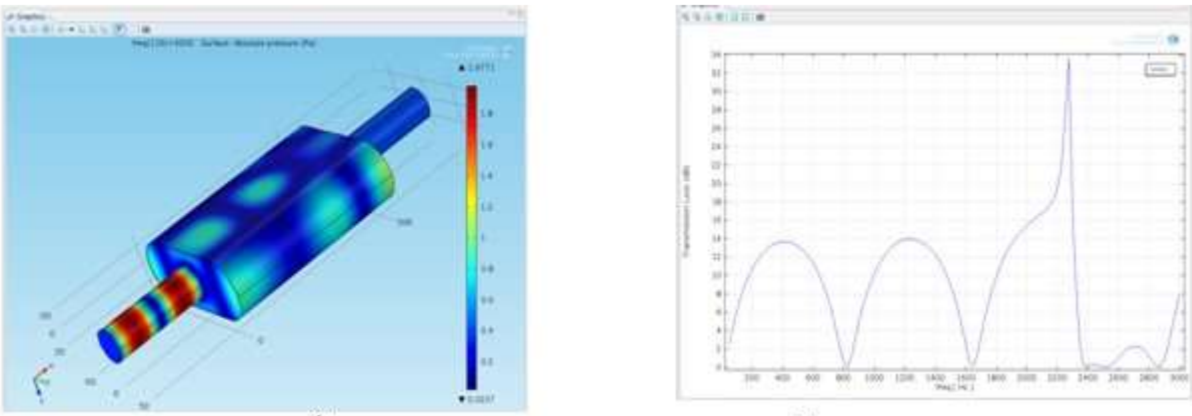
2.3.2 a=158.20 mm b= 63.28 mm i.e., a/b = 2.5



(a) (b)

Figure 11: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

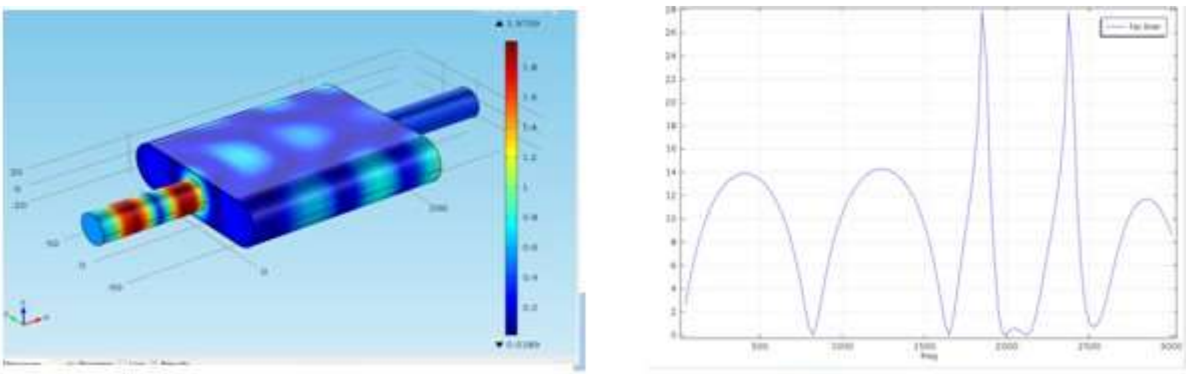
2.2.3 a=177.30 mm b= 57.6 mm i.e., a/b = 3



(a) (b)

Figure 12: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

2.2.4 a=187 mm b= 53.4 mm i.e., a/b = 3.5



(a) (b)

Figure 13: Analysis of circular Expansion chamber (a) Absolute pressure (b)Transmission loss

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Results & discussion

Table 4. Result of circular Expansion chamber for effect of L/D Ratio

S. No.	Circular Expansion chamber with Diameter (mm)	Circular Expansion chamber with length (mm)	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
1	D=200 mm	L = 211 mm	15.02	1.65
2	D=220 mm	L =174.58 mm	14.14	2.04
3	D=230 mm	L =159.73 mm	14.41	1.96
4	D=240 mm	L =146.69 mm	14.35	1.56

Graph of Transmission Loss for circular Expansion chamber for effect of L/D Ratio

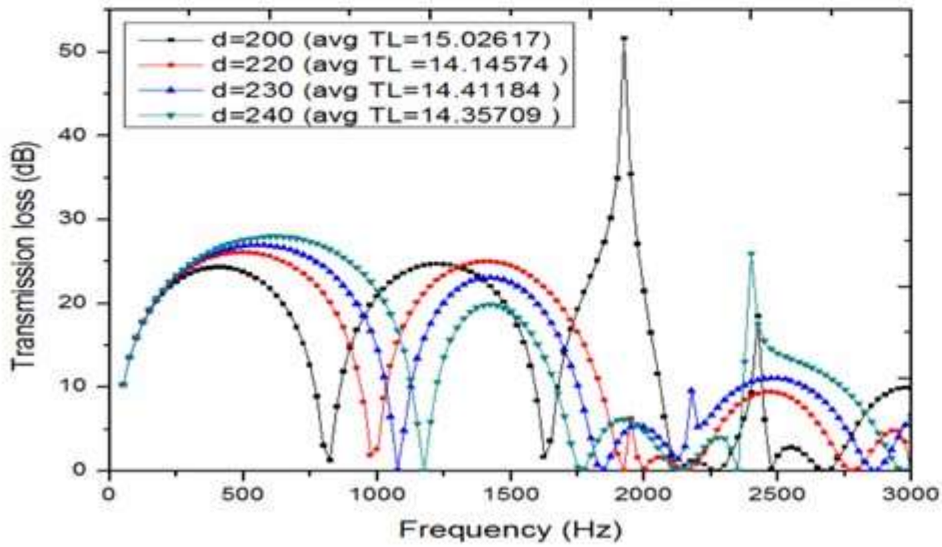

Figure 14: Transmission Loss for various circular Expansion chamber for effect of L/D Ratio

