Engine Simulation Environment Diesel
Combustion chamber design - easy, fast and reliable

Introduction
The AVL FIRE Engine Simulation Environment Diesel (FIRE ESE Diesel) is the first CFD simulation tool, which allows beginners, intermediate users and experts to set up, perform and analyse the injection and combustion process in Diesel engines reliably and accurately with minimum effort. Fulfilling combustion chamber analysis based on aerodynamics, injection and combustion simulation no longer requires highly specialized software users. AVL's FIRE ESE Diesel also opens the door to advanced CFD for designers, mechanical and testbed engineers, who previously could not handle such complex software.

The FIRE ESE Diesel is embedded in the AVL CFD Workflow Manager and utilizes many pre- and post-processing functions developed recently. It represents state-of-the-art technology in computational model creation, simulation set-up and result analysis. Suitable functions, sequences and processes have been automated and put

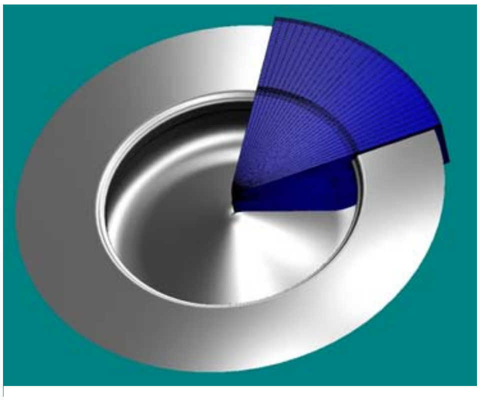

Figure 01: Diesel Engine Segment

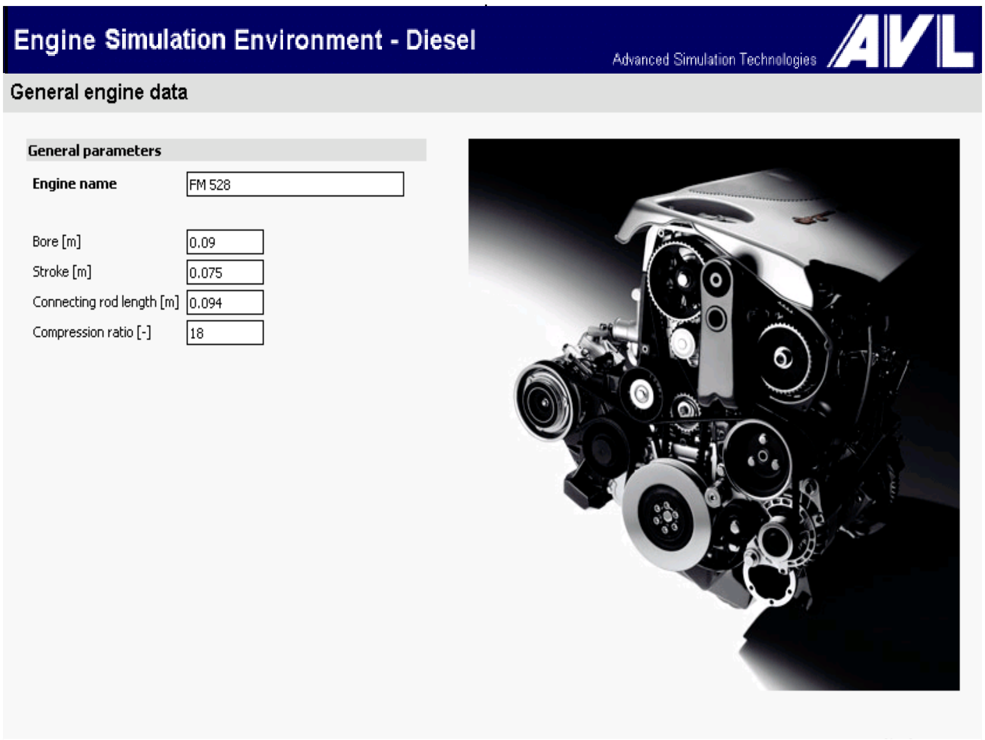

Figure 02: Graphical User Interface

together in a new linear workflow concept and then wrapped in a functional user interface. Thus the FIRE ESE Diesel sets new standards in the field of internal combustion engine simulation and analysis.

