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Analyzing the Loss of Sound Transmission for a Rectangular Cross Section Muffler with a Different Aspect Ratio in Same Gas Volume

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Abstract- The measurement of the acoustical transmission loss of an expansion chamber muffler with a rectangular cross section and different cross section aspect ratios is presented in the study. An essential component of noise management for reducing noise from gas flow sources, such as machinery exhaust, is a muffler, also known as a silencer. As a component of an internal combustion engine's exhaust system, mufflers are usually placed along the exhaust pipe to lessen noise. One-dimensional waves are utilized as simulation tools.

Index Terms- Rectangular Cross Section Muffler, FEA Acoustic Module- wave 1-D, Sound Transmission loss

I. INTRODUCTION

A muffler, also known as a silencer in English or a back box in Irish, is a device used in the UK to lessen the noise produced by an internal combustion engine's exhaust [1].The main purpose of mufflers is to lessen noise from fans, compressors, high pressure gas or steam vents, and internal combustion engine exhausts. These illustrations support the idea that a muffler permits fluid to flow while simultaneously limiting the unrestricted flow of sound. Transport vehicles are the biggest source of noise that annoys individuals and has an effect on their surroundings [2]. Our culture has become characterized by the significant rise in mobility brought about by technology advancements over the past century, together with high levels of background noise, especially from traffic [7].

A reactive or dissipative muffler can be used to reduce the volume of sound waves traveling through a pipe. A dissipative muffler extracts energy from the wave's acoustic motion as it passes through it by using sound-absorbing material. Human health is negatively impacted by noise levels exceeding 80 decibels [3]. Therefore, a silencer or exhaust muffler, a crucial noise control component that reduces the acoustic pulse produced by the combustion processes, is installed in internal combustion engines to lessen noise [4].

The difference between the power incident on the muffler proper and the power transported downstream into an anechoic termination is known as the transmission loss. It assumes an anechoic termination at the tail pipe and is source independent. It explains how well a muffler works [5].

Objectives and Modelling

The expansion chamber's capacity is held constant while the rectangular cross section muffler's aspect ratio is varied in order to assess the transmission loss of the muffler. The acoustical simulation tool wave 1-D, which is already proven software, is then used to model the FEA results.

The transmission loss of the basic expansion chamber is analyzed using the following design conditions:

- The expansion chamber's volume remains constant during the modeling and analysis process.
- Circular expansion chamber modeling with a constant expansion chamber length of 500 mm.
- A rectangular expansion chamber with a constant cross section of 31329 mm2 is modeled.

II. ACOUSTIC MODULE WAVE 1-D MODELLING

Table 1: Modeling of rectangular expansion chamber with different aspect ratio

S No.	Lenth of the cross section in mm	Width of the cross section in mm	Constant Volume of the Muffler 15664500 mm^3 having length 500 mm	Aspect Ratio (Length/Width)
1	177	177	177X177X500	1
2	200	156.6	200X156.6X500	1.28
3	250	125.3	250X125.3X500	2
4	306.17	102.39	306.17X102.39X500	3

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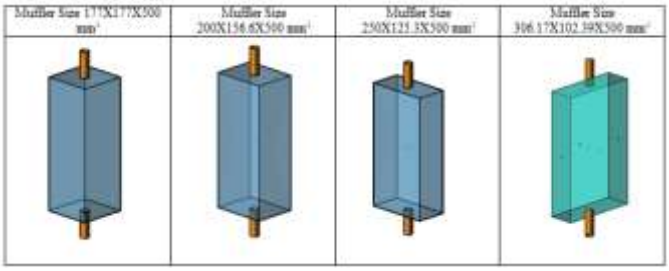

Figure 1: Different Configurations of Rectangular cross section muffler

III. POST PROCESSING BY USING WAVE 1-D

WAVE 1-D is based on Computational fluid dynamics code which is collaborated with ANSYS used to calculate the calculate orifice noise and insertion loss as well as radiated shell noise using these codes, tailpipe noise of exhaust system, information about the engine as an acoustic source is needed [4].

