

# PRACTICAL NOTES ON THE ROLE OF WHEEL BOND IN THE SUCCESS OF DIAMOND-SPARK GRINDING

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**ABSTRACT:** *On the example of treatment of heat-resistant covering after fusing on, the problems of rational use of diamond grinding wheels in combined technologies, based on the introduction of electrical discharges into cutting area (diamond-spark grinding) are considered. The main attention is related to the need a lessening of tool's expense and increase in tool life achieved by the correct choice of the metal bond of diamonds in the grinding wheel, with mechanical and electrical modes of abrasive treatment of workpiece and abrasive surface dressing of tool corresponding to this choice.*

**KEYWORDS:** diamond abrasive, metal bond, combined grinding, tool wear, reasonable dressing

## 1. INTRODUCTION TO THE PROBLEM

In many cases, certain technological and environmental advantages compared with conventional abrasives can be achieved using superhard materials in tools [1]. However, significantly higher costs of superhard abrasives over conventional ones requires careful economic analysis for technological alternatives, increased attention to the characterization of superhard tools in specific applications.

With increasing in the relative contribution of the grinding powder cost in the price of the wheel, corresponding to the transition from typical to superhard abrasives, the role of the bond as a grain holder increases: economic efficiency of superhard materials is mainly dependent on the integrity of cutting grains usage in wheels. When using diamond grinding powder of higher strength and graininess, this tendency is even more so [2].

Improvement of the technologies of synthetic superhard materials, expanded application of competitive heat-, wear-resistant and other hard-to-work materials in advanced industries, as well as toughening of the realities of market economy and consumption of superhard abrasives naturally lead to the extended use of high-strength steel bonds with increased reliability of diamond retention. For example, over 50% of modern range of grinding wheels manufactured at Poltava Diamond Plant (<http://www.poltavadiamond.com.ua>), the largest in Ukraine and one of the largest in the history of the world industry of synthetic superhard materials and tools made of them, is presented in metallic bonds.

Rise in the bond strength inevitably reduces the ability of the wheels to self-sharpening due to its natural attrition and destruction in the processes in grinding area. In this case, the necessary compliance of the wheel working surface for refresh of cutting relief is ensured by forced dressing in cutting area or independently produced continuously or periodically [3]. Work of dressing is realized owing to introduction of specially generated additional energy, mostly electricity (source – impulse current generator and direct current generator), mechanical vibrations (ultrasonic generator) as well light (laser), plasma (plasmatron), and their possible combinations [4-6].

In NTU «KhPI» the theoretical and experimental bases, as well special equipment for the

respective grinding and dressing technological processes according to the referred above additional energy are developed. Introduction of additional energy in a form of electrical discharges in cutting area (diamond-spark grinding) has the greatest development [4]. Among other technological methods of similar application, diamond-spark grinding are favorably notable for its relative simplicity of the modernization of machine tools, low cost of special energy sources, high controllability and reliability of working process. The method is an effective tool to solve various problems of optimization of technological processes of grinding, to enhance the productivity and quality of processing, to reduce its cost and power consumption [7].

Following the logic of the processes in diamond-spark grinding area [8], under the comparable processing conditions the tools on different metal bonds, physical and mechanical properties of which are characterized by different strength, wear- and erosion resistance, will wear at different intensity. Practical experience of diamond-spark grinding of hard-to-work materials shows that these differences in wear rate of wheels on different metal bonds and, consequently, in their tool life under the same grinding conditions (with a different approach to some optimal one for each of a bond) can be significant.

## 2. GRINDING PRACTICE AND CALCULATIONS FROM ITS DATA

The experimental data and the calculations following from them were obtained and are presented here for the diamond-spark grinding of heat-resistant chromium-tungsten overlaying weldings of the 3Cr2W8V type used in the renovation of rolls of metallurgical rolling mills [9]. Composition of overlaying weldings – according to acting in Ukraine technical requirements of State standard of USSR 5950-73.

The experiments were carried out with a given productivity ( $1.60 \text{ cm}^3 \cdot \text{min}^{-1}$ ) of grinding, and with introduction of additional electric-discharge energy into the cutting zone for stable sufficient operation of the tool. Registered deviations of actual productivity does not exceed 5% from nominal level in carried out experiments of diamond-spark grinding with inflexible wiring of production modes.