From sketch to analysis
The FIRE ESE Diesel can be started from the AVL CFD Workflow Manager.
Before creating a computational model the user must specify the main parameters of the engine to be analysed. The engine name is associated with all data, which will be created. Therefore analysing computational results and comparing them with those obtained for other engines is made easy.

A number of parameterised combustion chamber templates are available for the user to choose from, according to his requirements. Adjusting the parameters enables even users without any experience in handling CAD software, to describe the exact shape of the combustion chamber quickly.

If desired the shape of the injection nozzle can be integrated into the chamber description. The only additional requirement is the selection of an injector template and the adjustment of a few respective parameters.

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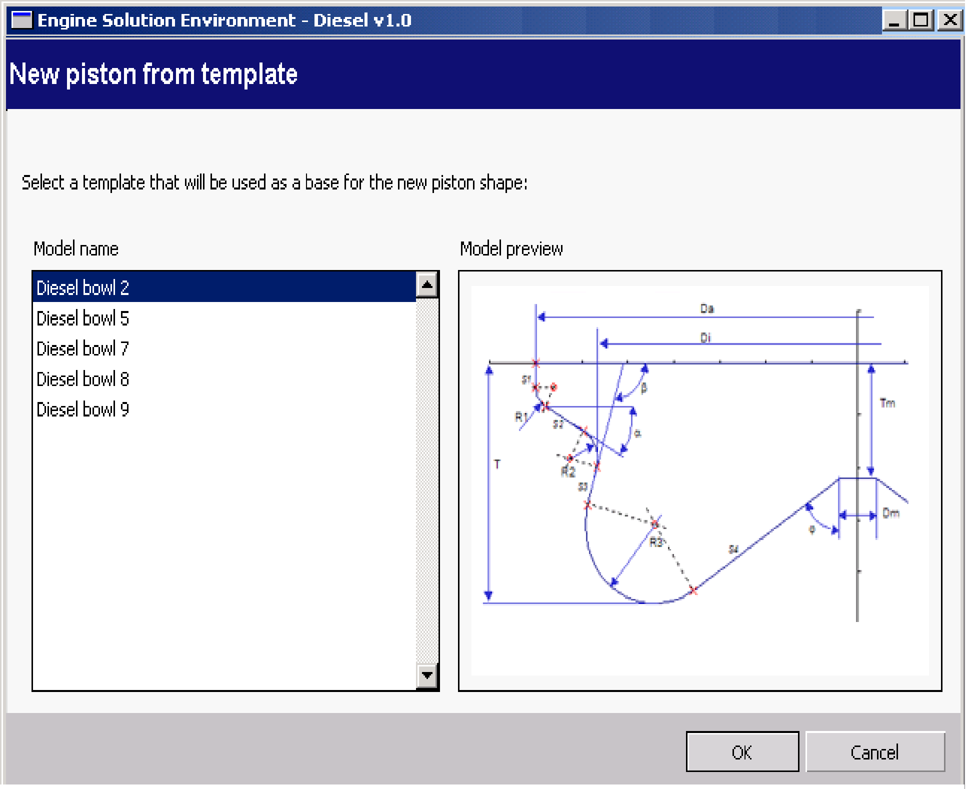

Figure 03: Template Selection

Creating a complete set of computational grids, necessary for performing the simulation of the fluid flow between intake valve closing and exhaust valve opening, only requires the specification of an average grid element size. Optionally a number of boundary layers with constant element thickness can be added to each of the computational grids. Furthermore a compensation volume located at the outer periphery of the squish area may be added to each grid. This volume compensates for the volume of geometrical details such as recessed or protruded valves, valve pockets and injectors, which are not considered in the parameterised description. In that way creating computational grids with a definitely correct compression ratio can be ensured.
A standard AVL FIRE project is created when the mesh is exported. Simulation parameters such as start and end crank angle including initial and boundary conditions are specified interactively via the user interface of the FIRE ESE Diesel. These data are copied to a standard simulation control file, which is then placed in the actual project directory. If required, simulation parameters can be adjusted using the Solver GUI of the AVL CFD Workflow Manager.
Using the AVL CFD Workflow Manager the simulation can be started in serial, SMP or MPI mode. This accesses all relevant software modules, physical and chemical models, such as turbulence models, models for gaseous and liquid fuel injection, combustion models and models calculating soot and NOx formation.

