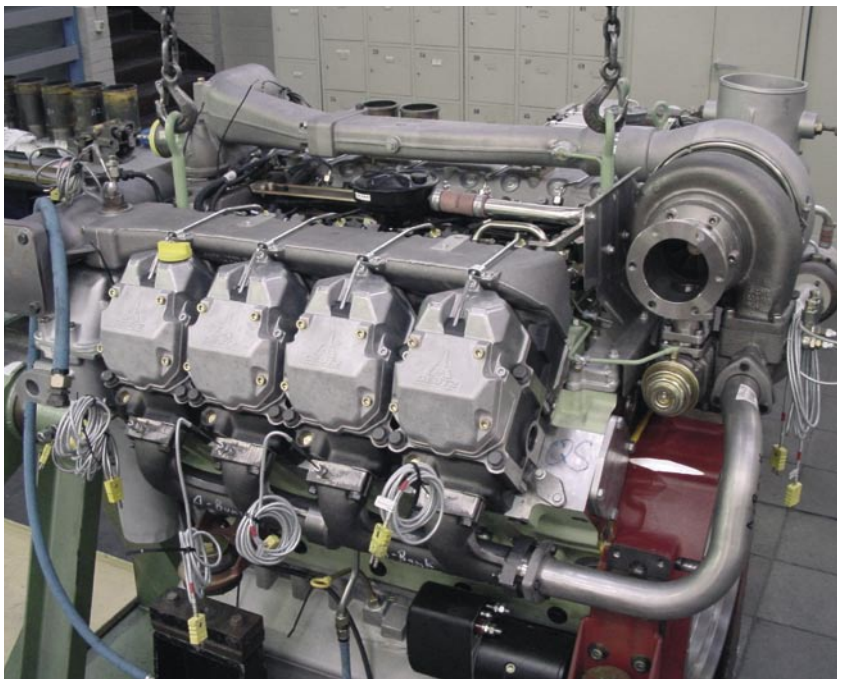
Dynamic Models for Deutz Diesel Power

- **Deutz release tests for diesel engine ECUs**
- **HIL test system based on dSPACE Simulator and ASM Diesel Engine Simulation Package**
- **Fast variant handling by dynamic models**

Deutz AG is relying on a test system based on dSPACE Simulator to run release tests on diesel engine electronic control units (ECUs). The hardware-in-the-loop (HIL) simulator works with the new ASM Diesel Engine Simulation Package. Optimum economy of the HIL test system was ensured by fast ECU variant handling and test automation. The model parameters can be accessed directly during run time for fast reparameterization, resulting in efficient ECU testing.

Engines from Deutz AG supply the segments for stationary and mobile machinery, agricultural technology, power generation, automotives, and marine technology. Products cover a broad range of 4-15 liter diesel engines with between 4 and 8 cylinders, and outputs from 64 to 500 kW. Some engines are also customized to meet requirements. The end result is an enormous number of engine variants and application versions in ECU software. The software is usually developed by the supplier of the engine ECU. As a rule, calibration and testing can be carried out on test benches and also in on-site trials. Deutz now supplement their testing procedures with hardware-in-the-loop (HIL) test systems



▲ *The Deutz TCD2015 V8 4V weighs approx. 1280 kg and has a maximum torque of 3050 Nm.*

Diesel Engine Model

The Deutz HIL system can run four ECUs from different suppliers, including controllers for the pump-nozzle, pump-line-nozzle, and common-rail injection systems.

