ABSTRACT

of thesis for the degree of Doctor of Philosophy (PhD) according to the educational program 8D07113 - «Additive manufacturing»

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on the topic « Scientific and technological basics for the manufacture of high-quality products by complex extrusion-additive technology from metal-polymer powder materials»

Relevance. Strict adherence to the technological regime of the foundry cycle and process stability allow us to produce various high-quality products from powder materials used in various industries. However, to manufacture products using injection molding technology, it is necessary to use complex molds; moreover, the production of each new part requires the design and manufacture of special molds, which is a source of significant financial costs.

In this regard, in order to eliminate the shortcomings of the current technology for the production of complex-shaped metal products with highly filled metal polymer compositions, research was conducted on a press installation for a 3D printer with the study of the technological foundations of 3D printing and sintering of the product.

3D printing has recently been actively used in various sectors of the economy, and research in this area is constantly being improved. Research on the study and further improvement of 3D printing to obtain high-quality products has a significant impact on the quality of products obtained using additive technologies, which is undoubtedly relevant.

The purpose of the work. Research and development of the design of a pressing plant for the release of a filament pressed from metal polymer composite granules, with the production of a 3D-printed model from a filament developed on a pressing device (PD), and the study of changing its structure by firing, sintering and improving quality.

The scientific novelty of the work is determined by the following results:

- - Based on physical modeling, as well as experimental studies, optimal filament processing modes have been identified;

- - The values of the stress-strain state (SSS) of the PD, ensuring its stable functioning, are determined;

- 3D printing modes have been determined that allow to obtain a metal-polymer composite thread for products that are not inferior in properties to injection molding;

- The influence of technological parameters by firing and sintering to remove binders in the composition of a sample made using 3D printing has been established.

In accordance with the set goals, the following tasks are formulated:

- To analyze the structural properties of a metal polymer composite material for the manufacture of a metal polymer composite thread;

- To develop design documentation for a new PD;

- On the basis of computer modeling to design a PD and calculate its geometric dimensions;

- Using simulation and physical modeling to calculate the strength and hardness of the main parts and assemblies of PD;

- Using the integrated computer modeling system MSC Nastran to calculate the SSS of the main PD nodes;

- To develop a program to determine the basic parameters of 3D printing using metal polymer composite filaments, and firing and sintering of products, as well as to investigate the hardness of sintered products.

Provisions made for the defense:

- Compaction of pressed metal-polymer composite material by 5-7%, consisting of a thread of stainless steel powders made on the basis of mixed compression of molten raw materials on a new PD;

- A program has been created to determine the parameters of printing on a 3D printer of metal polymer composite filaments based on improving the quality of the sample;

- Firing and sintering of samples printed on a 3D printer with a metal polymer composite thread, reducing the parameters of binder removal to 2-4%;

- Obtaining sintered samples having a volume reduction of up to 13% relative to the original volume of the original sample.

Approbation of the research results.

The main provisions and scientific results were discussed at scientific and practical conferences and conference materials were published:

1. Analysis of the method of making filaments from high-filled metal polymer composite material for MIM technology to FDM technology. Conference "Satbayev readings-2021". 2, 2021, page. 636-641, ISSN: 978-601-323-246-1.

Publications. As a result of the dissertation work, 5 articles were published in journals indexed in the Scopus and Web of Science databases and 3 scientific papers in publications included in the list of articles in publications recommended by the Quality Assurance Committee of the Ministry of Science and higher education of the Republic of Kazakhstan.

Works in journals included in the Scopus and Web of Science databases:

1. The stress-strain state (SSS) calculation of heavy loaded elements of a new-designed pressing device (PD) (article). Metalurgija. 61, 1, 2022, pp.250–252, ISSN: 0543-5846, (Metals and Alloys), Percentile: 37.

2. Development of the design and technology of extrusion of metal-polymer mixtures for the production of feedstocks (article), Eastern-European Journal of Enterprise Technologies. 4/1, 118, 2022 pp. 23–33, ISSN: 1729-3774, (Engineering), Percentile: 46.

3. Investigation of the effect of thermal post-treatment on density and hardness of a green part printed with FFF technology (article), Journal of Chemical Technology and Metallurgy. 57, 6, 2022, pp.1258–1266, ISSN: 1314-747, E-ISSN:1314-7978, (Engineering), Percentile: 38.

4. Modeling of stress-deformed conditions of heavy loaded elements of new equipment of metal injection molding technologies (article), Metalurgija. 60, 3-4, 2021, pp. 317–320, ISSN: 05435846, (Metals and Alloys), Percentile: 37.

5. Development of technological basis of 3d printing with highly filled metal-poly-dimensional compositions for manufacture of metal products of complex shape (article), Metalurgija. 60, 3-4, 2021, pp. 355–358, ISSN: 05435846, (Metals and Alloys), Percentile:37.

List of articles in publications recommended by the Quality Assurance Committee of the Ministry of Science and higher education of the Republic of Kazakhstan:

1. Investigation of Methods for Removing Polymers of a Sample Printed with a Metal-polymer Composite Material in Additive Manufacturing (article), Труды университеті. Раздел «Машиностроение. Металлургия». 3, 88, 2022, стр. 23-28.

2. Analysis of a new filament making mel pressing device (article), News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, Series of geology and technical sciences. 4, 454, 2022, pp. 6–15, ISSN: 2224-5278.

3. Computer modeling and verification of mechanical properties of metal-polymer composite materials used in the technological process of layer-by-layer growing of partsused in the technological process of layer-by-layer growing (article), BULLETIN of L.N. Gumilyov ENU. Technical Science and Technology Series. 2, 139, 2022, pp. 72–85, ISSN: 2616-7263, eISSN: 2663-1261.

Monograph. As a result of the dissertation, 1 monograph was written:

1. Progressive methods of processing materials by pressure. UDC 669:621.7, BBK 34.39, P 78, 2022, ISBN 978-601-228-473-7. (Printed and Electronic).

Patents. As a result of the dissertation, 1 invention patent was obtained:

1. «Continuous pressing device for the manufacture of long profiles from powder materials». Patent for invention No. 35634, 2020/0905.1, 01.07.2022

The dissertation work was carried out within the framework of grant funding projects AP08857034 «Development of a new design of a pressing equipment and a chamber with a gas-dynamic installation with program control for the manufacture of additive technology of high-quality products». The results of the study were put into production at the LLP Zhaken Kalsha plant.

Structure and scope of work. The dissertation work consists of an introduction, four chapters and a conclusion. The thesis contains: 103 pages, 57 figures, 17 tables, 96 bibliographic sources, 5 applications.