Table 5. Result of circular expansion chamber for effect of Expansion Ratio

S.No.	Tail pipe Diameter (mm)	Expansion Ratio	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
1	D=25 mm	m=8	19.58783	2.03
2	D=30 mm	m=6.67	17.09974	2.01
3	D=35 mm	m=5.71	15.02617	1.98
4	D=40 mm	m=5	13.38215	1.95

The diameter of Expansion chamber is kept constant i.e.; 200 mm .
Graph of Transmission Loss for circular Expansion chamber for effect of Expansion Ratio

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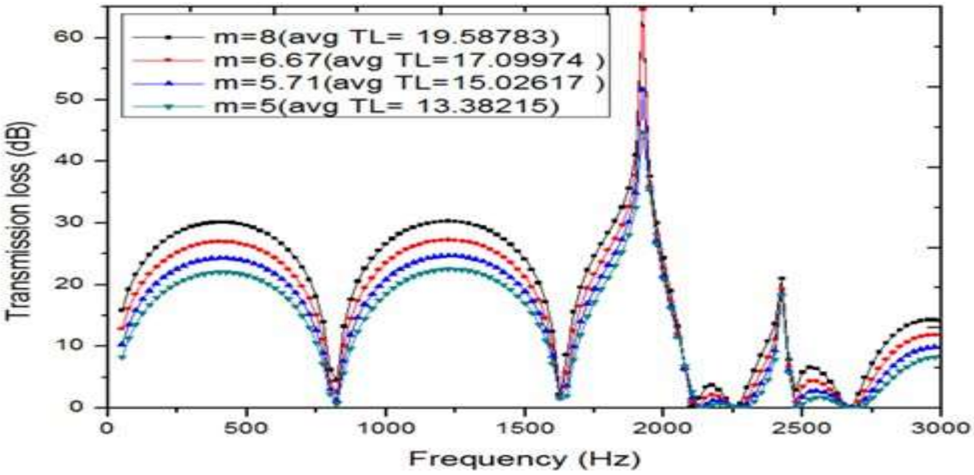

Figure 15: Transmission Loss for various circular Expansion chamber for effect of Expansion Ratio

Table 6. Result of Elliptical Expansion chamber for effect of Ovality Ratio

S. No.	Elliptical Expansion Chamber with major radius (a) in mm	Elliptical Expansion Chamber with minor radius (b) in mm	OVALITY RATIO (a/b)	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
1	141.4	70.7	2	8.367781	1.72
2	158.20	63.28	2.5	8.819668	1.97
3	177.30	57.6	3	8.722845	2.03
4	187	53.4	3.5	9.074405	1.97

Graph of Transmission Loss for Elliptical Expansion chamber for effect of Ovality Ratio

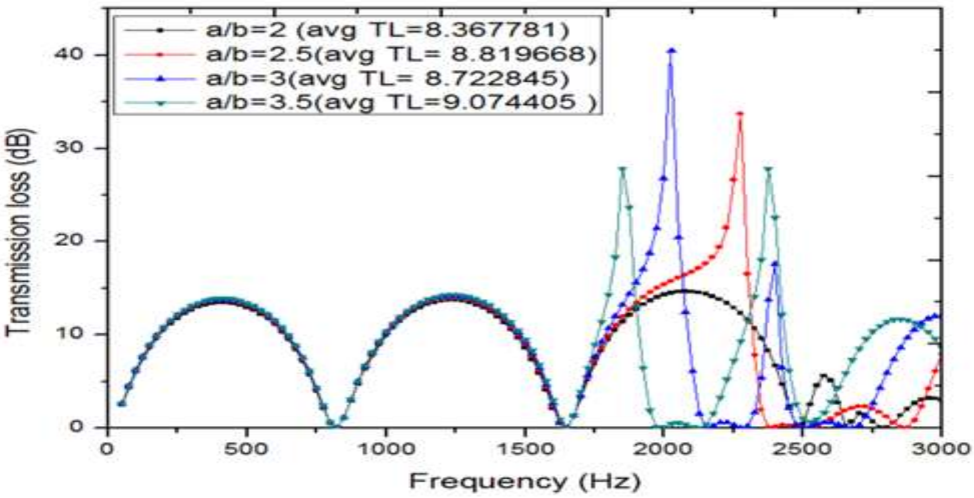

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Figure 16: Transmission Loss for various Elliptical Expansion chamber for effect of Ovality Ratio

Conclusion

The following conclusions are made with FEA results:

1. Effect of transmission loss by changing L/D ratio for circular cross-section chamber FEA results shows that while the L/D ratio increases the transmission loss increases having same volume.
2. Effect of transmission loss by changing expansion ratio for circular cross-section chamber FEA results shows that while the expansion ratio increases the transmission loss increases having same volume.
3. Effect of transmission loss by changing ovality ratio for elliptical cross section chamber FEA results shows that while the ovality ratio increases the transmission loss increases having same volume.

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