Flowmaster
Fluid thinking for systems engineers

Case Study

AVL GmbH

Added Value Through System Standardisation and Simplicity

System simulation with Flowmaster® V7 is an important component of the CAE-concept at AVL GmbH

"With Flowmaster we can work in a highly targeted way, right from the layout phase. We no longer have to make assumptions, but with numerical simulation programs we can determine realistic input data for the layout of water pumps and cooling systems based on project specific characteristics and empirical values from our validated CAE database."

Andreas Ennemoser, Manager CFD Analysis AVL in Graz

The Company

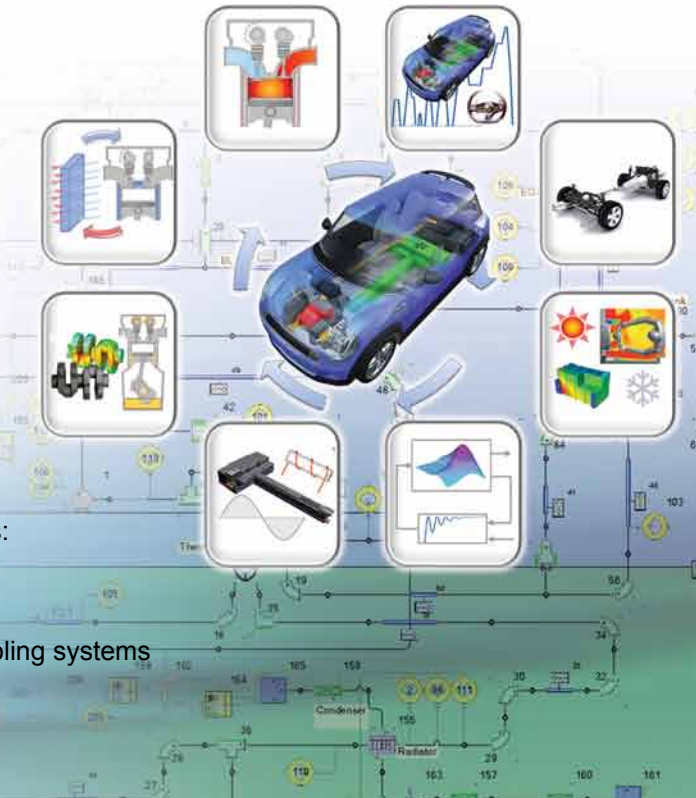
AVL is the world's largest privately owned company developing powertrain systems for internal combustion engines. AVL supports the Automotive industry with development across a full spectrum of powertrain systems including diesel engines, electric drives, alternative fuels, control software, transmissions and batteries. AVL boasts more than 60 years in the industry enabling them to offer highly creative, mature and application-specific solutions for customers to meet their future market challenges.

The company relies heavily on virtual simulation today and this is evident in the 300 projects each year that utilise simulation and calculation programs. Besides AVL-software tools (AVL Boost, Cruise, Excite and Fire) the engineers work with a number of third party programs including Abaqus, Nastran and Matlab /Simulink. For the simulation and analysis of complex systems (lubrication and coolant circuits) in their totality the engineers at AVL rely on Flowmaster V7.

Wide Variety of Tasks

AVL has been working with Flowmaster for more than seven years and have in that time built up a comprehensive expertise and extensive knowledge of the capabilities and application of the software. The program is used for many different tasks in all phases of the development process:

- Layout of water pumps
- Simulation of complete cooling systems
- Layout of oil circuits



- Simulation of the thermal management of the entire vehicle (incl. hybrid and Electric vehicles) with respect to fuel reduction measures in the cooling and oil circuits.

While a great portion of the incoming tasks, for example the layout of components and systems, can be performed with steady-state calculations, about 20 percent require transient simulation, for example the simulation of the entire vehicle for the prediction of fuel consumption and optimisation for different driving cycles (NEDC, FTP75, customer cycle (real life cycle)).

