INTEGRATED DYNAMIC ENGINE SIMULATION FOR AUTOMOTIVE NOISE & VIBRATION PREDICTIONS

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ABSTRACT

With the increasing demand in the automotive market place for more fuel efficient and powerful engines, understanding the Noise Vibration and Harshness (NVH) characteristics of a powertrain and being able to influence the engine design during the concept and prototype phase becomes more essential for the automotive OEMs, when trying to reduce the overall product development time. In the last decade automotive OEMs tried to find/define/develop methods to be able to analyze the NVH system behavior of the complete powertrain. The focus on accurate vibro-acoustic predictions has been critical in order to deliver the refinement in sound quality and smoothness customers expect.

This paper will showcase the integration of various CAE tools to predict vibrations and sound pressure levels for a complete V6 engine system under various load conditions. The new methodology consists of a fully coupled simulation which can model flexible bodies of the rotating cranktrain, valvetrain and cam-drive, all interacting with each other as well as their supporting flexible engine structure. The coupled system dynamic modelling is critical in order to fully the system dynamic interactions that could adversely affect NVH. The prediction includes engine vibration at various locations as well as engine sound pressure levels at the 1-meter microphone locations, as defined by the SAE J1074 standard.

The CAE tools involved in this process are:

- Finite-Element (FE) code, to account for the compliance and frequency characteristics of the individual powerplant components (engine + transmission + mounts).
- Multi-Body-Dynamics (MBD) code to model the non-linear system behavior and its moving components and to provide the surface velocities.

- Boundary-Element (BEM) code to predict the radiated noise spectrum and sound pressure levels, based on the provided surface velocities.

The process starts at the component and sub-assembly levels. Test data are used to ensure the accuracy of the dynamics and the required refinement of the models. An example of a subsystem model is the single valve, which involves by itself 4 components and has its own complex solution and NVH behavior. The single valve model is then used in a complete valve train model together with the camshaft to capture the dynamics of this subsystem. The combination of the complete valvetrain models with the timing drive (in this case a set of three silent chains) constitutes the coupled cam drive/valvetrain system. This system is then assembled with the bottom-end model and the non-moving components of the powertrain, represented as a flexible body, on its hydro and rubber mounts.

The analyses are performed at constant engine speeds; this allows minimizing the analysis runtime and efficiently handles the huge amount of analysis data. The generated surface velocities of the powertrain are used to compute the engine radiated noise using the BEM method.

This presentation will also showcase the CAE to test correlation obtained using this new process.