As a source of technological electric current (voltage 40V in the experiments under consideration) was used the electric power supply of model ITT-35 produced by Baku Machine-Tool Plant. The supply was specially designed to initiate and to keep electric-discharge processes in grinding area and recommended for completing special grinding, flat surface and cylindrical grinding machines modernized for diamond-grinding spark. It should be noted that on the same mechanical processing modes (longitudinal and cross feed respectively  $0.8 \text{ m} \cdot \text{min}^{-1}$  and  $0.01 \text{ mm} \cdot (\text{double pass})^{-1}$ , speed of workpiece and wheel respectively  $40 \text{ m} \cdot \text{min}^{-1}$  and  $25 \text{ m} \cdot \text{s}^{-1}$ ) productivity of grinding process is gradually noticeably declining when electric power supply is off. So, 50-60% of productivity reference value is lost in 25-30 min without electric discharges for wheels on bonds M1-10 or M2-01.

In the conducted experiments, bonds of diamond wheel have a combined metal base according to Ukraine Technical Conditions or Enterprise Standards developed at the Institute of Superhard Materials of NAS of Ukraine: pure Cu-Sn (bond mark M2-01, TU2-037-181-85), with a basis of Cu-Sn-Sb (bond marks M2-09, STP 90.1140-88), Cu-Al or Cu-Al-Zn (M1-01, TU2-037-57-81; M1-04, STP 90.504-85; M1-10, STP 90.877-83; M2-12, TU2-037-325-82). In the text above, “TU” and “STP” are equivalent in Latin to Ukrainian abbreviated practice in Cyrillic for indicate respectively “Technical Condition” (“Tekhnichni Umovy” in transliteration from Ukrainian) and “Enterprise Standard” (“Standart Pidprijemstva” in transliteration from Ukrainian).

In the diamond-metal wheel composites of considered here practice, according to the current Ukraine State Standard 9206-80, diamond powder of synthetic diamonds with the following characteristics was used: make AC6 (with an average compressive strength of 600 N), grit 250/200 (analogs: D251 FEPA standart,  $\mu\text{m}$ ; 60/70 US standart, mesh), the concentration of 4 (the share of diamonds in a unit volume of the diamond-metal composition of the working part of the instrument is 0.25).

In calculating the resource of the grinding wheel according to the rate of consumption of the diamond abrasive calculated from the experimental data, the data on the mass of diamonds in the wheel as its passport characteristic were used. For example, for the known standard size characteristics of the grinding wheel 1A1 200x10x5 and the proportion of diamonds in the unit volume of the working (diamond-bearing) layer of the tool 0.25, the estimated mass of diamonds in the wheel is 135 ct (27 g).

In calculating the rate of mass consumption of diamonds and the resource of the grinding wheel (Table 1), a technique was used that refers to the experimental data on the specific consumption of diamonds [10].

**Table 1.** Calculated consequences of experimental data

Code of bond	M1-10	M2-01	M2-09	M1-04	M2-12	M1-01
Velocity of mass consumption of diamonds, $\text{g}\cdot\text{h}^{-1}$	1.884	1.920	2.082	2.208	2.604	2.790
Tool life of diamond wheel, hours&minutes	14&20	14&04	12&58	12&14	10&22	9&40

In respect to the specific conditions of diamond-spark grinding under consideration, tool life of a diamond wheel in Table 1 is determined as a prediction of total duration of its involvements in the specific working processes at repeatability of the reproducible conditions, the consequence of which would be almost constancy of processing productivity and specific diamond content in successive acts of grinding. Thus, the data obtained experimentally covers the entire life of the tool [10].

As shown in [11], the practice of price formation for diamond tools is indifferent to the brand mark of the metal bond of the wheel. However, as follows from the data in Table 1, the brand (composition) of the bond can significantly affect the technical and economic indicators of the production process.

According to the data of [12], for example, it follows that replacement of the diamond wheel on bond M2-01 (binary intermetallic structure of 80 wt. % Cu and 20 wt. % Sn) with the same one, but on less wear-resistant bond M1-01 (solid solution based on 62 vol. % intermetallic  $\text{CuAl}_2$ , 27 vol. % alloy combination Al-Zn and 11 vol. % Si) increases the necessary tooling costs by more than 1,800 U.S. based on one-shift annual load of the grinding machine.

### 3. CONCLUSIONS

Both violation of the established science-based technological regulations of diamond spark grinding, and the absence of such science-based regulations, can sometimes provide the required processing productivity, but at the same time lead to a significant reduction of tool life and, therefore, incomplete use of cutting potential of diamond tools, increased costs on the tool and idle time for service of its replacement on the machine during the execution of the manufacturing task.

Correct choice of metal bond of diamond tools will have a very significant positive impact on the technical and economic indicators of functioning of the technological machining system with electroerosive dressing of wheels, in particular, in the cutting zone during diamond-spark grinding.

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