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Muffler Design with Baffle Effect and Performations on Transmission Loss

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A typical sound generated by vibrational waves is usually based on the experience and design experience, which can be enhanced by optimizing the internal structure of the exhaust system. The use of baffles and perforations has a significant effect on reducing the transmission loss in a silencer exhaust system. In order to evaluate the response effect of a silencer, the effect of baffle and perforations, without baffles and perforations, was evaluated in COMSOL5.2 software. Which results in numerical results with close experimental results and the effect of buffaloes and perforations, have shown a good reduction in transmissibility, and their partial differences are due to the features of geometry design.

Keywords: FEM, reactive muffler, absorptive muffler, transmission loss.

1. Introduction

Inward burning engines are regularly prepared for and debilitate suppressor on smother those acoustic pulse created toward those ignition methodology. A high intensity pressure wave produced toward burning in the motor barrel propagates along the fumes channel and radiates from the fumes channel end. Those pulse repeats toward those terminating recurrence of the motor which may be characterized by f = (engine rpm x number from claiming cylinders)/120 to a four stroke motor. The frequency content of exhaust noise may be commanded by an pulse in the terminating frequency, Be that it Additionally need An broadband part on its range which extends to higher frequencies. Over general, heartless waves propagating along a channel could a chance to be weakened utilizing whichever a dissipative or a sensitive suppressor.

Reflective (or reactive) mufflers - the individuals that reflect acoustic waves Toward Sharp territory expansions or progressions about impedance.

Dissipative mufflers - mufflers in view of dispersal of acoustic vitality under heat through viscous misfortunes done stringy materials or flow-related (resistive) misfortunes clinched alongside punctured pipes. Sensitive mufflers are best suiting for those low recurrence range the place just plane waves might propagate in the system, same time dissipative mufflers with fibers need aid productive in the mid-to-high recurrence go. Dissipative mufflers dependent upon stream losses, on the different hand, worth of effort additionally during low frequencies. An ordinary car debilitate framework may be a mixture development comprising of a blending of reflective Also dissipative suppressor components. Sensitive silencer configuration will be built whichever on the guideline of a. Helmholtz resonator or an extension chamber, Also obliges the utilization from claiming acoustic transmission line hypothesis. Previously, a Helmholtz resonator plan and pit may be joined of the fumes channel. During a particular recurrence those pit will reverberate and the waves in the fumes channel need aid reflected back towards the sourball. Nonetheless there need aid also pasquinade band frequencies the place the resonator need no impact along these lines resonator suppressor plan will be focused on should particular frequencies the place the dominant part of the weakening is needed. In exactly designs, the suppressor need a few resonators from claiming distinctive sizes should target a range from claiming frequencies. The reflective parts are typically tuned with uproot ruling low-frequency motor sounds same time those dissipative parts need aid planned on fare thee well of higher-frequency commotion.

The silencer is one of the sound control devices used to reduce sound. The mufflers usually are placed in the path of a fluid flow to reduce the sound of the output stream. This flow of fluid in various industries may be the flow of air or gas or Steam The use of each of these silencers in each field will ultimately be used to reduce the level of sound. As shown in Figure 1. The placement of a muffler is shown on an exhaust system[1].

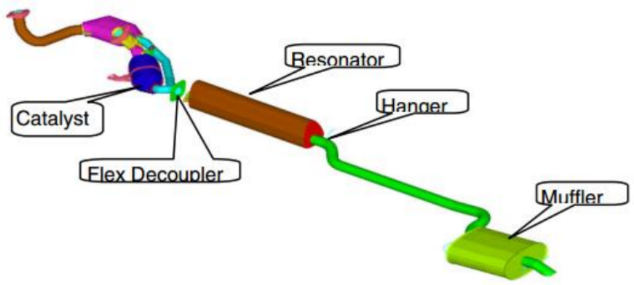

Figure 1 Schematic of an exhaust system

Transmission Loss parameter (TL) compares the amount of signal intensity in a certain range from one source to another in an environment[2]. Several numerical methods for reducing Transmission Loss in exhaust silencer have been investigated in CONSOL software and Actran software[3].
Mo and Huh were analyzed transmission Loss reductions in silencer analytically in NASTRAN software with comparative experimental results [4]. Vasileve Gillich have been evaluated and calculated harmonic waves of pressure in a silencer by the internal combustion engine exhaust system to reduce and transmit Transmission Loss in the COMSOL software [5]. Potente and colleagues have calculated the principles of design and benefits of mufflers for numerical analysis [6]. Kore and colleagues also investigated a silencer reaction to reduce Transmission Loss in a fluent environment [7].

