FORMATION OF BIMETALLIC PRODUCTS FROM NICKEL-BASED SUPERALLOY AND BRONZE BY WIRE-FEED ELECTRON BEAM ADDITIVE TECHNOLOGY *

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Investigations of methods for obtaining bimetallic and functionally graded materials remain an urgent task of the last decade [1]. Such materials are in demand in various industries from medicine to astronautics, when it is necessary to provide in a single product the properties characteristic of different materials. One of the ways to achieve this task is welding or another method of obtaining integral joints of dissimilar materials. However, this approach produces at least three different zones in the material: the base metal, the heat-affected zone and the fusion zone. These areas may differ in structural-phase composition and properties, which in turn leads to the formation of defects. Another way to obtain products from heterogeneous materials is the use of additive technologies. Since this approach involves growing the product layer-by-layer and each layer is periodically remelted and heat treated, the base metal area is absent as such, and most of the product is represented by the structure inherent in the heat affected area.

One striking example of the need to obtain products from dissimilar materials is a rocket engine, in which the key structural elements are the copper liner, which provides thermal properties, and its jacket of nickel alloy, which is responsible for the strength of the product [2].

In the present work the products in the form of walls from the nickel-based superalloy Udimet 500™ (wt.%: 53Ni - 18Cr - 18Co - 4.0Mo - 2.9Ti - 2.9Al - 0. 006B) and the heat-resistant bronze CuCr1 (wt.%: 0.08Fe - 0.7Cr - 99Cu - 0.3Zn) using wire-feed electron beam additive manufacturing (EBAM). These materials are heterogeneous but isomorphic, i.e., the matrix phase of each material has a FCC crystal lattice. In the course of the study, three strategies for printing bimetallic products were chosen. The first was at begin form a 3 cm high bronze wall and then deposit a 3 cm high nickel alloy wall on top of it. In the second approach, on the contrary, the nickel part was formed first and then the bronze part. In the third case, parallel formation of dissimilar materials took place: first a layer of nickel alloy was obtained and next to it a layer of bronze, then a second layer of nickel alloy and a second layer of bronze were deposited, and so on. General views of the obtained products are shown in Fig. 1.

Fig.1. Ni-Cu bimetallic products obtained by EBAM.

The product obtained by parallel formation of layers was found to be unsatisfactory because pores and voids up to 3 mm in size were present between the dissimilar materials. When forming a nickel wall and bronze on top of it, the bronze material spreads out excessively and loses its geometry, which is also a significant defect. And the most satisfactory was the product obtained using the first printing strategy. For example, no macro defects in the form of cracks and fractures were detected between the layers of nickel material and bronze. It is worth noting that in this work a sharp transition between heterogeneous materials was used in the formation of products. However, since nickel and copper have unlimited solubility with respect to each other, the formation of Ni-Cu solid solutions of different composition occurs throughout the first few layers of the nickel alloy, resulting in a gradient transition from one alloy to another.

REFERENCES

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