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The Faculty of Mechanical Engineering and Aeronautics

Abstract of doctorate thesis

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This doctoral dissertation investigates the influence of high-temperature plastic deformation on the microstructural evolution and mechanical properties of the Haynes 282 nickel-based superalloy produced by investment casting. The primary objective of the study was to determine the relationship between deformation temperature, strain rate, and the mechanisms governing microstructural evolution, with particular emphasis on dynamic recovery (DRV) and dynamic recrystallization (DRX). A comprehensive technological route was developed, including investment casting of the alloy, evaluation of casting quality, phase and microstructural characterization, differential thermal analysis (DTA), solution heat treatment, and high temperature compression testing using a Gleeble 3800 thermomechanical simulator. Compression tests were performed within the temperature range of 700–1200°C at two strain rates: 0.001 and 0.008 s^{-1}. The experimental methodology combined optical microscopy (LM), scanning and transmission electron microscopy (SEM, TEM), STEM-EDS and SAED analyses, X-ray diffraction (XRD), hardness measurements, and mechanical testing. The results demonstrated that the quality of the initial material strongly depends on the investment casting parameters. Porosity and microstructural analyses confirmed that castings with appropriate geometric accuracy and sufficient quality could be obtained for subsequent thermomechanical processing. DTA measurements identified characteristic thermal effects and provided the basis for selecting the temperatures applied during solution treatment and high temperature deformation. Within the temperature range of 700–800°C, the alloy exhibited the highest deformation resistance and maximum flow stress, accompanied by pronounced work hardening. TEM observations revealed a high dislocation density, well-developed slip bands, and local initiation of microcracks. Increasing the deformation temperature to 850–1000°C promoted dislocation rearrangement, dynamic recovery, and dynamic recrystallization, 128 resulting in the formation of new equiaxed grains and a gradual reduction in deformation resistance. Above 1050°C, grain growth became the dominant microstructural process, leading to a decrease in hardness and an increase in the average grain size. TEM, SAED, and STEM-EDS analyses enabled the identification of MC-type carbides enriched mainly in Ti, Mo,

and Nb. These precipitates were shown to interact with the dislocation structure and grain boundaries, influencing the migration of grain boundaries and the kinetics of microstructural restoration during hot deformation. The study demonstrated that the most favorable deformation conditions correspond to the temperature range of 900–1000°C, where the alloy exhibits an advantageous combination of reduced deformation resistance, intensive dynamic recrystallization, and the formation of a fine-grained microstructure. The obtained results provide a scientific basis for further optimization of thermomechanical processing routes for investment-cast Haynes 282 components intended for high-temperature applications.

Keywords: Haynes 282, nickel-based superalloy, investment casting, hot deformation, dynamic recovery, dynamic recrystallization, Gleeble 3800, microstructure.