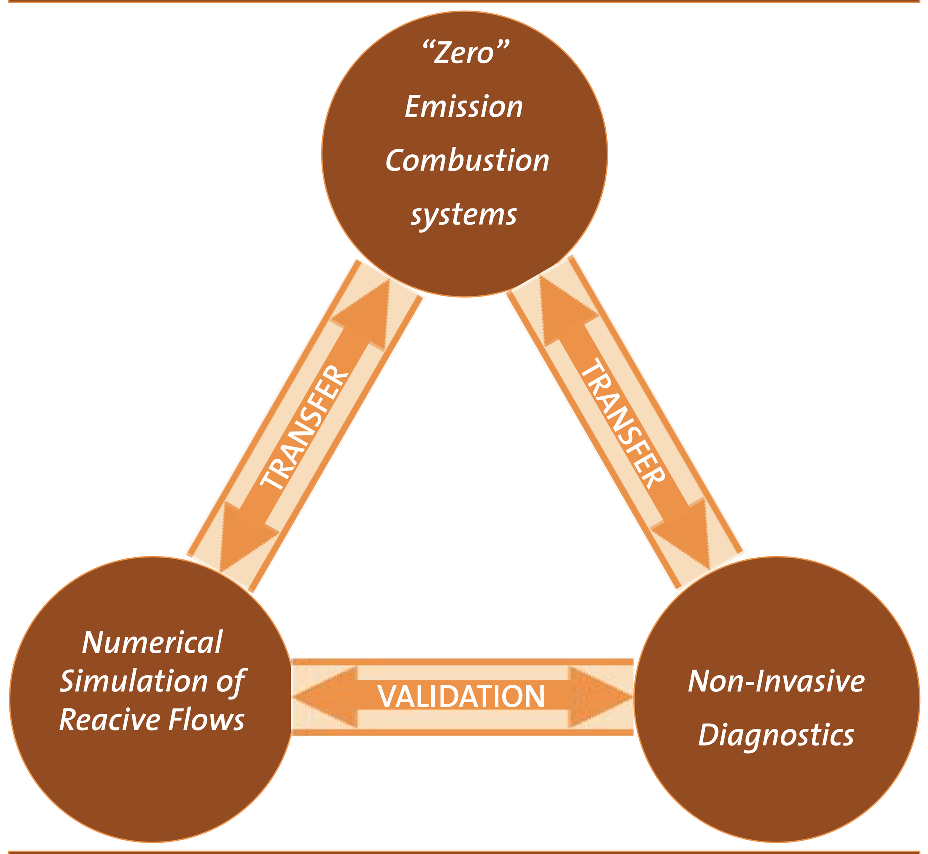
ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

LAV
Laboratorium für Aerothermochemie und Verbrennungssysteme
Aerothermochemistry and Combustion Systems Laboratory

