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Repair of Slide Guides of Metal Cutting Machines using Composite Materials

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ABSTRACT

This article discusses engineering capabilities of repair of slide guides of metal cutting machines using advanced composite materials. The applied composites are characterized, the main stages of repair technology are highlighted, which are comprised of determination of slide guides wear rate, their alignment and wear compensation by means of applying composite onto sliding carriage. The positioning accuracy is provided by specialized tool equipped with micrometer screws. The proposed engineering approach with application of composites characterized by antifriction properties provides complete repair of slide guides and required operation accuracy.

Key words: Composite materials, antifrictionality, repair, polymerization, release agent, positioning accuracy, wear.

1. INTRODUCTION

Nowadays the fleet of metal cutting machines in Russia is obsolete, it does not provide reliable operation in primary production and maintenance. Extended fleets of metal cutting machines are used at various enterprises, it is highly important to maintain their operability and operation accuracy [1]. Taking into account long-term experience of repair of metal cutting machines, the main task is restoration of initial (according to specifications) mechanical machine stand, mainly slide guides of metal cutting machines. Application of antifriction composite materials for repair of slide guides and control systems of deviations from out-of-flatness (at least 1 μm per 1 m) makes it possible to obtain the values of specifications regarding accuracy even for high precision boring machines. Engineering methods of solution to this very complicated problem are highlighted in this work.

Wear and damages of machine slide guides lead to loss of engineering precision, decrease in quality of processing, and their operation in usual process cycle becomes impossible [2]. Restoration of initial (according to specifications) mechanical machine stand is the most consuming and technologically complicated problem upon repair and modernization. Requirements to decrease time consumptions and costs of repair, impossibility to dismount machine stand for polishing using specialized equipment dictate the necessity to repair complicated and large-sized machine on site of their initial installation [3]. Positive experience of stand repair without dismounting allowed to develop and to apply the following procedures and solutions:

- application of specialized antifriction composite materials for restoration of friction couple in slide guides;
- high-precious measurements of deviations from out-of-flatness (at least 1 μm per 1 m);
- application of specialized accessories for polishing with numerical control systems and active monitoring of polished surface size.

2. METHODS

Application of repair composite materials upon restoration of slide guides significantly differs from energy intensive procedures (welding, soldering, plating, sputtering), which can be successfully substituted in certain cases [4].

Metal Slide composite material (Chester Molecular, Poland) is proposed for restoration of slide guides. In terms of cost/quality, this material is characterized by certain advantages in comparison with other foreign specimens and has been successfully applied for actual repair of hydraulic cylinders and slide guides of metal cutting machines [5].

Metal Slide is a two-component thixotropic metal-filled composite material based on epoxy with addition of graphite and fibrous fillers, which provides antifriction properties. It is successfully applied for repair and sealing of friction surfaces of parts, units, bearing joints, for restoration of surfaces in the area of sealing rings, slide guides of metal cutting machines. This composite is a thixotropic paste of dark grey color with the density of 1.49 g/cm^3, its components are mixed in the volumetric ratio of 2:1, herewith, its operation lifetime is 20–25 min, which provides possibility of its application during specified period. Curing time of Metal Slide is 7 h, then it can be mechanically processed. Complete chemical stability of the material is achieved after 7 days. Superior

mechanical and physical properties of the composite are as follows:

- ultimate compression strength: 146 MPa;
- ultimate shear strength: 24 MPa;
- temperature stability: from –50°C to +150°C;
- maximum temperature stability (short-term to +20°C) [6].

Metal Slide is a chemically stable material. It is resistant against water, oils, motor fuels. High quality of the material is confirmed by its long-term storage time: 36 months [7].