Andreas Ennemoser, manager CFD analysis at AVL in Graz and responsible for Flowmaster V7:

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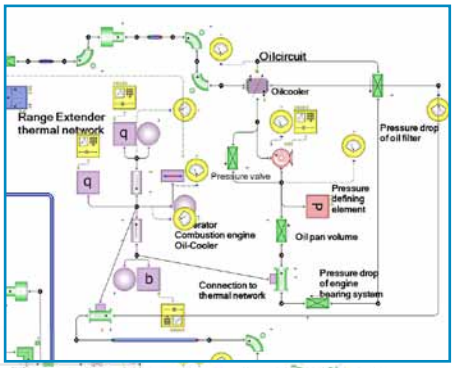
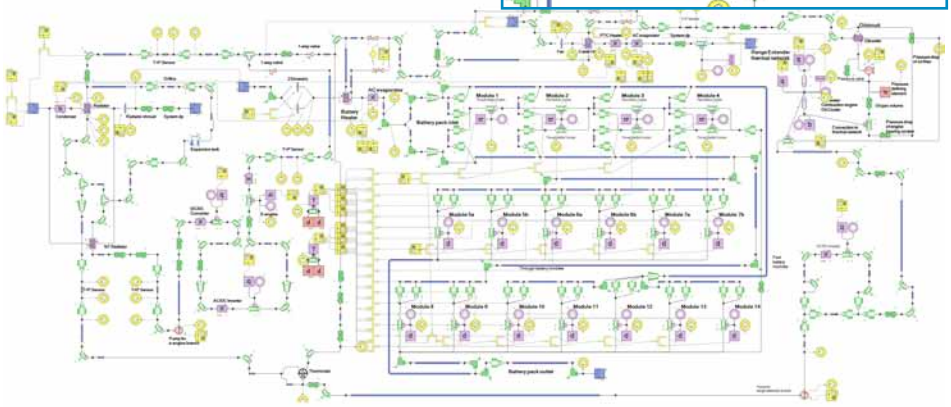
Realistic Initial Values Speed Up the Layout Process

The Flowmaster V7 simulation model is used to evaluate realistic input data for the layout of the water pump - based on project-specific characteristics and empirical values.

At the advance detail design stage the Flowmaster model is complemented by the evaluated pump characteristics and is continuously refined

The layout of the water pump is of critical importance to the dimensions of the entire cooling circuit and also to packaging considerations. The following simulation and optimisation of the cooling circuit demonstrates how different configurations can quickly be simulated and compared in Flowmaster V7.





Initially a Flowmaster simulation model is used to evaluate realistic input data for the layout of the water pump - based on project-specific characteristics and empirical values (e. g. pressure loss in the cooling jacket). At the advancing detail design stage the Flowmaster V7 model is complemented by the evaluated pump characteristics and is continuously refined (additional geometrical information,

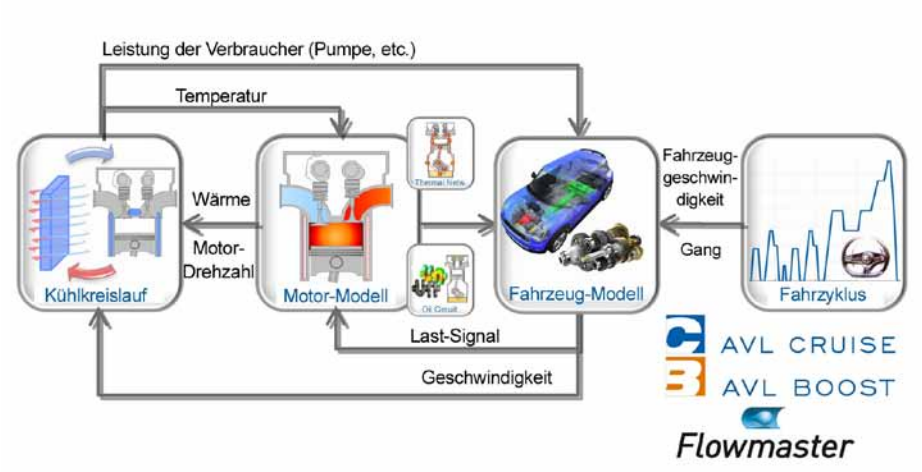
piping, etc). Finally, with data from the component suppliers, calculations under changing boundary conditions are processed and the system will be optimised to meet the target figure.