Overview

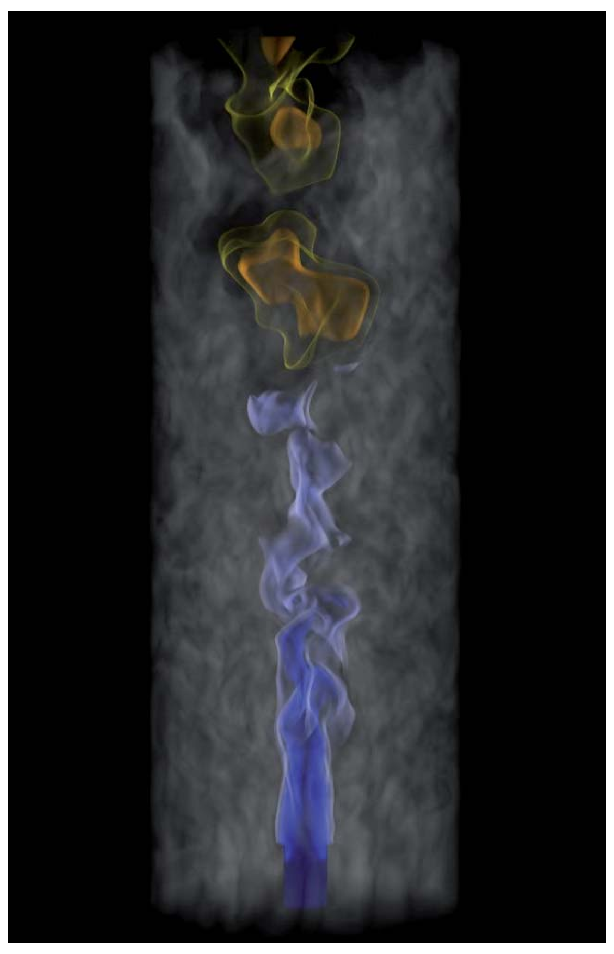
The research at the Laboratory for Aerothermochemistry and Combustion Systems focuses primarily on the investigation of chemically reactive flows, through the use of numerical simulations and non-invasive, optical diagnostics. These tools enable the fundamental physical processes of turbulent combustion to be modelled, as well as provide a means by which these models can be validated.
Our application-orientated research uses the knowledge from fundamental investigations to optimize combustion systems (knowledge and technology transfer), with the ultimate goal of realising "Zero" Emission Technologies.
A particular focus of the Laboratory is the formation and destruction of particulate matter in commonly used combustion systems, such as the diesel internal combustion engine. Both experimental and numerical investigations are being used to understand the fundamental processes of particulate matter generation and oxidation, keeping in mind the ultimate goal of providing feasible Zero Emission Technologies.



Projects

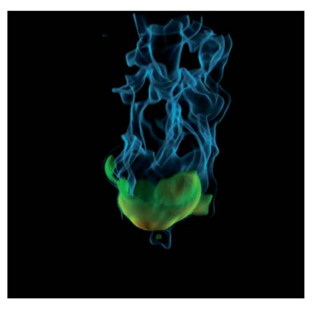
Fundamental Research

Turbulent Non-Premixed Hydrogen Autoignition



Three dimensional direct numerical simulations are performed to investigate turbulent inhomogeneous autoignition of a laboratory-scale setup where hydrogen is injected into high-temperature, turbulent co-flowing air.

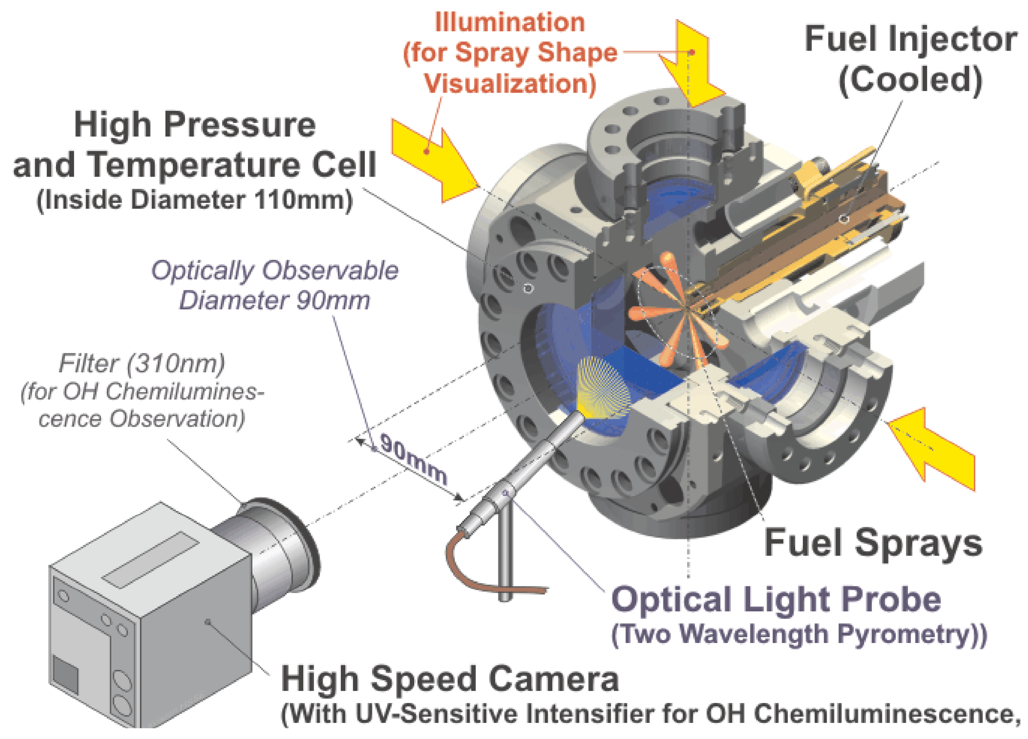
All the experimentally observed regimes are captured and the simulations are in good agreement with the reported experimental results. The simulations focus on the random spot regime where seemingly random autoignition kernels that cannot lead to the establishment of strongly burning flames are observed. As in the experiments, significant spread in the ignition location is observed. Increased turbulence intensity results in delayed autoignition and increased spread of the autoignition spots.



