Prediction and Control of Motorcycle Engine Noise Under Combustion Load

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Abstract

Engine is a major source of noise in a motorcycle. In engines there are many sources of noise such as intake, exhaust, piston slap, gear whine, valve train and combustion noise etc. The combustion noise is produced by a rapid rise of pressure, which is responsible for engine structural vibration. Combustion induced vibrations are transferred from the power train to engine casings through bearings and radiate noise.

The Acoustic Module within COMSOL Multiphysics® is used to carry out the acoustic analysis of engine [1]. Figure 1 shows the mesh used to carry out acoustic analysis of engine. Engine skin (outer surface of engine) is extracted from the FE model. Engine skin is located inside a computational domain defined by a Cartesian perfectly matched layer (PML). In order to provide the sufficient resolution of the waves, computational mesh size is used in such a way that it satisfies the criteria of minimum of 6 elements per wavelength [2]. Swept mesh containing 6 elements is used for the PML to dampen the outgoing waves optimally.

Engine surface acceleration obtained from the vibration analysis is used as input for the acoustic analysis in COMSOL Multiphysics. These nodal accelerations were then interpolated using Interpolation function available in COMSOL, to map it as per the engine skin mesh data. 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. Figure 2 shows the interpolation of surface acceleration. Far field calculations are used to determine SPL outside PML.

Results: Far field SPL is calculated for each frequency using COMSOL Multiphysics. Frequency Vs SPL plot is used to identify the critical frequencies at which SPL is higher. 3D surface SPL plot of engine at critical frequencies obtained through the acoustic simulation are studied and compared with the test results. It helped to identify the critical locations on engine responsible for high SPL. It also helped to take corrective action for SPL reduction.

Conclusion: Acoustic analysis of engine can be used in product development phase to identify critical areas of engine structure 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.
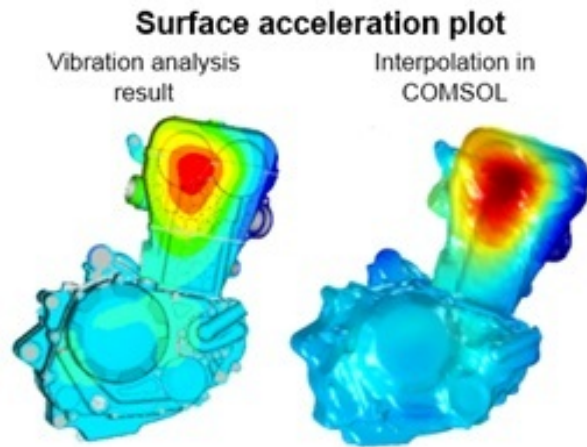
Reference

1.U.Mohite, et.al. ,"An Approach for Prediction of Motorcycle Engine Noise under Combustion Load," SAE Technical Paper 2015-01-2244, 2015, doi:10.4271/2015-01-2244.
2.COMSOL Multiphysics Documentation, Acoustic Module User's guide.

Figures used in the abstract
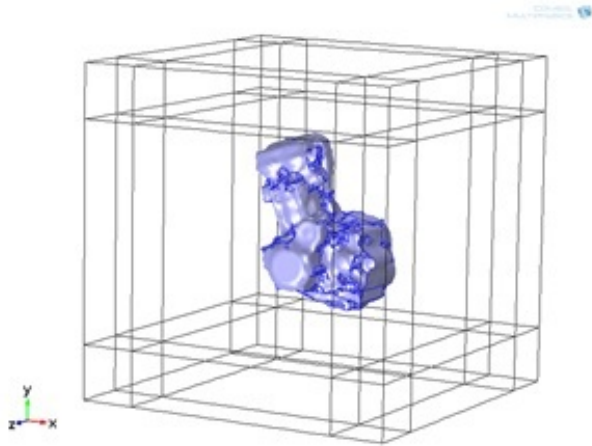
Figure 1: Mesh for Acoustic Analysis.

Figure 2: Surface Acceleration Plot.