Restoration of worn guides is initiated usually with adjustment of the stand [8]. Nonworn part of the machine stand is selected and used as base. The adjustment is based on the usage of precision torpedo and frame levels with the accuracy of at least 20 μm per 1 m [9]. Then, in order to select procedure of elimination of guide wear, the wear of stand and adjacent surface (carriage, headstock or portal) is detected using rule, measuring stick, and dial indicators. The wear estimation should be consider4ed as qualitative, the measurement accuracy should be at least 0.05 mm. Generally, in the case of loss of machine precision, the stand wear for high precious machines is 0.1–0.3 mm, for machines of regular precision it is 0.5–1.0 mm.

The curve of wear Δ_u as a function of length of slide guides exposed to wear is plotted on the basis of the measurements (Figure 1) [10].

The guides with the mentioned wear level are restored by scraping using mechanical manual tools and specialized polishing accessories. The results are verified by rulers of zero class with the length of 0.6–3.0 m [11]. Processing of hardened guide surfaces slightly increases the time and labor intensity of the procedures [12].

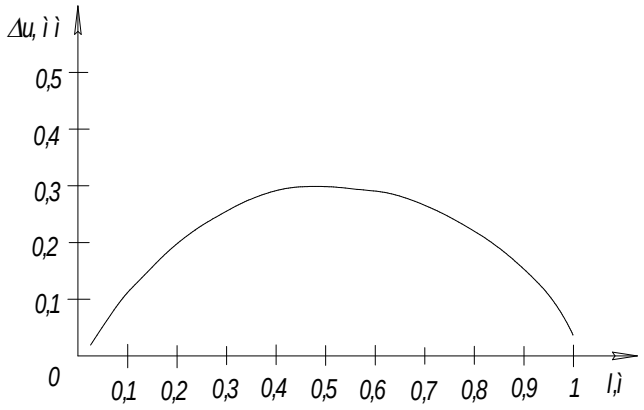

Figure 1: Variations of wear of slide guides of screw cutting lathe

Metal losses occurring upon scraping or polishing and generated gaps between the support and stand guides are compensated by application of antifriction composite material selected on the basis of long-term tests [13]. Composite material is a two-component composition characterized by good adhesive properties upon application onto metal surfaces, high strength and wear resistance, low friction coefficient, including the cases of near-zero velocities [14]. The material is highly resistant against the impact of water, oils, solutions of acids and alkalis, it retains its operation properties in wide temperature range. Another advantage of the material is its capability to transfer from plastic to solid state without shrinkage at ambient temperature in 24 h [15].

The composite material is applied in accordance with the special procedure developed by experts of RGUTIS University in cooperation with Mosintrast Company. Technological operations are executed in the following sequence:

- notches are milled on carriage guide for better adhesion of the composite material, herewith, the thickness of cleaned material should be 1.5–2 mm;
- the composite material is applied in excess on the carriage guides;
- the support carriage is installed on the main stand, preliminary treated by special separating liquid in order to prevent adhesion of the composite material to the stand;
- the support carriage is positioned on the stand using special accessory, predetermined gap is adjusted by micrometric screws to provide carriage position according to the specifications, see Figure 2;
- after 24 h holding, the carriage is shifted by lateral impact, the parameters of new position of the support are verified, and the newly obtained surface of support guide is scraped, if necessary.

