THE ESTIMATION OF Ni-BASED SUPERALLOYS THERMODYNAMIC CHARACTERISTICS

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This paper presents the results of a thermodynamic calculation of the structural and phase characteristics of VZhM1 (generation III), VZhM4 (generation IV) and VZhM8 (generation V) alloys. The lattice parameters of the γ and γ' phases, the γ' solvus temperature, the interfacial energy at the γ/γ' phase boundary and the antiphase boundary energy were determined.

Negative misfit ($a_\gamma > a_{\gamma'}$) contributes to an increase in creep resistance. It is shown that the VZhM8 alloy exhibits the highest negative misfit (−0.27% at 20 °C and −0.41% at 1200 °C), while the VZhM1 alloy has a positive misfit (0.07% at 20 °C and 0.14% at 1200 °C), which is due to the absence of ruthenium in its composition. The γ'-solvus temperature is a critical parameter for thermal stability. The highest γ'-solvus temperature (1322 °C) is observed in the VZhM8 alloy due to its high ruthenium content (6%) and optimal balance of W (4.2%) and Ta (6%). VZhM1 and VZhM4 have similar γ'-solvus temperatures (1299.3 and 1294.5 °C, respectively).

The interfacial energy at the γ/γ' boundary determines the morphology of γ' particles: low energy promotes uniform particle distribution, increasing the alloy's strength. The lowest interfacial energy at the γ/γ' boundary at 1200 °C was found in the VZhM4 alloy and is 32.8 mJ/m². In the VZhM1 and VZhM8 alloys, the interfacial energies are 37.1 and 37.7 mJ/m², respectively.

The antiphase boundary energy affects the microstructure's resistance to degradation. The highest energy value was observed in the VZhM1 alloy (238.9 mJ/m² at 1200 °C), while in the VZhM4 and VZhM8 alloys it was lower (200.3 and 203.6 mJ/m²), which is due to the ruthenium content.

An analysis of the dependence of the calculated values of the structural-phase characteristics on the alloy composition showed that rhenium, tantalum, and tungsten increase the γ'-solvus temperature, slowing down atomic diffusion and stabilizing the γ'-phase; chromium and cobalt reduce thermal stability by reducing the solubility of aluminum in the γ'-phase; Ruthenium, when present in the alloy at a content of up to 6-7%, increases the γ'-solvus temperature, but when present in excess, causes lattice distortions, worsening the properties.