2. Define the model

In this paper, modeling for two silencer modes with Baffle effect and perforations and not affecting this feature in SolidWorks software has been taken Fig. 2.

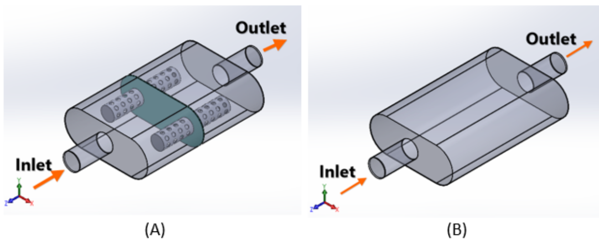

Figure 2 Muffler modeling A) baffle muffler and perforations B) muffler without baffle and perforations

Finite element method enables efficient evaluation scheme, using the mathematical model provides and put a wider range of design choices available to the user, optimizing design makes it possible **[8]** Therefore, one of the key points in the analysis, the analysis of the exhaust system It is suitable for a FEM element. When a mesh in a silencer is split into relatively large elements, a relatively large calculation error will occur. The maximum length of the mesh elements is generally calculated by the maximum frequency, the thickness of the mesh element is determined by the highest frequency. The calculated frequency range of the muffler will be determined according to the exhaust frequency. In this paper, the amplitude of the muffler between 20 and 3000 Hz has been evaluated **[9]**. In Figure. 3 the silencing mesh is shown in COMSOL software.

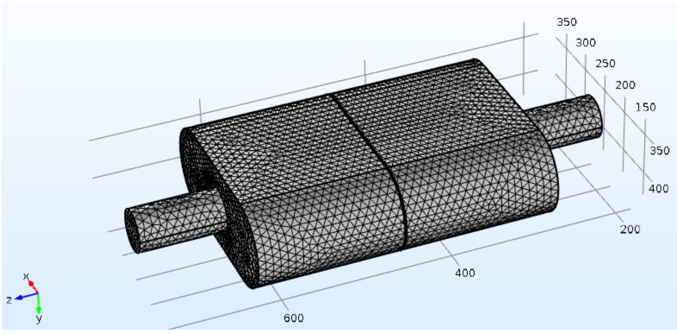

Figure 3 Mesh muffler in COMSOL software

3. The theory of analysis on the model

To solve this problem acoustic pressure is used in the frequency range. This corrected equation of the Helmholtz equation for solving the acoustic pressure equation P: Equation (1):

$$\nabla\left(\frac{\nabla p}{\rho_0}\right)+\frac{k^2 p}{\rho_0}=0 \tag{1}$$

where in:
$k = 2\pi f/c_0$ – wavelength,
ρ_0 – material density,
c_0 – sound speed.
Transmission loss is not dependent on the internal flow, which is used as a silencer in the silencer (Eq. (2)), is defined as the incident sound (Eq. (3) over transmitted sound powers (Eq. (4)) calculated using[10]:

$$TL = 10\log\left(\frac{P_{in}}{P_{tr}}\right) \tag{2}$$

$$P_{in} = \int \frac{p_i^2}{2\rho c_0} dA \tag{3}$$

$$P_{tr} = \int \frac{p_{tr}^2}{2\rho c_0} dA \tag{4}$$

This module contain many sub-module, we solve this problems in the Pressure acoustics module. The physics interfaces play a vital role to couple with other physics interface in COMSOL5.2 Table 1 [10].
To solve this problem, three boundary condition are as follows:

- Hard wall boundary where velocity is zero.
- At the inlet combination of incoming and outgoing plane waves.
- At the outlet radiation condition for an outgoing plane wave.

Table 1 List of Parameters required for simulation

Name	Value	Description
pressure	1[Pa]	Amplitude of incoming pressure wave
temperature	423 [k]	Wall surface temperature
Speed	41 [m/s]	Inlet Air Speed
temperature	735 [k]	Inlet Temperature
Density		The density of Air
Material	Q235-steel	The Material of the Muffler

4. Results and discussion

An experimental [9] and numerical comparison of the Transmission Loss results of the silencer in terms of frequency is shown in Fig. 4. Usually, reactive silencers are effective in low frequency bandwidth. The cut-off frequency in the current muffler is calculated at a frequency of 3000 Hz, which is obtained using the equation $fc = 1.84c/(\pi \mathrm{d})$, where c is the sound speed and d is the silencer diameter. In the frequency range from 600 to 750 Hz, the maximum attenuation of 50 dB for buffer geometry with baffles and perforations, as well as baffle-free muffler geometry and perforations in the frequency range 1300-1400 Hz has reached a maximum decay of 91 dB. In fact, numerical and experimental results can be said to be in good agreement. The minor difference between baffle silencer geometry and perforations is the experimental results due to the geometric differences between the two, but the geometry without silencer along with the baffles and perforations of Normal mode goes far beyond indicating that this does not improve the important Transmission Loss feature, and in the end, Baffle's effect and perforations can be well understood in the results.

