The assessment of cutting ability of super hard grinding wheels after electro-discharge dressing using rotating electrode

Ocena zdolności skrawnej ściernic supertwardych po elektroerozyjnym obciąganiu elektrodą wirującą

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In the paper investigation results concerning assessment of cutting abilities of super hard grinding wheels shaping after electro-discharge dressing process using rotating tool electrodes have been presented. For assessment of cutting abilities of grinding wheels the method of grinding of outer standard has been applied. Basing on this method the temperature and relative grinding efficiency have been determined.

KEYWORDS: super hard grinding wheels, electro-discharge dressing, cutting abilities, grinding temperature, relative grinding efficiency

The condition of the active surface of the grinding wheel (CPS) has a decisive influence on its machinability and the course of the grinding process and results, in particular the shape-dimensional accuracy and the condition of the surface layer of the workpieces. Progressive abrasive wears during grinding - caused by, inter alia, grinding of abrasive grains and CPS grinding by grinding - significantly reduce its cutting capacity. The consequence of this is an increase in the grinding force, raise grinding temperature and generate excessive vibration of the OUPN system (machine tool - handle - workpiece - tool) and thus - deterioration of grinding quality and performance indicators. It is important to monitor CPS status during grinding and to restore its cutting ability in the dressing process [1, 4, 5].

Dressing of super-hard grinding wheels is designed to regenerate the microstructure, i.e. shaping of the CPS micro-graphometry (obtaining the grinding grain edge over the metal binder) and removing the CPS grinding products. In the case of super hard abrasives, conventional dressing methods that use mechanical processing are inefficient and uneconomical [1]. The specific physico-mechanical properties of super-hard grinding wheels require the use of erosive dressing methods [1-3]. Among them can be characterized as jet, laser, chemical, electrochemical, electro-erosion and hybrid dressing [1, 3]. In industrial applications, a particularly attractive method is electrosurgical dressing (EDGD) with a rotating electrode.

Next, the results of a study on the evaluation of super-hard abrasive ability, formed under different conditions of electro-erosion of spinning electrodes, were presented. The external grinding method was used to evaluate the cutting capacity, consisting of a several-second grinding test, which determined the grinding temperature of the Θt standard and the relative grinding performance of the Qv standard. The description of the measuring device for assessment of cutting capacity, the methodology of measurement and the method of determining the Θt and Qv indicators are presented in previous publications [2, 3].

Research stand and test conditions

The electro-discharge dressing was performed on an ECBT8 type surface grinder, equipped with special carbon fiber spinning electrodes, Marcosta current pulse generator, and dressing-up control. The general view of the test bench for electro-erosion of super hard abrasive blanks is shown in fig. 1, and the process view and the working area view - fig. 2.

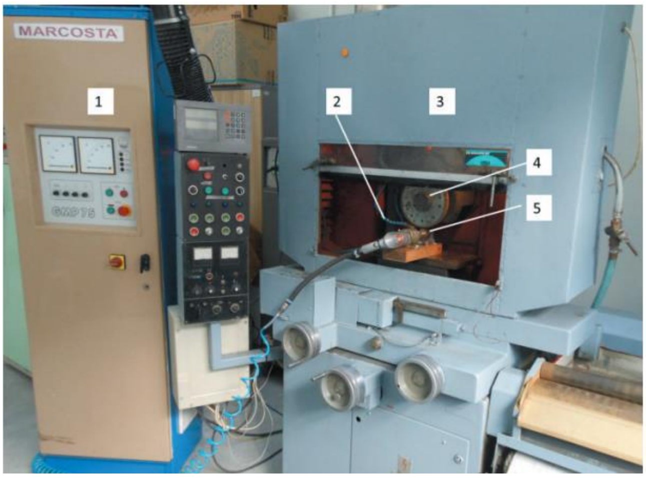

Fig. 1. View of the electro-discharge grinding station: 1 - electric pulse generator, 2 - dielectric feeding nozzle, 3 - surface grinder ECBT8, 4 - grinding wheel, 5 – rotating electrode

