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The field of use of additive technologies

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Abstract
The issues of additive technology in relation to combined methods of tool manufacturing using electromagnetic and other types of fields as an influence on the process are considered. It is shown that the use of additive technologies in mechanical engineering is most promising for flexible-structured industries, where the products are in a state of constant improvement and updating, and are produced in a limited series. In this case, it is required systematic replacement of the tool, which ensures the receipt of parts with the required configuration and quality level.

1. *The paper proposes a new approach to the use of additive technologies in combined processing methods, where the concept of a traditional tool in the form of a solid body having a mirror image of the working part relative to the treated surface is expanded to non-contact and non-force contact effects, in which the removal of the allowance and the change in operational characteristics occurs due to thermal, chemical, magnetic influences or their combinations with mechanical factors.*
2. *The ways of solving the problem of managing operational characteristics by creating parts from conjugate layers, the properties of which are formed by optimizing technological modes, are proposed.*
3. *The field of effective use of the technology of sequential layer-by-layer build-up or changing the properties of layers during contact and contactless processing on serial equipment without time-consuming readjustment or modernization of technological equipment by designing a software product for modern computing equipment is disclosed.*
4. *The issues of additive technology in relation to combined methods of tool manufacturing using electromagnetic and other types of fields as an influence on the process are considered. It is shown that the use of additive technologies in mechanical engineering is most promising for flexible-structured industries, where the products are in a state of constant improvement and updating, and are produced in a limited series. In this case, it is required systematic replacement of the tool, which ensures the receipt of parts with the required configuration and quality level.*
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7. *The field of effective use of the technology of sequential layer-by-layer build-up or changing the properties of layers during contact and contactless processing on serial equipment without time-consuming readjustment or modernization of technological equipment by designing a software product for modern computing equipment is disclosed.*

Keywords: Additive Technology, Tool, Combined Methods, Equipment, Modernization, Management, Field of Use.

Introduction
When using combined processing methods with the imposition of various fields, the control of the build-up of layers and changes in their properties occurs without direct force contact of the tool with the treated surface, and in some cases only due to the local movement of thermal, magnetic and other fields in the processing zone. This significantly reduces the requirements for the mechanical characteristics of the tool, highlighting the electro-thermal, chemical properties and manufacturability of the design. The requirements for such tools vary according to the depth of the layer, which can be performed in basically, by controlling the properties of each mating layer using additive manufacturing methods. The formation of the profile and properties of products by controlling the effects of combined processing methods makes it possible to fully utilize the capabilities of sparsely populated and unpopulated technologies in flexible structural production. At the same time, the accuracy of the contour boundaries of the workpiece is ensured by the localization of the field area when applying each layer by controlling the power of the supplied energy during combined processing. The considered approach

significantly accelerates technological preparation of production during the development of new or modernized high-tech products, especially in the aerospace industry of machine building.

The Field of Use of Additive Technologies for The Manufacture of Tools

A significant part of metal-cutting tools is standardized and when designing a serial process, the work is reduced only to selecting an object from the proposed product range. Combined processing methods (CMOS) with the imposition of various fields belong to non-traditional technologies, where in most cases the tool has individual characteristics and is developed taking into account the operational requirements for specific products, including those mastered in production, during repair and maintenance of facilities. When working out the manufacturability, the choice of a tool for CMOS is carried out taking into account the following factors:

➢ The ability to perform operations using traditional technologies. If this is not feasible at the present stage of technology development, then further stages of technological development are carried out in the direction of adapting the CMOS to the plan of operations, the purpose of the tool and its manufacturing technology, including using additive technologies;

➢ Feasibility study of the use of the selected tool for the CMOS. Here it is necessary to analyze the required and available means of technological equipment, the company's ability to purchase new equipment, the prospects for its loading and payback.

When working out the manufacturability, it is advisable to apply the accumulated experience of creating a tool for CMOS using additive manufacturing technologies. Figure 1 shows the types of tools used for CMOS. They are made, mainly, taking into account the experience of manufacturing and mastering high-tech products of the aerospace engineering industry, where flexible structural production is most often used. Naturally, as the use of additive technologies expands, the list of tools for CMOS and other applications will be systematically replenished.

Using additive technologies are performed. (Figure 1) electrodes-tools (EI) having a working part in the form of a mirror reflection of the profile in the processed part [1,2,3], unprofiled EI [4], templates [4,5],which are a carrier of information about the geometry of the place of processing of the part by means of anodic dissolution [6], ensuring the required quality indicators of products [7].

