

LEC FFF
Future Fuel Fundamentals

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET Module

Type of project: strategic

Short title: LEC FFF

Duration: 2024-2027



© LEC GmbH, Photo Jorj Konstantinov

VISUALIZATION OF TURBULENT AMMONIA FLAMES

TO INVESTIGATE THE PROCESSES INVOLVED IN AMMONIA COMBUSTION IN LARGE ENGINES, AN OPTICALLY ACCESSIBLE COMBUSTION CHAMBER WAS DESIGNED AND BUILT AT THE LEC, WHICH ENABLES STUDIES OF THE FLAME UNDER CONTROLLED TURBULENT CONDITIONS.

The challenge

Green ammonia is a promising energy carrier and can be used as a fuel in large engines without producing CO₂ emissions. However, the combustion properties of ammonia differ significantly from those of conventional carbon-based fuels, which necessitates both an adaptation of the engine combustion process and of the numerical simulation models used to analyze combustion. Real-world processes in the engine typically occur under highly turbulent conditions, which significantly complicates a comprehensive understanding of the underlying complex combustion processes. For a deeper understanding of ammonia combustion, it is therefore crucial to investigate the individual sub-processes and, in particular, the detailed influence of turbulence on the behavior of the ammonia flame. Designing an experimental environment that allows for the optical observation of the flame under precisely controllable turbulent conditions and

the systematic evaluation of the resulting findings is correspondingly challenging.

The innovation

To investigate these highly complex processes, the LEC has developed an optically accessible constant-volume combustion chamber (CVCC) equipped with rotors for turbulence generation, which allows for the optical measurement of flame propagation under defined turbulent conditions. This makes it possible to separate the influence of turbulence on combustion from that of the background flow. The measurement data obtained also form an important basis for modeling and simulating these underlying processes.

The implementation

The key requirement when developing the design for the combustion chamber was to create as realistic and engine-like combustion conditions as possible while ensuring high flexibility and optical accessibility.

SUCCESS STORY

The first step was to determine a suitable chamber design in advance using simulations, for which the freely available CFD code OpenFOAM was employed. The results of simulations of various design variants were evaluated, and the design that generated the turbulence conditions most suitable for investigating the effects was identified. Symmetrically arranged, counter-rotating rotors in a spherical combustion chamber provided very good conditions in terms of the required characteristics of flow field and turbulence within the observation range. Based on these findings, the combustion chamber was designed and built and, in a first step, used for initial reference measurements with a quiescent charge.

The impact

The turbulent combustion chamber provides a valuable research tool that allows relevant combustion processes to be examined in isolation. Based on the optical measurement data obtained, simulation models are developed that can be used to better predict future combustion processes involving new fuels like ammonia, hydrogen or methanol. In combination with high-resolution simulations, detailed insights into the underlying structure of the ammonia flame can be gained, and from these, more resource-efficient simulation models can be derived through simplifications, which are predominantly used in practical applications for engine simulations nowadays.

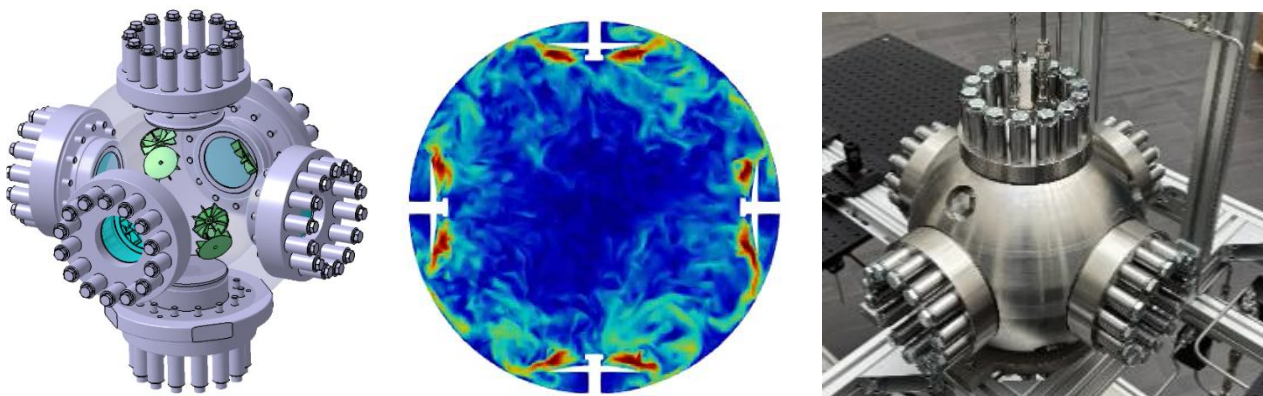


Fig. 1: Initial design (left), CFD analysis of the observation range (center), assembled chamber (without rotors, right), © LEC GmbH

Project coordination

Dr. Gerhard Pirker
COMET Module Project Manager
LEC GmbH
T +43 (0) 316 873 30130
gerhard.pirker@lec.tugraz.at

K1 COMET Center LEC GETS

LEC GmbH
Inffeldgasse 19/2
8010 Graz
T +43 (0) 316 873 30101
office@lec.at – <https://www.lec.at>

Project partners

- INNIO Jenbacher GmbH & CO OG, Austria
- AVL List GmbH, Austria
- WinGD Ltd., Switzerland
- Graz University of Technology, Austria
- University of Applied Sciences Northwestern Switzerland, Switzerland

This success story was provided by the centre management and by the mentioned project partners for the purpose of being published. LEC FFF is a COMET Module within the COMET – Competence Centers for Excellent Technologies Programme and funded by BMIMI, BMWET, and the provinces Styria and Tyrol. The COMET Programme is managed by FFG. Further information on COMET: www.ffg.at/comet