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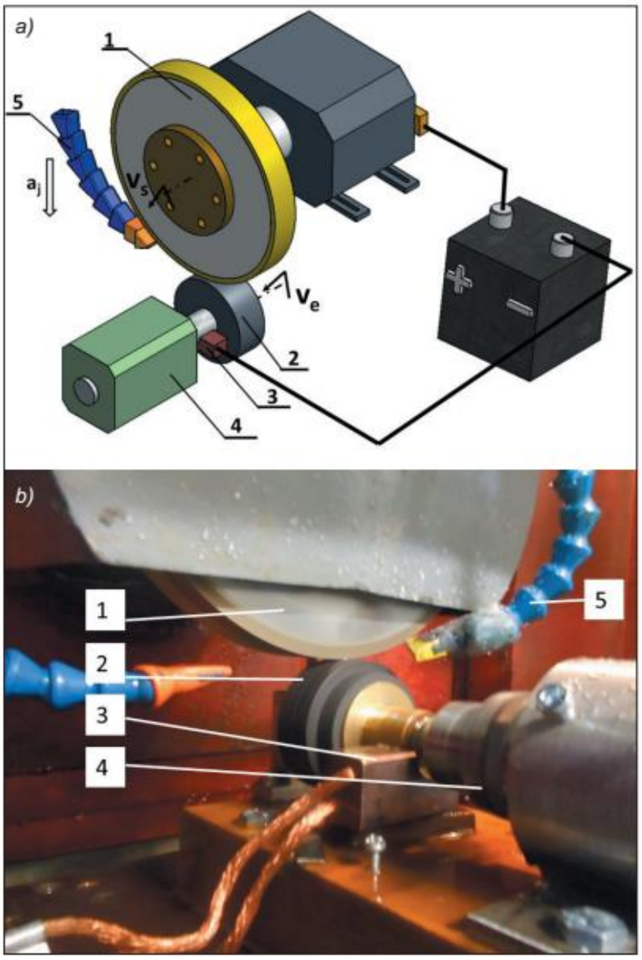

Fig. 2. Electro-discharge dressing of the abrasive wheel with a rotating electrode: a) process diagram, b) view of the working area (1 - grinding wheel, 2 - rotating electrode, 3 - voltage from the pulse generator, 4 - electrode assembly, 5 - dielectric feeding nozzles, ve - electrode speed)

For electro-discharge dressing of grinding wheels, a rotary carbon electrode (E28S) with a diameter of 70 mm and a width of 30 mm rotating at a speed of 750 rpm is used.

The aim of the study was to determine the influence of the electrical parameters of the pulse generator and the time of dressing in subsequent infeed of the wheel to the electrode on the cutting capacity of grinding wheels to be dressed.

The test plan included 3 series of abrasive dressing tests with the following power settings of the pulse generator: Pi (U = 100 V, I = 12A), P2 (U = 200V, I = 25A), P3 (U = 300 V, I = 50 A). In each series of tests, an equal value of 0.1 mm grinding of the grinding wheel to the electrode, divided into 10 infeed rates of 0.01 mm, was used, while the dressing time was different in the consecutive grinding units of the grinding wheel – and was as follows:

- in series I - t_{o1} = 30 s,
- in series II - t_{o2} = 60 s,
- in series III - t_{o3} = 90 s.

Abrasive grinding abilities after electro-discharge dressing tests were determined on the basis of the comparison of the grinding index values [2, 3], i.e. the relative grinding performance of the external standard Q_v [mm^3/s] and the grinding temperature of the standard Θ_t [°C]. As an external standard, titanium alloy samples were used in which K type thermocouples were mounted.

Taking into account the evaluation of the efficiency of the electro-discharge dressing of grinding wheels using this method, the relative consumption of the electrode k_v was determined in particular dressings by the following formula:

$$k_v = \frac{\Delta V_e}{\Delta V_s} \cdot 100\%$$

where: ΔV_e - volume wear of electrode [mm^3], ΔV_s - volume of grinding wheel [mm^3].

