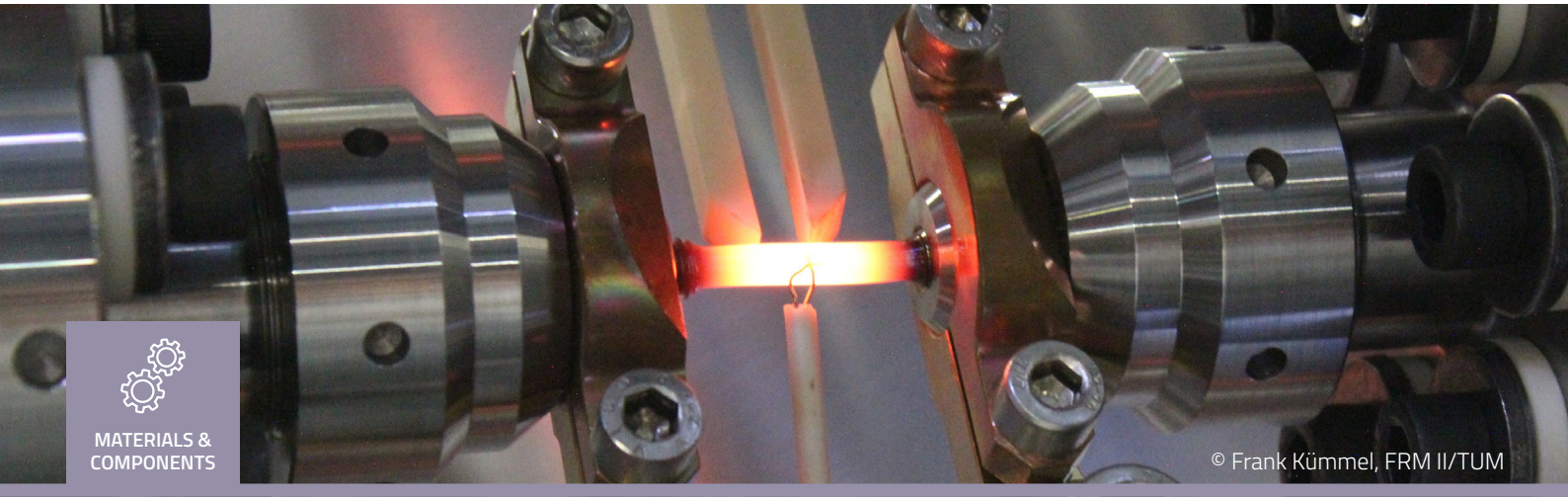

PRESSURE AND HEAT: TESTING ALLOYS FOR GAS TURBINES

VDM Metals is a high-performance metal provider. In the HiMat project,[1] together with the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), VDM tested its VDM® Alloy 780 using a specially developed testing machine at the Research Neutron Source, Heinz Maier-Leibnitz Zentrum (FRM II).

THE CHALLENGE

Gas turbines must endure extreme conditions, including high forces at temperatures above 600°C. The new nickel VDM® Alloy 780 is resistant to high temperatures and corrosion, making it ideally suited for use in gas turbines. To develop new materials, investigations under operating conditions are required.

THE EXPERIMENT

To replicate the conditions in a gas turbine, a special sample environment is necessary. The new testing machinery generates temperatures of up to 1200°C, and recreates a vacuum or air environment similar to a gas turbine. The testing system also generates forces such as tension or compression on the sample, simulating the large centrifugal forces experienced by a turbine in operation.

While extreme forces were applied to the sample, changes in the alloy were studied using neutrons. In addition, neutrons were used to study the structure of the sample before and after loading to identify pores and cracks.

THE RESULTS

The experiments at MLZ enabled the research team to better understand the properties of the alloy, providing insight into the material's structure and how it is affected by high temperatures and forces. With this information, VDM can adapt the manufacturing process to further optimise the alloy.

1. The HiMat project was funded by the German Federal Ministry of Education and Research (BMBF).

Fig 1. Dr Frank Kümmel inserts a sample into the testing apparatus. © Reiner Müller, FRM II/TUM

> The good interaction of the three cooperation partners has been very successful: the MLZ as a large-scale research facility with the FRM II neutron source and the FAU Erlangen with its special knowledge in microstructures and methods that complement us, and finally the industrial partner VDM Metals, which is further developing the alloy.
>
> **Frank Kümmel**
> Advanced Materials Group, MLZ

Kümmel, F. et al. (2021) 'Deformation Mechanisms in Ni-Based Superalloys at Room and Elevated Temperatures Studied by In Situ Neutron Diffraction and Electron Microscopy'. *Metals*, 11(5), p.719

INDUSTRIAL APPLICATIONS OF NEUTRON SCIENCE

LENS LEAGUE OF ADVANCED EUROPEAN NEUTRON SOURCES

For decades, European neutron facilities have established productive collaborations with a diverse range of industrial users. Such partnerships have delivered important results for industry, providing insights into materials and methods that have driven process optimisations and technological innovations.

WHY USE NEUTRONS?

STUDY STRUCTURE

Neutron wavelengths are are comparable to the spacings of atoms and molecules.

STUDY DYNAMICS

Neutron energies are comparable to the time scales of molecular diffusion, vibrations and rotations.

STUDY MAGNETISM

The neutron's magnetic moment can be used to study the microscopic magnetic properties of materials.

PENETRATION POWER

Neutrons can penetrate deep into matter (including many different metals) enabling the study of large samples - even within complex sample environments.

NON-DESTRUCTIVE

As a non-destructive, non-invasive probe, neutrons are suitable for the characterisation of delicate and precious samples.

VERSATILE SAMPLE ENVIRONMENTS

Sophisticated sample environments enable measurements under operating conditions - including extreme temperatures, pressures, etc.

SENSITIVITY TO LIGHT ELEMENTS

The neutron scattering power of nuclei varies in a quasi-random manner such that lighter atoms (e.g. H, Li) can be studied in the presence of heavier ones.

ISOTOPIC CONTRAST

Neutrons are sensitive to different isotopes of the same element, so isotopic substitution (e.g. H/D) can be used to highlight specific structural features.

COMPLEMENTARITY

Neutron scattering is highly complementary to other techniques, such as X-ray scattering, electron microscopy, magnetic resonance and computational methods.

HOW CAN INDUSTRY USERS GET ACCESS TO NEUTRON FACILITIES?

European neutron facilities provide industrial users with access to advanced instrumentation for R&D. No prior experience is needed – expert scientific and technical staff provide support for users to get the most from their experiments.

Neutron facilities offer a variety of mechanisms to access their infrastructure, including proprietary access, academic partnerships and public beamtime.

For more information, email contact@lens-initiative.org