

LEC FFF

Future Fuel Fundamentals

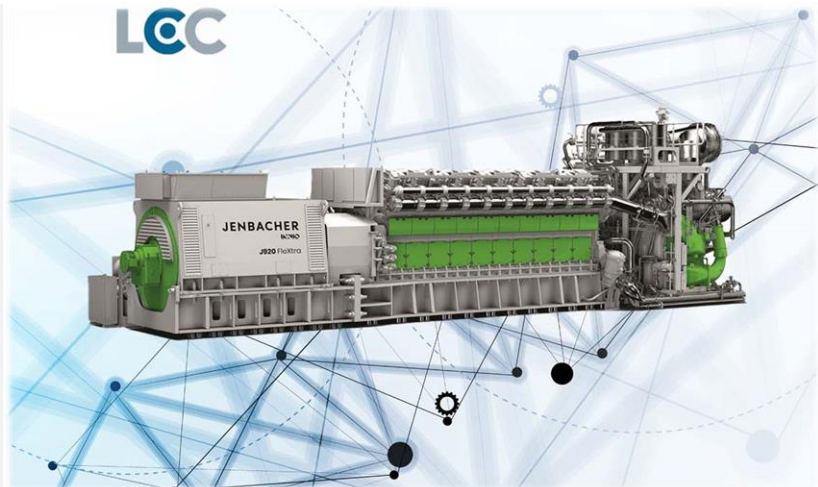
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SYSTEMATIC ANALYSIS OF AMMONIA FLAMES BASED ON A HOLISTIC APPROACH

THE COMBINATION OF FLEXIBLE, OPTICALLY ACCESSIBLE TEST RIGS AND HIGH-FIDELITY NUMERICAL SIMULATIONS PROVIDES DETAILED INSIGHTS INTO THE PROPERTIES OF AMMONIA FLAMES IN LARGE ENGINES.

Ammonia is a promising future energy carrier and fuel. Green ammonia is carbon-free and can be produced from renewable energy, air and water. Due to the combination of high production efficiency, high volumetric energy density and low energy requirements for storage, green ammonia is an extremely economical energy carrier for the transportation of renewable energy over long distances, from sunny and windy regions to regions with high energy demand. However, in order to use ammonia efficiently as a fuel in large engines, a comprehensive understanding of the engine combustion process is required. The combustion properties of ammonia differ significantly from those of conventional carbon-based fuels. Therefore, within the COMET module LEC FFF, a holistic approach combining flexible optically accessible test benches of varying complexity and complex numerical simulations was developed to deepen the understanding of ammonia

combustion and to enable the development of CO₂-neutral combustion processes for large engines.

Concept for holistic ammonia combustion analysis

In order to understand the combustion behavior of ammonia, it is crucial to identify the factors that influence the combustion process. To this end, fundamental experiments in optical test rigs of varying complexity are combined with numerical simulations. While a constant volume combustion chamber (CVCC), which is operated with a quiescent charge, allows the determination of laminar flame characteristics, a CVCC equipped with rotors enables the investigation of ammonia flames under idealized turbulent conditions. In combination with direct numerical simulation (DNS), detailed insights into the underlying structure of the ammonia flame can be gained. Due to the potential requirement to use turbulent jet ignition (TJI) for

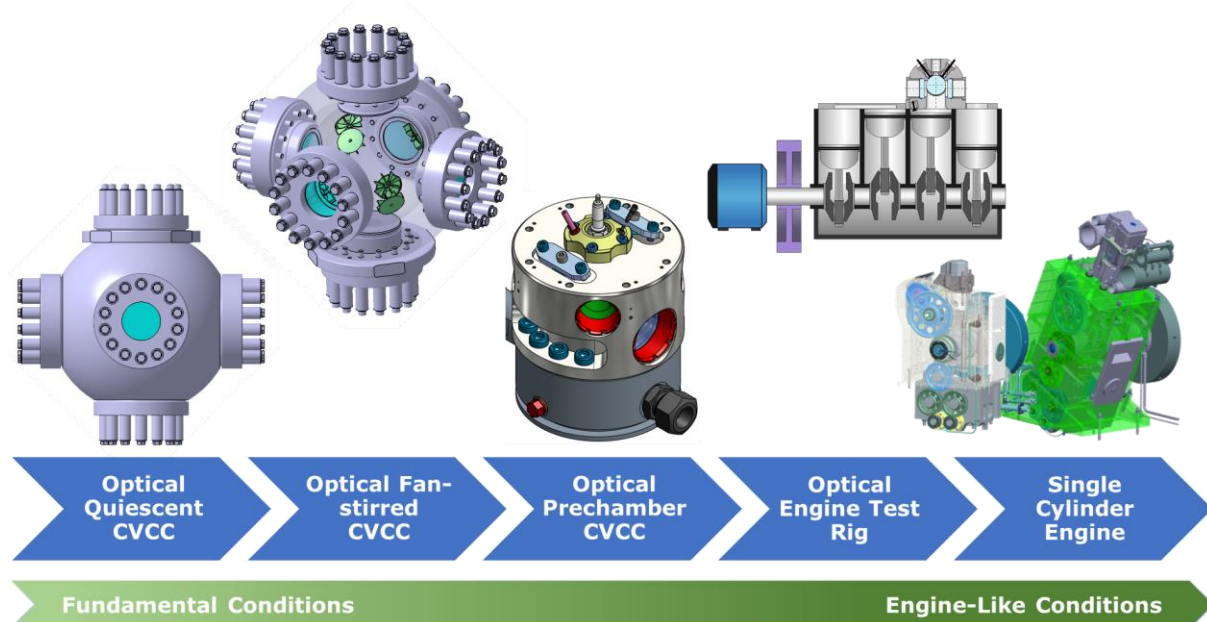
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ammonia in lean operation, a further specially designed optical CVCC with pre-chamber enables the detailed analysis of the TJI combustion process. To this end, an optical engine test rig in combination with large-eddy simulations enables a detailed analysis of flame propagation under engine-like thermodynamic and turbulent conditions.

Application of the findings for the development of CO₂-neutral combustion processes in large engines

The effective combination of different experimental and numerical methods enables the adaptation of turbulent

combustion models, originally developed for carbon-based fuels, to the requirements of ammonia combustion. Building on this, flexible single-cylinder large engine test beds converted to ammonia operation, supported by numerical simulations based on advanced turbulent combustion models, form the basis for the development of highly efficient and sustainable ammonia combustion concepts, which will ultimately find their application in full-scale engines in CO₂-neutral energy and transportation systems.



Overview of research test rigs implemented in the methodology for visualizing ammonia combustion, © LEC GmbH and FHNW

Project coordination

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