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Research of the Temperature of the Electric Diamond Grinding Process

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Abstract: Cutting is a universal method of dimensional processing and therefore occupies an important place in mechanical engineering. The method makes it possible to process the surfaces of parts made from the most commonly used structural, hard-to-cut materials of various shapes and sizes with high accuracy and a specified roughness. The article discusses the influence of grinding temperature on electrolyte consumption and cutting (grinding) tools.

Keywords: Grinding, cutting, abrasive tool, temperature, cutting fluid, machining

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Introduction

It is known that the grinding process significantly impacts the physical and mechanical properties of the surface layer of the material being processed [1-3].

High-speed steels are widely used to manufacture cutting tools, machine components, etc [4-6]. At the same time, high-speed steels belong to the class of difficult-to-cut steels. The carbides of tungsten, molybdenum, and vanadium included in the steel composition determine the strength of the material and make it difficult to process them by mechanical cutting in a hardened state.

Currently, the processing of high-speed steels in a hardened state is carried out with wheels made of white electrocorunade and CBN, but the productivity of the process does not exceed 400 ... 600 mm^3/min [2].

Attempts to increase processing productivity lead to the appearance of defects on the machined surface in the form of burns and microcracks, which ultimately reduces the durability of the cutting tool during its operation [5].

Heat generation, temperature in the cutting zone and in the thin surface layer during diamond abrasive processing have a decisive influence on the quality of the machined surface and the intensity of tool wear. This is explained by the fact that when cutting materials, about 77 ... 99.5% of the work turns into heat [9-12].

Methods

In the contact zone of the abrasive wheel and the workpiece, a high temperature arises, reaching in some cases 1000 - 1600°C. All cutting processes generate heat, but when grinding it is generated much more than when processing with cutters, milling cutters or other multi-edged tools. This is explained by the following: the grinding speed is 10–20 times higher than the processing speed with cutters and milling tools; abrasive grains, as a rule, have negative rake angles and therefore, during cutting, a lot of energy is spent pressing the grinding wheel against the workpiece, as a result, the chips are more crushed and a lot of heat is generated.

The temperature generated in the cutting zone during electric diamond grinding can, in some cases, cause a change not only in the physical and mechanical properties of the surface layer but also in the geometric shape of the workpiece.

Let us consider the results of a study conducted to identify the influence of electrolyte consumption and the characteristics of a diamond tool on the temperature generated in the cutting zone during electric diamond grinding of hard alloys.

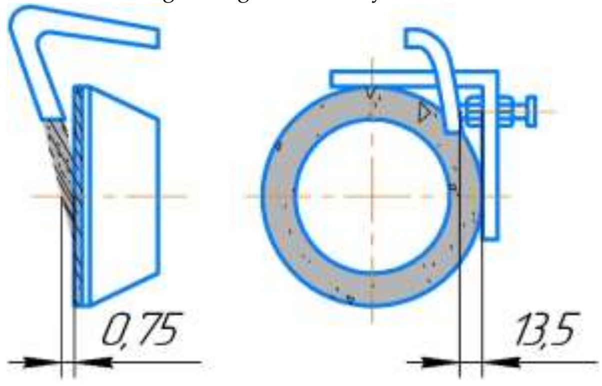

Fig. 1. *Diagram of a device for installing the electrolyte supply nozzle in a given position relative to the processing area and the diamond wheel.*

The study was carried out on a grinding machine model of 3A64M with hydraulic and mechanized feed. The object of the study were plates made of hard alloy VK8 (shape 0227A) with a groove 1.5-2 mm wide and 0.5-1 mm deep ground along the length of the middle part and welded in this groove at a distance of 1.5 mm from the surface being treated with a thermocouple Chromel-alumel made of wire with a diameter of 0.08 mm. The diameter of the thermocouple junction in all experiments remained the same (0.15-0.16 mm), which made it possible to exclude the influence of this value on the experimental results. The distance from the thermocouple junction to the treated surface and the diameter of the junction were controlled using an MPB-2 reading microscope, after which the thermocouples were insulated with ED-6 epoxy glue.

