Combined multi-electrode piercing of holes in hard-to-process materials

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Abstract. The possibilities of combined piercing through and "blind" holes in hard-to-process materials are considered. The possibilities of intensifying the processing process by using multi-electrode tools are presented. A fundamentally new element of the new technology is the creation and use of a new working environment based on a rheological fluid with variable viscosity. This determines the conditions for mass removal of processing products from the hole forming site and creates conditions for process stabilization. The method is protected by a Russian patent and has been used in many factories countries. The article considers the technology of processing parts in the proposed working environment, which implements the proposed method in the form of a technological process in the manufacture of parts with holes of different cross-sections. At the same time, the use of combined multi-electrode cross-linking allowed up to 3 times to speed up the production of channels for cooling parts of the hot zone of thermal machines, and to achieve stability of cross-section sizes within +5%. This technology expands the use of electrical processing methods in General and special engineering in the manufacture of parts from hard-to-process alloys.

1. Introduction
In Russia, a new method [1;2] of combined flashing using a metal nanofill as a working fluid has been developed and used for the manufacture of deep holes (depth-to-diameter ratio up to 50) of small cross-section (from 0.05 to 3 mm2). The method is protected by patent No. 2621325 of Russia (Bulletin of inventions No. 16,2017) [3] the Process has undergone industrial testing on parts of heat engines.

2. Object of research
Figure 1 shows the turbine blade, which made several thousand holes with a diameter of 0.5 mm and a depth of 20 mm. Attempts to perform this operation by drilling failed, because at different angles between the axis of the tool and the surface of the workpiece drill bent and destroyed. The use of combined firmware with the imposition of an electric field made it possible to create technological processes for individual and group processing at a firmware speed of more than 1 mm per minute. The size spread for the entire group of holes within the processing zone does not exceed +5%.
3. Technology for piercing holes in a rheological environment

A method for creating a working environment for the considered types of processing and a device for its implementation under patent No. 2621325 are proposed [3]. In figure 2 shows the scheme of the method and the device for its implementation.

**Figure 1.** Part with deep through holes.

**Figure 2.** The scheme of the method and device according to patent No. 2621325.
In figure 2, the working medium is selected on the basis of a rheological liquid including a conductive component 1 with a metal nanofill 2. It enters the magnetic gravitator 3 with the action of the magnetic field in the direction of the arrow 4. The magnetic gravitator 3 through the dielectric seal 5 is connected to the zone 6 of the electrochemical or combined erosive chemical dimensional processing, in which the processing products 7 enter the working medium. Zone 6 is connected by a dielectric seal 8 with a magnetic separator 9 in the direction of the magnetic field in the separator 9 which is connected by a channel 11 to the device 12 of cleaning the working medium from the processing products 7. To move the liquid 1 in the tank 13 is the channel 14. At the outlet of the liquid 1 from the tank 13 in the channel 15, a liquid flow regulator 16 1 is installed, connected to the viscosity meter 17 of the working medium in the mixer 18, to which the nanofill 2 enters from the separator 9 through the channel 19. Through the channel 20, the working medium in the direction 21 enters the input 22 of the gravitator 3, moves along it in the direction 23 and then together with the processing products 7 moves through the zone 6 in the direction 24, forming a connected hydraulic circuit. In the separator 9, the working medium moves in the direction 25 and at the end of the separator 9 is divided into streams 26 and 27. Next, the liquid 1 moves in the directions 28, 29 to the tank 13, then in the direction 30 to the mixer 18.

The technological process of processing with a single and multielectrode tool includes a number of stages. First the current supply fluid 1rom the tank 13 through the channel 15 is fed to the liquid flow regulator 16 1. On the signal from the mixer 18 to the meter 17 viscosity of the working medium regulator 16 delivers in the direction of 10 the amount of liquid 1 in the direction of 30 in the mixer 18, necessary to maintain the specified viscosity of the working medium. Further, in the direction 21 through the channel 20, the liquid is pumped to the entrance 22 of the gravitator 3, where in the magnetic field acting in the direction 4, the nanofill 2 moves towards the 4 action of the magnetic field, where it is required to overcome the action on the nanofill 2 of the earth's gravitational field. After that, the working medium moves in the direction 23, past the seal 5 and enters the zone 6 of theelectrochemical dimensional or combined processing and moves in the direction 24, forming a connected hydraulic circuit. Generated in the process of anodic dissolution treatment products 7 arrive in the working environment and through the grommet 8 in the direction 25 is moved with the working medium in the separator 9, where under the influence of a magnetic field in the direction of 10 shared working environment on the flow of the liquid 1 with food processing 7, which is in the direction 26 through the channel 11 into the device 12 for cleaning the working environment from food processing 7, and the second part stream containing mostly filler 2 moves in the direction 27and the channel 19 to the mixer 18, where a working environment, including liquid 1 after cleaning in the device 12 and moving in the directions 28, 29 through the channel 14 to the tank 13.

The method provides stabilization of the composition and properties of the working medium during electrochemical dimensional and combined processing of blanks from metal materials. This is achieved in that at the entrance to the treatment area, the working medium is passed through a magnetic field with a displacement vector of the nanoparticles in the direction opposite to the gravitational force, and the output of the treatment area of the working environment with food processing is passed through magnetic field with a displacement vector of the nanoparticles in the opposite direction, and then divide the streams, of which the first, consisting of liquid treatment products, is directed to a device for cleaning liquids from food processing, and the second - in the mixer to obtain a working medium based on a purified liquid with a given viscosity of the working medium. The device includes a magnetic gravitator at the entrance to the processing zone, and a magnetic separator at the exit, forming a connected hydraulic circuit having a viscosity meter of the working medium connected to a liquid flow regulator in the working medium.

The developed technology [4] of using rheological fluids with metal nanofillers was tested by piercing holes in the workpieces shown in figure 1. The treatment was carried out in a working medium of rheological liquid, including 5% aqueous solution of sodium chloride and 6% (by weight) of metal nanoparticles with dimensions of 9-10 nanometers. Details are made of alloy 12X18H10T
due to the stabilization of the process is required to obtain a roughness of no more than Ra=0.16 microns. According to the book "reference technologist / edited by A. G. Suslov // Moscow: Innovative engineering, 2019", page419 select and calculate the processing modes, including: medium pumping speed 0.5 m/s, magnetic field strength in the gravitator 100 A/m, separator 1000 A/m.

As a result [5;6;7]the stability of the parameters of the flashing process was achieved, which allowed at the feed rate of the electrode-tool made of copper 0.8-1.0 mm per minute to achieve a surface roughness after processing Ra less than 0.16 microns.

4. Conclusion
The given technology allows to expand the scope of application of electric methods of processing on production of complex-shaped details from hardly processed alloys at the limited access of the tool to a processing zone.

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