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Research Of Hardalloyed Burnishing Tool Durability With Coatings By Ion-Plasmous Sputtering Method

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Abstract: In this paper the effect of different types of coatings on durability increase of the tool for surface plastic deformation is considered. Wide burnishing processing with coated tool was selected as such research was performed for the first time. The influence of the type of coating on the tool durability has been explored.

Introduction

Researches of improving of tool's wear-resistance are actual for the machining processes of materials [1]. The requirement to reduce the specific cost of the treated surface unit promotes development research of construction and material of tool's work part. For a long time the only material used for processing by surface plastic deformation method (burnishing) was natural globular shaped diamond (0.5 carat per tool, radius up to 4 mm), hereinafter substituted to synthetic polycrystalline diamond that is less wear-resistant, but cheaper. Development of new methods of processing such as wide burnishing, radically different from classical burnishing by interaction conditions (processing is performed without line feed, but only with cross-feed; besides, the diameter of the tool is equal to the length of the work surface) and processing conditions (the force of classical burnishing - 150 N, wide burnishing - up to 5000 N). All this conditions has been required the application of different tool materials such as hard alloys. The cause for this change was the lack of diamonds with required size and high force value which able to crush a natural diamond.

Manufacturers are constantly improving the structure of hard alloys and chemical composition of incoming components. The main tendency in the structure is a graininess reducing of hardalloyed powder. Over the past few years, the grain size of hard alloy decreased more than fivefold. Improvement of coating technologies also is conducted [2,3].

Studies of burnishing tool's durability in the current production is carried out on the equipment for finishing of lip seal journals of crankshaft of LADA Priora cars. Process realization of wide burnishing is performed on an automatic machine with two tool modules disposed in the machine site (Fig. 1).

Russian instrumental hard alloys in terms of their cost can be divided into five main groups:

1) cheap tungsten (VC) and titanium-tungsten (TC),
2) three-carbide titanium tantalum-tungsten (TTC) system of WC-TiC-TaC-Co and obsolete types (WC -Co) + TiN and [(WC-TiC-Co) + TiN] with a single layer;
3) multi-carbide systems WC- (Ti, Ta, Nb, Re) -Co and three-carbide (WC-TiC- TaC-Co) + (TiN / TiC / Al203) multi-coated;
4) multi-carbide type [WC- (Ti, Ta, Nb, Re) -Co] + (TiN / TiC / Al203) with multilayer wear-resistant coating;
5) solid tungsten (BVTS) type system TiC-Ni-Mo and TiCN-Ni-Mo with a coating and without it.

Fig. 1. General view of the wide burnishing machine

During durability test Lada Priora's crankshafts after "final polishing" operation were used as rough workpieces. Work surface requirements (Fig. 3):

- geometric dimensional accuracy: $Ø80_{-0,05}$ mm, $Ø28_{-0,03}$ mm;
- basic surface roughness Ra = 0.7…0.8 µm;
- maximum roundness accuracy error ○ 0,005 mm;
- maximum linearity error — 0.005 mm;
- work surface hardness HRC 42…48 (after hard-surfacing with HFC);
- work material: high-duty cast iron with globular graphite Gh75-50-03 (numbers represent the following breaking point, yield point, modulus of elongation).

