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Balance of power

As the auto industry embraces the EV movement, what does the future hold for transmission pioneers?

SHOCK AND AWE

Developing a DCT for the most powerful Ferrari ever was a major technical challenge for engineers

ALIVE AND SHIFTING

The game's far from over for manuals and automatics, says Peugeot Citroën's powertrain chief, Christian Chapelle

HOME TRUTHS

Ford's head of transmissions, Chuck Gray, on why it's crucial to retain R&D and production expertise in the USA

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Efficient TCU development

Integrating two industry leading software development packages enables AT controller developers to fully streamline their workflow when analyzing complex system behavior

Specialized CAE software packages are widespread throughout all aspects of the automotive industry. The benefits of engineering design and analysis in a virtual environment in order to realize advances in innovation and efficiency while reducing development time and associated costs are well established.

Over a number of years, Smart Manufacturing Technology (SMT) has developed MASTA to be a leading specialized software program used daily by engineers in automotive companies worldwide for the further design and analysis of transmissions and drivelines.

MASTA has a proven track record – from the design concept stage, through to analysis, optimization and manufacturing. MASTA is also useful in solving issues in existing designs that show up during testing, such as durability and NVH problems. Until recently, software packages, such as MASTA, have been limited to static, quasi-static and frequency domain dynamic analyses, which are sufficient to simulate many problems, but are not suitable for the analysis of any scenarios where the loading is highly dynamic or transient. Such scenarios include engine dynamics and gear rattle.

New forms of analysis

New functionality developed by SMT, called DRIVA, extends MASTA into the time domain by including a flexible multibody dynamics analysis mode that can be used to solve these remaining transient problems via an existing MASTA model.

A case study introduced later in this paper focuses on the use of DRIVA in the development of a transmission control unit (TCU) for an automatic transmission. In the development of a TCU, a detailed mechanical model of the transmission is required within the plant model. The plant model and controller code are commonly developed in Mathworks Simulink. Because of this, the mechanical model is often built within Simulink as well. However, when designing and optimizing the transmission, CAE software, such as MASTA, is usually used, resulting in a duplication of work – two separate models have to be built in two separate software programs for the two separate tasks. As such, it is important that the two models are kept in sync, which is not easy to do with two separate programs.

In addition to this, general-purpose software, such as Simulink, is not optimized for creating a mechanical transmission model, so this is often a time-consuming and error-prone process for engineers.

In order to significantly improve the workflow for the engineer, to reduce the time required for modeling and to reduce possible errors, DRIVA offers a Simulink interface that removes the need for two separate mechanical models of the transmission. The transmission engineers and the controller engineers can use the same model, ensuring maximum integration.

The DRIVA-Simulink interface makes all important inputs to the DRIVA model available, including throttle, clutch pressures and applied torques. Any result that can be logged within DRIVA can also be returned as an output via the interface. These include, for example, shaft speeds, mesh torques and oil temperature.

As well as removing the need to create two transmission models, a mechanical model in DRIVA has many advantages over one built into general-purpose products, such as Simulink. In MASTA, the design engineer defines the transmission model in terms of the geometry of the shafts, gears and bearing. DRIVA then creates the simulation model automatically, based on the level of detail required, which can be defined on a per load case basis without creating a new model. For a simple, fast simulation, it is possible to treat all shafts as rigid and ignore effects such as gear backlash. However, in a different load case it is possible to include the full six-degree-of-freedom flexibility of all shafts, fully non-linear bearings and variable mesh stiffness due to the backlash and tooth passing.