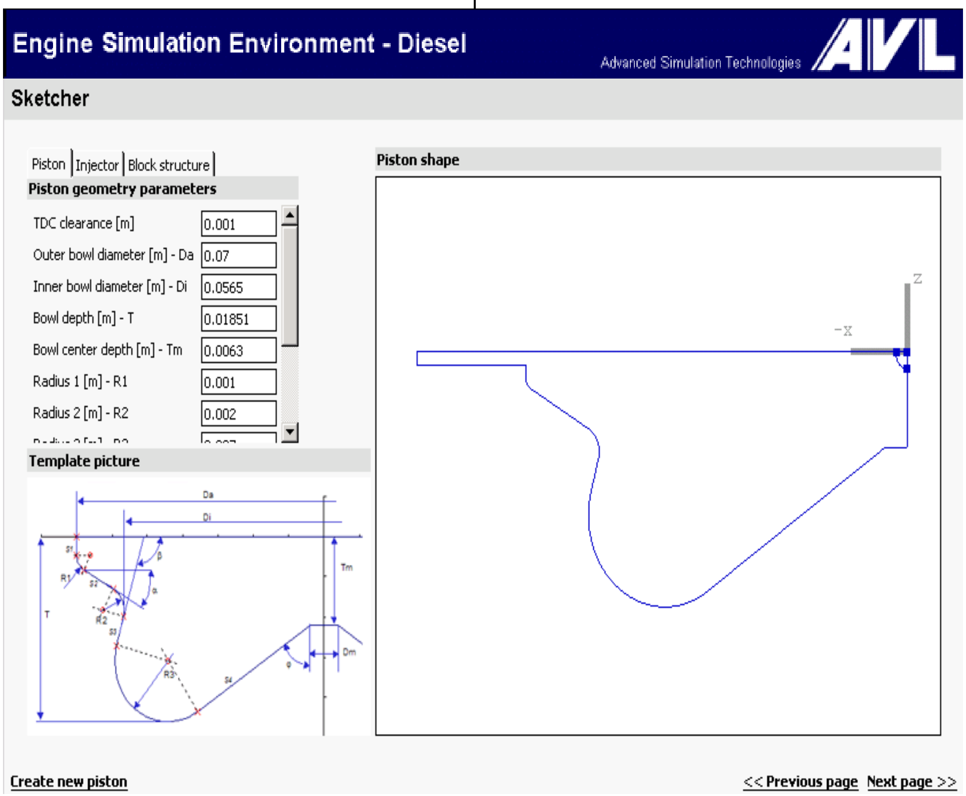

Figure 04: Parameter Adjustment

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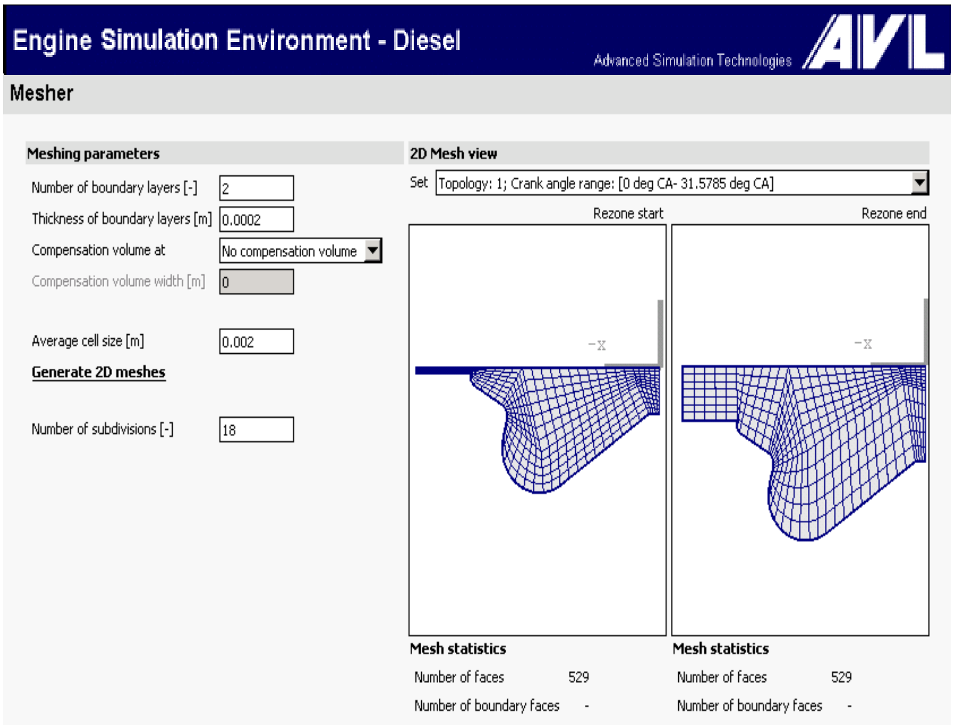

