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Modeling of in 738 LC Alloy Mechanical Properties Based on Microstructural Evolution Simulations for Different Heat Treatment Conditions

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Abstract : Conventionally cast nickel-based super alloys, such as commercial alloy IN 738 LC, are widely used in manufacturing of industrial gas turbine blades. With carefully designed microstructure and the existence of alloying elements, the blades show improved mechanical properties at high operating temperatures and corrosive environment. The aim of this work is to model and estimate these mechanical properties of IN 738 LC alloy solely based on simulations for projected heat treatment conditions or service conditions. The microstructure (size, fraction and frequency of gamma prime- γ′ and carbide phases in gamma- γ matrix, and grain size) of IN 738 LC needs to be optimized to improve the high temperature mechanical properties by heat treatment process. This process can be performed at different soaking temperature, time and cooling rates. In this work, micro-structural evolution studies were performed experimentally at various heat treatment process conditions, and these findings were used as input for further simulation studies. The operation time, soaking temperature and cooling rate provided by experimental heat treatment procedures were used as micro-structural simulation input. The results of this simulation were compared with the size, fraction and frequency of γ′ and carbide phases, and grain size provided by SEM (EDS module and mapping), EPMA (WDS module) and optical microscope for before and after heat treatment. After iterative comparison of experimental findings and simulations, an offset was determined to fit the real time and theoretical findings. Thereby, it was possible to estimate the final micro-structure without any necessity to carry out the heat treatment experiment. The output of this microstructure simulation based on heat treatment was used as input to estimate yield stress and creep properties. Yield stress was calculated mainly as a function of precipitation, solid solution and grain boundary strengthening contributors in microstructure. Creep rate was calculated as a function of stress, temperature and microstructural factors such as dislocation density, precipitate size, inter-particle spacing of precipitates. The estimated yield stress values were compared with the corresponding experimental hardness and tensile test values. The ability to determine best heat treatment conditions that achieve the desired microstructural and mechanical properties were developed for IN 738 LC based completely on simulations.

Keywords : heat treatment, IN738LC, simulations, super-alloys
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