During the electric diamond grinding process, a layer of hard alloy 1.2-1.3 mm thick was removed from the surface of the plate so that a distance of 0.2-0.3 mm remained between the cutting zone and the thermocouple junction, ensuring reliable results. As a cutting abrasive tool, a diamond cup wheel of type AChK150X20X3 with ASV grade diamonds in a TM2-5 bond of various concentrations and grain sizes was used. A solution of the following composition (%) was used as an electrolyte: sodium nitrate 5%; soda ash 1.3%; borax 0.5%; sodium tungstate 0.3%; the rest is water.

Results

The temperature was recorded simultaneously with the recording of the cutting force components on an H-105 oscilloscope. The temperature in the cutting zone was determined by the method of extrapolation of thermal field curves using the Lagrange formula. Using a special device (Fig. 1), the nozzle for supplying electrolyte from the surface to be ground was constantly installed at a distance of 13.5 mm; The distance between the nozzle and the circle, taken to be 0.75 mm, was checked with a feeler gauge before each experiment. The minute consumption of electrolyte was recorded with a measuring flask and a stopwatch.

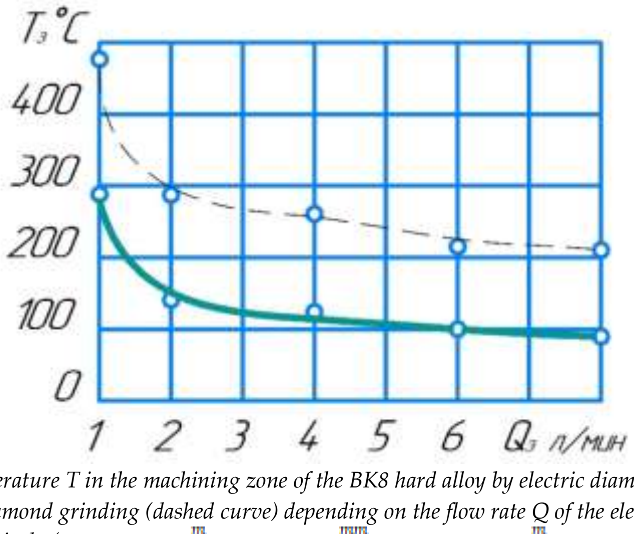

Fig. 2. Temperature T in the machining zone of the BK8 hard alloy by electric diamond grinding (solid curve) and diamond grinding (dashed curve) depending on the flow rate Q of the electrolyte and cutting fluid, respectively (at $v_{kr} = 24{,}7\,\frac{m}{s};\ s_{pop} = 0{,}05\,\frac{mm}{rev}.\ move:\ s_{pr} = 3\,\frac{m}{min};\ U = 8V;\ I = 30A;$*; wheel characteristic: ACB 80/63-100% TM2-5)*

Simultaneously with EAS of carbide plates, in order to obtain comparative data, they were processed under similar conditions by diamond grinding (DG); in the latter case, the solution used as an electrolyte in EAS was used as a cutting fluid (CF).

The conducted studies showed that with an increase in electrolyte consumption Q both during EAS and coolant during AS, the temperature T in the processing zone decreases (Fig. 2). In both cases, a significant decrease in T is observed in the range 1<Q<2 l/min; a further increase in Q leads to a slight decrease in T. Research has also shown that the temperature in the EAS treatment zone, all other things being equal, is lower than in the ADS treatment zone.

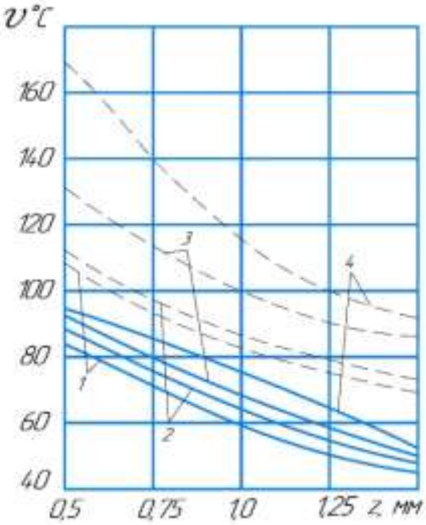

Fig. 3. Distribution of 0°C heating temperature over the cross section of a BK8 hard alloy plate (z-distance from the machined surface), subjected to electric diamond grinding (solid curves) and diamond grinding (dashed curves) with wheels with different concentrations of K diamonds (at $v_{kv} = 24{,}7\frac{m}{s};\ s_{pr} = 3\frac{m}{min};\ s_{pop} = 0{,}05\frac{mm}{dv}.\ xod;\ U = 8B;\ I = 5A;\ wheel\ characteristic;\ ASV\,\frac{100}{80} - TM2 - 5;\ Q = 2l/min)$: *1)K=100%; 2)K=50%; 3)K=150%; 4)K=200%*

