Karlsruhe Institute of Technology

Division III – Mechanical and Electrical Engineering

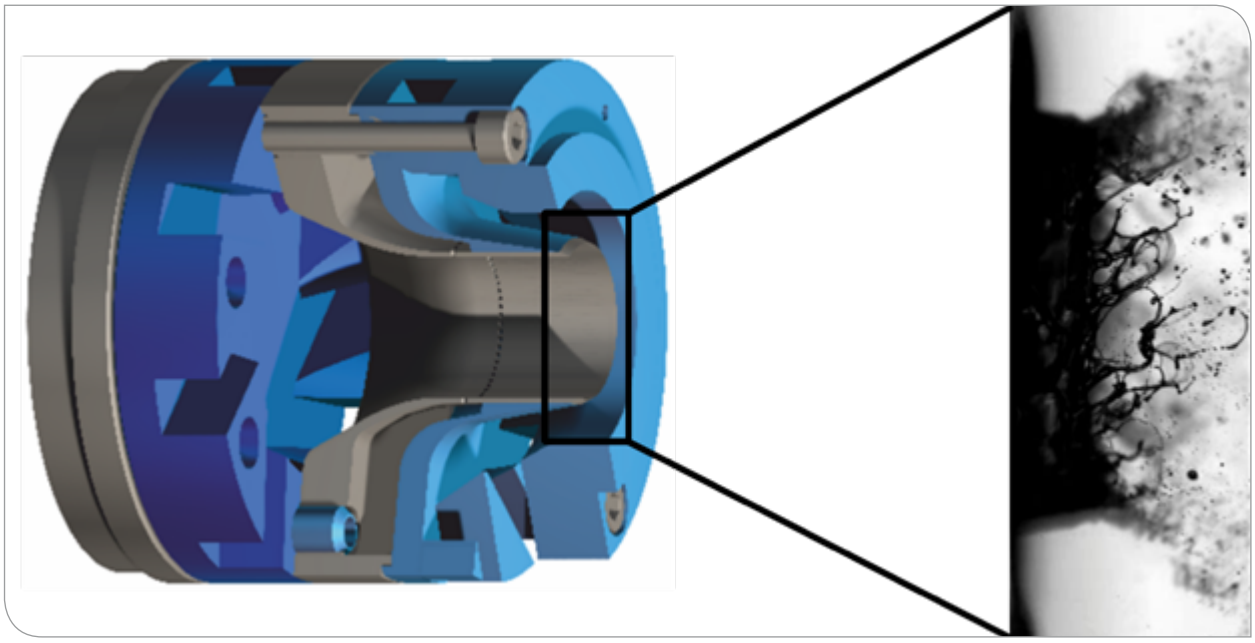
Institute of Thermal Turbomachines

Research 4.0: Virtual Atomizer Test Rig

Fully Digital Experiment

Fluid dynamics of liquids and gases play an important role for a number of technical processes. For example, the injection of gasoline or diesel into an internal combustion engine is of major importance for the formation of environmentally hazardous nitrogen oxides and soot. Consequently, engineers and product developers are constantly working on the optimization of the fluid dynamics of a multitude of technical applications. Computational fluid dynamics (CFD) software significantly supports the development and optimization of flow configurations. Currently, mostly grid-based simulation methods are used. These methods are characterized by representing the liquid and gaseous fluids as volume fractions inside the grid cells. In case of complex problems, such as fuel injection, the mesh has to be adapted and moved together with the liquid/gas interface, which causes a tremendous computational effort. When applied to complex multi-phase flows, this technology may reach its limits.

Scientists of KIT's Institute of Thermal Turbomachines (ITS) are pursuing a new approach. They have developed a numerical computation method based on smoothed particle hydrodynamics. The fluid, which may be a liquid, a gas or both of them, is subdivided into parcels, which are called particles. These particles move according to the laws of fluid mechanics. Realistic flow fields can be simulated by the movement and interaction of individual particles. With this mesh-free approach, complicated boundaries and interfaces that are subject to strong deformations can be handled easily. Based on this approach, a virtual test rig



Typical injection nozzle and photography of the atomization process

was developed, which includes all important steps of flow simulation, from pre-processing of the CAD data to computational fluid dynamics predictions and, finally, visualization in the post-processing step. Apart from conventional animations, the simulation data can be accessed via virtual reality devices giving the user the opportunity to view the temporal evolution of the flow from different perspectives and to interact with it.

Setup

- Software for the numerical prediction of multi-phase flows.
- Workflow for processing of CAD models for the computation.
- Post-processing tools for the analysis of fluid disintegration.
- Immersive, virtual reality for data analysis and interaction.

Goals

- Prediction of fluid disintegration.
- Analysis of atomization systems.
- Improvement of fuel injection into combustion systems.
- Development of design principles for liquid atomization systems.

Spray in the virtual test rig

Analysis using virtual reality

Karlsruhe Institute of Technology (KIT)
Institute of Thermal Turbomachines
Dr. Rainer Koch
Phone: +49 721 608-44249
Email: rainer.koch@kit.edu

Karlsruhe Institute of Technology (KIT) · President Professor Dr.-Ing. Holger Hanselka · Kaiserstraße 12 · 76131 Karlsruhe, Germany · www.kit.edu