Future Fuels for Diesel Engines

Investigation of fuel spray propagation for evaporating and non evaporating, non reactive conditions; and of fuel spray ignition, combustion and soot production for reactive conditions, for eight synthetic fuels with specially tailored compositions (FVV Research Project 940)

New synthetically produced Diesel fuels offer new possibilities to further reduce the pollutant emissions of Diesel engines. In our lab (LAV) we examine fundamental aspects of the behavior of such fuels, especially with respect to spray propagation, the influence of evaporation and the ignition delay times, ignition locations, combustion process and soot production. Together with the results of the engine tests performed at IVK (University of Stuttgart) this permits an assessment of the influence of the specific fuel components.



Simulations

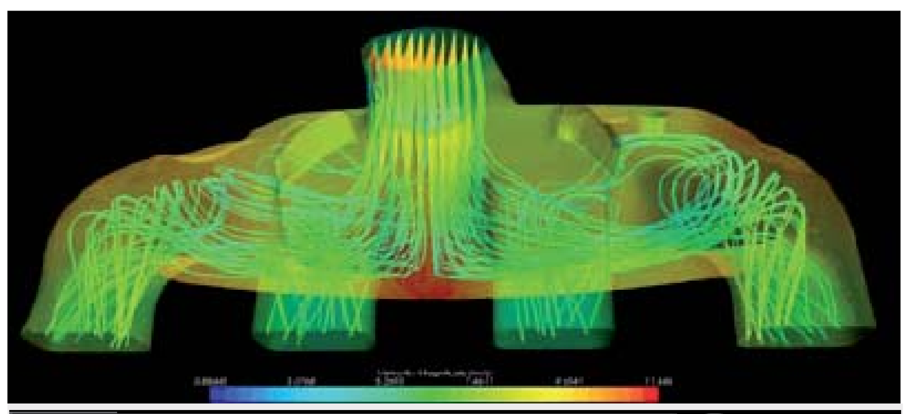
Experiments

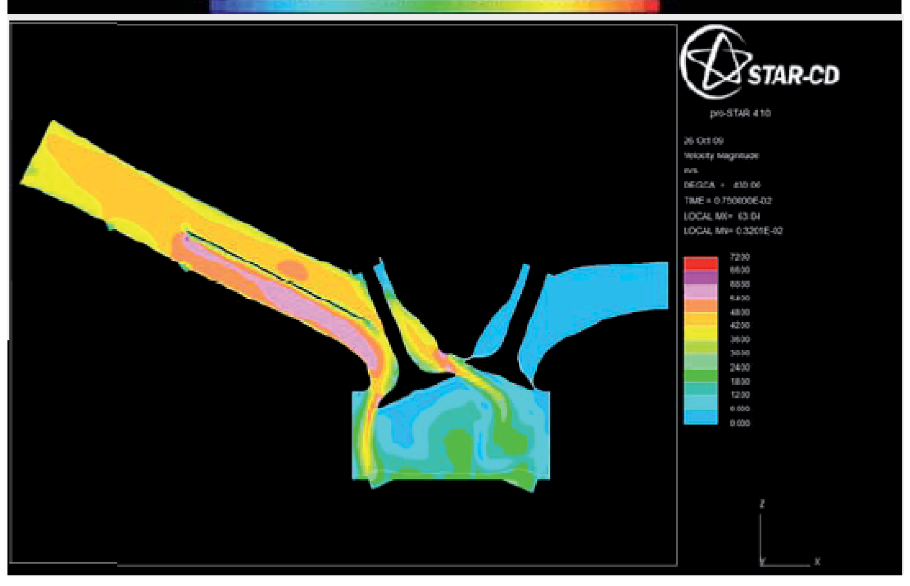
CNG Vehicle Propulsion

Strategies for hybrid component sizing have been developed and different driving strategies have been analyzed for various driving cycles. NEDC-simulations show, that in combination with the optimized combustion engine the targeted CO_2 emission reduction can be realized.