WAVE is a 1-dimensional gas dynamics code which is based on finite volume method for simulating engine cycle performance. Tools using this one dimensional approach accurately predict all engine breathing characteristics.

This enables engineers to Consider air system and combustion effects during analysis. A. F. Seybert model is used to compare the wave result.

The working fluid was perfect air having following boundary conditions [4]:

- Gas Volume approximately: 6636500 mm3.
- Exhaust gas Temperature: 300 K.
- Exhaust Gas pressure: 1.0 bar.
- Initial fluid composition: Fresh Air.
- Upper frequency Limit: 3000 Hz.
- Lower Frequency Limit: 25 Hz.

Model is prepared on wave build 3D with inlet & outlet boundary condition shown in figure 2.

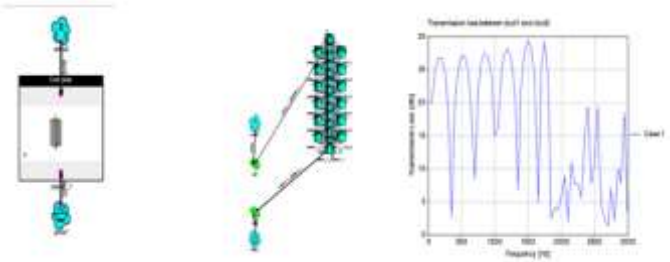

Figure 2: Transmission Loss evaluation by using WAVE 1-D

IV. RESULTS AND DISCUSSION

Table 2: Results of rectangular expansion chamber for transmission loss

S No.	Constant Volume of the Muffler 15664500 mm^3 having length 500 mm	Aspect Ratio (Length/Width)	Average Transmission Loss (dB)
1	177X177X500	1	16.30
2	200X156.6X500	1.28	17.21
3	250X125.3X500	2	14.97
4	306.17X102.39X500	3	16.18

Now table 2 shows the result of transmission loss for rectangular expansion chamber with different ratio

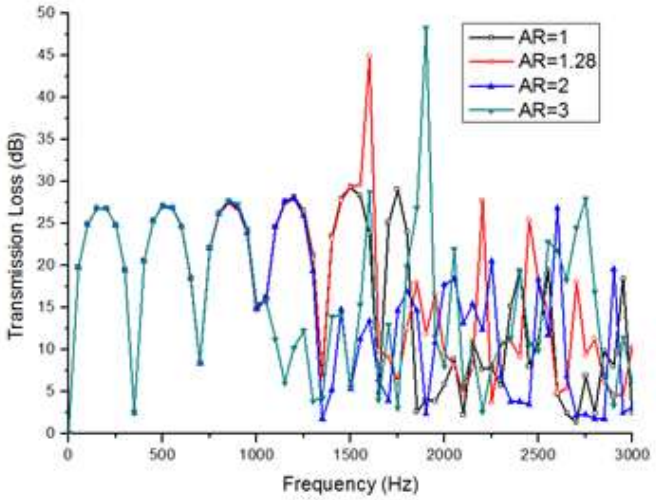

Figure 3: Transmission Loss vs Frequency curve by using WAVE 1-D

Any arbitrary shape box, canister, straight or curved tube with or without perforation, or baffle with or without perforation can be used to represent gas volume using Wave Build 3D. For the necessary meshing, an appropriate mesh parameter can be made. A larger aspect ratio attenuates the noise level in the mid-to-high frequency zone, according to the effect of transmission loss measured by altering the rectangular expansion's aspect ratio. The highest average transmission loss among them is displayed for the aspect ratio of 1.28.

IV. CONCLUSION

Any arbitrary shape box, canister, straight or curved tube with or without perforation, or baffle with or without perforation can be used to represent gas volume using Wave Build 3D. For the necessary meshing, an appropriate mesh parameter can be made. A larger aspect ratio attenuates the noise level in the mid-to-high frequency zone, according to the effect of transmission loss measured by altering the rectangular expansion's aspect ratio. The highest average

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