Evaluation of cutting capacity of diamond grinding wheels with metal binder

Sample test results, illustrating changes in cutting capacity of SD 125/100 M75 in individual series and electro-discharge dressing tests, are shown in fig. 3 and fig. 4, and the relative wear values of the electrode are given in Table I. Analysis of the results showed that the increase in generator power caused a slight decrease in the grinding temperature of the standard Θ_t in the individual dressing series (by about 12% in the I series, 7% in the II series and 9% in the III series).

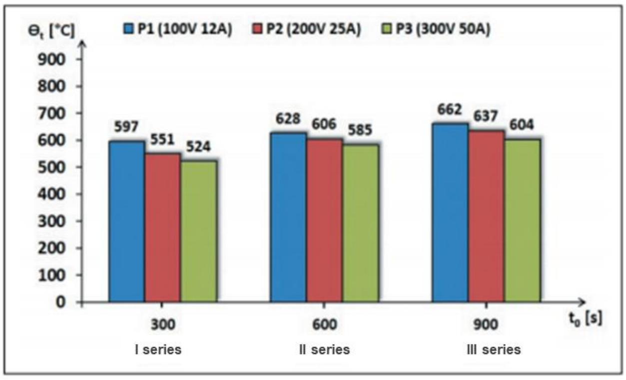

Fig. 3. Influence of the generator power and time of electro-discharge dressing of the grinding wheel SD 125/100 M75 on grinding temperature of the external standard Θ_t (grinding wheel grinding temperature Θ_t = 622÷667 °C [3]).

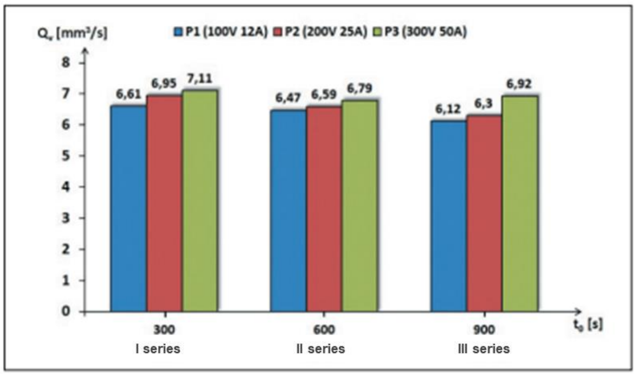

Fig. 4. Influence of the generator power and time of electro-discharge dressing of the grinding wheel SD 125/100 M75 on relative grinding performance Qv (relative grinding performance Qv = 4.87÷5.3 [3])

TABLE I. Comparison of results of relative electrode wear after electro-discharge dressing of SD grinding wheel

Power of electric current	Relative electrode wear, %		
	series I (t_{o1} = 30 s)	series II (t_{o2} = 60 s)	series III (t_{o3} = 90 s)
100 V · 12 A	45,30	42,02	41,18
200 V · 25 A	46,73	45,51	44,89
300 V · 50 A	47,15	46,93	47,01

The results also confirmed that lengthening of the dressing time after consecutive infusion (series I-III) resulted in a slight unfavorable increase in grinding temperature Θ_t - by about 5% in the II series and 3% in the III series. Analysis of changes in the relative productivity index of Q_v grinds indicates that with the increase in generator power there is little improvement in grinding machinability: 8% in series I, 4% in series II and 12% in series III. It has also been found that the lengthening of the dressing time after consecutive infeed (series I-III) affects the reduction of the relative grinding performance of Q_v. These Q_v changes were about 4% in the II series and 5% in the III series. It further demonstrates that increasing the power of the generator results in an increase in relative electrode consumption (Table I): about 4% in series I and II and 12% in series III.

Evaluation of cutting capacity of cBN grinding wheels with metal binder

The results of the study illustrating the changes in cutting capacity of CBN 125/100 M75 in particular series and the electro-discharge dressing tests are presented in fig. 5 and fig. 6, whereas the values of relative electrode wear are presented in Table II.