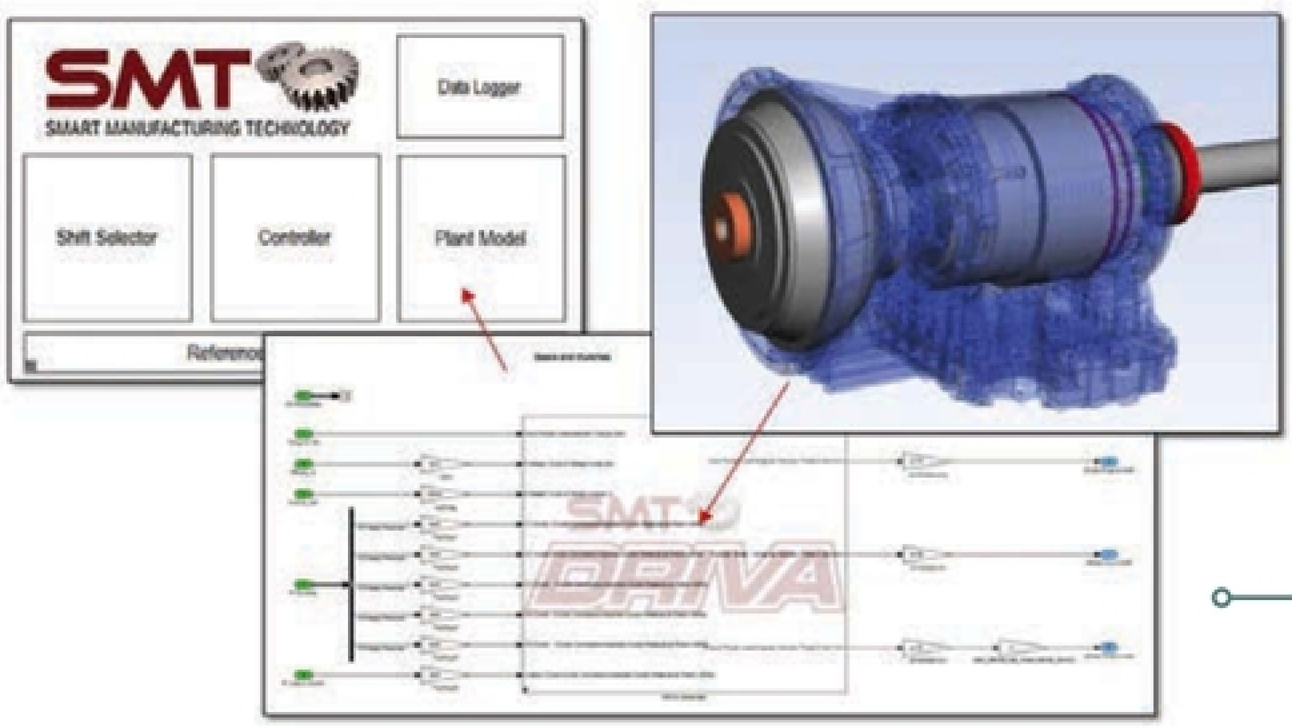
Depending on the development stage, a highly detailed model may not be required. For this reason, two levels of detail are offered in the DRIVA-Simulink interface. The basic Simulink block represents the transmission as an inertia and ratio. This model is suited to the development of shift strategy and fault case behavior in the TCU. The advanced Simulink block is used when the full power of DRIVA is necessary for the analysis of shift quality where the flexibility of the drivetrain is important.

DRIVA also makes full use of the component analysis technology built into MASTA, which includes calculations not found in other commercially available software. For example, bearings and gears can be rated to the major standards as a result of the dynamic loading.