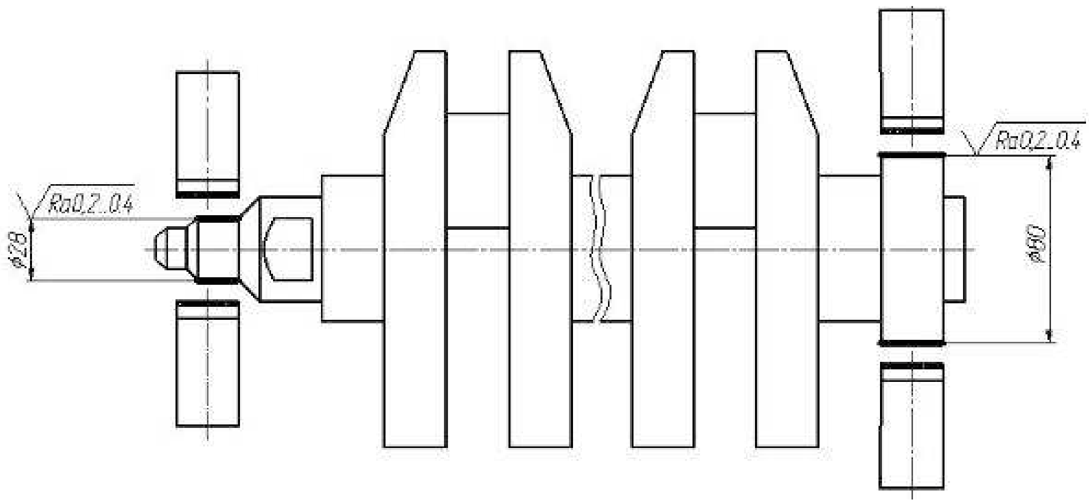

Fig. 2. Setting up

The module body (Fig. 3) is formed by two hardened steel plates 1 and intermediate slats 2 connected by screws and pins. Levers 3 and 4 with hinged tool holders 5 on the ends are situated inside the body. Indenters 6 are fixed in the tool holders with screws. Each holder can rotate by a small angle to the horizontal plane around axis 7. This rotation provides self-adjustment of the indenter and tool's work part fit to work surface along the entire length. The levers 3 and 4 are supported on the axis 8 and rods 9 are hinged to the upper ends of the levers. The second ends of rods connected to the hydrocylinder rod 10 mounted on the top slat of the block. The force of hydrocylinder depending on the diameter of the work surface and must be 2000 ... 3000 N. The gain of the linkage system from 3 to 4.

