Ensuring the required manufacturing quality of hydraulic-cylinder rods in mining machines

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Abstract. This article presents the results of experimental studies of the finishing treatment by hard turning of the chrome-plated surfaces of critical elements of hydraulic drives of mining machines and hydraulic distribution systems. It was revealed that in the process of galvanic chromium deposition on the working surfaces of the rod and other parts subject to intensive wear, along with provision of physicomechanical and operational characteristics of the surface layer, there is also formation of unacceptable macrogeometric deviations of the parts’ surfaces that are commensurable with the tolerance on the strengthened surface size. It is shown that the deviation from roundness (ovality) formed during chrome plating of the rod’s cylindrical surface is successfully eliminated by hard turning with the cutters equipped with cubic boron nitride plates. At the same time, along with ensuring the specified parameters of dimensional accuracy and geometric shape, the required roughness of the processed surfaces $R_a$ is within 0.32 ... 0.26 μm. Thus, the hard turning method can be reasonably recommended as an alternative to polishing, which is widely used after chrome plating of surfaces. The paper presents the methodology of the experiment, the geometrical parameters of cutting plates and technological processing modes, providing the required geometric accuracy and roughness of chrome-plated surfaces.

1. Introduction

The geometric accuracy of machine parts in accordance with accepted standards is characterized by dimensional accuracy, shape accuracy of the surfaces forming the part, and accuracy of their relative position. Unregulated deviations of macro- and microgeometry of work surfaces from the set values reduce the operational properties of friction units of mining equipment and mining vehicles, affect the temperature in the contact zone of mating parts, as well as the nature and intensity of wear of the critical surfaces [1-5].

2. Relevance of the subject

In mountain machines, pump-controlled hydraulic drives are widely used. The most widely used are piston hydraulic cylinders of progressive motion, the output and the most loaded element of which is the rod. Considering harsh operating conditions of mining machines and perceived loads, it can be stated that the efficiency and resource of rods directly depend on the quality of their manufacture, which is largely determined by the methods of finishing treatment of work surfaces. In this regard, provision of the required parameters of hydraulic drive parts’ quality through the development and implementation...
of advanced technological solutions is an important scientific and practical task, and its solution will significantly increase the life of hydraulic cylinders.

It is known that galvanic chromium plating is widely used to increase the wear resistance of the rods’ work surfaces, as well as a rather large range of parts of mining machines [6, 7, 8]. At the same time, the accuracy parameters of the critical surfaces are achieved in the process of round grinding immediately before the deposition of coatings, and the required surface roughness is obtained by polishing after chrome plating.

The study of geometric accuracy of the surfaces of 40X steel samples after galvanic deposition of coatings showed that in some cases chroming leads to the formation of an error in the geometric shape of cylindrical surfaces in the form of circular deviation. Analysis of the obtained circular patterns showed that circular deviation is manifested mainly by ovality. At the same time, the received tolerance of the surface shape turned out to be almost equal to the size tolerance, which is unacceptable for rods and a number of other valve parts, the dimensional accuracy of which corresponds to IT7-IT8, and the shape accuracy must be no more than 1/3 of the size tolerance [9].

3. Task setting

It is impossible to eliminate poor shape precision by a traditional polishing. In this regard, on basis of the analysis of technological capabilities of various finishing methods [1, 10–14], it was decided to perform the finishing treatment of chrome-plated samples with hard turning.

In this case, cutters equipped with CBN cubic boron nitride plates were used, since hardness of the surface layer of the samples varied from 62 to 64 HRC. The geometric characteristics of the used plates produced by ZCC-CT (PRC) are presented below in Table 1 [15].

Table 1. Geometric characteristics of cutting plates

| No. | Cutting plate     | Cutting-edge angle (degrees) | Corner radius (mm) |
|-----|-------------------|-----------------------------|-------------------|
| 1   | CNGA 120404       | 80                          | 0.4               |
| 2   | CNGA 120408       | 80                          | 0.8               |
| 3   | DNGA 150404       | 55                          | 0.4               |
| 4   | DNGA 150408       | 55                          | 0.8               |

Table 2 presents the results of experimental studies.

Table 2. Surface roughness Ra of chrome-plated parts, obtained by machining with different cutting plates in different cutting modes

| No. | Cutting speed (m/min) | Supply (mm/rev) | Cutting depth (µm) | Ra, µm |
|-----|-----------------------|-----------------|-------------------|--------|
|     |                       |                 | CNGA 120404       | CNGA 120408 | DNGA 150404 | DNGA 150408 |
| 1   | 300                   | 0.04            | 40                | 0.5     | 0.29      | 0.36      | 0.14      |
| 2   | 300                   | 0.06            | 80                | 0.39    | 0.64      | 0.44      | 0.32      |
| 3   | 300                   | 0.08            | 120               | 0.35    | 3.71      | 1.23      | 0.53      |
| 4   | 400                   | 0.04            | 120               | 0.55    | 0.37      | 1.38      | 0.65      |
| 5   | 400                   | 0.06            | 40                | 0.41    | 0.52      | 0.32      | 0.85      |
| 6   | 400                   | 0.08            | 80                | 0.58    | 0.46      | 0.46      | 0.55      |
| 7   | 500                   | 0.04            | 80                | 0.37    | 0.33      | 0.50      | 0.57      |
| 8   | 500                   | 0.06            | 120               | 0.86    | 0.21      | 0.62      | 0.96      |
| 9   | 500                   | 0.08            | 40                | 0.32    | 0.42      | 0.41      | 0.28      |
4. Practical significance. Results
As a result of hard turning, it was possible to ensure the required parameters of a geometrical shape accuracy of the rods and other parts of hydraulic distributors, while roughness $R_a$ of the treated surfaces came up to 0.32 ... 0.26 μm, and circular deviation amounted to 30% of the size tolerance. Roughness of the treated surfaces was determined using Mitutoyo SJ-310 profilograph. The surface roughness after chrome plating was in the range of 2.5 ... 1.6 μm, and the circular deviation amounted to 100% of the size tolerance.

Fig. 1 shows a roller, the chrome-plated steps of which were treated by hard turning with a cutter equipped with a plate made of CNGA 120404 cubic boron nitride in the following cutting modes: $V = 500$ m/min, $S = 0.08$ mm/rev, $t = 40$ μm.

![Figure 1. Chrome roller steps after hard turning](image)

For finishing the chrome-plated surfaces of hydraulic elements of mining machines, the authors of the article also implemented diamond smoothing for the first time, the results of which will be presented in subsequent publications. With the help of diamond smoothing, performed directly after chrome plating, the required roughness parameters of the surfaces $R_a$ within 0.32 ... 0.4 μm were achieved without reducing the adhesion of the coating to the substrate.

5. Conclusions
The results of experimental studies showed feasibility of using hard turning as a finishing treatment for the surfaces of chrome-plated parts of hydraulic devices. The use of lathe cutters with plates made of cubic boron nitride eliminates poor shape precision of the parts, in particular, ovality that occurs during the electrolytic coating deposition, while ensuring the required surface roughness $R_a$ within 0.32 ... 0.26 μm.

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