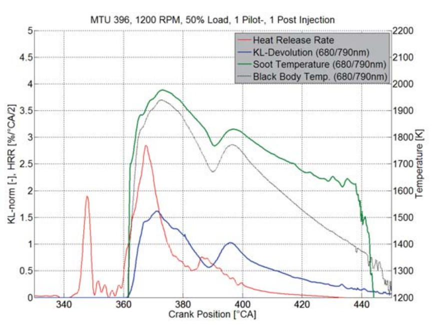
To meet the desired vehicle performance, a turbocharger has been designed using a validated 1D-model for the CNG combustion engine. Further, the compression ratio and valve train have been optimized. For high efficiencies the wastegate should be kept open whenever possible. In fact this causes poor response, but it can be compensated by the hybrid components. Using the above strategy, the efficiency of the CNG-engine can be increased by 3.5% over a wide load range.

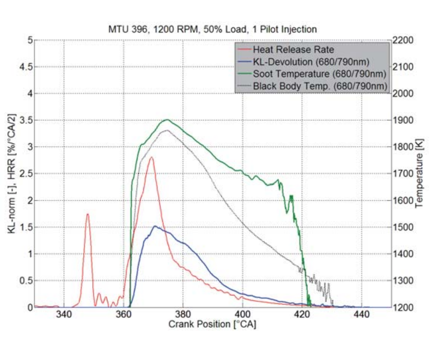
First 3D-CFD simulations provided feasible results (figures). To understand and optimize intake flow and mixing processes, more simulations will follow. A good homogenization, high turbulence intensity and a reproducible lambda value in the region of the spark plug are crucial for a clean and efficient combustion.



