POLITECHNIKA ŚLĄSKA
WYDZIAŁ INŻYNIERII MATERIAŁOWEJ

PRACA DOKTORSKA

Wpływ pierwiastków stopowych na mikrostrukturę oraz właściwości nowych nadstopów kobaltu umacnianych fazą $L1_2$

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Katowice, styczeń 2023

Abstract

The work presents a new generation of γ-γ′ superalloys based on cobalt and the current state of knowledge regarding this group of heat-resistant alloys. Many research teams from around the world have started research on a group of materials of a new class of cobalt-based superalloys strengthened with a precipitation-coherent γ' phase with an $L1_2$-type lattice. Research on this group of materials was initiated in 2006 and is a response to the existing limitations of nickel-based superalloys, which do not allow the current pace of development of aircraft engines to be maintained. At established times, γ′ phase supplemented nickel superalloys are still unrivaled in any application, while they may be supplanted by their cobalt-based equivalents in the future due to their potential to improve growth properties. However, to achieve this state is a continuation of the research process of developing a new generation of superalloys. The doctoral dissertation presents a study on new γ-γ′ type superalloys based on cobalt in terms of their material, microstructure and thermal structure.

The first stage of own research was designing the chemical composition of the material for testing, making melts and preparing a set of samples for microscopic examination. The material for the tests were cobalt-based superalloys: Co-Al-Mo-Nb, Co-Ni-Al-Mo-Nb, Co-Ni-Al-Cr-Mo-Nb, Co-Ni-Al-Mo-Nb-Ti , melted in a VSG 02 Balzery vacuum induction furnace in Al_2O_3 crucibles embedded in a coil using manually compacted Konmix MAPI molding sand. In accordance with the defined cognitive objective, a thorough study of the primary microstructure of selected alloys was provided. These studies were aimed at characterizing the general and detailed picture of the dendritic structure, identifying the types of precipitates, places of occurrence of individual types of precipitates and hardness measurements. Research in this area was carried out based on simulations of the crystallization process using the CALPHAD method and a completely new method of structure maps. These results were verified by a detailed assessment of the phase composition using the S/TEM method. The next stage of own research included the development of heat treatment parameters using thermal differential analysis (DTA) and the performance of multi-variant heat treatment of samples, i.e. solutioning and aging. The solutioning was carried out at a temperature of 1250 ^{o}C for 5 hrs in an atmosphere of nitrogen and hydrogen, and then

individual samples were quenching into ambient temperature in various conditions: in water, in the calm air and in an annealing furnace. The next stage of heat treatment was the aging process. After the solutioning and quenching into cold water, the samples were aged at 800, 850, 900, 950, 1000 and 1050^{o}C for 3 hrs, respectively.

After the heat treatment, the changes that occurred in the microstructure of individual alloys on the cobalt matrix were tested and the assessment of how the influence of individual alloying elements affects the order-disorder transformation temperature, the share and morphology of the γ'. The last stage of the work is the final summary of the results and conclusions.