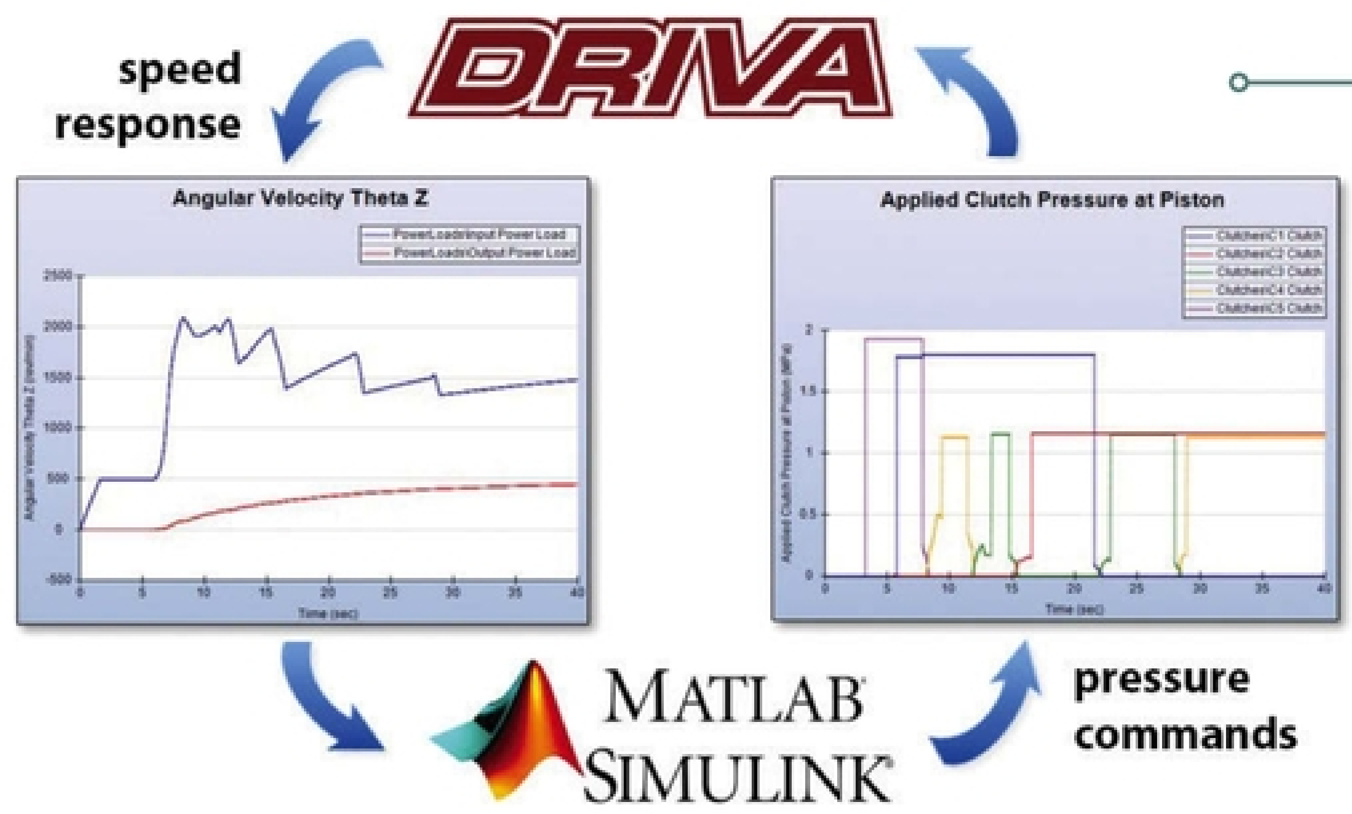
As well as the standard gearbox components, DRIVA includes specialized components found within automotive transmissions, including torque converters, multiplate clutches and vehicle models. Oil temperature changes during clutch and torque converter operation are also calculated and can be taken into account in the friction coefficient of the clutch.

Case study of a 6-speed AT

The case study of a 6-speed AT illustrates some of the possibilities of the DRIVA-Simulink interface. A Simulink model is used to represent the entire system – consisting of the TCU and plant model, which itself typically includes several major subsystems: engine, hydraulics, transmission, driveline and vehicle. The engine, transmission, driveline and vehicle form the mechanical part of the plant model, which



