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Assessment method of cutting ability of CBN grinding wheels

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Abstract

In the paper authors described a method of CBN grinding wheel cutting ability evaluation and research results achieved with this method during grinding process. Research results, which allowed for verification of the method (e.g. measurements of grinding force components, surface roughness and waviness parameters and stress level in surface layer) were also presented.

Keywords: Assessment; Grinding wheels; CBN; Cutting ability

1. Introduction

Superhard grinding wheels (CBN, natural diamond-CD and synthetic diamond wheels-SD) are well known because of its excellent functional properties and long life [1–3,5,11]. However, these tools are expensive. In order to use superhard wheels in economical way it is necessary to supervise variations of its cutting ability. This is a basis for decision making process concerning dressing operation.

Laboratory methods concerning grinding wheel cutting ability examination have been described in several publications [6–11]. They focus for instance on measurements of surface roughness, residual stress in top layer, microhardness of ground surface, ground surface colour, grinding force components, grinding power, specific grinding energy, grinding temperature, chatter amplitude of machine-tool-fixture-workpiece system or acoustic emission.

However, these methods are difficult to apply in industry due to limitation of equipment, technology, staff and methodology. Most of grinding machines applied in industry is not equipped with any simple device which would allow for evaluation and supervision of grinding wheel cutting ability. Especially in case of tool grinders [4].

Decision concerning selection of appropriate moment for dressing operation, is usually made by grinder's operator. He decides when to start dressing process on the basis of his observations of workpiece (shape and dimensions) and the grinding wheel. This method, however, should not be recommended in case of superhard wheels, where variation of cutting ability is difficult to notice.

Unnecessary dressing leads to high costs due to wear of the wheel and dressing tool. On the other hand, too late dressing can generate several undesired changes in ground surface. The result of too late dressing, when machining with superhard wheels, can be serious although not always visible, mainly because of possible stress in ground surface. Therefore, objective method of cutting ability evaluation of superhard wheels is necessary especially in industry.

In this paper, authors focused on the method of tool state evaluation, which could be easy to apply in industry. Description of the method and examples of measuring results are shown below.

2. The two-parameter method of CBN grinding wheel cutting ability evaluation

The method is based on short-time grinding test of special tester (thermocouple) at constant grinding conditions, outside grinding zone. During the measurement the tester is pressed towards grinding wheel twice (first time with constant force and then with constant speed).

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As a result of grinding test, two basic parameters are determined:

- length decrement of the tester, described by cutting ability factor Q'_{t}, measured during tester's movement towards the wheel with constant force, shown in equation (1),

$$Q'_{\mathrm{t}} = \frac{\Delta l}{\Delta t} \quad (1)$$

where Δl-length decrement of the tester (μm), Δt-grinding time (s);

- average grinding temperature of ground tester Θ'_{t} (°C), measured during tester's movement towards grinding wheel with constant speed.

The test enables observation of cutting ability of the wheel during grinding process. When grinding wheel loses its cutting ability, both parameters (Q'_{t}, Θ_{t}) change their value, before any visible change takes place on ground surface.

A schematic diagram of the construction of measuring equipment for recording Q'_{t} and Θ_{t} parameters is shown on Fig. 1 and the view of measuring device in Fig. 2.

The measuring device is fixed on fast headstock of surface grinder. The device can be placed in two perpendicular positions, in order to realise movements not only towards cylindrical surface of the wheel, but also towards the face. This siting of measuring equipment does not limit the access to working zone of the grinder.

During measurement, the tester (thermocouple)-5 is pressed towards the grinding wheel. The system enables controlled movement of the tester towards grinding wheel-1, outside the grinding zone. The tester is fixed to a saddle-9 with bearing system, what makes continuous longitudinal movement possible. Movement of the tester is realised by screw-rolling transmission-10 and stepper motor-11 with belt transmission. Force sensor-6 measures grinding forces achieved during tester's grinding and ensures control of the tester's movements.

