Contribution ID: **87** Type: **Talk**

Hydrogen distribution in single-crystal superalloys and its dependence on the y/y' lattice misfit

Wednesday 3 December 2025 17:10 (20 minutes)

The importance of hydrogen embrittlement (HE) will increase with the energy transition, as hydrogen (H) is a promising fuel for CO_2-free power generation. In aviation, the replacement of kerosene by H requires turbine materials resistant to HE. Single-crystal (SX) superalloys are the material of choice for the hottest turbine sections, where the lattice parameter misfit between y and y' is a critical design parameter. As y' precipitates are coherently embedded in the matrix, the sign and magnitude of the y/y' misfit determine local elastic stresses that may influence H partitioning. In this study, three SX superalloys were investigated: CMSX-4 (slightly negative misfit, ~-0.1 %), LDSX6A (large negative misfit, ~-0.8 %), and VF60 (positive misfit, ~+0.5 %). Samples were H-charged under high pressure (900 bar, 300 ℃) and studied ex situ by neutron diffraction (ENGIN-X at ISIS) and laboratory XRD. Results show that H consistently accumulates in the y' phase, independent of misfit. Thermal desorption spectroscopy also indicates that H solubility is governed primarily by chemical composition. Compression tests reveal earlier fracture and reduced work-hardening rates in hydrogen-charged samples, which is further characterized with SEM/TEM of interrupted tests.
These findings provide important insights into the influence of y/y' lattice misfit on hydrogen uptake and its consequences for mechanical properties.

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Session Classification: Neutrons & Users 2a

Track Classification: Neutron Methods