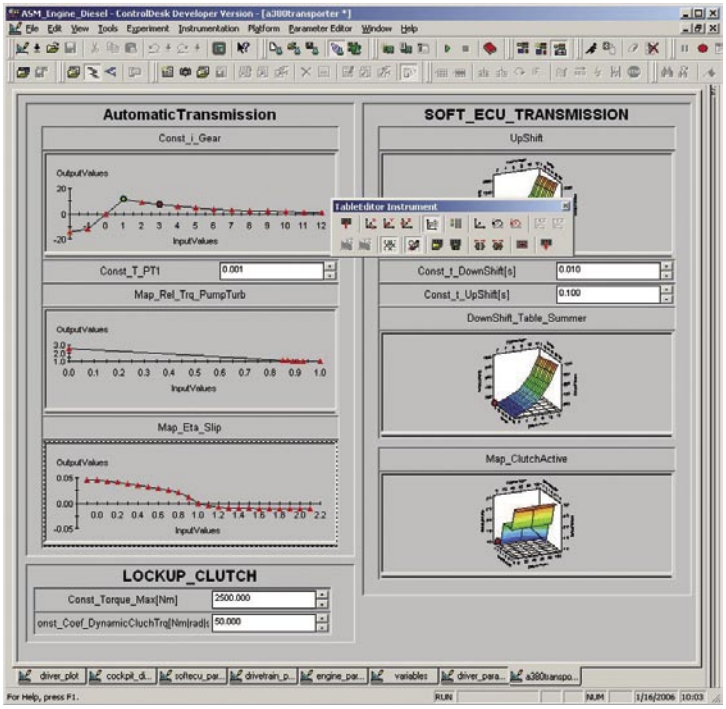
> *"With its flexible, fast configuration, the ASM Diesel Engine Model enables us to cover all our engine variants with a single model, and to switch back and forth between the variants very fast."*
> *Mark Zimmermann*

dSPACE developed an engine model which supports switching back and forth between the three injection systems, parameterization, and simulation.
The dSPACE ASM Diesel Engine Simulation Package contains not only the engine model, but also a transmission model and a simple vehicle dynamics model. All model parts are open, and can be extended easily and quickly to fit Deutz-specific engine variants. For example, the Viscotronic fan model with varying hysteresis curves, a rail pressure leak model with a mechanical pressure relief valve, and several different turbochargers were integrated into the model. In addition, the drivetrain model includes a test bench environment for simulating towing and sudden load variations as if they were on real test benches. This makes it possible to compare measurements on test bench engines with those from HIL simulation.

Preparameterizing the ECU Software

One special application for the HIL system is preparameterization of ECU software components that

cannot be parameterized on the Deutz test benches (cruise control, fan, speed control). Preparameterization via HIL helps to ensure that on-site commissioning runs smoothly. One example is the aircraft tractor for the A380. A speed control had to be prepared and tested for this, holding a maximum speed of 25 km/h, both without load (50 t) and with full load (500 t). Because we could calibrate the model's parameters online, the following approach was sufficient to simulate operation with the aircraft attached, and ascertain the resulting acceleration, braking, and speed profiles: Using ControlDesk, the experiment software, the A380's starting weight of 500 tons is added to the tractor's mass of 50 tons. It is not necessary to reparameterize the model or to repeat code generation for it. The drivetrain components also have to be designed to achieve sufficient starting torque for this weight. This is easily done by selecting the characteristic of the torque converter and suitable transmission in ControlDesk. Testing the speed control in this way was enough to come to a qualifying decision on whether the software version is suitable for further study in the actual vehicle.



▲ *ControlDesk provides direct access to important model parameters during run time. The screenshot shows the transmission settings and the torque converter features.*

Test Automation

Deutz developed its own test automation system on the basis of dSPACE AutomationDesk. The individual automation steps are stored as Python scripts, and the test cases are parameterized via Excel reference lists. There are already about 1100 test cases, which run overnight for up to 11 hours. Test automation and model simulation processes have to be completely stable for this. Some test cases require particularly precise model behavior, so the model has to be generally of a very high quality. One example is a stable and stationary working point as a function of rail pressure, load, and loading air pressure, which in some test cases must not leave a tightly defined range.

Practical Benefits

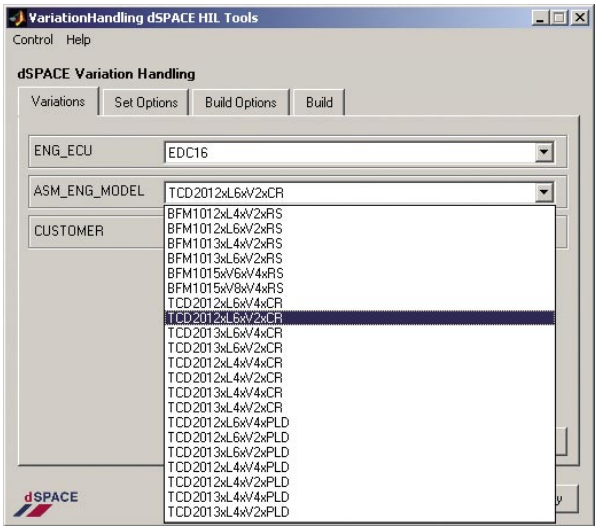
The Deutz HIL system operates almost to capacity, and Deutz AG benefits greatly from obtaining test results quickly. The system's main areas of use are in the software development process and in the automatic release of various data sets. Test automation enabled us to immediately find errors in new software that had just been supplied – including errors which would have resulted in damage to a real engine. HIL tests have also prevented damage to real engines in the development of new data sets. Compared with a real test bench, the Deutz HIL simulator has the advantage that all the ECUs' inputs and outputs can be measured, and different engine variants, with

