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Enhancing the Technological Capabilities of Universal Grinding Equipment

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Abstract. A method to enhance the technological capabilities of universal grinding equipment and improve the durability of grinding wheels is proposed. A device that allows to implement this method by using of continuously variable grinding speed is proposed. This reduces the cost of manufacturing products of various structural materials.

Keywords: grinding, rotation frequency, durability of grinding wheels, variable grinding speed, frequency converter.

I. INTRODUCTION

In a world tendencies towards an increase in the degree of convergence with the manufacture of machine tools are planned. Including [1]:

- expand the range of metal cutting equipment to provide multipurpose treatment on a single machine complex parts, through a series of combined or sequential operations;
- more widely used multi-functional machines and machining centers that allow to combine milling, grinding, chemical and electrochemical machining, heat treatment;
- different types of abrasive handle combine on the machine, for example, internal and external grinding;
- increase the possibility of treatment different materials on the same equipment, such as the grinding of ceramics and hardened steels.

Difficulties of grinding at single machine tool for various materials with different physical and mechanical properties are caused mainly by the need of select and install the appropriate grinding wheel and device for its truing. Thus, for example, hardened steel more efficiently handle by wheels of cubic boron nitride (CBN), and ceramics – diamond wheels. This requires an appropriate adjustment of the cutting conditions. The problem with using the same grinding wheel in the processing of various materials occurs due very low (in some cases) of the cutting ability, which define the abrasive tool life.

One reason for the loss of cutting ability is clogging of the grinding wheel. GOST 21445-84 (RU) determines the «clogging» as the transfer on the working surface of an abrasive tool of sludge particles. As a result, the operation of grinding some viscous materials with high adhesion properties is irrational and replaced by the edge cutting. Such materials include a of nonferrous alloys, some complex alloyed steels and alloys, metallic and non-metallic composites.

In this regard, the expansion of technological capabilities of grinding equipment, which allows to increase the range of different materials to be processed using the same tools and equipment is important for the tool, engineering and machine tool industries.

A significant amount of researches devoted to increase the efficiency of the grinding. However, many of the obtained positive results are not implemented in the real production sectors. This is due, inter alia, to the fact that industrial companies are reluctant to modernize the standard equipment, the use of non-standard technologies and special cutting tools. This important fact to consider when selecting a vector of scientific researches and the routes of rationalization.

II. MATERIALS AND METHODS

In [2] the authors proposed and justified the method to eliminate the clogging of grinding wheels due by using comprising variable (continuous variable) cutting speed of grinding. On the basis of this idea developed practical methods that can be implemented by modernization of machine tools. As part of the research received a patent for utility model «Device for abrasive machining with a variable cutting speed» (RU 129444), and the patent for the invention «Method of abrasive machining of flat surfaces with a variable cutting speed» (RU 2608867).

The present paper describes an improved and more universal method of varying the cutting speed of the grinding process, which «complements» the existing universal equipment. Wherein processing is

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held by conventional grinding wheels using conventional cutting conditions.

The method is based on the use of the frequency converter, allowing continuously variation of the frequency of rotation of the output shaft of the three-phase asynchronous motor. Overall scheme of control shown at Fig. 1.

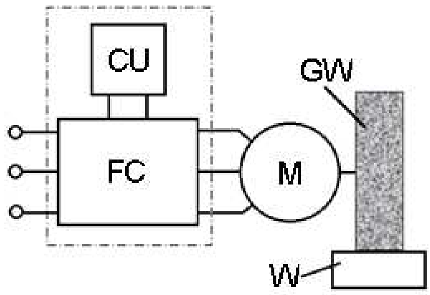

Fig. 1. Scheme of control of the rotation frequency of the grinding wheel: M – asynchronous motor; GW – the grinding wheel; W – workpiece; FC – frequency converter; CU – control unit

The frequency converter (FC) and the control unit (CU) (Fig. 2) is further connected to the electric circuit of the machine tool.

CU sends a signal to the analog input of FC and actually control it, that allows you to varying grinding conditions. A feature of the device is the possibility of varying the output shaft speed by a certain law, for example, sinusoidal. And CU allows you to change the period, the amplitude and the nominal value of the rotational speed of the grinding wheel.

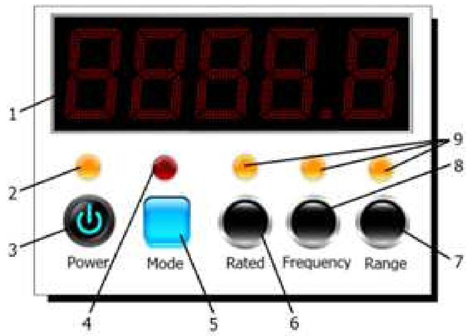

Fig. 2. The control unit: 1 – digital display; 2 – the network indicator; 3 – power button; 4 – overload indicator; 5 – mode button; 6 – switch selection of rated speed; 7 – switch selection of the oscillation amplitude; 8 – switch selection of the oscillation period; 9 – mode indicators

The frequency converter is connected to the electric circuit of the machine tool after branching to engines «1M» and «2M», in order to control the main drive «M» and do not affect the operation of other drives (hydraulic drive «4M», drive of accelerated movement of the wheelhead «6M», the electric pump of cooling «1M» and magnetic separator «2M») (Fig. 3).

