Contribution ID: **10** Type: **Talk (25 + 5 min)**

Monitoring the precipitation of the hardening phase in the new VDM® Alloy 780 by in-situ high-temperature small-angle neutron scattering, neutron diffraction and complementary microscopy techniques

Monday 20 March 2023 11:00 (30 minutes)

The hardening phase precipitation process plays an important role in the development of new Ni-base superalloys. In the present work, we apply a powerful combination of advanced characterization techniques to characterize in-situ the γ'precipitation in the new VDM® Alloy 780. During the whole heat treatment process, in-situ time-of-flight (TOF) neutron diffraction (ND) unambiguously identified the γ'phase as well as its weight fraction and the misfit with the matrix while in-situ small-angle neutron scattering (SANS) provided precise precipitates'size analysis. Atom probe tomography (APT) and scanning electron microscope (SEM) provided detailed microstructural characterization and chemical composition of the phases necessary for a proper neutron scattering data evaluation.

This contribution reveals more detailed information on the nucleation, growth, and Ostwald ripening processes starting from the early precipitation stage in bulk samples using the complementary microstructure investigation methods. The nucleation and growth kinetics of precipitates at 720 ℃ depend on heating rates and the size distribution obtained in the pre-heating history of the sample. A subsequent heat treatment step at 620 ℃, typically used in Ni-base superalloys, does not lead to similar progressive precipitation or growth. The expected matrix-diffusion-controlled Ostwald ripening process of the γ'precipitates was in-situ monitored by SANS on full precipitation hardened sample at expected operating temperatures (750 ℃) showing smaller coarsening kinetics than other reported Ni-based superalloys.

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Session Classification: Engineering 1

Track Classification: Engineering applications