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Precipitation modelling in nickel-based superalloys

Challenges

The project focuses on the development of simulation tools that can be used to predict precipitation kinetics in Nickel based superalloys. The modelling capability is needed to assist in the design of heat treatments and for use in assessing component performance.

Background

The Nickel based superalloys used in turbine disc components tend to be strengthened through the presence of γ' or γ^* phase precipitates. The size, shape and spatial arrangement of these precipitates impact mechanical properties, and thus component performance.

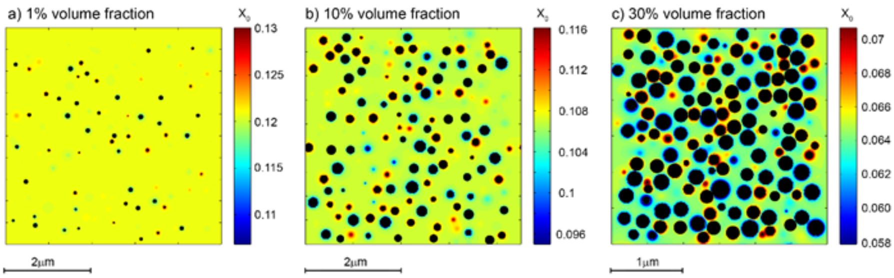
Statistical information regarding the precipitate dispersion is needed for further use in calculating mechanical properties such as creep and fatigue. The precipitation behaviour is a diffusion process driven by energy minimisation, with energy contributions arising from the interface between the precipitate and matrix, and elastic misfit strain caused by lattice differences between the precipitate and parent phase.

Results

Mean-field models have been developed to simulate the nucleation, growth, coarsening and dissolution of these precipitates during complicated thermal cycles. The models apply a multi-component and multi-phase description of the alloys, utilising a thermodynamic and mobility database to determine chemistries, chemical driving forces and diffusivities.

A method to extend the modelling framework to include coalescence events has been derived, utilising nearest neighbour functions to capture the spatial arrangement of the particle dispersions. Further developments have been made to include the evolution of the precipitate composition during thermal exposure. The model has also been implemented in a commercial Finite Element software, to capture location specific properties during manufacture. The models developed have been applied to assist in the design of heat treatments, predict the kinetics of precipitates during creep, and predict precipitation phenomena during an advanced joining process. BlueBear has allowed for the fast application of the models to component analysis allowing for location specific property prediction, and the generation of process maps that can guide the design of heat treatments.

BlueBear has greatly increased the number of conditions which the model can be applied, allowing for the location specific predictions describing a component, and the generation of process maps that can guide the design of heat treatments.



Case study

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Product Used
ThermoCalc TQ FORTRAN interface
MATLAB, Abaqus, DEFORM

Funding
Rolls-Royce plc and Innovate UK

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