REACTIVE MUFFLER ANALYSIS BY BOUNDARY ELEMENT METHOD & EXPERIMENTAL METHOD TO CALCULATE TRANSMISSION LOSSES

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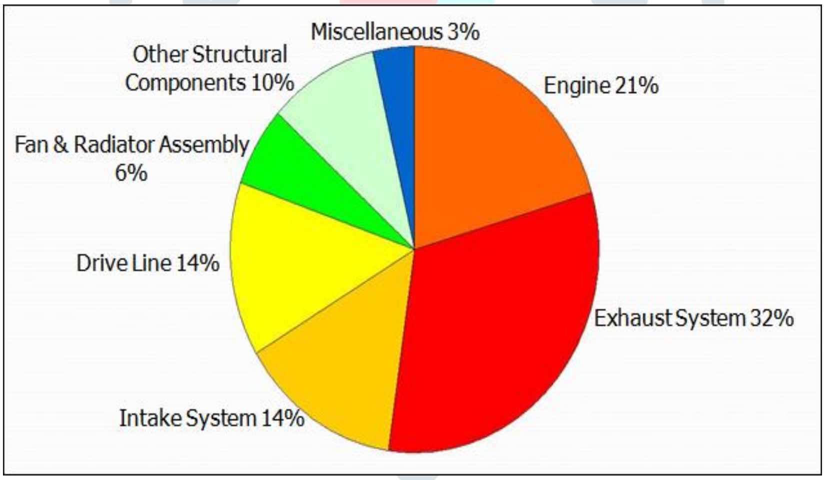
Abstract— For an automotive exhaust system the noise level, transmission loss & back pressure are the most important parameters for the driver & engine performance. In order to improve the design efficiency of muffler, resonating of the exhaust muffler should be avoided by its natural frequency. Mufflers are most important part of the engine system and it is commonly used in the exhaust system to minimize the sound transmission level which is caused by exhaust gases. The design of muffler becomes more and more important for noise reduction. The solid modeling of exhaust muffler is created by AUTO-CAD 2009 and analysis is carried out by using COMSOL Multiphysics 4.4 to study of muffler.

IndexTerms—AUTO-CAD 2009,COMSOL Multiphysics 4.4,FFT Analyzer

I. INTRODUCTION

The vehicle noise comprises three major sources, viz., power unit, wind turbulence and tyre/road. The power unit consists of engine, cooling fan, exhaust and transmission. Main components of engine are injection system, intake system and cylinder block, etc. Fig. 1.1 shows that major noise contribution is by exhaust system which needs to be reduced. This requires knowledge of the mechanism of noise generation, propagation; radiation and principle of impedance-mismatch needs to be understood and must be appropriately used in design of exhaust system.



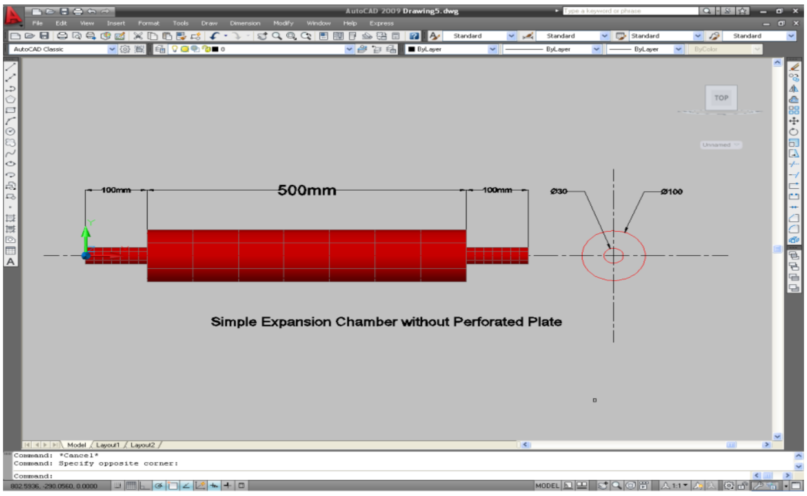
Due to more competition, now a day's every manufacture try to either enhance the noise which is coming out from system or they try to eliminate the noise. Practically it is not possible to eliminate the entire noise coming out from engine so they to keep the noise as low as possible. As a result of this each time they try to develop the exhaust system much efficient than previous one.

