WIRE FEED ELECTRON BEAM ADDITIVE MANUFACTURING OF METALLIC COMPONENTS

S.V. FORTUNA, A.V. FILIPPOV, S.Yu. TARASOV, E.A. KOLUBAEV

Institute of Strength Physics and Materials Science of Siberian Branch Russian Academy of Sciences, 2/4, pr. Akademicheskii, Tomsk, 634055, Russia, e-mail: s_fortuna@ispms.tsc.ru, ph.: 8(3822)286863

Fast development of additive manufacturing is a global challenge in modern technology development, which determines provisions for developing and using new advanced, high-production and competing processes. This work has been focused on developing an electron multibeam additive directed energy wire deposition process and commercial high-production robotic equipment for manufacturing large metallic components.

This process involves a layer-by-layer deposition of metal by electron beam melting of wire and obtaining then a near-net-shape component. The advantage of this process is its high deposition rate up to 12 kg/h which is unachievable with other additive processes [1]. Also it allows making large up to 5000 mm size fully dense and structurally homogeneous components from both refractory and heat-resistant alloys [2]. Extra feature of this process is a feasibility of simultaneous deposition of dissimilar metals and thus forming a composite structure inside a vacuum chamber [3]. Therefore, it excludes any oxidizing of the component.

The project implementation allows filling a commercial niche both in home and abroad markets of equipment and materials needed for high-production additive manufacturing of large complex shape components. Achieving such a goal will provide our technological leadership in high-production electron beam additive manufacturing.

The purpose of this work is the development of laboratory 3D-printing equipment and chooses the technological mode of samples producing from stainless steel 321 grade.

To examine the macro-and microstructures of the material produced under various conditions of 3D printing, structural studies of cylindrical samples in a cross section were performed by optical microscopy methods. In order to determine the gradient of mechanical properties and the manufacturing quality of thin-wall (<3.5 mm) axisymmetric cylindrical and conical bodies, mechanical compression tests were carried out.

In this paper, a set of laboratory equipment for wire feed electron beam additive manufacturing of metallic components has been developed. Optimal process parameters have been found and used for manufacturing axisymmetric samples from the SS 321 wire. The structure and mechanical properties of the samples have been studied.

The compression strength of sample No. 3 was the highest and even higher than that of base SS 321. Samples No. 1 and No. 3 had clearly seen fusion interfaces between the successively deposited beads. For a more homogeneous specimen No. 2 in the macrostructure, a high anisotropy of the conditional yield point was observed. Sample No. 1 had high anisotropy of mechanical properties both in the directions of growth and deposition.

It was established that varying the additive process parameters such as wire feed rate, substrate rotation rate one may obtain finally printed components of various microstructure and mechanical characteristics. Manufacturing components with their mechanical characteristics either higher or close to those of base cast metal is also feasible. Moreover, it becomes possible to obtain microstructures of either high or zero anisotropy.

The work was financially supported by the Russian Federation via the Ministry of Education and Science of the Russian Federation (Agreement No. 14.610.21.0013, project identifier RFMEFI61017X0013).

References

1 *Ding, D., Pan, Z., Cuiuri, D. et al*. Wire-feed additive manufacturing of metal components: technologies, developments and future interests Int J Adv Manuf Technol 81.1, 465 (2015).
2 *Lewandowski, J.J. Seifi, M*. Metal Additive Manufacturing: A Review of Mechanical Properties, Annual Review of Materials Research 46, 151 (2016).
3 *Wang, J. Tang, H.* Review on metals additively manufactured by SEBM, Materials Technology 31,2, 86 (2016).