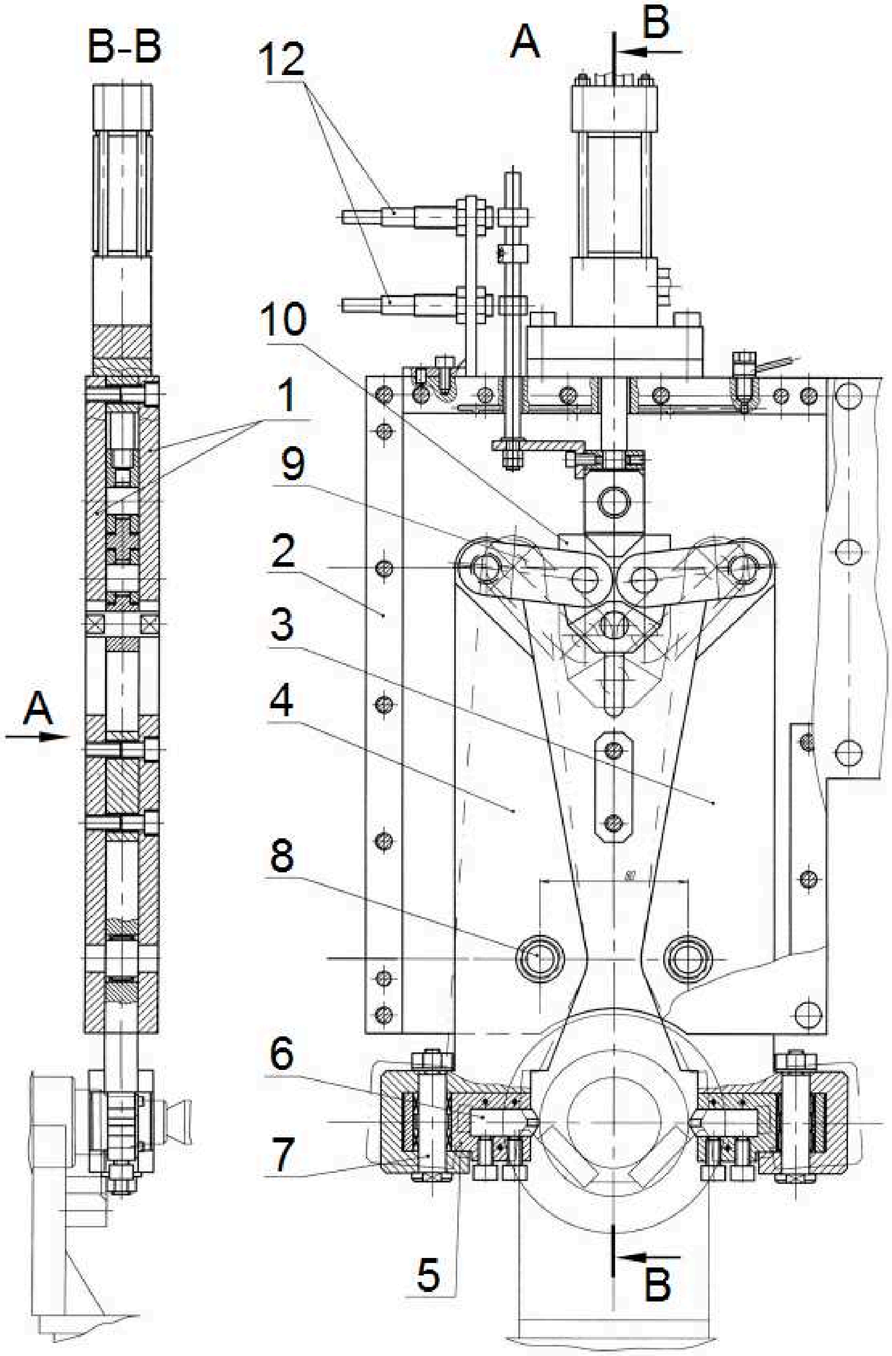

Fig. 3.Tool unit

Taking into account application of various burnisher body materials were developed two types of engineering design with different types of burnishing element mounting, with soldered and with mechanical fastening. Figure 4 shows a photo solder tool fastening a burnishing element of a hard alloy to a holder. The roughness of the burnisher active face should be adopted in accordance with

Ra = 0.01 ... 0.02 µm (measured by the roughness of the tool active face to be made on surface analyzer with accuracy of not less than ΔRa ± 0.005 µm).

During our test was used a special self-aligning tool comprising burnishing element with a length of the body 15 ... 20 mm. Since working process was performed without sliding feed by covering the entire length of the treated tool surface, in the development processing kinematics problem was to fit exact tool along the entire rough part length. This problem was solved, thanks to the burnisher nose, allowing through the pin joint installation, to ensure a snug fit working surface of the tool to the rough part. The tool was installed in the burnisher head parallel to the axis of the work piece.

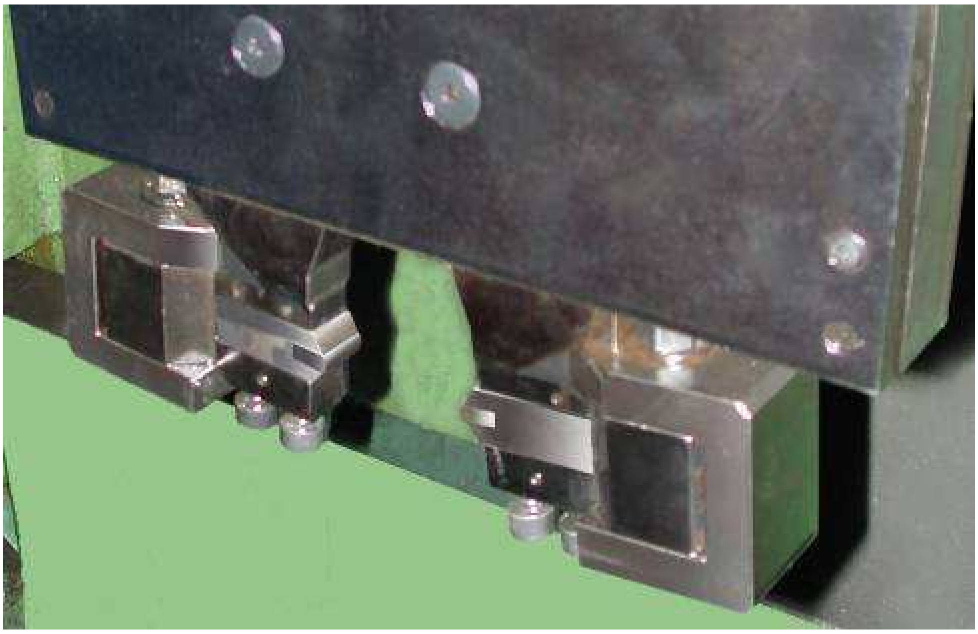

Fig. 4.Tool mounts and wide burnisher

For wear resistant characteristics test conducted in three stages were selected alloys VK6 and T30K4. Experiments showed that the burnisher made of alloy T3OK4 quickly goes down, there is active face destruction (possible cause of inadequate safety margin by bending stresses).

In the process of burnisher wear resistant testing tools control measurements on roughness subjected every tenth item. Thus, machined surface roughness was measured at 3 points located at an angle of 60 °, for the quaesitum of the arithmetic mean is taken. After the roughness Ra was out-of-control condition of the tolerance (Ra> 0.4 µm), the test was ended. Durability L (in meters of the treated surface) was calculated by the formula:

$$L = 10^3 \pi d n K, \qquad (1)$$

d - feedstock diameter, mm; n – number of rounds during processing, K – the number of machined parts.

