SUCCESS STORY

LEC FFF
Future Fuel Fundamentals

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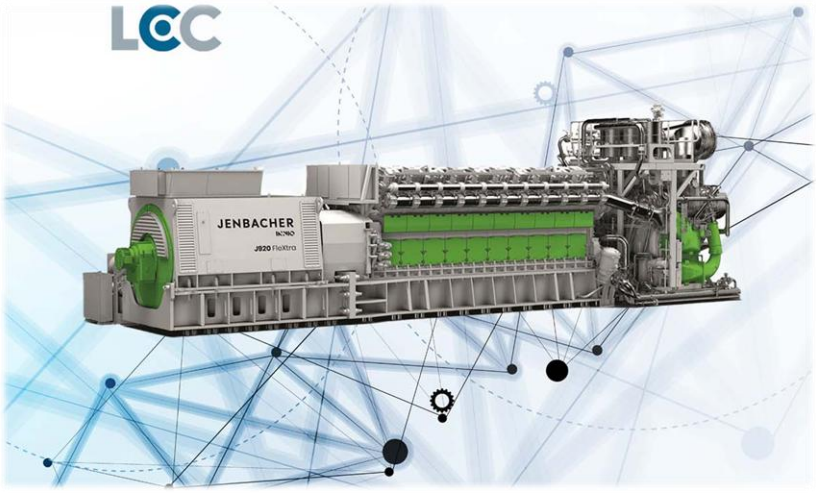

SYSTEMATIC ANALYSIS OF AMMONIA FLAMES BASED ON A COMPREHENSIVE APPROACH

THE COMBINATION OF FLEXIBLE, OPTICALLY ACCESSIBLE TEST RIGS AND HIGH-FIDELITY NUMERICAL SIMULATIONS PROVIDES DETAILED INSIGHT 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. The combination of high production efficiency, high volumetric energy density and low energy demand for storage makes green ammonia an extremely economical energy carrier for transporting renewable energy over long distances—from sunny and windy regions to regions with high energy demand. However, the efficient use of ammonia as a fuel in large engines requires a thorough understanding of the engine combustion process. The combustion properties of ammonia differ significantly from those of conventional carbon-based fuels. Therefore, the COMET Module LEC FFF developed a comprehensive approach combining flexible optically accessible testing equipment of varying complexity and complex numerical simulations to deepen the understanding of ammonia combustion and to enable the development of CO_2-neutral combustion processes for large engines.

Comprehensive analysis of ammonia combustion

In order to understand the combustion behavior of ammonia, it is essential to identify the factors that influence the combustion process. While laminar flame characteristics may be determined in a constant volume combustion chamber (CVCC operated with a quiescent charge, a CVCC equipped with rotors facilitates the investigation of ammonia flames under idealized turbulent conditions. In combination with direct numerical simulation (DNS), it yields detailed insight into the underlying structure of the ammonia flame. An optical CVCC with a prechamber permits a thorough analysis of the turbulent jet ignition (TJI) combustion process, which is favored for ammonia combustion in lean mixtures. Finally, flame propagation under engine-

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like thermodynamic and turbulent conditions can be analyzed in detail on an optical engine test rig in combination with large eddy simulations.

Application to CO_2-neutral combustion processes in large engines

Through the effective combination of different experimental and numerical methods, turbulent combustion models originally developed for carbon-based fuels may be adapted to meet the requirements of ammonia combustion. Building on this, experimental investigations on flexible single-cylinder research engines converted to ammonia operation—supported by numerical simulations based on advanced turbulent combustion models—provide the basis for the development of highly efficient and sustainable ammonia combustion concepts, which will ultimately find their application in large-scale CO_2-neutral energy and transportation systems.

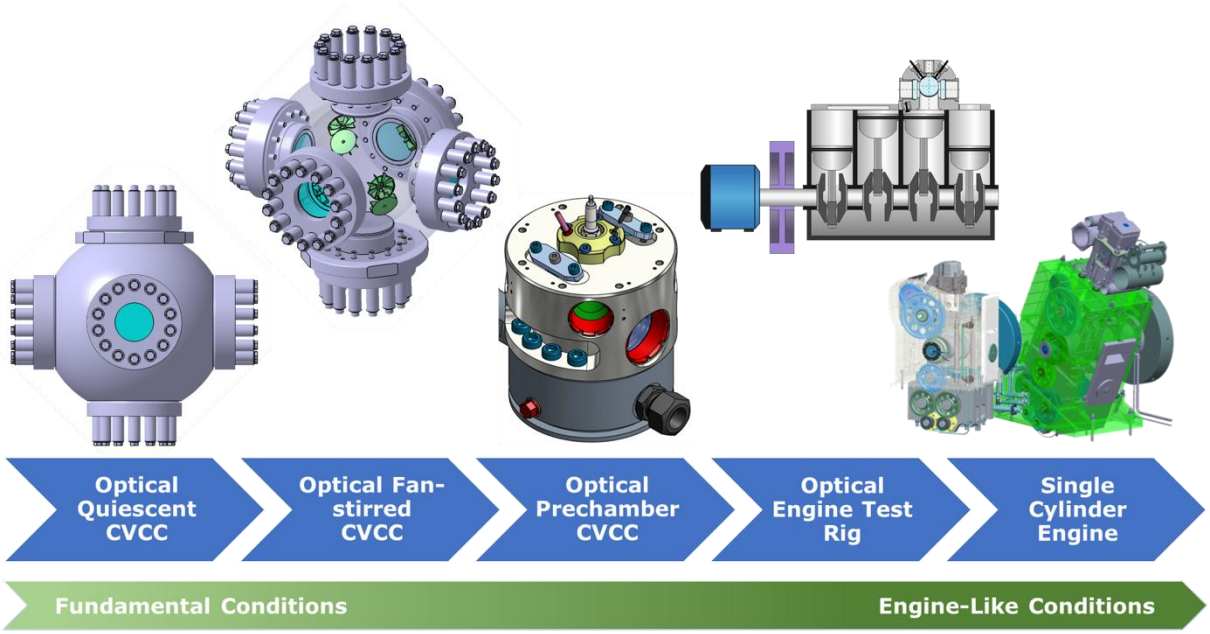

Fig. 1.: Overview of the research test rigs employed in the methodology to visualize ammonia combustion, © LEC GmbH and FHNW

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