New combined antifriction treatment of the guides of machines and mechanisms

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Abstract. The technology description of the combined antifriction treatment, including three stages, is presented. These stages are the following: abrasive rough-down for surface preparation to coating with antifriction material; surface rubbing with antifriction material; surface plastic deformation of the processed surface area. These stages are executed with one instrument. The article presents the technological modes of this treatment allowing the formation of wear resistant surface layers of guides of machines and mechanisms.

1. Introduction

The extensive friction surfaces of guides, applied in machines, elevators, conveyers and other handling equipment, are exposed to intensive wear. The effective means of longevity increase of such surfaces is forming wear-resistant coatings at antifriction treatment [1, 2]. However the existing technologies of antifriction treatment are executed, as a rule, stage-by-stage on different equipment, which makes them labour intensive and expensive. Nowadays the application of antifriction coating in the narrow extensive area of the cylindrical guide, which contacts the carriage rollers, presents well-known difficulties. In this connection a new technology of the combined antifriction treatment, including three basic stages performed simultaneously, has been developed: abrasive rough-down for preparation of the surface to application of antifriction material; surface rubbing with antifriction material; surface plastic deformation of the processed surface area with hard-tempered spheres.

2. Basic part

For realization of such technology an instrument (Figure 1) that can process an external cylindrical (part of an external cylindrical surface) or flat extensive surface is developed and manufactured. It consists of body 1 that is executed in the disk form with an opportunity of axial rotation from an external drive and has a conical surface, which vertex faces the workpiece. The following elements are body-mounted: processing element 2 in the form of a removable petalous polishing butt-end disk, having a mechanism of the axial throw in the form of springs 4 tightened with bolts 3; rubbing element 5 from antifriction material in the form of the ring, which consists of the ultimate amount of sectors, having the opportunity of self-centering on the processed surface due to deformation of rubber 6; pressing element 10 in the form of hard-tempered spheres from steel ШХ15.

The rubbing elements have a mechanism of the axial moving in the form of adjustment springs 8 tightened with bolts 7 tightening compound disk 9. Burnishing elements also have a mechanism for moving towards a workpiece in the form of adjustment springs 12 tightened with bolts 11, which allows changing the application force of the burnishing element to the processed surface of workpiece 13, thus creating a required hardened surface layer with durable adhesive bonds.

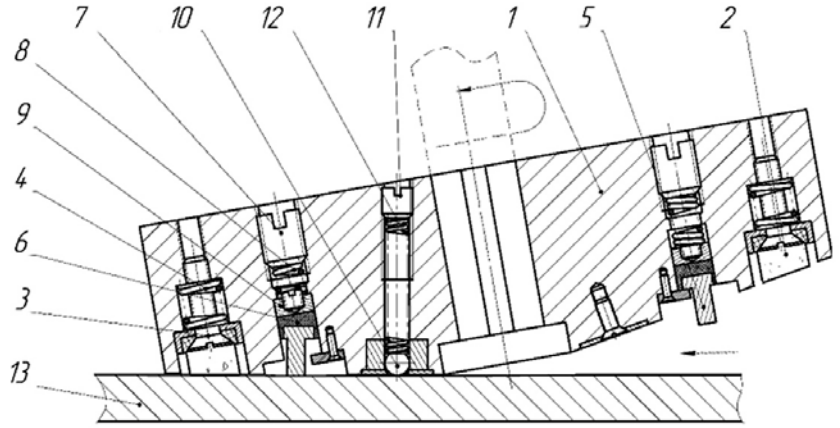

Figure 1. Scheme of the combined antifriction treatment

The working surface of the guide is formed as follows. In the spindle of the machine, for example a vertical milling one, one installs this instrument and brings it to the workpiece so that to provide the simultaneous contact of the workpiece surface with processing, rubbing and burnishing elements. It allows enhancing the quality the applied antifriction layer due to the friction heating of the rubbing element and a subsequent plastic deformation of the coating by burnishing elements. Further, by rotating screws 7 and 11 one provides necessary tightness of rubbing and burnishing elements in the direction of the processed surface. An external drive transmits an axial rotation to an instrument, whereupon one advances it at a tangent to the processed surface of workpiece (Figure 2).