Embed the DRIVA advanced block within the Simulink plant model



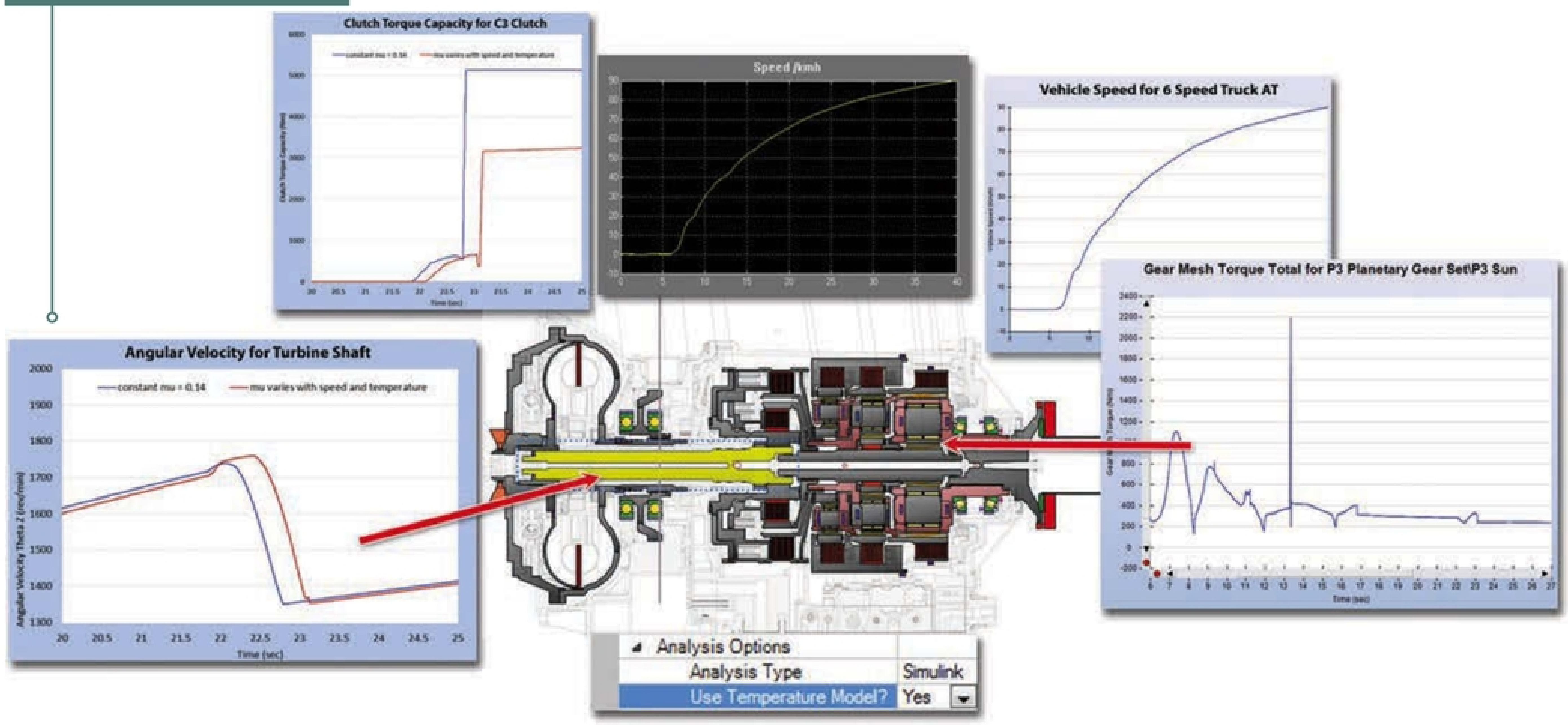
Co-simulation schematic showing data passed between DRIVA and Simulink packages

means that they can all be replaced with a single DRIVA model.

Full co-simulation between both Simulink and DRIVA is implemented by the advanced Simulink block. In DRIVA, the simulation was set up to apply full throttle to the engine and the Simulink controller, and it then used the engine and vehicle speed output to calculate the appropriate clutch pressures to pass back to DRIVA, performing gearshifts or locking up of the torque converter during acceleration. Detailed component results, such as the gear mesh torque, can be saved in DRIVA following the analysis, for later viewing or output in Simulink.

A second simulation was run, this time using a variable coefficient of friction for the clutch plates rather than the fixed value used initially. The variation of the coefficient of friction with both speed and temperature was input by using data published by Holgerson and Lundberg. When the results of the two simulations were compared, the effect of temperature variations on plate friction and torque capacity produced a noticeable change in turbine (input) shaft speed response during gearshifts. The results show the importance of considering changes in clutch plate temperature and its effect on torque capacity in maintaining good gearshift quality.

Using the advanced multibody analysis capabilities of DRIVA, combined with the DRIVA-Simulink interface, important, complex system behavior can be identified by transmission engineers and designers more quickly and easily through the use of simulation during the development of TCUs compared with other development routes. Not taking this into account can lead to inferior controller behavior and increased time spent during the testing phase, which then has a knock on effect in terms of cost. As such, this integrated technology allows for time to be saved while errors can be reduced by the use of software optimized for the further design and analysis of transmission models. ◎



Simulation results can be viewed in Simulink and DRIVA. Result shown for a fixed coefficient of friction compared with one varying with speed and temperature levels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