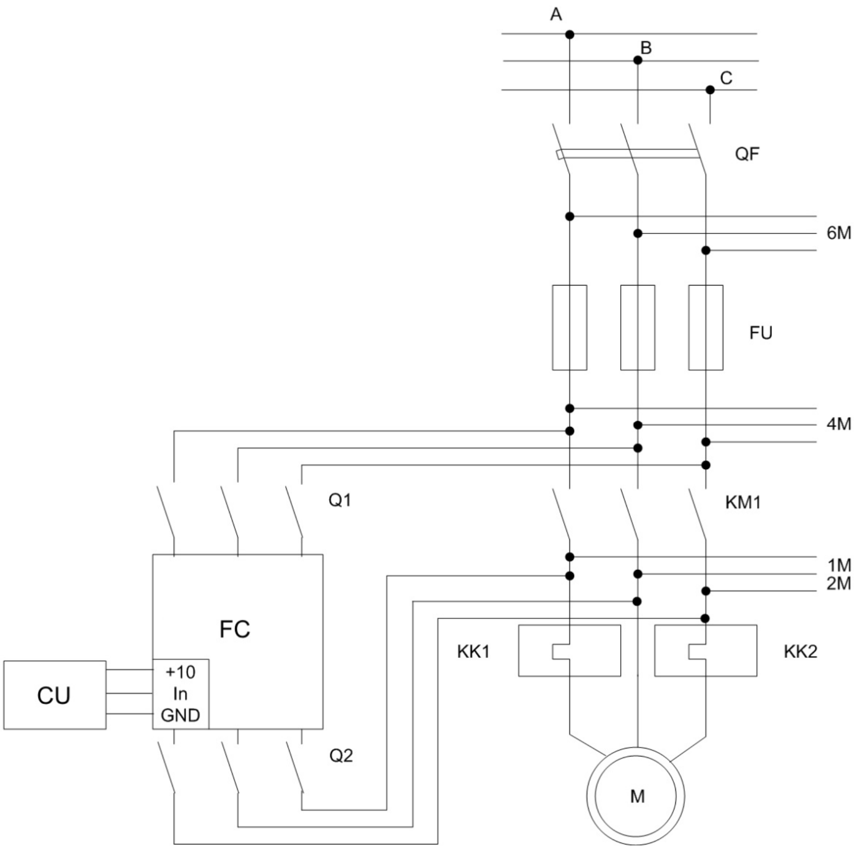

Fig. 3. The scheme of connection of the frequency converter

The frequency converter connected to the computer in debug mode and mode of adjustment for grinding operations of a variety of structural materials. Monitoring of major control parameters was carried out on the basis of a special program «Scope movitools» (Fig. 4).

These settings include: Y1 – the current speed (rev/min); Y2 – setting speed (rev/min); Y3 – converter frequency (Hz); Y4 – motor current (in % of the nominal value), etc. The interface of the program allows you to visually track the changes in these parameters over time.