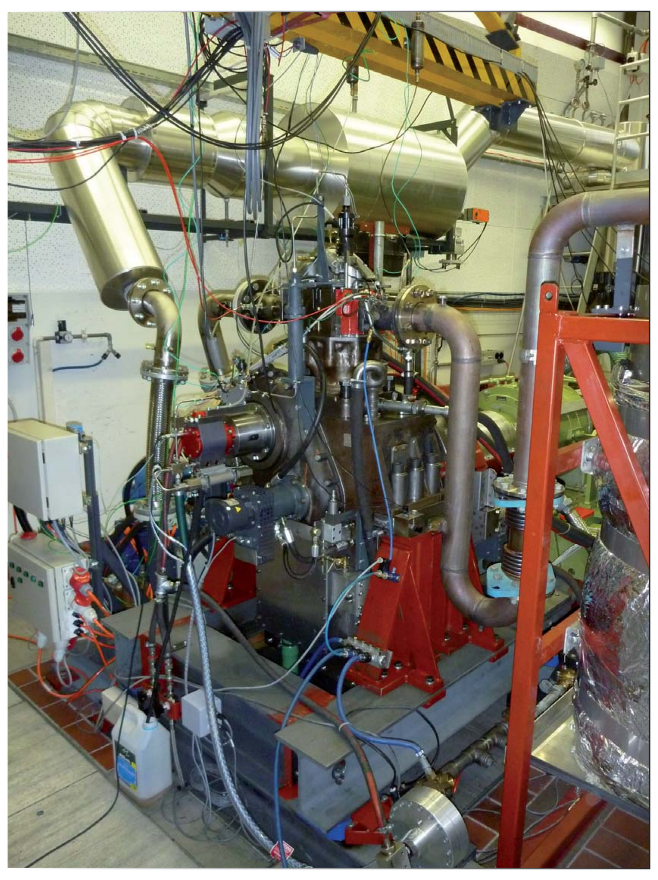


Development of a Virtual Soot Sensor



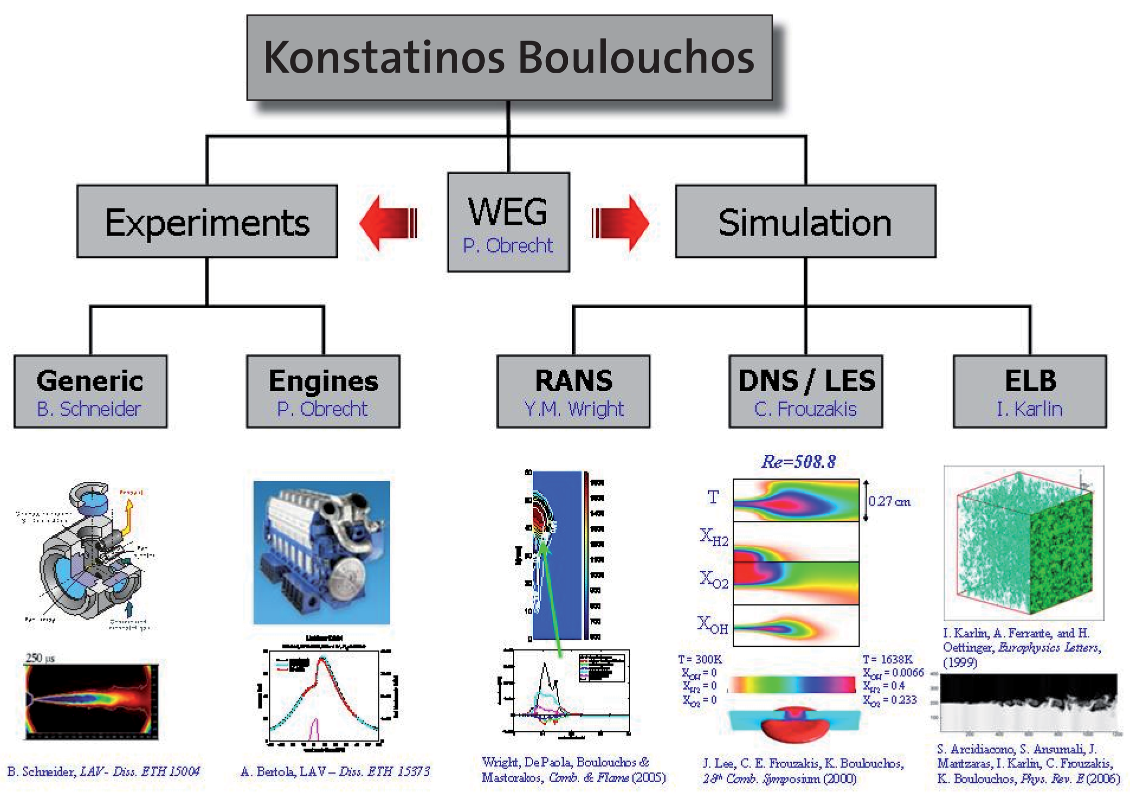


The Virtual Soot Sensor (VSS) will be designed as a phenomenological model of the soot formation in Diesel-combustion and will be used to provide a real-time estimate of the soot emissions. An existing mean value soot model which has been developed previously by the LAV is used as the basis for the VSS. Additionally the information of the cylinder pressure is used to be able to calculate the thermodynamic states and to use characteristic points of the heat release analysis as model inputs. In experimental research on a MTU single cylinder engine (see picture), especially phenomenological correlations between the injection rate, the heat release rate and the devolution of KL (optical soot density) are investigated (see figures). Once completed, the VSS will be implemented in a control strategy to minimize the soot emissions from a modern Diesel engine (FVV Research Project 986).



Applied Research

Organization, Partners & Funding



FVV (Forschungsvereinigung Verbrennungskraftmaschinen)
Wärtsilä
Kistler
BMW
ABB
BFE (Swiss Federal Office of Energy)
BAFU (Federal Office for the Environment)
KTI (Innovation promotion agency)
SNF (Swiss National Science Foundation)
7th Framework Programme

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