▲ *Specially developed for giants like the A380 Airbus, the towbarless AST-1X aircraft tractor from Goldhofer has two Deutz diesel engines.*

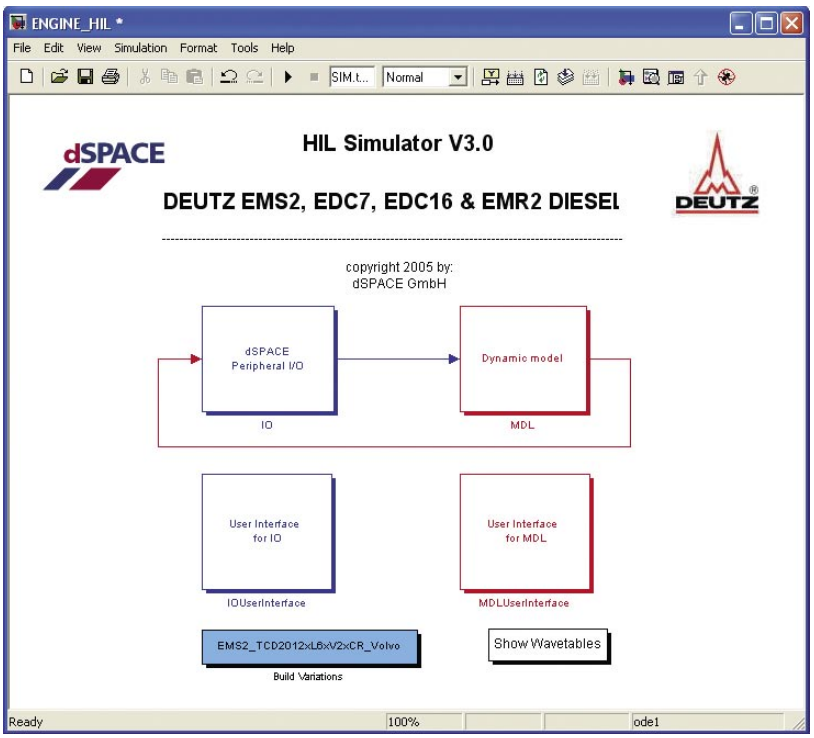
individual drivetrain characteristics, can be set. Moreover, the Deutz HIL system can simulate ideal load variations that would not be possible with the electrical test bench brakes. These are all optimum conditions for ECU testing. From the point of view of cost, an HIL simulator consumes only electricity, so several thousand liters of diesel are saved in the release process.

Conclusion

dSPACE provided Deutz AG with a robust engine model. Easy-to-use engine variant management simplifies the handling of the approx. 50 engine models and customer applications. The interfaces to the model and to the hardware make it easy to interact with test automation. Test automation reduces the workload that would be needed for manual tests on new software. At current estimates, the 1100 reproducible test cases save 4 man weeks. Preparameterization via HIL improves and speeds up the commissioning of engines for on-site trials. HIL simulation has become a firm fixture in our release process for data sets and software. With its broad range of practical applications, the Deutz HIL system quickly proved its value.



▲ *The variant management feature allows the 50 engine configurations to be switched in and out quickly and easily.*



▲ *The open ASM Diesel Engine Model can be viewed in Simulink, right down to block diagram level.*

Outlook

Deutz will increase the proportion of software tests run via test automation, to reduce the number of tests still performed manually. The data set release processes and new ECUs will be added to the test automation system. Deutz aims to extend and adapt the system for model-based bypass function development.

Mark Zimmermann
Development Engineer Engine Electronics
Electronics – Advance Development
Deutz AG
Germany

Glossary

Variant handling – Tool-supported process for switching between the parameter sets and configurations of the test system software

Calibration – Tuning the ECU software