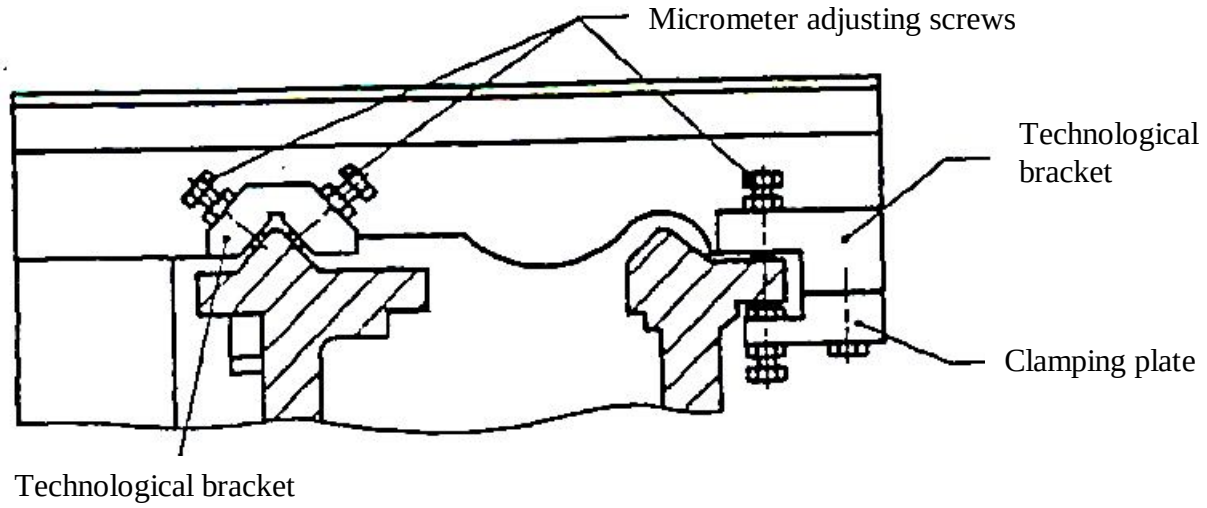

Figure 2: Positioning of carriage on machine upon application of composite

In the new composite–metal friction couple of carriage (Figure 3), the requirements to the hardness of carriage material are different, additional quenching of guides after repair is not required.

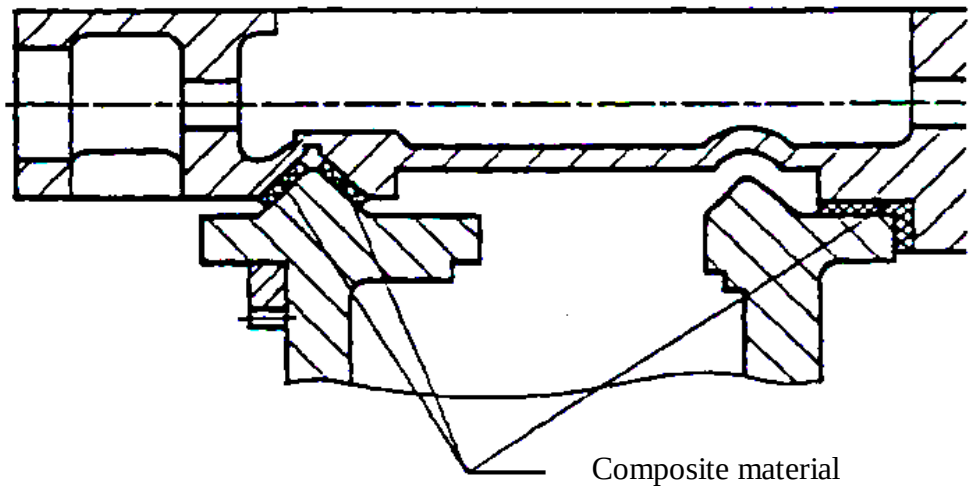

Figure 3: Guides after repair

3. RESULTS AND DISCUSSION

Wear in composite–metal friction couple takes place only on composite material, and in order to repair guides, it is required to apply composite coating in the future. It has been demonstrated in practice that this procedure is required at least after 6–8 years of machine operation. As a result of application of antifriction composite materials for repair, significant amount of energy resources are saved, usually consumed upon welding, soldering, plating, sputtering, etc.

On the basis of practical experience of experts involved in implementation of repair procedures with composite materials, it has been established that reasonable usage of their physical and chemical properties would allow to reduce prime costs and labor intensity by about 50-60% and to decrease metal consumption by 40-50%.

4. CONCLUSION

The technology of repair and modernization of metal cutting machines using composite materials characterized by antifriction properties makes it possible to reduce significantly expenditures for procurement of expensive equipment and to provide extension of operation lifetime of existing machines, which is economically and technically reasonable under conditions of primary production and maintenance services.

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