The greatest use of dpj CMOS has been found by the most simple to manufacture solid metal EIS, the housings and the central part of which can be made from standard profiles, by casting, stamping, assembling from various sufficiently simple materials for the manufacture of fragments. Additive application of surface layers with special properties is necessary in exceptional cases to form a complex geometry of the working part of the EI or to obtain the final shape of the tool from standard profiles with smaller standard geometric dimensions, while the applied layers may be homogeneous or have different performance characteristics, for example, electrical or thermal conductivity, hardness. The list of local properties of coating layers is very wide. In [8], the experience of layer-by-layer changes in the properties of materials by exposure to electromagnetic fields, purposeful changes in the phase composition and thermochemical transformations in the depth of the surface layer of parts, which can be used in the manufacture of, for example, long-length EI to relieve internal stresses and align the profile of metal rods. Additive technologies make it possible to perform EI with local electrically insulated sections, which can reduce current dissipation and increase the accuracy of the machined parts.

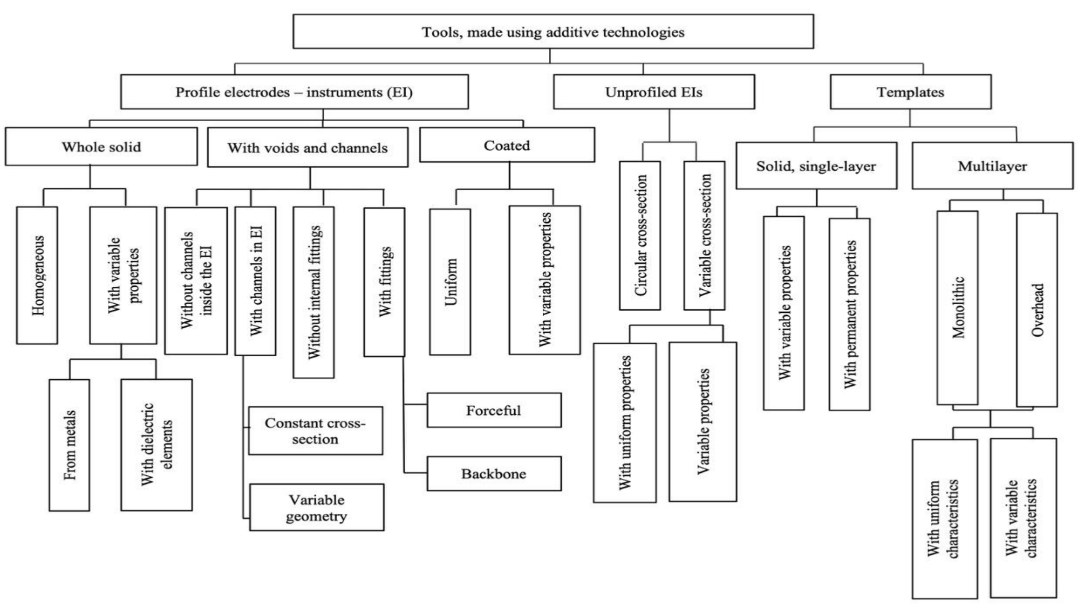

Figure 1: Structure of instruments for CMOS manufactured using additive technologies.

In some cases, the most effective information carrier is a template obtained using additive technologies by applying multilayer coatings with different properties [5,6].

For the combined stitching of the inter-blade channels in solid (from a stamped blank) impellers of turbopump units of liquid rocket engines (Fig.2), profile electrode tools (EI) , which wear out and require either systematic replacement or repair by increasing part of the working surface. The use of additive technologies opens up the possibility to replace the scarce copper of the tool body with cheaper and more affordable materials, and to restore the working part by multilayer coating with any alloys, including silver, which it is practically not used for the manufacture of EI, although it has valuable technological advantages. With its local application in the places of tool wear, the use of silver may be economically justified, although it requires increased accounting for the consumption of this precious metal.

Figure 2: Interscapular channels in turbopump units.

It is known from [6] that the use of alloys with special performance properties for EI opens up the possibility to expand the scope of use of combined processing methods. In particular, the use of refractory tungsten alloys applied using additive technologies for multilayer coatings of EI makes it possible to create an almost wear-free tool and reduce the cost of technological equipment even for serial production. One of the advantages of the new methods of EI recovery is the possibility of using products without finishing the final operation, because micro-dimensions are not transferred to the workpiece, and the productivity of the coating process increases [6,9] when using roughing modes.

A new area of research is the creation of multilayer unprofiled electrodes-tools according to the patent [10]. In [6], the experience of using unprofiled tools made of standard brass wire with a diameter of 0.1 to 0.3 mm with a uniform galvanic zinc coating with a thickness of up to 50 microns is given. But when using wire electrodes, wear occurs unevenly and it is required to have an increased layer size on the side of the EI feed for cutting into the part.

In some cases, the most effective information carrier is a template obtained using additive technologies by applying multilayer coatings with different properties [5,6].

Finishing of the Outer Layers of Coatings with Additive Technologies for their Production

After applying the coating layers, it may be necessary to finish the working part of the manufactured tool in order to reduce the height of micro-dimensions., the value of which can be many times higher than the required limit value (Figure 3).

