

Multiphysics Simulations of Automotive Muffler

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Abstract

The effect of automotive engine emission and exhaust noise on the natural environment has become a critical problem in our daily life. Exhaust system is known to be a critical component of the automotive emission and noise pollution. Exhaust noise from an Internal Combustion engine is one of the key components for environmental noise pollution. Acoustical Engineering of automotive muffler or silencer has gradually reduced the noise pollution level in an effective manner. Automotive exhaust systems are engineered to attenuate noise level, meeting desired emissions and sound quality based on pollution regulatory control. Therefore automotive muffler design has become a key parameter for research and development. The design validation of such complex mufflers has always been a big challenge for Engineers; hence it is an active area of research and development in recent years.

Design and analysis of mufflers is a complex work that affects noise attributes, emission and fuel efficiency of an internal combustion engine. Thus a muffler design becomes more important for exhaust noise reduction. For suitable design of a muffler, Transmission loss (TL) and Insertion Loss (IL) are the key parameters that need to derive for further experiments. Among these two, Transmission Loss (TL) is more preferred and widely used for predicting both muffler and engine performance. Generally muffler design has been an iterative process by trial and error methods. However in recent years the advances in Multiphysics Engineering simulation has made it possible for engineers to save time by reducing prototype building and physical testing. In this paper, multiphysics design of automotive muffler is considered for better engine performance and noise reduction.

A 3D model of reactive muffler [Figure 1] was designed and validated with COMSOL Multiphysics® to predict both engine and muffler performance. For current investigation, the Pressure Acoustic, Frequency Domain interface COMSOL Multiphysics has been used to predict both engine and exhaust performance in steady state study environment. The CAD and Mesh interface has been used for geometry modification and discretisation. The value of Acoustic pressure [Figure 2], Sound level [Figure 3], Transmission Loss (TL) are derived in a frequency range of 100 Hz to 2000 Hz and plotted in graph [Figure 4] as shown.

The potential of Acoustic simulation of an automotive muffler for performance improvement was demonstrated in this paper. Further investigation on the effects of resonating chamber will be reported. A coupled problem of acoustic, fluid dynamics and heat transfer on the design for innovative muffler is our future scope.

Reference

- 1."Foundations of Engineering Acoustics [Book] " by Fahy Frank J Fahy.
- 2.Shah, S., Kuppili, S., Hatti, K., and Thombare, D., "A Practical Approach towards Muffler Design, Development and Prototype Validation," SAE Technical Paper 2010-32-0021, 2010, doi:10.4271/2010-32-0021.
- 3.D. Borelli and C. Schenone, DIPTEM, University of Genova, Genova, Italy; "Analysis of Sound Propagation in Lined Ducts by Means of a Finite Element Model" COMSOL Technical Paper.

Figures used in the abstract

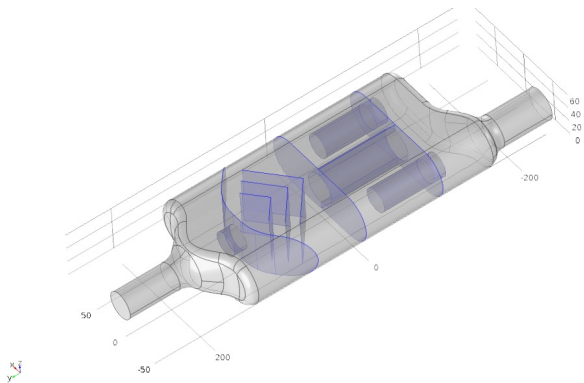


Figure 1: 3D Model of Muffler.

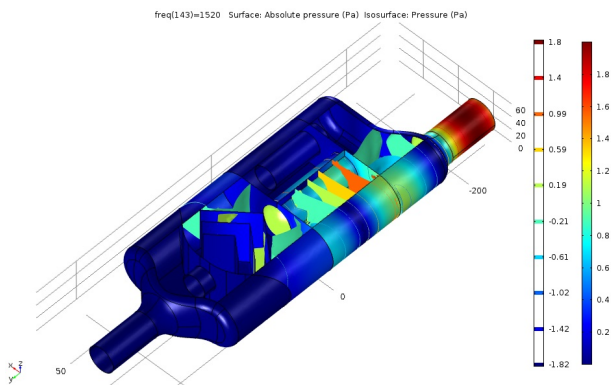


Figure 2: Surface plots of Absolute Pressure.

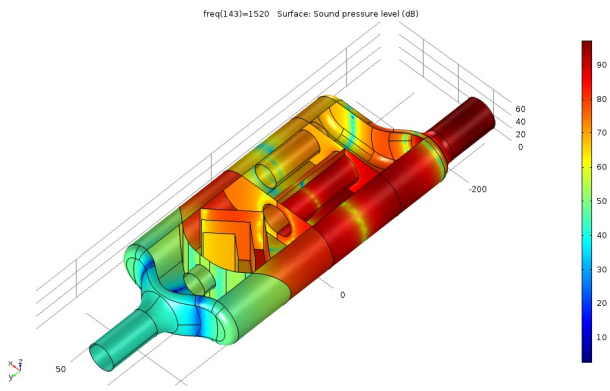


Figure 3: Surface plots of Sound Level.

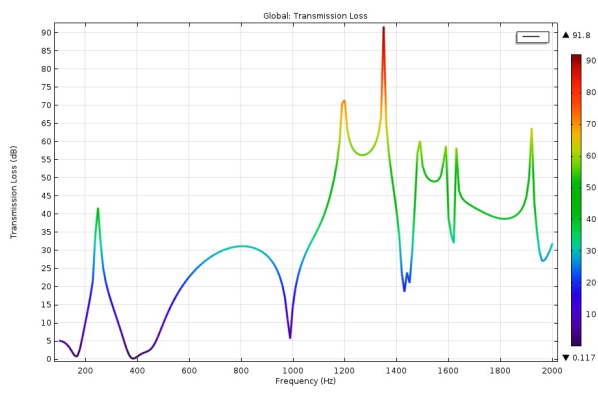


Figure 4: Results of Transmission Loss.