
Fuel consumption, exhaust emissions and other vehicle properties can be influenced by parameter settings and software algorithms alone. It is very easy to adjust a vehicle's handling adaptively to suit the requirements: comfortable and restrained for more leisurely driving or sporty and with reserves of power for more demanding drivers. To do this, all available signals are evaluated: wheel speed, accelerator pedal actuation, steering wheel movement, or the GPS location. Modern vehicles optimize their behavior according to the route selected, and they learn when the same route is driven again. It is no surprise, therefore, that these vehicles consume less fuel on a familiar test cycle than in real operation, and that opportunities to recognize test-stand operation are exploited.

Exhaust emissions and fuel consumption are subject to legal standards that are determined on test stands in accordance with the rules applicable. It is not yet clear where to draw the line to fraudulent behavior. A control program that executes different parameters on the test stand than on the road is obviously seen as fraudulent. But for adaptive systems, the decision is not so simple. The more complex the system is, the more unavoidable it is for a control unit to recognize test stand operation, as otherwise the engine would not run! A vehicle's behavior is dependent on the interaction between many parameters and systems: adaptive gear selection, intermediate energy storage, warm-up control, etc. For that reason, final acceptance should take place in the long term under everyday conditions as encountered on the road.

At the moment, a huge amount of effort is being focused on measuring exhaust composition and fuel consumption in real road tests and on finding out why they differ from those measured during test stand tests. However, it is also possible with relatively little effort to test the conformity of a real ECU in a virtual road test. All that is required is a Hardware-in-the-Loop (HiL) test stand and suitable simulation models. HiL test stands in which interconnected ECUs are tested in a laboratory set-up to verify their safe operation and diagnosis properties are already standard equipment today at OEMs and suppliers. Cycle simulation under conditions close to reality and with detailed representation of auxiliary units is part of everyday business in powertrain development, although the models in that case do not have to be real-time-capable.

By contrast, the engine simulation model needs to fulfill additional requirements. If it interacts with a real control unit, it must be able to depict fuel consumption or exhaust data depending on very complex control parameters, such as the injection timing or ignition angle. I am not aware of any program that can do this absolutely reliably in real time. However, the engine model included in TESIS DYNAware fulfills all the requirements for making at least quantitative statements on exhaust composition. The cyclic process calculation in enDYNA Thermo is fed with engine analyses or complex, multidimensional calculations, thus enabling the pressure curve and temperature in the cylinder to be calculated dependent on control variables in real time via the crank angle. The pressure and temperature curves are important input data for the subsequent calculation of the exhaust characteristic values. For the DYNA4 simulation framework, TESIS DYNAware supplies several packets in which the virtual vehicle can be configured in detail: vehicle dynamics, powertrain, on-board power system. Customers with their own component models can integrate these as an FMU or on a Simulink level.

The "Virtual Conformity Test" is an application that can be used to acquire data on Real Driving Emissions in a virtual vehicle. This has become increasingly important due to recent events and is still in the process of development. The models of the DYNA4 product family include the components necessary for achieving this.