Laser Additive Manufacturing of Bioresorbable Magnesium Implants and Means of its Automation

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Magnesium and its alloys belong to a class of degradable biomaterials with a mechanical strength similar to that of bone. Rapid creation of an individual implant from magnesium powder according to an electronic geometric model as a result of a laser additive process eliminates the need for an operation to remove it. However, the complexity of the laser fusion process when performing the part construction cycle due to the high chemical reactivity of magnesium, which creates the risk of ignition, does not allow yet practical application of this material in medicine: orthopedics, traumatology and pediatrics. In the course of fundamental scientific research, an interdisciplinary group of researchers of the Far Eastern Branch of the Russian Academy of Sciences studied the effect of many factors affecting the mechanical characteristics and chemical properties of layer-by-layer samples created from magnesium powder MPF-4 [1–3] in the LPDED ("laser powder-based directed energy deposition") process of additive manufacturing.

The analysis of 3D modeling and 3D printing applications in surgery [4] and the results of our own research [5] made it possible to develop an algorithm for the transition from the initial information contained in computed tomography files to the program code that specifies the additive process of forming the physical shape of the bone implant by fusion metal powder material when exposed to laser energy.

The process of stage-by-stage formation of a conceptual prototype of a bone implant from magnesium powder MPF-4 is schematically shown in Figure 1.

To automate the design stage of an additive technological process for the synthesis of an implant according to its model, the concept of a decision support software for LPDED additive manufacturing processes based on an ontological approach is proposed [6].

The results of the research are accumulated in the databases of the knowledge portal of technological processes (operations) of the additive manufacturing of metal products (parts) using laser technological equipment. This portal, which is based on the concept [6], was created on the IACPaaS cloud platform [7,8] and is intended for development of optimal (according to the quality criterion of the additive manufacturing process) technological modes suitable for practical use.

The research work aimed at creating a program for the synthesis of parts of a given shape in the process of laser additive manufacturing was both scientific and practical, since the results obtained can be used in medicine, in particular, in surgery in

the manufacture of bioresorbable magnesium individual implants for bone osteosynthesis.

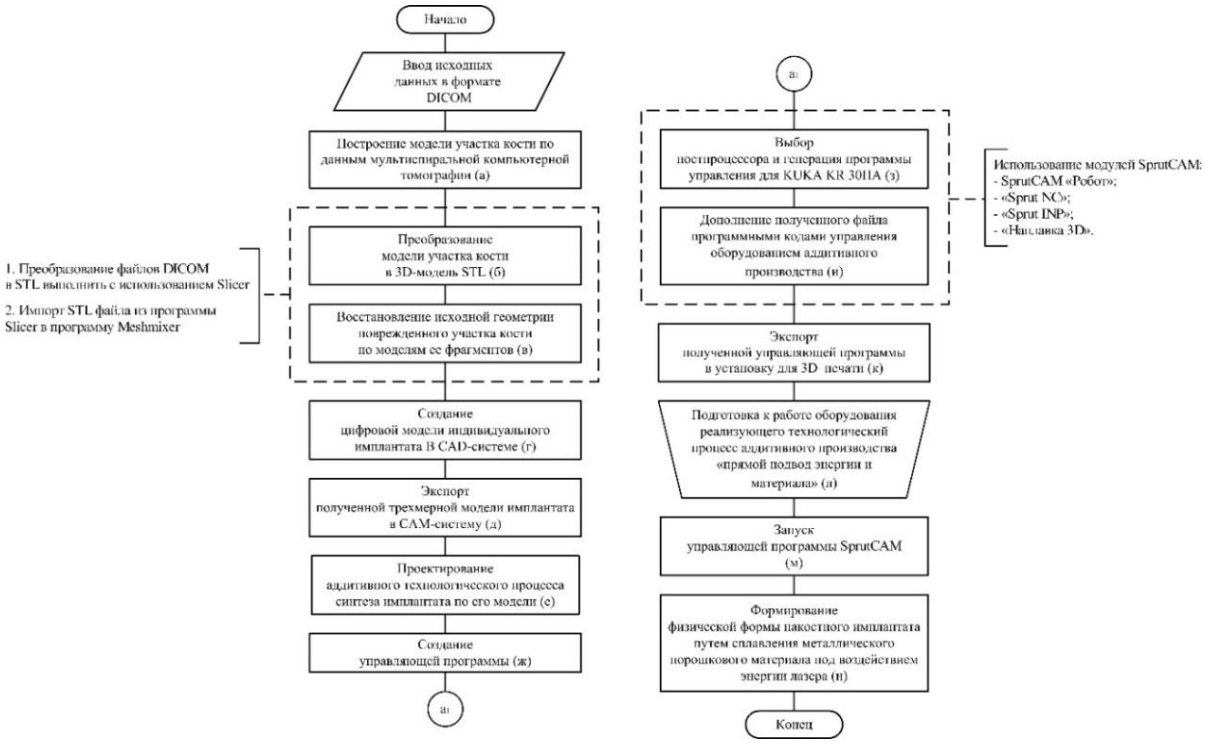

Fig. 1. Diagram of the process of forming an extra-bone implant according to a virtual model for the process of additive manufacturing "laser powder-based directed energy deposition".

The databases of the knowledge portal will be useful in the process of training laser equipment operators, and their formalized representation will provide the possibility of using this information by decision support software systems.

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