For that there are various tests conducted in laboratories. The instruments used for these developments are as following one by one

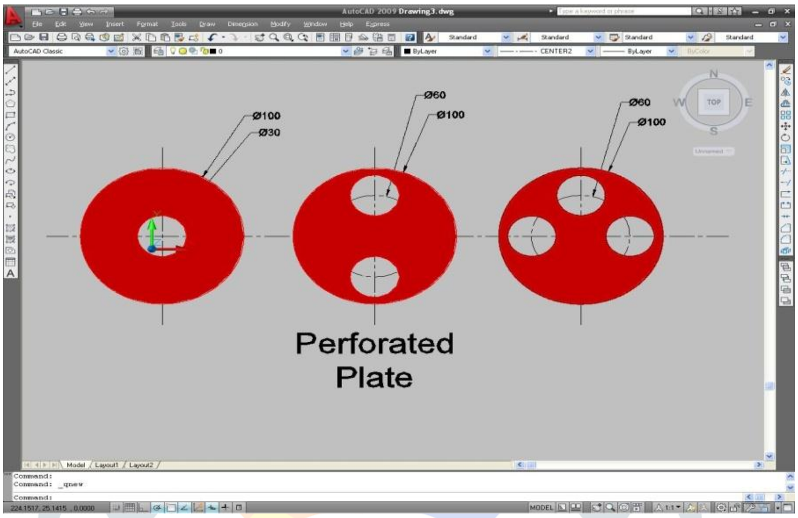
- FFT Analyzer /Matlab results.
- For Validation purpose COMSOL Multiphysics or other software's are used.

II. MODELING OF SIMPLE EXPANSION CHAMBER IN AUTO-CAD 2009

Simple expansion chamber model is modified into three different geometries by keeping the volume of the chamber same. In one model a baffle with central hole of diameter 30 mm is inserted at center of the expansion chamber and in other model the baffle with two holes at 30mm distance from center and its dia. 30mm. The third model is having three holes at angle 600, in this model two holes are having 35 mm dia. and the one hole having 30 mm dia. All the models are as shown in figure. The models are prepared in AutoCad 2009 and meshing is done in COMSOL multiphysics 4.4 with a size of 6 mm. The same procedure is used for calculating the TL for all models. The values of TL for all models is calculated and compared with the TL simple expansion chamber. The effect of baffle and the different holes with varying diameter is discussed in chapter result and discussion.



Fig, 2.1 - Simple Expansion Chamber without Muffler



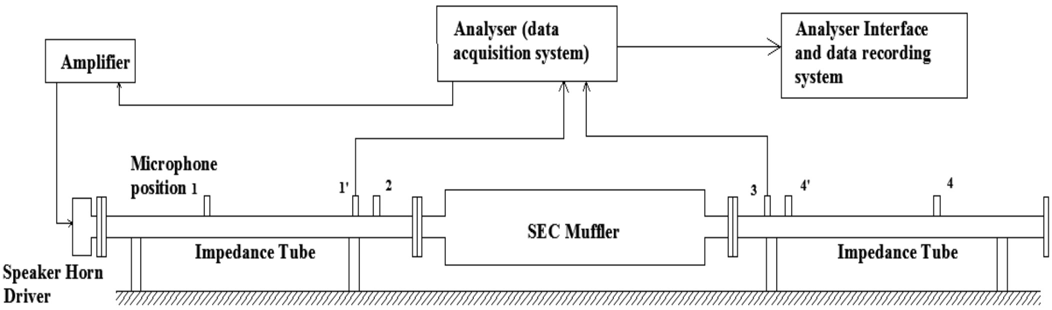
Fig, 2.2 - Perforated Plates with 1, 2 & 3 Holes

III. EXPERIMENTAL SETUP

A schematic diagram of experimental set up for calculating TL of simple expansion chamber is as shown in figure 4. It consists of a noise generation system, noise propagation system and noise measurement system. The TL is measured by transfer function method.The set has following main components,

- Impedance Tube
- Data acquisition system
- Noise source with amplifier
- Sound pressure measuring microphones

