

# Vibro-Acoustic Analysis of Motorcycle Engine Under Combustion Load

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## Abstract

Noise radiated from automotive engine is gaining significance in order to meet regulations concerning noise levels and to fulfill customer demands of quiet products. In IC engines, combustion pressure is one of the major excitations which is transmitted through powertrain to the casings and radiates noise. Structural and acoustical modeling and simulation methods can be used to predict and control engine NVH performance at the product development phase. Early identification and correction of the critical areas of structure contributing to noise will lead to substantial cost and developmental time reduction of new products.

Using COMSOL Multiphysics® software, acoustic radiation of IC engine under combustion forces has been predicted.

This study is divided into three stages:

1. Multi Body Dynamic (MBD) simulation to determine excitation forces.
2. Vibration analysis of engine under combustion load.
3. Acoustic analysis of engine to predict Sound Pressure Level (SPL). Analysis has been carried out using single cylinder engine of a motorcycle.

MBD simulation is carried out at a specified operating condition to determine forces. Forces obtained from MBD simulation are used as input to the FE model to carry out vibration analysis of engine.

COMSOL Multiphysics® is used to carry out acoustic analysis of engine. Nodal accelerations obtained from vibration analysis are used as an input to carry out acoustic analysis. These results are interpolated by COMSOL and applied to outer skin of engine. Perfectly Matched Layer (PML) is modeled to surround the engine skin. Far field calculation feature is used to determine pressure outside PML. SPL is predicted at a distance of 1 meter from the engine for desired frequency range.

In this method, nodal acceleration input was taken from the external '.csv' file format. This process has to be repeated at each frequency step (~40 steps) hence, process automation is carried out using Java script.

Far field SPL is calculated for each frequency at 1m location for the two sides (Left and Right) of engine as shown in Figure 1. Frequency Vs SPL plot is used to identify the critical frequencies at which SPL is higher. 3D surface SPL plot (Figure 2) of engine at critical frequencies obtained through the acoustic simulation are studied. It helped to identify the critical

locations on engine responsible for high SPL. It also helped to take corrective action for SPL reduction. Results obtained from acoustic analysis are compared with test results.

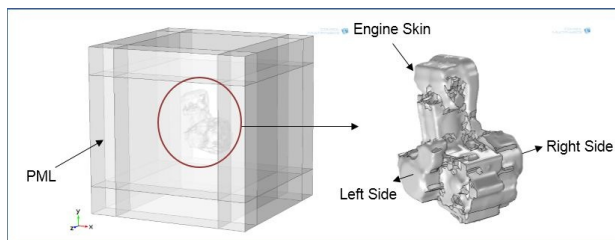
### Conclusion

In the present work, acoustic radiation analysis of engine under combustion load using COMSOL Multiphysics® has been carried out. This methodology can be used in product development phase to identify areas of engine structure critical for noise radiation. Corrective actions by carrying out structural modifications can be implemented based on analysis results in early design stage. Thus it helps to reduce time and cost involved in product development.

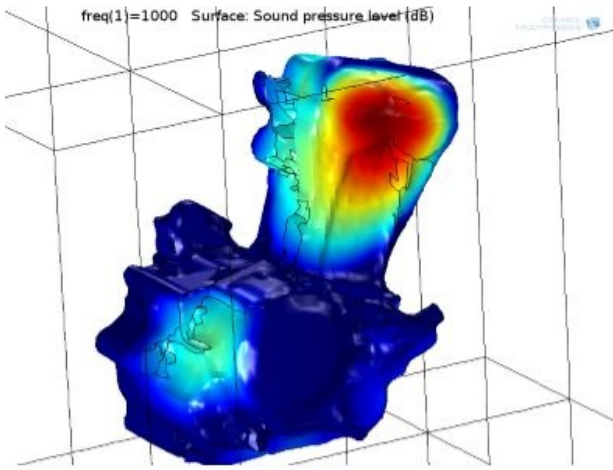
## Reference

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## Figures used in the abstract



**Figure 1:** Mesh and nomenclature for engine acoustic analysis.



**Figure 2:** Surface SPL plot.