MICROSTRUCTURE FEATURES OF AN ADDITTIVELY FORMED NICKEL-BASED SUPERALLOY ON AN ISOSTRUCTURAL SUBSTRATE [i,ii]

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In modern industry, the formation of products with single-crystalline or directional structures (for example, the fan blades of gas turbine engines from nickel superalloys) is carried out by directional solidification with a liquid-metal cooler. In this approach, the mold box with the crystallizing product is moved from the heating zone to the cooling zone, which is a molten easily fusible metal (e.g. aluminum). Such a process takes place at relatively low solidification rates (5mm/min), but the probability remains that undesirable radial components of the temperature gradient will be appear, leading to distortion of the growth direction of the structural elements. From this point of view, the application of additive manufacturing is a promising approach. In spite of the fact that in additive manufacturing the transition region from columnar structures to equiaxial structures (CET) is always formed [1], this region is melted at subsequent deposition of a new layer. Thus, in additive manufacturing products, equiaxial structures are observed only near the surface. Based on the above, the actual task is to identify structural features of products from nickel-based superalloys obtained by additive manufacturing.

At present, there are already works [2-4] devoted to this problem. A common approach among various authors is the use of a substrate made of the same material as the additive formed product. And the substrate, as a rule, already has a directed or single-crystalline structure. Due to the high cost of this approach, the use of substrates from more accessible materials is of interest. It is obvious that the use of a substrate made of a foreign material will lead to the appearance of a transition zone from the substrate to the formed product. This transition zone can have chemical and crystallographic effects on the material structure of the formed article. In addition, the appearance of undesirable phases in the substrate material may lead to distortion of the structural elements growth direction.

In order to assess the impact of the substrate on the formed product in this work by the method of wire-feed electron-beam additive manufacturing was obtained several walls of superalloy ZhS6u on a substrate of austenitic SS321 steel sheet.

According to the results of the research it was found that the border with the substrate is characterized by the thinnest dendritic structure, which indicates significant values of the temperature gradient. As the product grows, dendrites enlargement is observed, due to temperature gradient decrease. At the same time, directed solidification is realized with some inclination relative to the direction of additive growth. From the authors' point of view, the appearance of the slope is explained by the bending of the solidification front and one-way direction of 3-D printing. In turn, the bending of the molten pool boundaries is the result of two components of heat dissipation: into the material of an already formed product and into the chamber walls by means of radiation. The heat sink by radiation reaches maximum values at the top of the molten pool, which explains the formation of the CET region. It is also shown in the paper that the predominant orientation of the FCC crystal lattices γ - and γ' -phases, which are the basis of the material of the formed product, along the normal to the substrate surface corresponds to the crystallographic direction of type $\langle 001 \rangle$.

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[i] The work was performed according to the Government research assignment for ISPMS SB RAS, project No. III.23.2.11.

[ii] The reported study was funded by RFBR, project number 19-38-90130.