Delphi Diesel Systems
Going green with innovative diesel fuel injection systems

Product
LMS

Business challenges
Offer “greener” injection systems solutions
Reduce vehicles’ environmental impact
Develop reliable products

Key to success
Optimize the design of injector nozzles
Reduce the number of costly, time-consuming physical tests
Exchange models among internal teams and customers

Results
Maximized simulation predictability
Improved collaboration internally and externally
Significantly reduced testing, costs and time-to-market
Delivered high-fidelity fuel injection system models per customer requirements
Advanced brand attributes: sustainable development and reduced impact on the environment

New rules of the game: tighter emission standards and shorter time-to-market
Vehicle emission regulations are becoming more and more stringent. For example, the Euro 6 emission standards will go into effect in 2014 and original equipment manufacturers (OEMs) will continue to face tough environmental regulations throughout the world. This also affects automotive suppliers, who must adopt a “greener” approach, reducing pollutant emissions while increasing fuel economy.

Delphi Diesel Systems (Delphi) designs, manufactures and assembles diesel fuel injection systems and components (including injectors, fuel pumps, rails, fuel filters and engine control units), and develops control strategies. Diesel injector design is one of the core competencies of the Delphi technical research and development (R&D) center, located in Blois, France and employing about 700 R&D specialists.

This R&D center must operate under the new rules of the game on the worldwide auto market. To meet emission requirements, it is vital to optimize combustion, which requires accurate control of the quantity of fuel injected into the combust-
tion chamber. In addition, the design of the injector nozzle affects the mechanical durability of the injector and the performance of the whole engine. Injection systems optimization wouldn't be possible without simulation, because of the high cost of physical parts needed for tests. Moreover, the time required for physical testing would result in a huge amount of data to manage and analyze, making it impossible to meet the company's time-to-market goals.

Modeling of the injector nozzle using LMS Amesim

Delphi started using Siemens PLM Software's LMS Imagine.Lab Amesim™ software for the injector simulation several years ago. The company chose this multi-domain system simulation platform because of its extensive libraries of components representing elementary physical phenomena, which can be assembled in complex system models. Moreover, using the control validation functionality of LMS Amesim enabled

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the Delphi solenoid injector simulation service to supply models to the injection systems team that is in charge of system control strategies development. Today, Delphi is actively using the LMS Imagine.Lab automotive package, and in particular the hydraulic component design, hydraulic resistance, thermal and control libraries.

To precisely control the amount of injected fuel, Delphi engineers created a supercomponent, enabling them to represent injector functioning within a temperature range from -40 to +120 degrees celsius (C) and a pressure range from 80 to 2000 bars, as accurately and realistically as possible. Delphi studied different geometries of the nozzle seat. To guide the flow during the full lift, an untruncated needle is often used for low-flow injectors, whereas a truncated one is used for high-flow injectors to reduce pressure losses. Delphi started looking for a solution that would allow its engineers to model these complex hydraulics phenomena and maximize simulation predictability.

The solution came from the use of LMS Amesim. Delphi decided to adapt the LMS Amesim poppet with the conical seat component to narrow the specific application. This LMS Amesim component enables engineers to model pressure losses at the truncation, seat and sac entry levels. To optimize the use of the LMS Amesim component, Delphi engineers carried out computational fluid dynamics (CFD) nozzle analyses.

From the flow versus lift and force versus lift curves obtained, the engineers found that the force applied on the nozzle was less linear in the case of the truncated needle. They then compared results obtained using the LMS Amesim component and CFD.

The correlation between force-lift curves, especially for the truncated needle, was not adequate. So Delphi used CFD to understand flow phenomena and used the results to adjust parameters of the super-component, which took into account the restriction between the needle and the nozzle. This allowed Delphi to optimize force modeling in accordance with the lift, without affecting the flow-lift curve.

Streamlined, collaborative and green
The above method enables Delphi to keep central processing unit (CPU) time short. The use of CFD results, in conjunction with LMS Amesim modeling, enables Delphi to analyze one injection point in less than 30 seconds. The entire injector mapping process (40 working conditions) now takes about 15 minutes.
In addition, the use of LMS Amesim enables the injection systems team to supply OEMs with “black box” models with restricted access to sensitive model parameters and reduced CPU time, but with enough data to understand the exact amount of fuel injected.

Today, the main brand attributes of Delphi diesel products are sustainable development and reduced impact on the environment. Injection systems optimization projects underpin this approach. More accurate injectors enable Delphi to limit fuel consumption as well as reduce energy supplied to the system and, as a result, reduce each vehicle's carbon dioxide (CO₂) emissions impact. Moreover, LMS Amesim is a key factor in improving sustainability.

The success of the LMS Amesim roll-out has Delphi interested in LMS Imagine.Lab™ Sysdm software, a collaborative solution for model and data management. This would enable the solenoid injector simulation and injection systems teams to easily share their models, capitalize on different versions and optimize the organization’s system simulation process.

“Model-based systems engineering is truly our future,” says Vincent Pichon, solenoid injector simulation manager at the Delphi technical R&D center. “Simulation is the way forward. It enables us to study as many injector architecture choices as possible, with different parameters and test conditions. LMS Amesim is an ideal tool for this. Allowing for model exchange internally as well as with Delphi’s customers, LMS Amesim meets our needs well.”

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