Optimization of Sound Pressure Level of Air Intake System by using GT-Power

Vishal Vaidya, P. P. Hujare

***Abstract*—This paper focuses on the use of GT Power software for optimizing the sound pressure level (SPL) of an air intake system. There are different ways for optimizing the sound pressure level and that can be explored by using the capabilities of the GT Power software. One of the ways for sound pressure level reduction is with increase in transmission loss. This papers talk about the resonator size determination to reduce the SPL. To determine exact volume calculation GT-Power software is used.**

***Index Terms*— Air intake system, Resonator, GT Power Acoustics Simulation**

I. INTRODUCTION

The intake system of an engine has three main functions. Its first and most identifiable function is to provide a method of filtering the air to ensure that the engine receives clean air free of debris. Two other characteristics that are of importance to the engineers designing the intake system are its flow and acoustic performance. The flow efficiency of the intake system has a direct impact on the power of the engine is able to deliver. The acoustic performance is important because Government regulations dictate the maximum noise level that vehicles can make during a pass-by noise test. The speed of air generated by the intake system can be a significant contributor to this pass-by noise and separated flow. So to know about the acoustics performance of the system advanced simulation technique to be used. In today's scenario there are different softwares that can provide this kind of services. Recent advances in modeling and accurate performance prediction has led to the use of simulation methods for resonator calculation in commercial design. Resonator design needs simple, fast and accurate modeling tools, especially in the preliminary design evaluation stages. A resonator can be an effective acoustic attenuation device at low frequencies.

II. GT-SUITE

GT-SUITE is an integrated set of computer-aided Engineering (CAE) tools developed by Gamma Technologies, Inc. for design and analysis of engines, power trains and vehicles. These tools are contained in a single executable form which is essential to its use in "Integrated Simulations". GT- SUITE comprised of six solvers (GT-Power, GT-Drive, GTVtrain, GT-Cool, GT-Fuel, and GT-Crank), a model-building interface (GT-ISE), a powerful post-processing package.

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(GTPOST), and a collection of supporting tools. GT-ISE provides the user with the graphical user interface (GUI) that is used to build models as well as the means to run all GT-SUITE applications.

III. GT POWER

GT-Power is the industry-standard engine simulation tool, used by all leading engine and vehicle manufacturers and their suppliers. It is also used for ship and power-generation engines, small two and four stroke engines and racing engines. It provides the user with many components to model any advanced concept. Among its advantages is its ease of use and its tight integration with the rest of GT-SUITE, which give GT-Power a "virtual engine "perspective".

GT-POWER provides many advanced capabilities in the area of acoustic modeling, including:

- Microphone model for predicting noise radiated from intake/exhaust opening
- Intuitive, 3-D CAD based preprocessor for importing, cleaning, and meshing
- complex geometries found in mufflers, molded air boxes, and irregular plenums
- Four microphone transmission loss analysis
- Fast, linear analysis for rapid concept evaluation, standard nonlinear analysis for final concept validation
- Advanced post-processing for easy creation of Campbell diagrams, order cuts, etc.
- Audio output generation for subjective sound quality assessments.

In an acoustics simulation GT Power can have a different microphone positioning as per the requirement and can also adjust the ground level

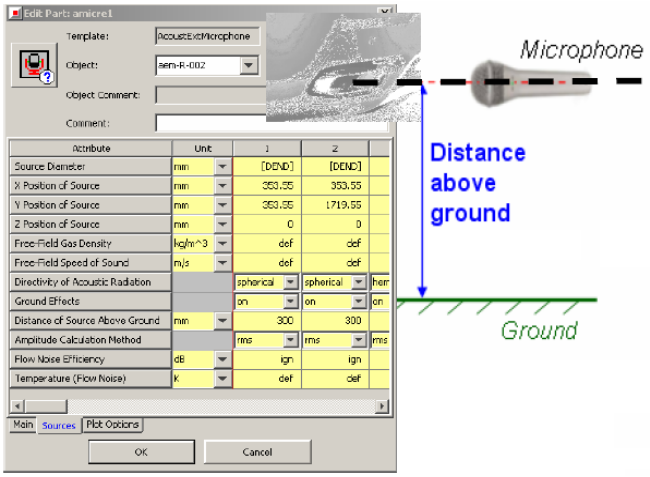

Fig. No. 1 Micro phone settings in GT Power

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There are some different Microphone settings are available in the GT power with some standard and customized values. These settings are as below. Microphone distance (customer specification's)
- With ground effects
- Directivity of acoustic radiation: spherical
- Maximum microphone frequency: 1000 Hz

IV. ACOUSTICS SIMULATION

In acoustics simulation phase, first 3D CAD model is converted in to the 1D model by using Gem 3D software and 1D model is prepared for the simulation in GT Power. Acoustics simulation has been done for the different order of the engines like 2nd and 4th order and as well for the low frequency and high frequency.3D model used for the simulation purpose is provided in the .stp format for the preparation of the 1D model and to build it for the execution.