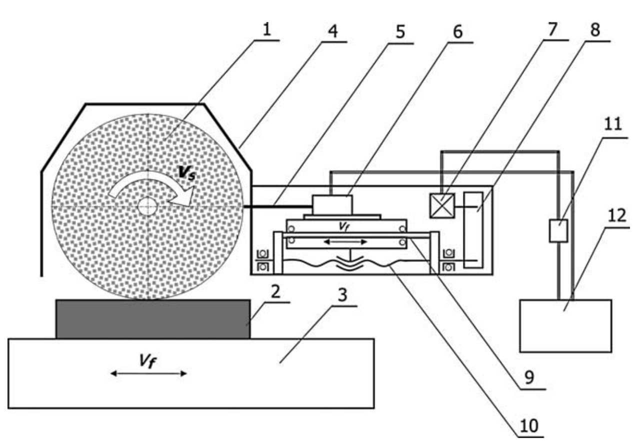

Fig. 1. The scheme of measuring device for evaluation of superhard wheel cutting ability: 1-CBN wheel, 2-workpiece, 3-grinder's table, 4-fast headstock, 5-tester (thermocouple), 6-force sensor, 7-stepper motor, 8-belt transmission, 9-saddle,10-screw-rolling transmission, 11-stepper motor controller, 12-computer, v_S-grinding speed, v_f-workpiece speed.

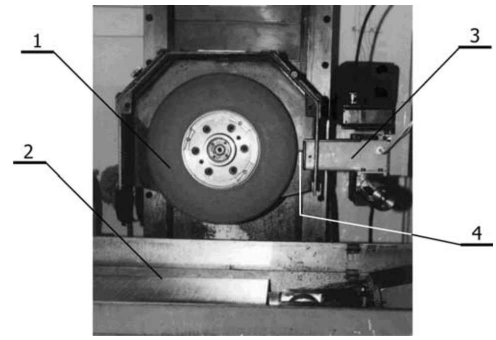

Fig. 2. Measuring equipment fixed to the SPG 30×80 surface grinder: 1-grinding wheel, 2-grinder's table, 3-measuring device, 4-tester (thermocouple).

The device can work in two different modes. In the first one linear decrement of the tester (described by Q'_{t}) is measured. In this mode the tester is pressed towards the wheel with constant force. Speed of the tester is controlled by force sensor, computer and stepper motor controller. In the second mode, temperature of ground tester (Θ'_{t}) is measured. During this measurement the thermocouple travels towards grinding wheel with constant speed. The speed is controlled by stepper motor and computer.

The tester (thermocouple) plays an important role in this method. During the research, measurements were carried out using two types of testers (shown on Fig. 3). Both types of testers were coated with aluminium layer, isolated from steel background. Such construction (two metal layers isolated from each other) enables measurement of grinding temperature of the tester (Peltier and Thomson Phenomenon).

The tester called 'tester type 1' was made of 0.1 mm thick steel (toughened chromium steel: 6H13), specially profiled in order to keep high rigidity. This tester was successfully applied in circumferential grinding with CBN wheels, however, dimensions of the tester were not suitable in case of face grinding. New type of the tester, called 'tester type 2', was then created. The idea of previous applied thermocouple (steel and aluminium) remained unchanged,

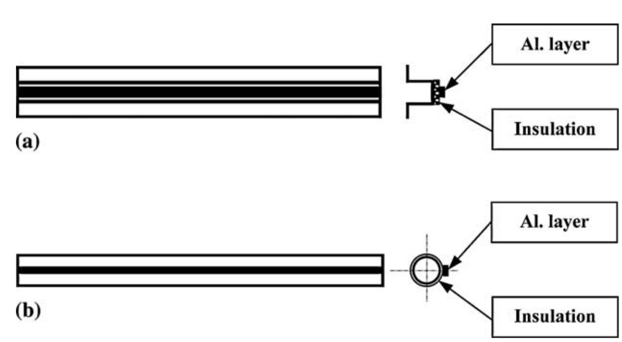

Fig. 3. Scheme of the tester: (a) type 1, (b) type 2.