Figure 05: Grid Generation

Having completed the simulation of the fluid flow process, the analysis of the results can be performed by evaluating not only output such as fluid, spray and combustion quantities but also by looking at very engine specific quantities which are most commonly used by designers and testbed engineers. Including this unique analysis approach offers a full understanding of CFD simulation results for people less familiar with simulation as well as expert software users.

The FIRE ESE Diesel provides two-dimensional graphs to analyse the computational results.
In addition the integrated post-processor, can display computational results in two and three-dimensional coloured plots. Furthermore animations can be created to display the highly transient fluid flow phenomena which take place in internal combustion engines.

Set up and analysis of design variants

The parameterisation of the curves used as templates for combustion chamber and injector layout is the key to a fast set up of design variants and performing geometrical parameter studies. Furthermore the ability to handle parameterised curves is a precondition for connecting the FIRE ESE Diesel to optimisation tools like AVL CAMEO or iSIGHT.
To simplify the analysis of design variants, the FIRE ESE Diesel links the engine name, specified by the user when starting a new project, with the results of the simulation.
A database can be created as all two-dimensional results are stored in a common data location. The user can easily access and compare results obtained for design variations and similar engines.

Ease of use, reliability and accuracy

The FIRE ESE Diesel distinguishes itself from any other product of similar functionality in its ease of use, reliability and accuracy of simulation results.
Beginners of CFD simulation software may be concerned about usability. But with a strictly linear workflow based on parameterised curves, which requires only minimum user input, an easy-to-use software is presented. Needless to say this tool offers all the functionality from previous AVL FIRE solutions.
Causes for user errors are rare due to minimum user input in combination with the automation of processes. An extensive test phase ensures high quality software.
The FIRE ESE Diesel runs the simulation of the fluid flow in the internal combustion engine based on expertise collected in a pre-configured solver steering file.

