APPLICATION OF MINIMUM LUBRICATION METHODOLOGY FOR DIAMOND SPARK GRINDING

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Abstract: The electric discharge bases of the technological advantages of diamond spark grinding make it possible to consider this processing method among the environmentally promising in nature. A decrease in the thermo-mechanical tension of mass micro-cutting in the zone of diamond spark grinding, which is ensured by the development of its working relief, supported by the action of electric discharges on the bond of the wheel, also makes it possible to consider approaches to organizing this process using the minimum lubrication methodology. The paper presents and summarizes the experimental results of using a number of solid lubricants, gives practical recommendations and defines the tasks of further research. Work in this direction is focused on reducing the use of water in servicing industrial needs, which is an urgent global environmental challenge to the development of civilization and meets the modern technocratic strategies of the European Union (Industry 4.0), Japan (Society 5.0), China (Made in China 2025) and other leading world economies.

Keywords: hard alloy, finishing, technological productivity, jet watering, water saving, solid lubricant, stearin, sebacic acid.

Introduction

The technological advantages of diamond spark grinding, emanating from the stable development of the cutting relief, are due to the action of electric discharges in the processing zone, which is included in the electrical circuit that generates them. Ozone therapy of the environment, which is characteristic of the action of electric discharges in the air, allows us to consider this method of treatment in a number of environmentally promising by it's nature [1].

The support of the development of wheel working relief by the action of electric discharges on the its bond significantly inhibits the growth of thermo-mechanical tension of mass microcutting in the zone of diamond spark grinding over time. The introduction of tracking control directly over the formation of the cutting relief (its height and sharpness) or the parameters of the thermo-mechanics of grinding (temperature regime, grinding power, power load in the direction of the main movement to material removal and on unproductive dissipation of consumed energy), with a feedback mechanism in the control of electrical modes in the circuit of initiation of electrical discharges according to a certain algorithm, allows to maintain the thermo-mechanical tension of the working process at a given level, below the average indicators of conventional diamond grinding with the same level of operating performance. The reduced level of thermomechanical stress of diamond-spark grinding in production operations with comparable mechanics [2-4] is an a priori attractive advantage of the process for

testing the minimum lubrication methodology.

The current relevance of minimizing the consumption of water resources for industrial technologies, including water-based lubricating and cooling technological agents, is associated with multi-regional drinking water hunger as a global environmental challenge to the development of civilization [5, 6] and meets the modern technocratic strategies of the European Union (Industry 4.0) [7], Japan (Society 5.0) [8], China (Made in China 2025) [9] and other leading world economies [10].

Purpose and objectives

The aim of the work is to check, demonstrate and comprehend the technological prospects for the use of solid lubricants in the processes of diamond spark grinding of difficult-to-machine materials using the example of tool hard alloy.

The objectives of the research are outlined by the need to reach: first, the technological indicators of diamond spark grinding with the usual organization of the lubricating and cooling medium (jet watering) and using the technique of minimal lubrication (solid lubricants); second, a comparison of the possibilities of different processing organization; thirdly, the choice of the preferred solid lubricant for further in-depth studies of the diamond spark grinding process with its use; fourth, a comprehensive forecast of the prospects of this processing method with the use of solid lubricants in the direction of increasing technological productivity, functional quality and environmental friendliness of production facilities.

Organization of experimental research

The process of diamond spark grinding with the use of various solid lubricants was investigated in relation to the processing of T15K6 carbide inserts.

Experimental studies were carried out on the 3D642E model of a universal grinding machine produced at the Mukachevo Machine-Tool Plant in Ukraine and modernized at the NTU "KhPI" to implement the process of diamond spark grinding by installing a power source 6 and additional conductive devices (Fig. 1). A special HO6506 pulse generator, produced on the production base of the Design, Technological and Experimental Institute "Ukrorgstankinprom" in Ukraine (Kharkov), was used as a power source, which converts an alternating current with a voltage of 380 V into a unipolar pulse with an adjustable frequency and current strength.

The impulse current was supplied to the grinding zone through the graphite brush 5. At the same time, it was possible to connect one pole of the generator to the brush and through it to the diamond wheel 3, and the other to the processed carbide plate 7, fixed in the device on the machine table.