The curves presented in Fig. 3 show that as the concentration of diamonds in the diamond-bearing layer of the wheel used increases, the heating of the processed plate increases. This is explained by the fact that with increasing diamond concentration, the components of the cutting force increase, as a result of which the temperature in the cutting zone also increases (Fig. 4, a). As a result, the EAS of the plate being processed heats up significantly less than during the ADS process.

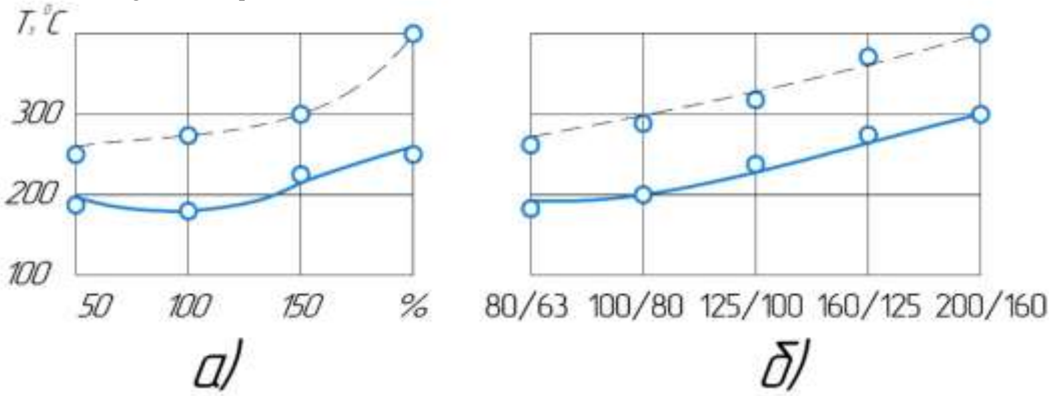

Fig. 4. Dependence of temperature T in the processing zone of the BK8 hard alloy by electric diamond grinding (solid curves) and diamond grinding (dashed curves) on the concentration (a) and grain size (b) of diamonds in the diamond-bearing layer of the wheel ($v_{kr} = 24{,}7\frac{m}{s};\ s_{pr} = 3\frac{m}{min};\ s_{pop} = 0{,}05\frac{mm}{rev}$. *move; U=8 B;I=45 A;wheel characteristics: ASV-TM2-5; grain size and concentration are indicated in the figures; Q=2 l/min*

The temperature in the cutting zone is also affected by the grain size of the diamond wheel (Fig. 4, b). As the grain size of a diamond wheel increases, the number of grains involved in the cutting process decreases, but the proportion of allowance removed by each grain increases. This leads to increased friction between the grains and the machined surface and an increase in cutting force. In addition, with increasing grain size, the proportion of mechanical metal removal during EAS increases, the interelectrode gap increases, which leads to a decrease in the efficiency of electrochemical dissolution of the metal being processed.

Discussions

The study found that the temperature in the cutting (grinding) zone is affected not only by the cutting speed, elements of the cut section, geometric parameters of the tool, lubricating and cooling technological media, physical and mechanical properties of the material being processed, but also by the grain size and concentration of grains in the grinding wheel. Because the cutting forces will increase with increasing concentration of grains in the grinding wheel at the cutting point, as well as increasing the grain size, which in turn affects the cutting force.

Conclusions

When electrodiamond grinding of hard alloys, the electrolyte consumption should be within 3-4 l/min. It is recommended to use diamond wheels with 100% concentration and diamond grain size 100/80 – 125/100.

At high temperatures in the cutting zone, a huge number of defects appear, which in turn affect the quality of the surface. Therefore, it is necessary to correctly select cutting modes that are optimal for the given processing conditions, taking into account the cutting speed, depth, wheel parameters, coolant characteristics and its correct supply. Failure to comply with so many factors leads to product defects.

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