The first stage used tools, the body of which was made of an alloy VK6, each tool has processed 1200 parts. Currently used as the burnisher body main material VK6 fully justified its use.

The second stage investigated operation tool with a coating - titanium nitride (TiN) during processing without coolants. Sputtering technique: surface coarse purification with argon; placing the instrument in an environment with a temperature of 723 K (450° C); condensation of titanium - from two cathodes during 40 min. Nitrogen was fed into the chamber as a gas, and ionized titanium surface. The depth of coverage in this case was 5 µm. Burnishing tool running-in time was unacceptably high, which can be explained by the presence of "drop phase," because of what the working surface is smoothed to matt and roughness increased to Ra 0,1 ... 0,12 µm.

The third stage coating technology has been modified to reduce the roughness of the tool. Nitrogen was fed into the chamber is not in a gaseous form, and as ions N+2. Coverage got finer, and "drip phase" occurs rapidly, which resulted in improved results.

Results and Discussion

Figure 5 shows the test results. Curve 1 corresponds to the instrument, with VK6 body when working with supply metalworking fluids RZH8.
Curve 2 characterizes an instrument clad TiN, and is offset relative to the axis 4 compared with the curve 1, as in the coating to enter the operating mode requires some bedding.
Curve 3, the appropriate tools coated TiN, deposited in an environment with ionized nitrogen. While tool running-in time decreased by 7 times, endurance increased by 20%.
Studied group of coatings and their method of application did not give significant results.
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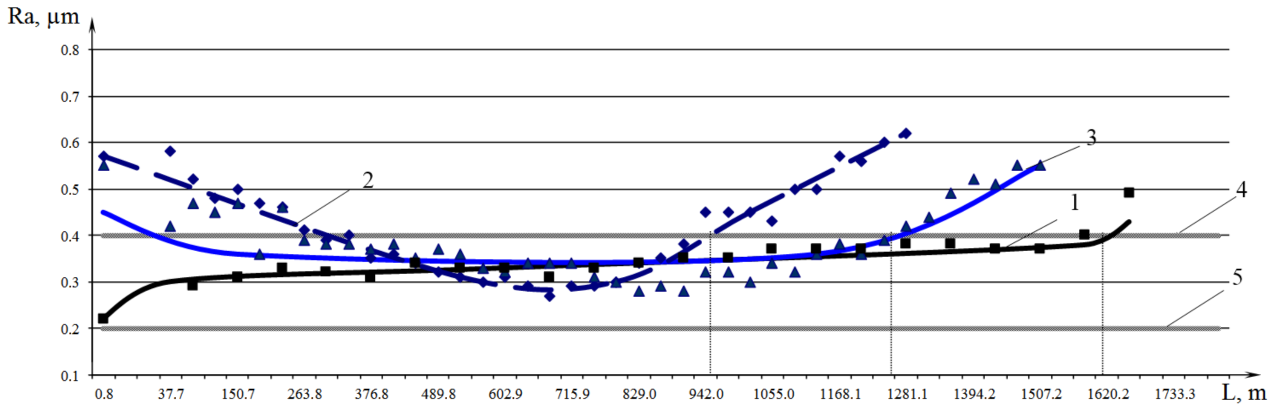

Fig. 5.Influence of the traversed path tool on lip seal journal machined surface roughness of a crankshaft from high-duty cast iron with hardness HRC 45: 1 – burnisher body from VK6 hard alloy; 2 – burnisher body from VK6 hard alloy with TiN coating; 3 – burnisher body from VK6 hard alloy with TiN coating, deposited in an environment with ionized nitrogen; 4, 5 – upper and lower tolerable limit

Conclusion

1. Applying a titanium nitride with classical methods increases tool running-in time and reduces its durability, the application of inexpedient.
2. Application of the sputter coating technique reduces the time to the running time of approximately equal of uncoated burnishing tool (as compared with the first method decreased in 7 times). However, during the running tool without a coating is within the tolerance, whereas a coated tool it exceeds the tolerance. Durability in this case was 20% higher than in the first case, but still less than for a tool without a coating.
3. The implementation of the pilot study confirms the feasibility of further work on the coating of tools for a wide burnishing. Despite the fact that the alloy VK6 is currently still widely used is promising applications of superhard alloys for processing (such as nano cubic boron nitride) or fine-grained hard metal (such as N10G) simultaneously with modern types of coatings.

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