Abstract

Thermal Management is gaining more and more in importance in today's vehicle development process. The increasing power density and the standards of modern engines, the aspects of comfort and the limitation in installation space in the engine compartment are resulting in very complex strategies for the successful layout of the thermal management in the vehicle. Within an efficient development process the use of numerical simulation tools is more and more attractive and has become meanwhile even inevitable for minimizing not only emissions and fuel consumption but also for minimizing production efforts, times and costs.

The huge benefit of the application of simulation models is lying in the fact, that they can be used even at a very early stage of development, where prototypes or other experimental hardware are not yet available. Because of the complexity and the difficult interactions of the individual components, a better understanding for the thermal behavior of the whole thermal system can mostly only be gained by the employment of numerical sensitivity analyses, where it is possible to isolate only single parameters and study their influences on the entire system. The comprehension of these interrelationships is absolutely necessary for the development and optimization process of the thermal management.

According to the actual stage of the vehicle development process, appropriate numerical simulation tools of different level of detail are required. The range of these tools reaches from 0D-Models, describing the heat transfer only by characteristic maps, to 1D-Models, describing the thermal behavior within one-dimensional circuits, up to 3D-Models, which resolve fully three-dimensional effects. Anyway, these subsystems are thermodynamically coupled. With increasing level of detail not only an increase of quality but also the requirement of more precisely defined input data is implied. Therefore every stage within the development process requires the choice of the appropriate simulation tool, which has to meet the actual needs of assessment for design decisions and which has also to be adapted to the current availability of input data.

This paper describes a proposed methodology of the application and coupling of different numerical simulation tools in special respect to the vehicle development process. This procedure starts with simple concept studies performed by 1D tools, continues with more sophisticated coupled 1D-3D simulation tasks for the phase of detail design, until it finally reaches the highest degree of complexity with the analysis of control strategies of the thermal management. The latter investigations are based on a global vehicle model, which tries to integrate the single subsystems into one global thermal management system and therefore allows the examination of the interactions of its single components.