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Optimizing fuel systems for noise and vibration

LMS Engineering services balance fuel-system noise with emissions performance

Benefits

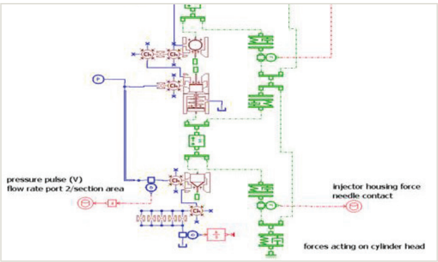
- Troubleshoot the root causes of fuel-system noise using test and simulation methods
- Provide coherent NVH and performance feedback on scalable solutions for engine-performance and controls engineers
- Deploy virtual verification methods to front load the analysis of noise phenomena before a prototype is produced
- Deploy a full-technology transfer and enable customers to independently implement test and simulation techniques to avoid NVH issues in the fuel system

Summary

LMS™ Engineering services diagnose the root causes behind fuel-system noise and vibration problems. By means of a combined test and simulation approach, a set of countermeasures are examined and implemented. Solutions are specifically designed to balance fuel system noise, vibration and harshness (NVH) performance with fuel-emissions concerns.

Automotive original equipment manufacturers (OEMs) need to comply with increasingly demanding emissions regulations. The most effective way to reduce carbon dioxide (CO_2) levels per kilometer is to produce a cleaner combustion engine. This can be achieved by increasing the pressure to 2,500 bar during the fuel injection procedure. By doing so, it atomizes fuel into minuscule particles that can be accurately directed to produce a clean combustion process. As a consequence of implementing such a system, often a persistent high-frequency noise (frequently referred to as a kind of tick) emanates from the injection system during engine operation.

LMS Engineering experts can deploy a fast and straightforward procedure to meet the diverging requirements of suppliers and OEMs. By combining know-how and application knowledge, the LMS Engineering team can effectively acquire data and accurately model and identify appropriate countermeasures to offer tailored solutions to its customers.

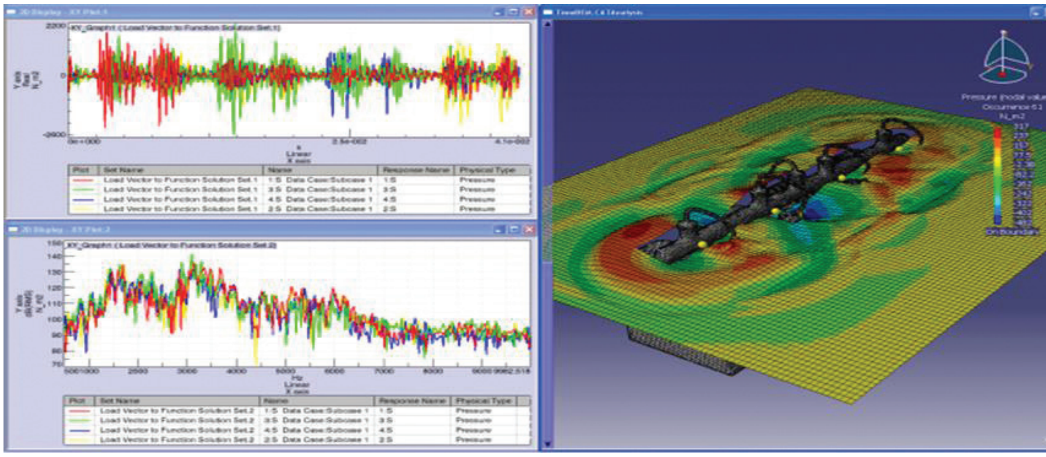


1D model of a piezo fuel injector.

Optimizing fuel systems for noise and vibration

A typical fuel system NVH optimization project is comprised of the following stages:

Root-cause analysis
An accurate diagnosis of the NVH issue calls for detailed measurements that trace the respective sources. Additional data is acquired, such as control signals (usually involving a voltage signal), pressure inside the system, noise and vibration at all points and revolutions-per-minute (RPM) dynamics on the pump. This data allows validation of the models that will be developed in the next phase. Finally, overall forces generated within and upon all involved components are determined.



3D acoustical model and time-domain analysis.

Modeling
To accurately model the noise-generation mechanism of the fuel system, a single simulation environment is often not adequate. Hence, hydraulic performance and control models require a 1D simulation platform, whereas structural-acoustical models call for a 3D approach. The 1D virtual model is used to generate and replicate the forces that will be applied to the 3D vibro-acoustic model. The latter will provide a thorough understanding of the vibration transfer throughout the structure of the fuel system, and the acoustic radiation that results from it. The 1D and 3D models are coupled so the resulting responses are correlated and validated at multi-levels by means of frequency- and time-domain analysis. The combination of simulation tools effectively provides insight into the relationship between injector activation peaks and subsequent high-frequency sound pressure responses.

Countermeasures
Based on these models, the fuel system design engineers can evaluate system sensitivities and propose a set of countermeasures. The LMS 1D models also offer OEMs and suppliers detailed and accurate information relating to emissions performance so countermeasures for NVH can be virtually cross-checked against the effect on emissions performance before accepting them. As such, engineers can carefully balance conflicting requirements so they can optimize design decisions for future fuel systems. When the required modifications have been verified in the model, they can be implemented in prototype form on the engine and retested to validate the countermeasures.

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