The introduction of additional energy into the diamond spark grinding zone with the polarity of the electrodes covering the processing zone (diamond wheel – anode, processed hard-alloy carbide plate – cathode), provides better auto-regulation of the cutting relief of the diamond wheel with a lower energy effect of electric discharges on the processing object (hard alloy), that reduces the likelihood of cracking.

The experiments were carried out with an average value of current $I = 4 ... 6$ A, no-load voltage $U = 60 ... 80$ V, pulse ratio $S = 2$ at a pulse frequency $f = 66$ kHz.

Grinding was carried out at a grinding speed $V = 25$ m/s according to an elastic scheme, when the transverse feed is not rigidly carried out by the feed mechanism, but is set by a certain force using weights on a special device. The normal pressure P_n in the presented series of experiments was 1.2 MPa.

In the process of research, cup-shaped diamond wheels 12A2-45 ° AC6-100 / 80 M1-01-4 were used. For their electrical

isolation, a coating 4 with a thickness of 30 ... 45 μm was applied to the bore hole by the method of plasma electrolytic oxidation according to the previously developed technological recommendations [11, 12].

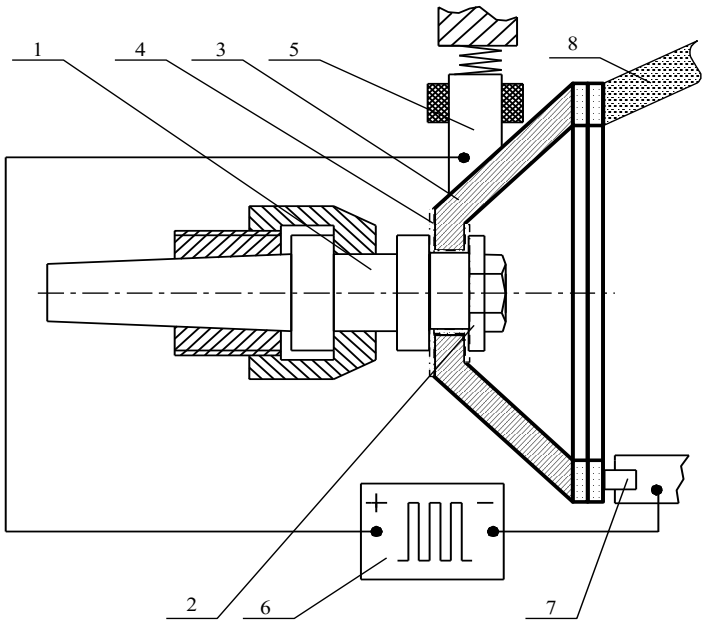

Fig. 1. Upgraded system "machine - device - tool - workpiece" for researching the process of diamond spark grinding: 1 – machine spindle; 2 – details for fastening the wheel; 3 – diamond wheel wramework; 4 – dielectric coating; 5 – current lead brush; 6 – pulse generator; 7 – processed insert (plate); 8 – solid lubricant

The solid lubricant was supplied by the contact method. A cast cylinder made of this material with a diameter of D = 10 ... 12 mm was installed in the device and with a small force of P = 5 g pressed against the wheel at an angle α = 60º, which ensured continuous contact of the lubricant with the working surface of the diamond wheel during grinding.

When choosing the composition of solid lubricants in experimental studies, we were guided by the recommendations [13], according to which the base components should provide a high lubricating effect - to reduce micro-seizure, scuffing, frictional heating and friction forces in the plate-tool contact zone. For comparison with the traditional method of jet watering with 3% soda water solution, three compositions of solid lubricants were used: 1 – technical stearin; 2 – sebacic acid; 3 – a mixture of stearin with sebacic acid (1:1).

Main results and discussion

The performance of the first task of the work according to the adopted organization of experimental research is summarized in Fig. 2, reflecting information on the minute grinding productivity (Q, cm^3/min), the consumption of superhard abrasive per unit of volumetric material removal (q, mg/cm^3) and the technological cost of processing in data conversion to conventional jet watering (C, %).

The solutions to the second, third and fourth tasks of the work also follow from Fig. 2.