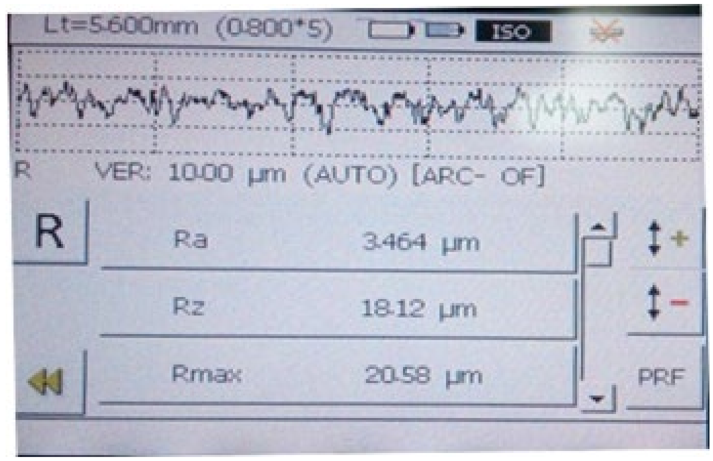

Figure 3: Roughness of the sample surface after additive application of layers.

The roughness of the sample after applying the layers is (Figure 3) Rz=18.12 microns, therefore, a finishing treatment of the outer layer is required to reduce the height of the irregularities to a value of no more than Ra=0.63 microns., without violating the operational characteristics of all applied layers.

For leveling the surface layer of coatings, a technology of finishing with a flexible tool has been developed according to the patent [12]. A flexible tool processing scheme is proposed, shown in Figure 4.

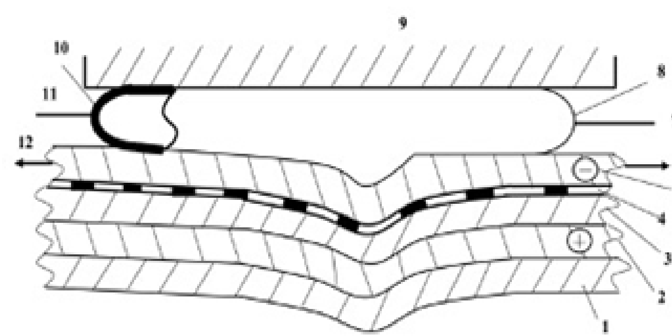

Figure 4: The scheme of the electroabrasive finishing of parts.1,3: Layers obtained by additive technologies; 4: Abrasive layer of the tool; 5: Flexible elastic conductive base of the tool; 6,12: Rods for moving the tool; 7,11: Rods for moving the chamber; 8: Hose; 9: Rigid support; 10: Sealed chamber.

The scheme proposed in Figure 4 provides the possibility of performing a finishing operation for the outer layer 3 even in the case of a one-way supply of the tool. In this case, the processing zone can be flat or compound, and the tool is a flexible conductive tool 5 with an abrasive layer 4 applied to it. If there is a recess on the workpiece, then it is required that the base 5 of the tool be elastic with the ability to ensure that the tool fits to the processing zone in all parts of the part. With limited access of the tool, it is delivered to the processing zone in a folded form, after which the base 5 is deployed with an abrasive layer 4 towards the applied layers, a sealed chamber 10 is applied. compressed gas is fed into it through the hose 8 (usually air at a pressure of 0.05-0.1 MPa). Before pressing one side of the camera to the support 9, and layer 4 to layer 3 without cutting the cutting edges of the tool into layer 3. A weak electrolyte is supplied, a low voltage current (6-8 V) (the instrument is a cathode).The specifics of the proposed method and tool include the removal of micro-irregularities mainly due to anodic dissolution with virtually no force action of the abrasive on the metal. The process of dimensional anodic dissolution of irregularities during combined electroabrasive treatment occurs during reciprocating movement of the tool with rods 6;12 until the removal of micro-irregularities. Then the pressure in the chamber 10 is reduced until a gap appears between layers 4 and 3, rods 7;11, the camera is moved and the finishing operation is repeated on the conjugate section of the treated surface.

The proposed method and tool provides the finishing treatment of the tool obtained using additive technologies until the specified performance indicators are obtained.

Conclusion

The paper considers the technology of additive processing of electrodes-tools for combined processing methods, taking into account the specifics of modern flexostructural production in the aerospace engineering industry. The analysis has shown that the scope of new methods can be significantly expanded by using multilayer coatings, templates, electromagnetic fields, layer-by-layer transforming the performance characteristics of parts in depth of layers. The ways of improving the quality of the surface layer of profiled and unprofiled electrodes-tools without violating the operational properties of their working area and restoring the operability of products are considered by building materials with predetermined properties using additive technologies.

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