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Simulation of the Thermal Management System with a Comprehensive Vehicle Simulation Model

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Modern vehicles have to fulfil the market requirements in consideration of the driving comfort and enjoyment, the safety systems, the fuel consumption and the emissions. This was the reason therefore that in the past the simulation of vehicle subsystems like engine, power train and cooling system gained more and more importance. The indicated manifold market requirements and the tight coupling of subsystems have rendered the traditional subsystem-oriented development process ineffective in meeting the actual challenges faced by the industry. The often divergence objectives of each subsystem causes that it is very difficult to find a global construction optimum against the requested boundary conditions which are set into the specification. Currently and in the future it is mandatory to keep the complex development process as short and cheap as possible. The demand for a comprehensive simulation model of a vehicle, which takes the interaction of the relevant subsystems into account, is indispensable.

One of the most significant subsystems in a vehicle is the cooling system, which executes influence to the other subsystems in a very strong way. It doesn't suffice to secure the engine form over-heating but it is also to realize to reach a warm engine condition within the warm-up-phase as fast as possible in order to reduce the fuel consumption and the mechanical wear of the bearings through a well working lubrication system.

Based on an example, the modeling of the cooling system and other relevant subsystems of the vehicle are shown. For the verification of the single subsystems experimental measurements on a vehicle dynamometer have been used. The comprehensive vehicle model is verified with the measurement data of a driving cycle on the vehicle test bench and on the experimental data of a road test. Key parameters such as coolant temperature, coolant mass flow through the radiator, fuel consumption and simulated energy distribution at discrete time points are compared between measurement and simulation, in order to assess the degree of achievable accuracy of the simulation model. The manually verification is of each single model is a long and expensive process. Therefore an automation of the model verification process leads to the goal to minimize costs and development time. A possibility to realize that will be given by the paper.