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MECHANICAL PROPERTIES OF METAL OF CAST PARTS OF COMPLEX SHAPE FOR GAS TURBINE UNITS

Heat-resistant, complex-alloyed nickel-based casting alloys are widely used to manufacture hot-gas tract components for gas turbine units. However, cast components face the challenge of structural inhomogeneity due to the development of liquation during alloy crystallization, leading to instability in the metal properties of different sections of the components. Achieving uniform structures is particularly challenging when casting turbine blades, which have complex airfoil profiles of varying thicknesses and voids due to the different crystallization conditions of the airfoil metal and the massive locking section. Therefore, studying the structure and properties of the metal in different sections of the airfoil and locking section of cast components is of interest.

This study investigated the microstructure and metal properties of cast rotor blades for gas turbines at compressor stations. The parts were manufactured from a heat-resistant, complex-alloyed nickel alloy, type X16H70, using investment casting in a vacuum. After casting, they underwent standard heat treatment, including high-temperature homogenization and process aging.

Metallographic studies of the microstructure of the airfoil metal compared to the blade key metal revealed significant differences. The airfoil metal exhibits a fine-grained structure with grain sizes of 1–3 mm, while the key metal has grains measuring 5–8 mm. Furthermore, the airfoil grains have a columnar structure and are oriented perpendicular to the airfoil walls. In the thinner upper sections of the airfoil, these columnar grains intersect. In the thicker lower sections, a small number of small equiaxed grains are present between them. The blade key metal exhibits only large equiaxed grains.

To determine the mechanical properties, small-sized flat specimens with a working cross-section of 1.5x4.0 mm² were manufactured, based on the possibility of fabricating them from blade airfoils. Mechanical tests for long-term strength at 850 °C and a load of 320 MPa showed that the airfoil metal has a significantly shorter time to failure (60...85 h) compared to the metal of the locking section (80... 40 h), which is likely due to the columnar grain structure of the airfoil metal with unfavorable grain orientation. Short-term strength tests at 850 °C showed that the yield strength and tensile strength of the airfoil and locking section metal are

identical; at the same time, the plastic properties of the airfoil metal are somewhat higher, but have a significantly greater spread of values.

Thus, the blade airfoil metal has inferior properties compared to the locking section metal due to its unfavorable grain structure. Clearly, by controlling the solidification of the part during casting, it is possible to improve the properties of the most heavily loaded working section.