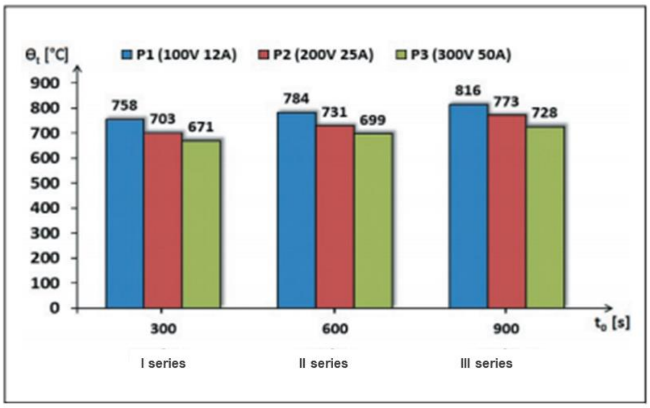

Fig. 5. Influence of the generator power and time of electro-discharge dressing of the grinding wheel CBN 125/100 M75 on the grinding temperature of the external standard Θt (grinding wheel grinding temperature Θt = 870÷825 °C [3]).

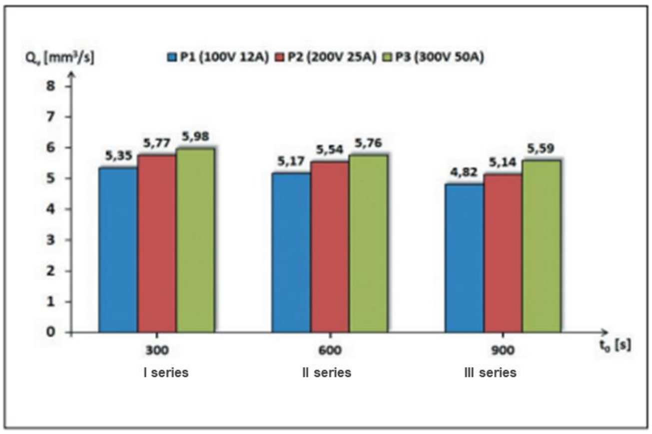

Fig. 6. Influence of the generator power and time of electro-discharge dressing of the grinding wheel CBN 125/100 M75 on relative grinding performance of external standard Qv (relative grinding performance Qv = 4÷4.4 [3])

TABLE II. Comparison of relative electrode wear results after electro-discharge dressing of grinding wheel made of cBN

Power of electric current	Relative electrode wear, %		
	series I (t_{o1} = 30 s)	series II (t_{o2} = 60 s)	series III (t_{o3} = 90 s)
100 V · 12 A	42,15	40,26	39,82
200 V · 25 A	48,63	45,78	41,12
300 V · 50 A	53,12	52,44	49,83

Analysis of the results shows similar tendencies of changes in cutting capacity indexes for grinding wheel made of cBN after electro-discharge dressing and relative electrode wear as in the case of SD grinding wheel. It was found that the increase in generator power caused a slight decrease in grinding temperature Θ_t. In the individual series of dressings, the bench grinding temperature was reduced by approximately 11% in series I and 10% in series II and III. It has been shown that an increase in the dressing time after consecutive infusion (series I-III) results in an unfavorable increase in grinding temperature Θ_t of about 6% to 9%. It has also been shown that the increase in generator power contributes to a slight improvement in the relative coefficient of machinability of the Q_v cutter, respectively: 11% in series I and II and 14% in series III. The lengthening of the dressing time after consecutive infeed (series I-III) does not result in significant changes in the cutting index Θ_t.

Under similar electro-discharge dressing of grinding wheels conditions, the preferred cutting rates Θ_t and Q_v were obtained for the SD 125/100 M75 wheel rather than the CBN 125/100 M75 wheel. There were also higher relative electrode wear values in the CBN 125/100 M75 grinding dress tests (Table I and II) compared to SD 125/100 grinding wheel dressing.

Conclusions

The research allowed for the verification of the accuracy of the electro-discharge dressing with rotating electrode method for the shaping of the diamond grinding wheels and cBN abrasives, bonded with a metal binder. The obtained results confirm the significant improvement of the abrasion ability of the abrasive wheels, expressed by Θ_t and Q_v, as compared to the blunt grinding wheels [3].

It has been shown that the increase in generator power contributes to an improvement in the value of Θ_t and Qv cutting grinding indexes. However, there was no significant effect of elongation of dressing time after successive unit infiltrations on the value of cutting indices.

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