Research of influence of electric conditions of the combined electro-diamond machining on quality of grinding of hard alloys

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Abstract. Improvement of production engineering of finishing machining of the hard alloys providing set parameters of quality and exactitude of products is an actual problem in the conditions of the modern industry. To reach objectives it is possible only at the expense of the solution of a complex of questions of fundamental and applied nature. Basic researches are directed on identification of main factors and the reasons of inefficient use of diamond grinding wheel at finishing machining of products from high-strength hard alloys materials. The applied party of research consists in development of recommendations about implementation of offered solutions under production conditions. In paper the problems connected with effective machining of modern high-strength materials are observed. The reasons of limited application of diamond grinding wheels on a metallic binder are noted when machining hard alloys. The carried researches allowed to establish advantages of a method of the combined electro-diamond machining of hard alloys and to define the rational modes providing high quality of products.

Introduction

Effective processing of products from hard alloys is an actual problem in the conditions of modern engineering manufacture [1, 4, 6, 7]. Methods of abrasive processing of hard alloys applied at the operations not always allow to provide the set parameters of exactitude and quality [2, 3, 5]. The widespread abrasive tools used for processing of hard alloys, in most cases do not allow to decide posed problems, and use of the productive tool from super hard abrasive materials is limited, in an aspect of the problems related with restoring of their cutting properties [5, 9, 11, 13]. Heightening of performance of application of synthetic abrasive materials at manufacture of products from hard alloys and high-strength materials probably at the expense of the solution of a complex of fundamental, designer and technological problems.

The assaying of a condition of a problem of processing of modern high-strength hard alloys materials allowed to mark prospects of the physicochemical and combined methods of processing [3, 9, 11, 13, 19]. The combined methods allow to combine in one process some methods in a different combination that leads to heightening of performance of processing. Authors [4, 9, 11] it is marked that widespread aspects of the combined processing of hard alloys is electrochemical grinding which execute a electrically conductive diamond wheel on the metallic binder, the being cathode, grinding with a continuous electrochemical straightening of a wheel, and also the combined electro-diamond grinding. However, accurate and uniform recommendations about a choice of aspects and conditions...
of the combined processing of hard alloys it is not worked out.

In this connection considerable interest represents research of features of influence of electric conditions of the combined electro-diamond processing on quality of grinding of hard alloys.

**Material and research methods**

In this research quality of the treated surface of hard alloys was evaluated at the combined method of electrochemical grinding with a simultaneous continuous straightening of a wheel. For estimate parameter of quality the roughness of the treated surface is selected [2, 3, 5].

The essence of a method consists in anode dissolution of products of grinding which are organized on a wheel surface that ensures functioning of a wheel in a self-sharpening condition, and a simultaneous electrochemical softening of a working area of a treated hard alloy. The method provides fixed cutting properties of a wheel and on the other hand under the influence of anode and chemical processes the specific is augmented removal a preform material, at the expense of it performance raises and expenditure of diamond wheels decreases. The technology is implemented using the developed techniques and special equipment designed [6, 8, 10, 12, 14-18].

The assaying of methods of electro-diamond grinding allowed determining the following factors influencing process of machining: current density of a straightening of \( j_{st} \) [A/cm\(^2\)], current density the etching of \( j_{et} \) [A/cm\(^2\)], rate of cutting of \( V \) [m/s], depth of cutting of \( t \) [mm/d.s] and stride of \( S \) [m/min]. In the conditions of the same instrument registration of process of machining these factors rather fully reflect technique of electro-diamond grinding.

For holding of research the design of experiments necessary for minimizing of amount of experiences in a stroke of definition of a mathematical sample piece of examined process for the purpose of abbreviation of material inputs and time is executed. In this case research of change of conditions and parameters of the combined machining from electric treatment schedules of hard alloys were carried out: current density of a straightening of a wheel of \( j_{st} \) [A/cm\(^2\)] and current density the etching of a detail of \( j_{et} \) [A/cm\(^2\)]. Thus, amount of factors of \( k = 2 \), amount of experiences – 4.