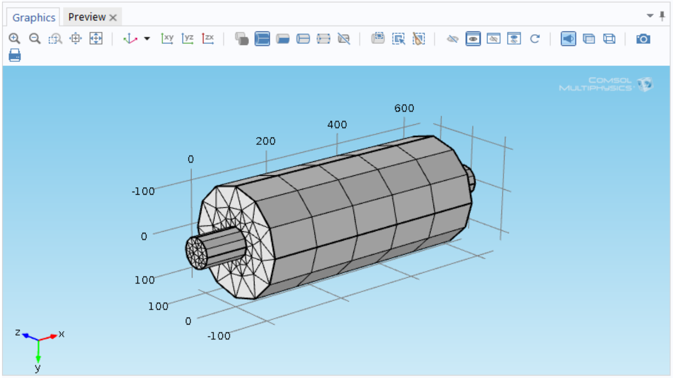
The data acquisition system used is a 4 channel FFT analyzer with an interface package called NV Gate V7.0 for the control and setting of analyzer. It collects the pressure data from microphones and feed it to data recording storage system. It also has a single output channel which fed to speaker through analyzer. A random noise signal is generated in analyzer and play by the speaker. The reason behind using random noise is it contains equal power density of noise for each frequency. Sound source used is of high wattage to produce at least 120 dB of noise. Pressure field microphones are used for measurement. The two microphones are sufficient as transfer function method is used. Transfer function is evaluated for each set of reading. The actual test set up with as component specifications is as shown in figure. Two configuration of set up is used with respect to end conditions here shows one configuration of no load condition.



Fig, 3.1 - Experimental set up with its components

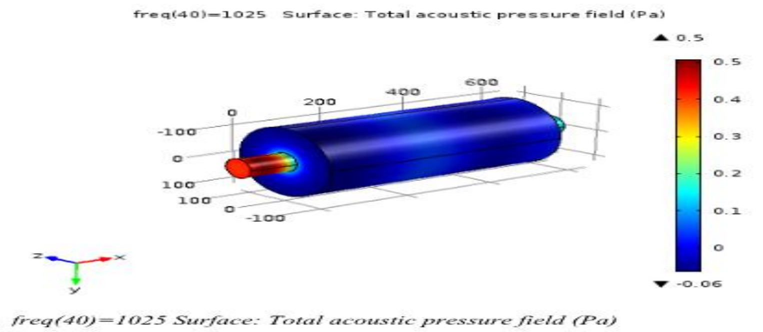
IV. ANALYSIS OF MUFFLER BY USING COMSOL MULTIPHYSICS

The below figure 4.1 shows the first step in COMSOL metaphysics 4.4. where we can mesh the muffler by using free triangular meshing for side of muffler plate and for remaining body we use the tetra hedral mesh type for meshing for main body.



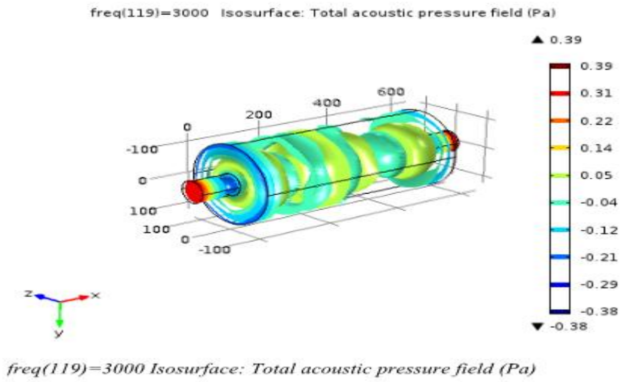
Fig, 4.1 – Meshing In COMSOL multiphysics 4.4

The below figure 4.2 shows the acoustic pressure result for simple expansion chamber without muffler / baffle i.e. (acpr).It also shoes the pressure intensity of sound wave. It is for frequency 1025Hz.

