FRAUNHOFER INSTITUTE FOR MECHANICS OF MATERIALS IWM

PRESS RELEASE

Faster qualification of components in hydrogen applications: Start of a research project by Fraunhofer IWM and the National Institute of Standards and Technology NIST

The HyLife project aims to develop a physics-based service life prediction tool for materials in contact with hydrogen. Innovative test methods and materials models will be used to reliably predict the service life of components under the influence of hydrogen, thereby making a decisive contribution to the safety and efficiency of hydrogen infrastructures.

The use of hydrogen as an energy carrier depends on safe infrastructures for its storage and transport. Materials and components for pressure vessels and pipelines for gaseous hydrogen must be tested and qualified regarding their susceptibility to hydrogen embrittlement. Currently, many components that come into contact with pressurized hydrogen are designed very conservatively or subjected to very time consuming and costly mechanical fracture and fatigue tests. The qualification of new materials for hydrogen applications can take several years. Materials characterization and qualification is therefore a success factor for the ramp-up of the hydrogen economy.

This is precisely where the HyLife research project comes in, a collaboration between the Fraunhofer Institute for Mechanics of Materials IWM and the National Institute for Standards and Technology (NIST) in the USA, which has just begun and will run until 2028. In its ICON (International Cooperation and Networking) research program, the Fraunhofer-Gesellschaft promotes strategic cooperation between Fraunhofer and an outstanding international research partner.

The overarching goal of HyLife is to develop less conservative, yet reliable design guidelines for components that operate under pressurized hydrogen. To this end, faster and more meaningful qualification concepts for hydrogen infrastructure components are being developed. The advantages are obvious: More materials-efficient design of infrastructures and time and cost-efficient qualification of components support the accelerated development of a sustainable energy sector.

The key to this is a validated physical prediction model for the service life of steel parts with welded seams. The model is intended to reliably predict the damage to materials in contact with hydrogen based on their microstructure and certain physical characteristics. This is set to be a paradigm shift in service life prediction and reduce the need for

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complex and expensive tests on the formation and propagation of cracks for safety assessments. The result: lower production costs and accelerated innovation cycles.

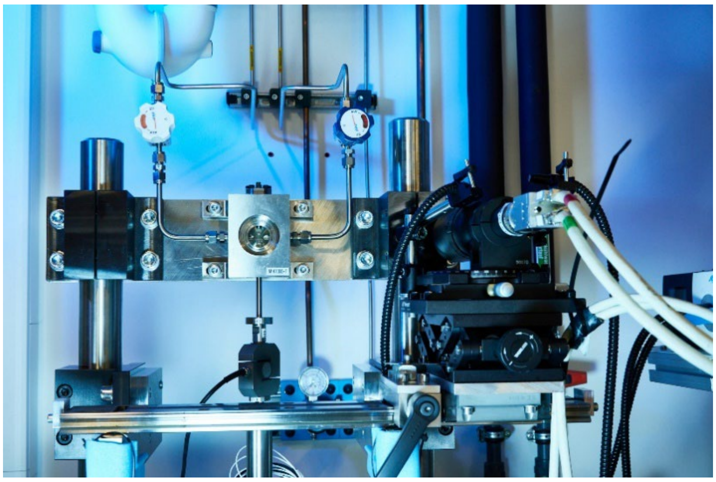
An innovative micro sample testing technique developed by Fraunhofer IWM is being used to determine fracture toughness and crack growth. The measurement results are compared with unique high-throughput fatigue tests on a macro scale conducted by NIST. The partners also complement each other in microstructure analysis, materials data evaluation, and modeling for the precise measurement of decohesion of mechanically stressed grain boundaries, which should lead to a better understanding of local damage caused by hydrogen. The aim is for the prediction model to require less materials data while at the same time better accounting for hydrogen-induced crack formation and propagation on the microscale.

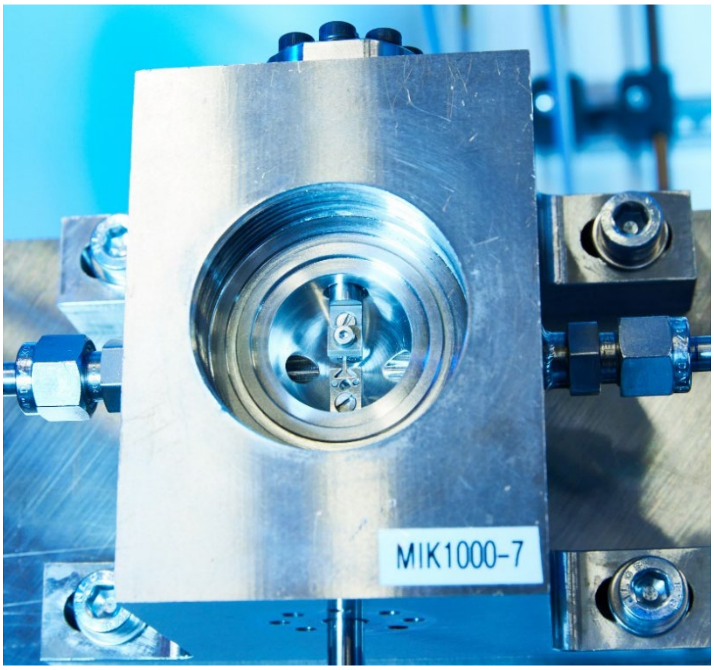
The project plan envisages that the HyLife model will be directly applied in the ASME B31.12 and ISO 11114-4 standards for the design of components, thereby increasing safety and efficiency in the hydrogen economy.

Complementary expertise for safe hydrogen infrastructures

Fraunhofer IWM specializes in elucidating damage mechanisms in materials and contributes unique expertise in the characterization and modeling of materials on the microscale. This allows precise materials data to be obtained directly from critical component areas.

The National Institute of Standards and Technology (NIST) is the leading research organization and standards authority in the United States. The Fatigue and Fracture Group at NIST is a global leader in high-throughput fatigue testing in hydrogen on the macro scale. Through close collaboration with standards bodies such as ASME and ISO, the results of NIST's research are directly incorporated into the development and updating of relevant standards.





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Hydrogen gas micro-autoclave setup for in-situ mechanical testing in gaseous H2 on micro specimens (above). Micro tensile specimen (6 mm length, bar width 0.4 mm) mounted in specimen holders (below).

The hydrogen gas micro-autoclave can be used to perform quasi-static tensile tests as well as mechanical fatigue and fracture experiments on micro samples up to a hydrogen gas pressure of 5 MPa (50 bar). The chamber of the micro-autoclave can hold a maximum amount of pressurized hydrogen equivalent to 4 liters of hydrogen at atmospheric pressure.

The **Fraunhofer IWM** is passionate about sustainability in industrial value creation. Through its research and development work, it opens up new pathways and design opportunities for durability and safety in components, resource efficiency in process chains, and energy efficiency in machines. The institute makes materials within process chains, components, and machines predictable in terms of their behavior and properties. It investigates the effects of mechanical, tribological, thermal, electrical, and chemical stresses on the function and durability of materials and develops solutions that allow these materials to be used as adjustable systems in processes and components.

The **Fraunhofer-Gesellschaft** based in Germany is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. A trailblazer and trendsetter in innovative developments and research excellence, it is helping shape our society and our future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Over 30,000 employees, predominantly scientists and engineers, work with an annual research budget of €2.9 billion. Fraunhofer generates €2.5 billion of this from contract research.