Treatment schedules are selected according to the recommendations guaranteeing excellence of a surface, developed earlier [11, 19]. According to recommendations current density of a straightening of a wheel should be no more \( j_{st} = 0.1…0.4 \) [A/cm\(^2\)], current density the etching of a detail of \( j_{et} = 10…40 \) [A/cm\(^2\)], stride \( S = 1.0…2.0 \) m/min, transversal feeding \( t = 0.01…0.04 \) mm/d.s, rate of cutting \( V = 15…40 \) m/s.

As an output parameter the roughness of the treated surface of Ra [µm] was examined. The condition of the treated surfaces of products from hard alloys was inspected with use of modern engineering of the visual and structural assaying.

Materials for holding of research selected hard alloys of several brands of WC3M (WC-97%, Co-3%, M - fine-grained), WC8 (WC-92%, Co-8%), WC15 (WC-85%, Co-15), TN20 (TiC-79%, Ni-15%, Mo-6%), in an aspect of their wide application on manufacture as structural and instrumentals materials.

In research diamond wheels on a on the metallic binder of brand \( M_1 - 01 \) and \( M_2 – 01 \) speckle 100/80 and 80/63 were used.

As an electrolyte the solute of salts was applied: 0.5 % of Na\(_2\)CO\(_3\) and 1.0 % of NaCl in water. According to observations Instruments for the measurement of conductivity KSL-101, conductance of an electrolyte made 26 Cm/cm, the contents of salts – 20 g/l.

**Results**

By results of research of an alloy of WC3M dependence of a roughness of Ra [µm] of the treated surface on electric treatment schedules of \( j_{st} \) [A/cm\(^2\)] and \( j_{et} \) [A/cm\(^2\)] looks like:

\[
Ra=0.2157+0.0174\cdot j_{st}+0.00065\cdot j_{et}+0.0106\cdot j_{st}\cdot j_{et}
\]

The surface of a response of the examined parameter is presented in figure 1.
Machining of a hard alloy of WC8 allowed to receive dependence of a roughness of Ra [µm] of the treated surface on electric treatment schedules of $j_{st}$ [A/cm$^2$] and $j_{et}$ [A/cm$^2$] the following aspect:

$$Ra = 0.3286 + 0.1376 \cdot j_{st} - 0.00568 \cdot j_{et} - 0.0017 \cdot j_{st} \cdot j_{et}$$

Response surface on the results of experimental studies are presented in Figure 2.

Figure 1. Dependence of a surface roughness of an alloy of WC3M from electric conditions of the combined electro-diamond grinding

Figure 2. Dependence of a surface roughness of an alloy of WC8 from electric conditions of the combined electro-diamond grinding
By results of research of an alloy of WC15 dependence of a roughness of Ra [µm] of the treated surface on electric treatment schedules of $j_{st}$ [A/cm²] and $j_{et}$ [A/cm²] looks like:

$$R_a=0.456+0.1098 \, j_{st}-0.0083 \, j_{et}-0.0069 \, j_{st} \, j_{et}$$

The surface of a response of the examined parameter is presented in Figure 3.

Machining of a hard alloy of TN20 allowed to receive dependence of a roughness of Ra [µm] of the treated surface on electric treatment schedules of $j_{et}$ [A/cm²] and $j_{st}$ [A/cm²] the following aspect:

$$R_a=0.2685+0.0618 \, j_{et}-0.0018 \, j_{et}+0.0054 \, j_{et} \, j_{st}$$

Response surface on the results of experimental studies are presented in Figure 4.
Discussion
Thus, experimentally it is confirmed that application of a method of the combined electro-diamond machining of products from hard alloys, at the expense of a combination of anode dissolution of a worked stock and an electrochemical straightening of a diamond wheel, is reached a minimum roughness of the treated surfaces of products which on the average for 60% is less, than at other methods to diamond and abrasive machining of such materials. 

The obtained data allowed to define the rational electric conditions of the combined machining ensuring excellence of the treated surface of hard alloys of \(j_{el} = 0.2...0.3\) A/cm\(^2\) and \(j_{el} = 20...30\) A/cm\(^2\) which can be recommended for a semi-finishing and finish machining. As rational mechanical treatment schedules conditions are accepted: stride \(S = 1.5\) m/min, transversal feeding of \(t = 0.02\) mm/d.s, rate of cutting of \(V = 35\) m/s. 

The proposed combined method provides high performance and quality of the machined surface and is recommended for rational and effective processing of products from hard alloys and hard materials.

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