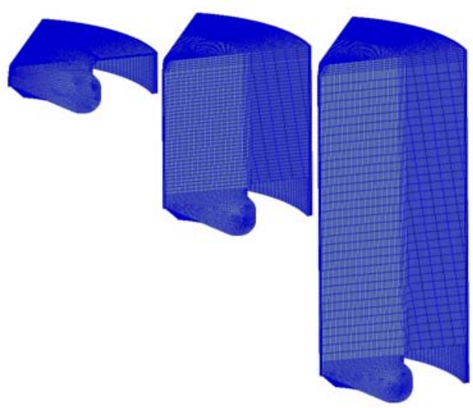

Figure 06: Engine Segment Model

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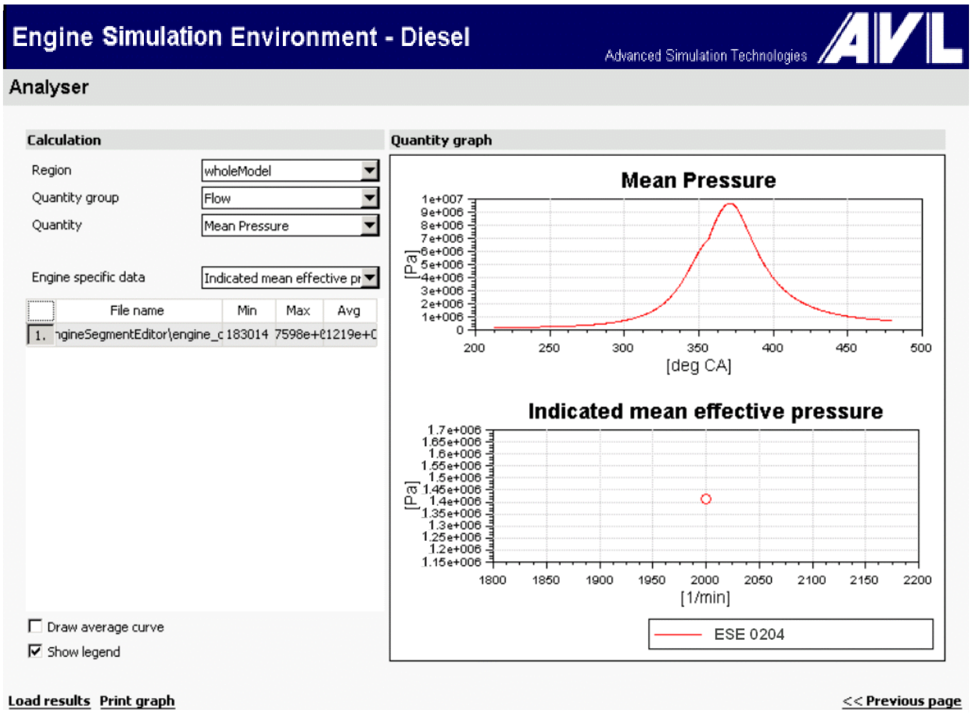

Figure 07: 2D Analyser

Only the FIRE main program and modules connected with it are accessed during the simulation. AVL software quality standards applied for FIRE are also valid for the FIRE ESE Diesel, thus ensuring the accuracy of the computational results.

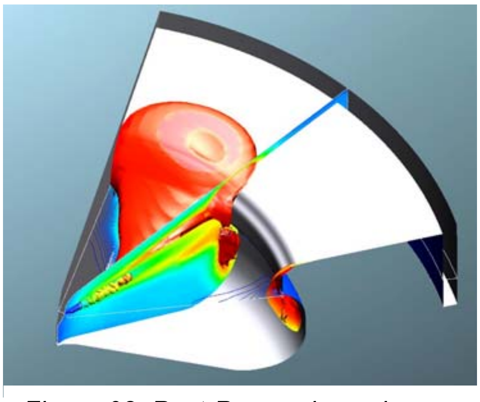

Figure 08: Post-Processing using AVL FIRE

Flexibility

A major pillar of the FIRE ESE Diesel is the use of parameterised templates for the geometry description.

Presently the tool allows the most common combustion chamber and injector layouts to be investigated. The template database can be increased without upgrading the installation of the FIRE ESE Diesel. AVL's CFD software support engineers can provide new templates on request or the user can generate his own.

Any new template can be integrated immediately into the FIRE ESE Diesel. It will then be accessible via the template-file selection dialog.

The user interface then configures itself according to the required input for this new template. Hence there is no difference in using templates provided with the FIRE ESE Diesel or those created by AVL's CFD software support or the user.

Summarized benefits

- linear workflow
- easy to understand and use
- maximum process reliability by running standard functions and processes without user interaction
- shortest possible turn-around times due to effective automation of pre- and post-processing tasks
- expert advice regarding simulation parameters using pre-configured simulation control files
- accuracy based on state-of-the-art solver and highly developed physical and chemical models
- high flexibility due to parameterised templates being the basis for geometry optimisation
- accessible to users of any level of experience in CFD simulation due to ease of use, reliability and accuracy
- no training required

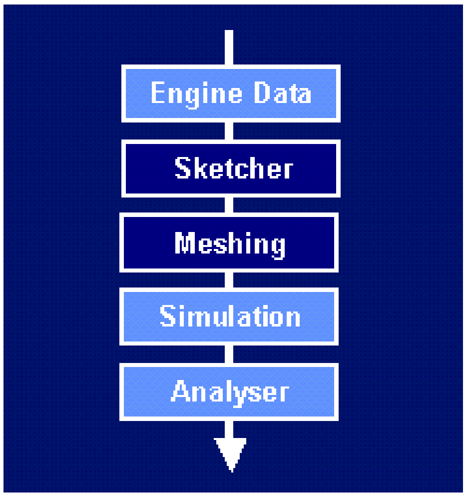

Figure 09: Linear Workflow Concept

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