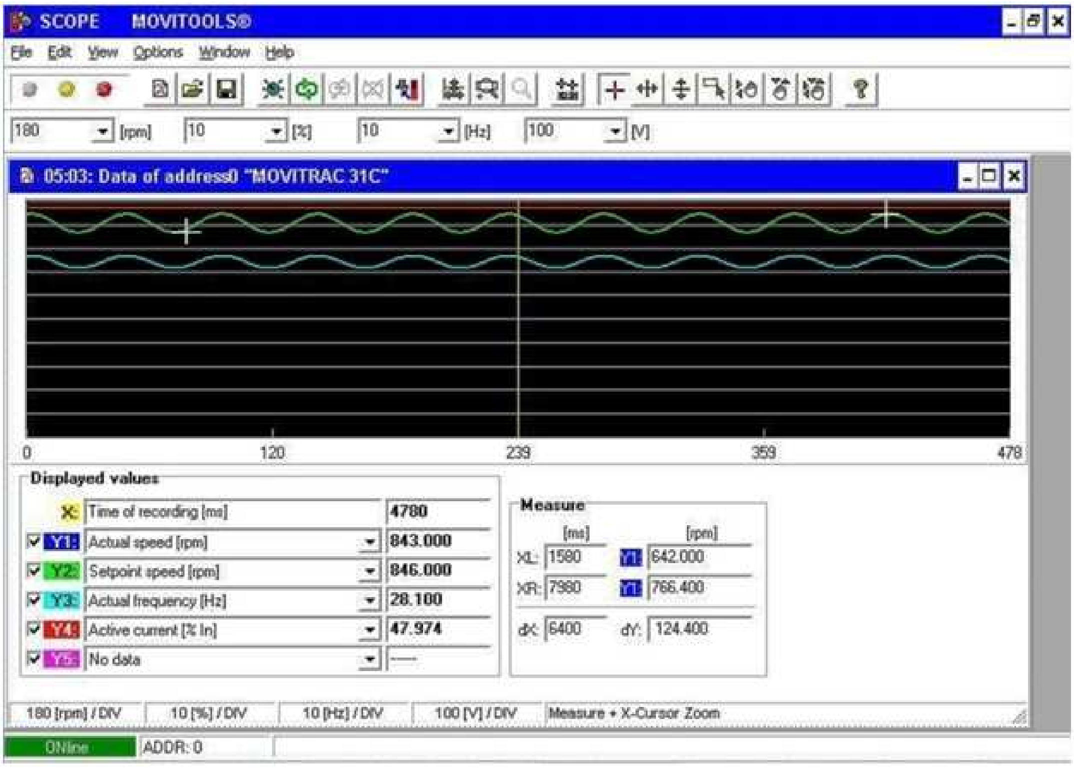

Fig. 4. «Scope movitools» interface

The experimental studies have been conducted in order to test the proposed method and technology. The aim of the research is to define the effect of continuously variation the cutting speed on the durability of the grinding wheel by white synthetic aluminum oxide. Data of the used equipment are summarized in Table 1.

Table 1
Equipment Characteristics

№	Name	Type	Model
1	Machine tool	Surface-grinding	3G71
2	Grinding wheel	White synthetic aluminum oxide	1-250x20x76WAF30L6V50-2
3	Frequency converter (FC)	Flux vector control without sensor	ATV32HU75N4
4	Control unit (CU)	Original	—
5	Power	3 phases, 380 V	—

III. RESULTS AND DISCUSSION

In the course of the experiment processed the following materials: carbon structural steel 1045, chromium steel 5140 (hardening) and high-speed steel T1 (hardening). Cooling was absent, dressing of grinding wheel by diamond-point dresser made before each experiment. Other conditions of the experiment and the obtained results are presented in Table 2.

Table 2
Conditions of the Experiment and the Obtained Results

Workpiece material	Hardness	S, μm /double m.p.	Parameter (v=var)		Wheel durability, s		Durability increase, %
			A, %	T, s	v=const	v=var	
Steel 1045	150 HB	5	±2,5	3,9	990	1250	26,3
Steel 5140	220 HB	10	±2,5	3,9	302	393	30,1
	280 HB	10	±2,5	3,9	91	137	50,5
Steel T1	57 HRC	5	±2	5,7	137	194	41,6

Note: Wheel rated speed range – 2760 rev/min; nominal cutting speed – 35 m/s; longitudinal feed – 12 m/min; S – wheel vertical feed per double manufacturing pass; A – amplitude of oscillation wheel rotation speed; T – oscillation period (sinusoid).

The table shows that the use of a grinding technology continuously varying cutting speeds improves wheels durability of 1.25 ... 1.5, depending on the material, heat treatment, grinding modes and control parameters.

Durability of grinding wheels was determined by the time of the intensive appearance of visible burn marks on the work surface. The machined surface was also seen under the microscope model Axiovert 40 MAT. Figure 5 shows a 3-D image of the machined surfaces (fragments with the largest area of burns). Workpiece material – steel 1045, grinding time – 990 s (corresponding to the durability range for grinding by the traditional technology, v = const). It can be seen that the number of burns is noticeably reduced at grinding with continuously variable cutting speed.

a) b)

Fig. 5 The 3-D microphotography of the machined surfaces: a – the traditional technology (v = const); b – the proposed grinding technology with variable cutting speed (v = var)

IV. CONCLUSION

Besides the main advantages of the proposed grinding technology with continuously variation of cutting speed – increase durability of wheel, to the advantages of proposed method can be attributed:

- flexibility, i.e. the ability to install additional equipment on the different types of machines: surface grinding, cylindrical grinding, internal grinding etc., without their physical upgrading;
- varying the frequency of spindle rotation in the range, the limited strength of the grinding wheel, power of machine and dynamic overload of control system;
- varying the amplitude and period of oscillation in a wide range of values;
- quick adjustment to the recommended settings for individual grade of processed materials;
- the ability to quickly disconnect additional equipment to work in normal conditions (for example, dressing of wheel).

Research on the use of new technologies continues. The next goal are: 1) the optimization of the control parameters with considering equipment and materials of wheel and workpiece; 2) improvement of the management system, bringing device to the industrial embodiment; 3) introduction of new technologies into production.

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