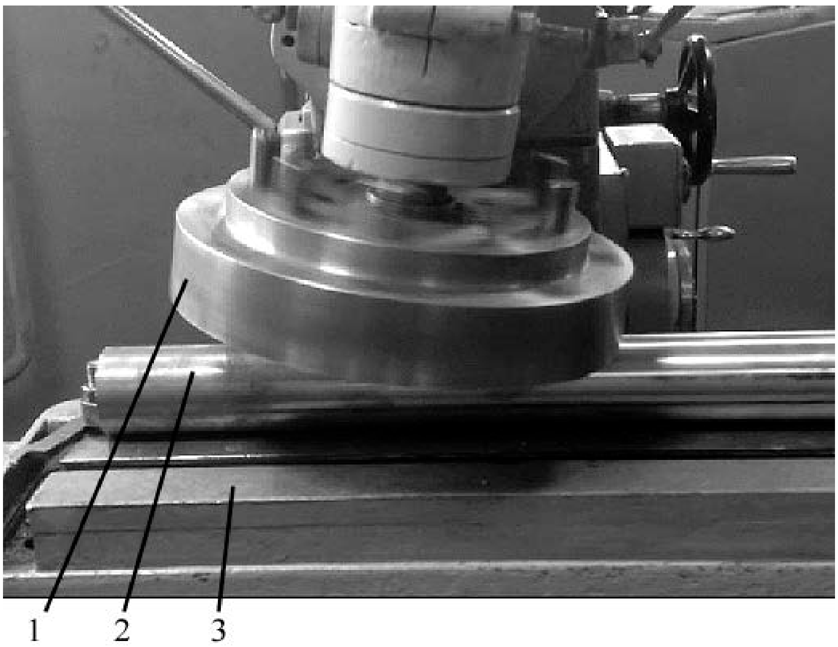

Figure 2. Antifriction sample treatment on the vertical milling machine: 1 – instrument for antifriction treatment; 2 – cylindrical sample; 3 – table of the vertical milling machine

The processing element removes the necessary allowance, and the required surface roughness, which provides the required coating adhesion, is formed. Then, a rubbing element applies a thin antifriction layer, warming up the surface of the workpiece. In future this layer is exposed to surface plastic hardening by means of the burnishing element, which enhances its quality. The construction of the instrument is protected by patent of the Russian Federation №118907 for a useful model.

In order to determine the technological modes of antifriction combined treatment of guide surfaces the number of experiments was conducted using this instrument on vertical milling machine 6T13. During experiments the following processes were modified: the rotation frequency of the spindle (50…200 min^{-1}), longitudinal instrument advance for antifriction treatment (0.2…0.8 mm/rev), pressing effort of the rubbing (250…3000 H) and burnishing (100…500 H) elements against the processed surface, granularity of processing abrasive petals (12…25 according to GOST 3647-80). While experimenting, glycerin was used in order to provide a qualitative antifriction coating. According to the results of experiments the modes of surface treatment of guides, providing stable formation of qualitative antifriction coatings throughout the whole processed area (Table.1), were determined.

Table 1. Technological modes of the combined antifriction treatment of external cylindrical and flat surfaces of guides

Type of the processed surface	Sliding velocity of rubbing (burnishing) elements, m/min	Pressing effort of rubbing elements, H	Pressing effort of burnishing elements, H	Longitudinal device advance, mm/rev	Granularity of abrasive petals according to GOST 3647-80
External cylindrical	60-90 (30-40)	350-400	140-170	0.2-0.3	12-16
Flat	80-100 (40-50)	> 2500	150-200	0.3-0.5	16-20

Notes: 1. Pressing effort depends on the width of the flat processed surface. 2. The indicated granularity of abrasive petals provided the roughness of surface equal to Ra=1.6…2.5 μm. 3. The surface roughness after treatment amounted to Ra=0.65…0.8 μm. 4. The antifriction coating thickness was in the range from 0.01 to 0.05 mm.