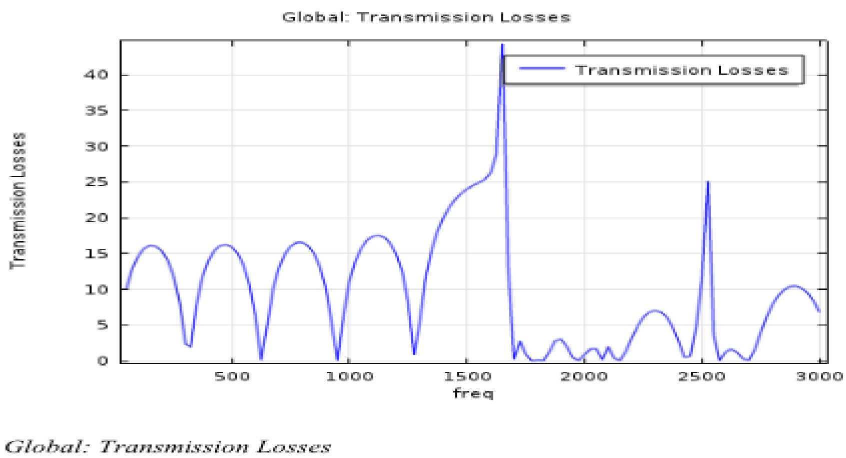


Fig, 4.2 - Acoustic Pressure (Acpr)

The below fig. 4.3 shows the sound pressure level for frequency 119 at 3000 Hz. i.e. (acpr). In below figure the light blue or sky blue colour show low frequency zone of the muffler. As seen in figure at the inlet portion of muffler it shows the red colour counters because while entering in chamber the intensity of frequency in very high.



Fig, 4.3 - Acoustic Pressure, Isosurfaces (Acpr)



Fig, 4.4 - 1D Plot Group 4

The above figure shoes the 1D plot of simple expansion chamber without muffler /baffle. As we can see in graph at the start of the chamber the frequency is very high while the given frequency is same through out simple expansion chamber main body i.e. SEC. and it also vary while the given frequency leaves the SEC and travel through the out let of the chamber.

V. EXPERIMENTAL RESULT OF SIMPLE EXPANSION CHAMBER (1,2 & 3 HOLE)

Reactive mufflers are effective at lower range of frequency, so the 10 number of frequencies are chosen with equal spacing from the frequency range i.e. 50 – 1700 Hz. For the BEM results TL is available directly at these frequencies and for experimental either directly from the result or by interpolation method. Then percentage variation is calculated for these frequencies which are as shown in the table 5.1.

Frequency Range	**Simple Expansion Chamber With Center baffle 1 hole**		**Simple Expansion Chamber With Center baffle 2 hole**		**Simple Expansion Chamber With Center baffle 3 hole**	
Hz	***Exper. TL (dB)***	***BEM TL (dB)***	***Exper. TL (dB)***	***BEM TL (dB)***	***Exper. TL (dB)***	***BEM TL (dB)***
200	17.45	16.295	21.989	17.513	21.354	18.408
400	28.095	23.372	21.455	18.856	11.111	19.529
600	18.366	17.03	21.512	19.933	8.339	17.149
800	5.185	4.0717	4.277	3.624	13.285	7.046
1000	25.989	25.253	14.801	13.587	6.203	16.124
1200	34.864	29.886	30.29	24.558	20.924	24.696
1400	14.529	13.453	21.952	19.957	12.998	11.151
1600	18.177	16.324	8.39	6.646	26.247	13.73
1800	34.143	28.011	26.614	22.141	21.202	25.214
2000	32.795	30.083	31.226	27.312	10.533	26.181

Table 5.1: Shows the percentage variation between the BEM and Experimental results As seen during the experimentation

VI. RESULT

Based on work carried out in this project, it can be concluded that:

1. We computationally investigated the acoustical performance of a reactive muffler i.e. TL of simple expansion chamber, which consist of baffles with different cross sections.
2. Among the reactive mufflers tested, the simple expansion chamber with center baffle withone hole has the best performance. The developed setup can be efficiently used for measurement of transmission loss of any muffler configuration with required accuracy. Any unforeseen behavior within the muffler reduces the reactive quality of the muffler. This reduces the performance of the muffler and as this behavior was not accounted for in the modeling also reduces the accuracy of the prediction.

VII. ACKNOWLEDGMENT

I feel happiness in forwarding this review paper as an image of sincere efforts. I am very much thankful to our respected guide Prof. Lagdive H.D. who has been a constant source of inspiration.

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