Physical tests haven't become obsolete in this scenario. In some instances certain losses only become noticeable in an installed state or in some instances designs are changed after the simulation process is completed, and in other instances component characteristics obtained from the suppliers do not always match the real behaviour. When the simulation model represents the test results within an acceptable accuracy margin then additional simulation based optimisation cycles are performed.

High Integration Capacity

The level of integration of Flowmaster V7 into a heterogeneous simulation environment allows for the prediction of the fuel consumption and pollutant emission.

The level of integration of Flowmaster V7 into a heterogeneous simulation environment allows for the prediction of the fuel consumption and pollutant emission. For this task AVL Cruise acts as the master-program and controls the bi-directionally coupled Flowmaster V7 by providing the boundary conditions and drive cycles on which the thermal simulation of all sub-systems is performed. This approach allows the comprehensive and efficient assessment of the effects of different optimisation measures on the total system. Operating strategies for the components of the cooling and oil circuit, like regulated thermostats, can then be designed with consideration of their impact on the fuel consumption and emissions.



Efficiency Needs Organisation

For the most efficient usage of CAE-programs AVL have developed a portal for calculation-engineers containing integrated data and a knowledge bank, this also has the ability for CAE-based component release. Five years after the project started the database-system is completely integrated into the development

process and has proven its worth.

Andreas Ennemoser:
"Because we have unified CAE task definition and execution, we could decrease the amount of non-value added activities by nearly 50 percent. Furthermore we could significantly intensify the re-use of existing simulation data."

About 230 calculations and testing tasks, including those within Flowmaster V7, are specified, described and stored in the iCAE. The browser-based database is accessible from all workplaces and perfectly integrated into the AVL development environment. CAD-Data (NX, Catia, Pro/Engineer) based on a bill of materials out of a PDM-system, project meta-data from SAP and engine-specific Data (AVL Engine-DB) can be processed.

Calculation engineers are supported by iCAE in the creation of the model and job structure, the job execution, the creation of documents and the editing and assessment of performance attributes. Even project managers and group leaders benefit from iCAE, because the system offers a complete overview of the project status at any time and provides support for the project definition, report release, management of performance attributes, time and quality management as well as the component release.

CAE-based Release Process

AVL assigns the system simulation with Flowmaster V7 a high significance. From comparatively simple resources Flowmaster V7 enables a quick and clear conception and analysis even of complex factual connections.

For a basic engine development up to 40 or 50 different calculation tasks can become necessary, with particular attention to the assessment of performance attributes and the target tracking in the CAE-process. As all calculations are stored in a structured and project-related manor, this data can be accessed even for new tasks and a benchmark database for components and systems can be created automatically. Currently engineers can choose between 4,000 attributes, sorted by functional aspects (emission, NVH, durability, etc). Queries, like for the typical pressure loss of a cooling jacket, are not only possible for the experienced engineer, but even an entrant can find the needed information just with a mouse click.

For the assessment of the new developments the results of older calculations - e. g. the maximum value for the temperature of the cylinder head - can be selected and compared with the results of the current project. A traffic light-function indicates if the assessment criteria were met or if a design change becomes necessary; only if all criteria, defined to be relevant for the development, are fulfilled a release in the frame of defined quality gates is possible.

Summary

The acceleration of the layout phase, the resultant quality and an increased transparency and understanding of relations and dependencies are some of the benefits of the numerical simulation of which Flowmaster V7 plays a key part. This backdrop provides AVL with greater flexibility and decreased risk in their development process.

AVL assigns the system simulation with Flowmaster V7 a high significance. From comparatively simple resources Flowmaster V7 enables a quick and clear conception and analysis even of complex factual connections. The tight integration into the iCAE-based CAE-concept, its high integration capacity and a modern and user friendly environment further strengthen these attributes.