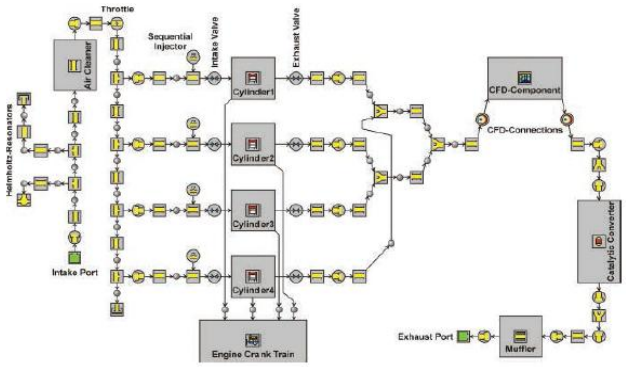

Fig. No. 2 Model Prepared in GT-Power

The drag and drop method is used to copy all the listed templates/objects of from the object tree. If the listed template/object is not inside the example object tree, it could be copied from template library. Modeling is started from pipe parts of air induction process. First of all, the pipe from inlet (intake part) to air cleaner will be modeled. Next, throttle part is modeled. It covers from air cleaner intake site to throttle, which is located in front of the surge tank. After intake manifold, engine is modeled.

V. BASLINE CONFIGURATION RESULT

At the start, baseline configuration is checked for the performance of transmission loss at different frequencies.

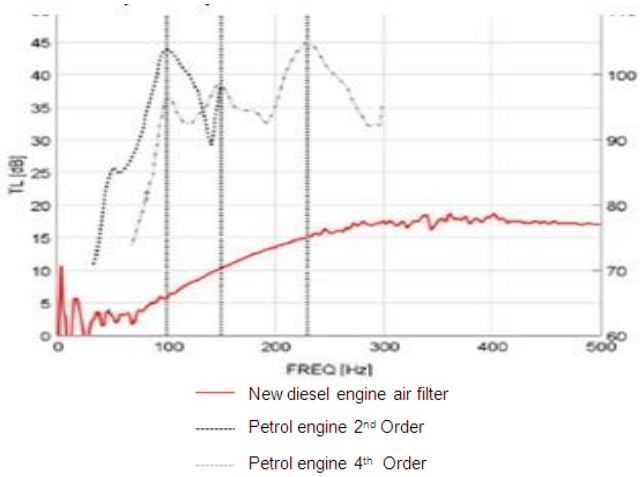

Fig. No. 3 Simulation Result

Above shown results are achieved and in this Petrol vehicle 2nd and 4th order TL details show peaks at the frequency of 100Hz and 230 Hz. There is no transmission loss in the air filter box to reduce the sound pressure level so need further design modifications to increase the transmission loss (TL)

VI. INTRODUCTION OF RESONATOR

A resonator simply works by oscillating some frequencies and in turn generating waves of precise frequencies. Resonators are commonly used in 'muffing' the sound from exhausts of vehicles. The oscillations made by the resonator are called resonant frequencies. An intake resonator chamber is located inside the passenger side fender-well. The resonator chamber is basically a muffler designed to reduce the intake noise by reducing the sound pressure level. However, it also restricts intake airflow. The intake noise is normally induced by firing of engine. Especially, the intake noise is enlarged by acoustic resonance at certain frequencies due to the length of intake system. To attenuate the acoustic resonance of the intake system at certain frequency, adoption of Helmholtz type resonator is popular.

VII. RESONATOR VOLUME CALCULATION

As discussed above there are two frequencies 100Hz and 230 Hz to be considered for further acoustics analysis and TL optimization. With reference to this simulation has been done to calculate the resonator volume required at the desired frequencies. As GT power simulation has calculated the resonator volume required for the targeted frequencies so subsequently CAD model of this calculated resonators are made and again this CAD model is again converted in to the 1D model for further simulation. GT power has calculated volume 0.5 liter for 100Hz frequency with the neck diameter of 25mm and length of the neck 260mm and for 230 Hz frequency calculated volume is 0.23 liter and diameter of neck is 23mm and length of the neck is 98mm. So for this new configuration again acoustics simulation is carried out and found the result as shown in below graph.