The next stage of research was the estimation of wear resistance of the coating layers formed according to the new technology of antifriction treatment. A stand imitating the real external environment of cylindrical elevator guides was created for this purpose. A stand works as follows. A test specimen is fastened to the prism and brought into contact with a roller. The necessary loading on the roller is created by the loads placed on the bowl of the loading device. Later, by switching on the power switchб the stand is fed with voltage, setting a geared motor into rotation and starting a reciprocating motion of the roller over the cylinder specimen. Then, using the voltage regulator (of rotation frequency) one settles the rotary speed of the geared motor up to a required magnitude, whereupon tribotechnical tests are performed.

During tribotechnical tests the loading on the specimens varied from 100 to 600 H. Loading variation resulted in the change of contact voltage between the roller and the specimen, the values of which were calculated according to a well-known H. Hertz formula.

During tests one fixed the time, after expiration of which the antifriction coating was worn down. The appearance of the base metal of the cylinder specimen in the area of antifriction coating served as a criterion of such wearout. Then the limit number of N-cycles of surface layer loading was determined. Later, one revealed the dependence of the limit number of N-cycles of loading on pressure $p_к$ when the roller contacts the specimen: $N = \alpha\ p_к^{\beta}$, where α, β – are the coefficients determined by a least-square method.

The developed technology of antifriction treatment allows coating of the broken-in and non-broken-in friction surfaces of guides. In this connection antifriction coatings were applied to specimens, which had rolling paths formed by the roller on the stand, and on the specimens without the indicated paths. This circumstance substantially influenced wear resistance of surface layers (Table 2).

Tribotechnical tests of friction specimen surfaces subjected to this antifriction treatment have shown that the service life of the surface layers made of antifriction material amounts to 8000…32000 cycles (from 3 to 12 years of normal operation of cylinder elevator guides). The service life depends on the thickness of antifriction coating, the grade of antifriction material, modes of treatment of the guide and loading at tests.

Table 2. Values of coefficients α and β

Antifriction material	Coating on the non-broken-in friction surface		Coating on the broken-in friction surface	
	α	β	α	β
Bronze	$3.0 \cdot 10^5$	-0.60	$2.1 \cdot 10^5$	-0.65
Copper	$2.5 \cdot 10^5$	-0.45	$1.4 \cdot 10^5$	-0.50
Brass	$1.7 \cdot 10^5$	-0.55	$0.9 \cdot 10^5$	-0.60

Notes: 1.Contact voltages $p_к$ varied in the ranges of 75 to 250 H/mm^2. 2. A significance and adequacy of dependences were checked according to Fisher F-criterion of Fisher with confidence probability of 0.95.

3. Results and Discussion

The analysis of results of experimental researches allowed concluding the following:

At the increase of sliding speed of rubbing elements over the processed surface above 100 m/min there is unevenness of antifriction coating forming. A substantial reduction of sliding speed results in the productivity decline of treatment and thickness of the formed coating, therefore the acceptable value of sliding speed is in the range of 70 - 100 m/min.

The pressing effort of burnishing elements against the processed cylinder surface should not exceed 350…400 H, as local destructions of antifriction surface coating can occur.

At the initial roughness of surface of more than Ra=3.5-4 µm there is a substantial consumption of antifriction material and forming of fragmentary coating on the processed surface. Fragmentary coating is also observed at the tool advance for antifriction treatment of more than 0.5 mm/rev. The most qualitative coating is formed at the initial surface roughness of Ra= 1.6-2.5 µm.

The surface layers containing bronze CuA19Fe3 become more wear-resistant, which is explained by the presence of iron that provides stronger adhesion relations with the specimen metal. The surface layers formed with the use of brass L63 appeared to be less wear resistant.

Antifriction coatings of the non-broken-in friction surfaces possess greater wear resistance (by 1.5-2 times) as compared to the similar coatings applied to broken-in surfaces of specimens. It can be explained by the presence of the considerable defective pre-surface layer of the broken-in surfaces.

The substantial decline (to 3-4 times) of wear resistance of antifriction coatings was observed contact voltages exceeded 130…150 MPa, therefore the accessible voltage in friction pairs with guides, the working surfaces of which are processed according to a new technology should be no more than 100…120 MPa.

4. Conclusion

It is more expedient to apply the described antifriction treatment when producing guides of machines and mechanisms, operating in the fatigue wear conditions. Surface forming by means of the developed instrument will have technological and economic effect, related to upgrading of antifriction coating of frictional unit components, increase of their service life and decrease of repair expenses.

References

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