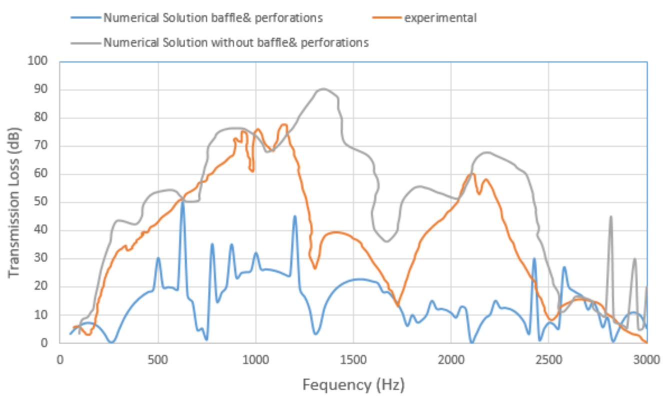

Figure 4 Transmission loss

In Figure (5a), the absolute pressure level reaches a maximum of 16.8 Pa, but in the Figure (5b) the pressure level reached 2.88 Pa at a frequency of 3000 Hz.

In Fig. 6, the acoustic pressure level of the muffler is shown at a frequency of 3000 Hz for buffer geometry and perforations, along with baffles and perforations for 1 Pa sound pressure.

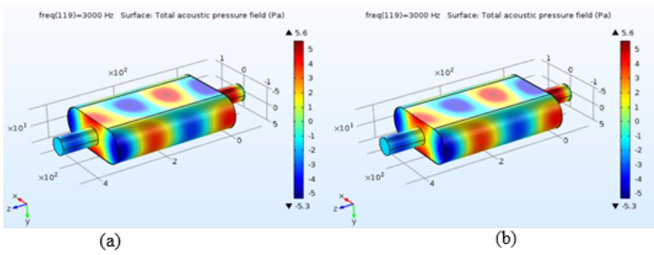

Figure 5 Acoustic pressure field a) without baffles and perforations b) with baffles and perforations

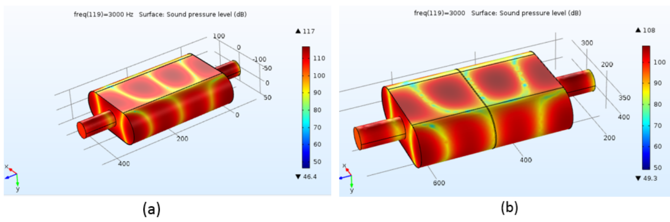

Figure 6 Acoustic pressure level a) without baffles and perforations b) with baffles and perforations

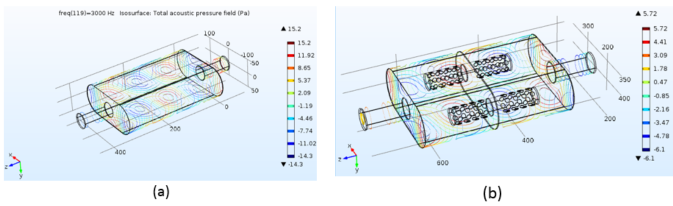

Figure 7 Isosurface: a) without baffles and perforations b) with baffles and perforations

5. Conclusion

In accordance with the standards and regulations that are set to reduce noise, automotive companies have been forced to make improvements in the engine noise and exhaust system. Given the geometry of the muffler and the cost of its production in the vehicle, the goal Design of smaller models with high capacity without loss of pressure before entering the muffler. Therefore, the proposed scheme in this paper has been analyzed with regard to acoustic and back pressure in muffler.
In this study, a silencer was evaluated with the effect of buffer perforations and without affecting it to obtain sound characteristics. The acoustic silencer pressure was compared with the experimental results and showed that the effect of the baffle and perforations in the process of reducing the transmission loss parameter resulted from a numerical analysis of the effectiveness and efficiency.

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