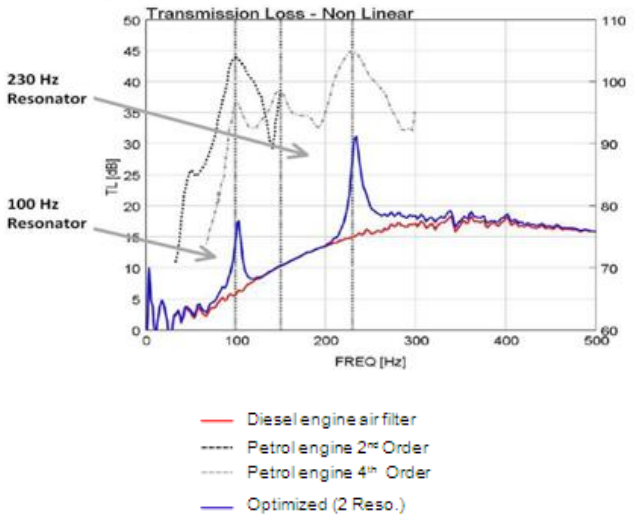

Fig. No. 4 Simulation Result with New configuration

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Addition of the resonator has shown the drastically improvement in the transmission loss (TL) at the 100Hz and 230 Hz frequency and also shows the same trend as of the petrol vehicle test result. But after considering this transmission loss, sound pressure level in dBA to be identified for the baseline and new configuration of the air filter box with the two resonators. And it has to be check for the different operating conditions of the engine and hence in an acoustics simulation both configuration has been checked for the below mentioned conditions and the performance is compared. Below graph shows significant effect of the resonator on the overall sound pressure level of an air intake system at following condition:

1. Total pulsation SPL,
2. 4th Harmonic dB (4 stroke, 2.0 order)
3. 8th Harmonic dB (4 stroke, 4.0 order)
4. 12th Harmonic dB (4 stroke,4.0 order

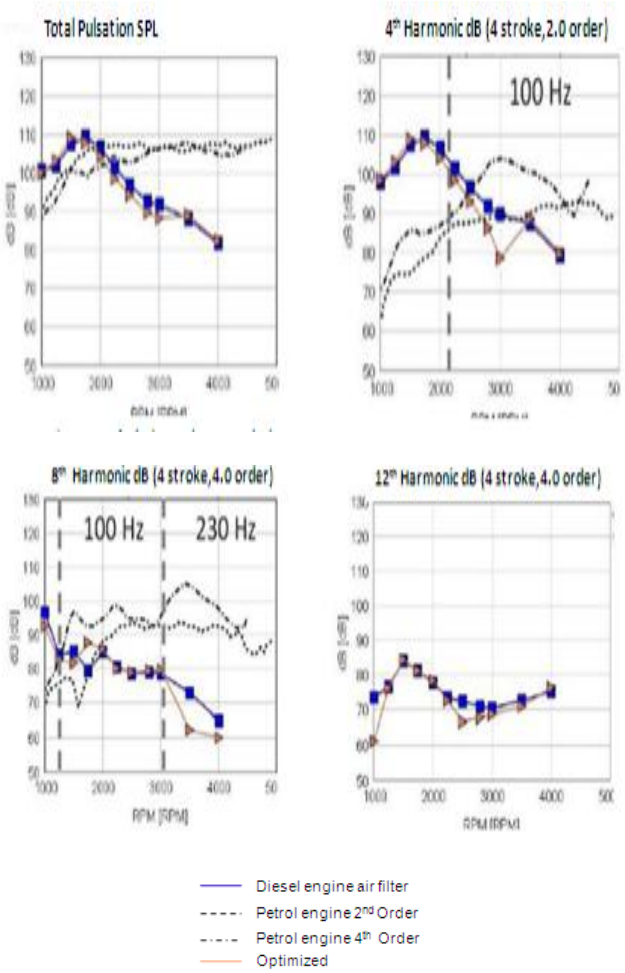

Fig. No. 5 Simulation Result at different engine speeds

At different engine order overall SPL of the new concept is low than that of the concept1 and at low frequency performance of the concept 2 with the resonators is better than the existing configuration.

VIII. CONCLUSION

The GT-Power is very sophisticated simulation software to be used in designing the automobile intake and exhaust system for acoustics performance. GT power helps in finding out the different possible ways to meet the desired target with providing the most accurate result. Resonator is having a significant effect on the transmission loss inside an air intake system and increase in transmission loss will reduce the overall sound pressure level.

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