ELECTRON-BEAM CASTING TECHNOLOGY FOR PRODUCTION OF NON-STANDARD TITANIUM ALLOYS FOR EXPERIMENTAL PRODUCTION AND ADDITIVE TECHNOLOGIES

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There are many tasks for modern materials development and their production. Experimental materials, especially multicomponent and complex-alloyed titanium-based compositions, are really hard and expensive to obtain. In that case, electron-beam casting technology is one of the most useful method to produce such materials in semi-commercial amount up to 2-10 kg. So, it makes possible to investigate technological properties of melt, get necessary number of specimens and to prepare details for coatings depositions or additional products like powders for 3D printing.

Keywords: electron-beam casting technology, experimental titanium alloys, additive manufacturing

Introduction. It is well known, that titanium alloys belong to most modern materials for many high-tech and responsible fields of application [1]. Commercial production of titanium alloys is now appropriate for limited number of compositions. Furthermore, modern productions require small amounts of experimental alloys. Many of them also cannot be produced by using classical methods like vacuum arc or vacuum-induction remelting. Especially it is difficult for compositions, that simultaneously contain high concentrations of light elements like silicon or aluminum and refractory components like niobium or molybdenum. The same problem is when alloy includes elements with radically different densities. For example, current trends in development of high strength, heat-resistant, low-modulus and biomedical titanium alloys require to work with such systems: Ti–Al–Zr–Si–Mo–Sn, Ti–Nb–Al, Ti–Nb–Ta–Zr, Ti–Zr–Nb–Sn and some others, that are difficult to obtain [1, 2]. That's why modern production needs new technological decisions to get complex-alloyed titanium compositions in a form of half-commercial ingots with weight up to 2-10 kg. From many reasons such way seems to be very effective from the point of economy, technological and scientific effectivity.

Experimental part. Production of finished and semi-finished products of such alloys may be carried out by electron-beam casting technology [4]. Such way gives an ability to provide e-beam independent heating of different charge parts, overheating them and to form homogeneous melt by using electromagnetic stirring. From the point of such alloy's experimental nature, there is a need to study the technological features such alloys smelting, determine the behavior of components in the melting process and melt preparation, obtain high-quality workpieces.

For example, complex-alloyed compositions of creep-resistant alloy Ti–(7-8)Al–(3-4)Zr–(0.9-1.1)Si–(0.7-1)Mo–(0.8-1.2)Nb–(2-3)Sn and biomedical Ti-13Zr-13Nb, Ti-13Zr-13Nb-5Sn alloys were produced. Also, Nb–26Zr–24Ti alloy for WAAM 3D-printing powder was obtained. During experiments, it was discovered that most difficult problems to solve are connected with aluminum and tin introduction to melt and their further digestion.

Electron beam smelting of indicated alloys with tin was carried by doubling its content in the charge. It was also found that high content of refractory components with high density and unlimited solubility with titanium in the liquid state (Nb, Mo, W, Hf), freezing of the melt on the metal scull occurs. An increased concentration of tin is formed in the existing liquid volume and, accordingly, its more intense evaporation happens. At the same time, there is a need to wash away the scull-frozen metal, which is associated with melt overheating and even more intense evaporation of tin. Effective aluminum content saving was provided by its addition in the end of melting process using special charge addition mechanism.

All of obtained specimens had homogeneous structure and even distribution of elements. Ti–Zr–Nb, Ti–Zr–Nb–Sn and Nb–Ti–Zr alloys were used for 3D-pronting powders production by HDH method. As a result – they had even small dimensions and good quality.

Conclusions. Electron-beam casting technology helps to solve problem of complex-alloyed titanium alloys production and shows practical advantages of using it on example of producing ingots for further investigations and powder preparation, used in additive manufacturing process.

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