Answering the second problem, it is obvious that the organization of treatment with jet watering is superior to the results of the use of sebacic acid, but inferior to the use of stearin and, especially, a mixture of equal parts of stearin and sebacic acid. In the results with the use of acid, an

explanation for the increased wear of the tool and, accordingly, a decrease in productivity and an increase in the cost price, apparently should be sought in the excessive renewal of the cutting relief, additionally to the erosion reduction of the wheel metal bond, by means of the acid etching effect as on the inter-granular wheel surface, and on the intra-granular metal binder – the inevitable heredity of the catalytic synthesis of synthetic diamonds [14].

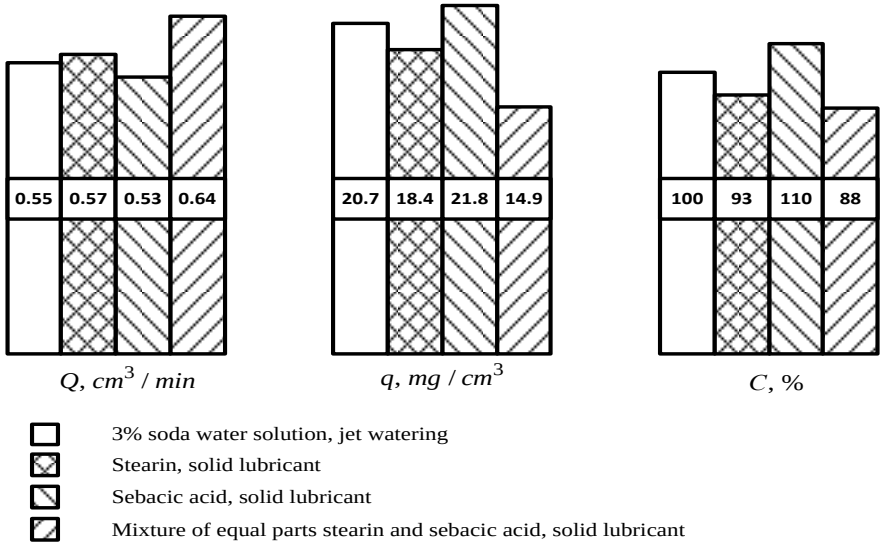

Fig. 2. Technological parameters of diamond spark grinding of hard alloy T15K6 using lubricating and cooling technological means of different composition and method of serving

Answering the third task, the best technological indicators in terms of processing productivity and tool wear, as well as technological cost, in comparison with the usual organization of the lubricating and cooling medium (jet watering with a 3% soda water solution), and with the independent use of ingredients demonstrates the use of an equilibrium mixtures of technical stearin and sebacic acid.

Compared with the traditional support of the process of diamond spark grinding by jet watering using this solid lubricant, the registered increase in processing productivity (Q) is over 15%, and the decrease in tool wear (q) and technological cost (C) is over 25% and over 10%. respectively. Therefore, we consider the equilibrium mixture of stearin and sebacic acid as promising for further in-depth studies of the diamond spark grinding process with its use.

The presented results of experimental practice allow us to meet the fourth problem. Diamond spark grinding is a promising processing method for the application of minimum lubrication technology. The use of solid lubricants in the working processes of diamond spark grinding can provide a complex effect of increasing both technological productivity (processing productivity) and functional quality (for example, with some modest decrease in the attainable level of processing productivity, by 5-10% from the obtained data on the use in grinding the hard alloy T5K10 of an equilibrium mixture of stearin and sebacic acid, and thereby providing a "margin of safety" in the formation of favorable thermo-mechanical heredity in the surface layer of the treatment object), while reducing water consumption for production needs and lower technological processing cost.

Conclusion

The goal of this work has been achieved – on the experimental basis of the processing of tool hard alloy, technological prospects for the use of solid lubricants in the processes of diamond spark grinding of difficult-to-machine materials have been determined.

Further in-depth studies of the diamond spark grinding process within the framework of the environmentally oriented concept of minimum lubrication are expedient to be carried out using an equilibrium mixture of stearin and sebacic acid, which has proven itself to be effective in supporting the processing of the tool hard alloy T5K10, with an increase in the wear resistance of the tool and the productivity of mass micro-cutting with diamond grains of its working surface, while reducing the technological cost.

Resource saving can be considered as a thematic space for further research from the standpoint of reducing the energy consumption of diamond spark grinding with the use of solid lubricants, determining new environmental frontiers and further technological prospects for the development of this method of intensified processing.

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