PHASE COMPOSITION AND STRUCTURE OF NICKEL-BASED ALLOY OBTAINED BY HIGH-SPEED DIRECT LASER DEPOSITION

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The structure and phase composition of products generated during additive manufacturing has a number of features that depends on the operating parameters of device, which affect the final mechanical properties of products. Thus, it is possible to manufacture products with a given mechanical property by varying the operating parameters. The structure and phase composition of nickel-based alloy obtained by the additive manufacturing of high-speed direct laser deposition is presented in the paper.

Lately one of the most promising methods of additive manufacturing of is the technology of high-speed direct laser deposition, since the use of technology is applied not only to creation of new parts of products with complex geometry, but also can be used for recovery operations of worn parts of products [1-3].

The main aim of the investigation was to study the influence of operating parameters on the structure and phase composition of nickel-based alloy obtained by high-speed direct laser deposition on the experimental device at Peter the Great St. Petersburg Polytechnic University. The laser power was varied from 450 to 1200 W during deposition of samples. Scanning velocity (45 m / sec) and powder feed rate (20 g / min), as well as the diameter of the laser spot, which are the main determining parameters of additive processing [4-6], remained unchanged. The choice of unchanged parameters and the coaxial geometry of nozzle was justified on the basis of previous experimental studies and mathematical modeling of complex geometry products [7-8].

After EDX analysis the powder was assigned to the Ni-Co-Cr system. The average size of spherical particles was 70 ... 90 μm. The surface of the particles had a smooth surface with dendritic structure. The materials of such system belong to nickel-based superalloys. High-temperature strength of alloys is provided by refractory alloying elements, forming a solid solution with nickel, and also by forming precipitating phase.

Structure of longitudinal section (relative to the laser beam) of all samples investigated with a help of light microscopy and scanning electron microscopyhad a dendritic morphology with separated layers from successive laser trajectory. Dendritic grains had an axes of the second order, which size depended on the used laser power. The height of the individual layer and the thickness of the grown wall of each sample also had a linear correlation with respect to the laser power.The cross section (relative to the laser beam) was typically equiaxedcellular structure the samples obtained at low laser power contained incompletely molten particles of the initial material with border pores. Areas with the growth of grains from the centers of the powder particles were revealed with increasing of laser power. Such areas indicate the occurrence of bulk crystallization [9].The structure with dendritic grains oriented toward the direction of laser scanning was observed at power above 900 W.

Decoding of the results of X-ray diffraction analysis of the initial powder and deposited samples shown the presence of solid solution based on nickel in all cases. The EDX analysis of the longitudinal section, carried out perpendicular to dendritic grains for identify the concentration zones of individual chemical elements, also showed the chemical composition corresponding to the initial powder throughout the samples section. Precipitating phase, as well as carbide and boride inclusions, were not detected at this stage due to their small size [10-11].

It is planned to conduct studies using transmission electron microscopy for determining the complete phase composition of the samples obtained at different laser powers.

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