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Investigation of tool wear resistance when smoothing parts

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Abstract

The article discusses the method of surface plastic deformation of steel parts by smoothing. The positive influence of this method on the wear resistance of the tool has been established under conditions of intense wear and with abundant lubrication.

Key words: wear, durability, tool, surface plastic deformation, friction pair, smoothing.

Introduction

The smoothening method is ideally suited to the hardening treatment of surfaces of revolution, using a diamond indenter-smoother with a spherical working surface. Despite the unique properties of diamond as a tool material (high hardness, increased wear resistance and compressive strength), its use is limited by an increased tendency to chemical interaction with structural materials, for example, with low-carbon steels, titanium and its alloys, etc. Lack of lubricating coolants in the burnishing zone only exacerbates this disadvantage of diamond tools [1-3].

The peculiarity of diamond burnishing as a method of sequential local action of a moving indenter on the workpiece surface being processed in the conditions of their mass production is considered as a disadvantage due to low processing productivity [4].

The technological advantages of the burnishing process are obvious, therefore, in this work they are used, but in a technical design with a significantly higher processing performance [5].

Research methodology

As the main criterion for choosing rational conditions for wide burnishing, the roughness of the machined surface of the parts was used, which is provided during the tool life. The durability of the ironing tool has been classified as the time of continuous operation during which it becomes functionally unusable. This condition can be identified as irreversible changes in the topography of the tool working surface through the wear area [6, 7].

To determine the wear area of the spent smoother, a special technique was proposed, which is based on digital processing of surfaces with different reflectivity characteristic of the initial and worn conditions.

The technique for quantifying the area of the worn surface of the tool includes the following steps:

1. Digital photographing of the working surface of the tool on a special stand.
2. Processing the bitmap image of the working surface of the tool in the graphics editor Adobe Photoshop in order to increase the contrast and prepare a digital photograph of the working surface of the smoother to determine the actual wear contact spot in the IZNOSOMER program.

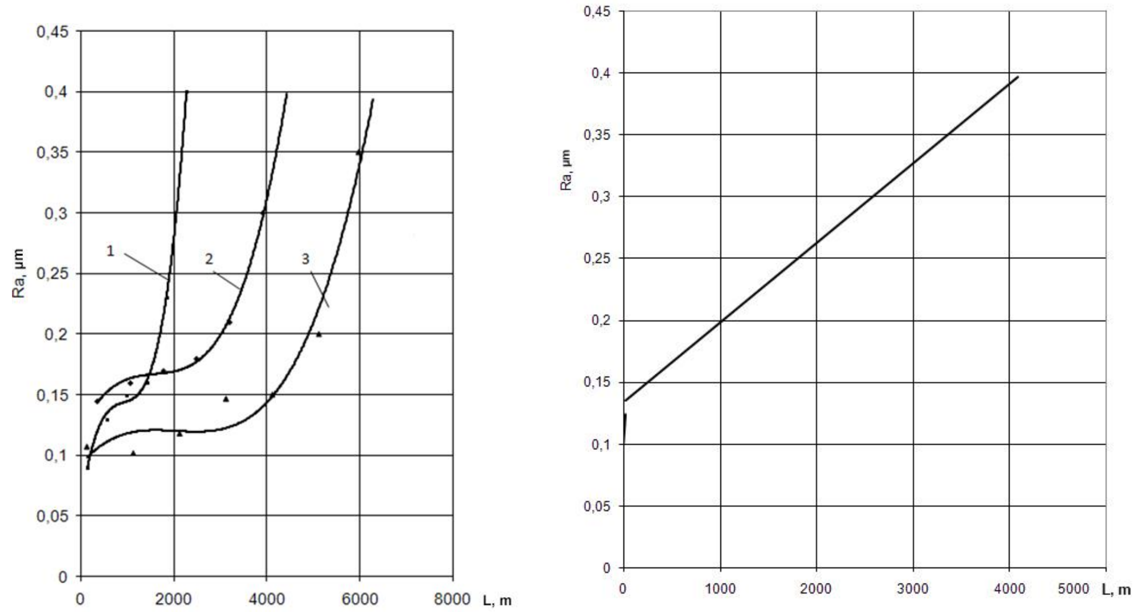
Research results

The burnishing process was carried out on samples made of materials: steel 40 and high-strength cast iron VCh 75-50-03. The samples were pretreated by grinding. The initial roughness of the samples from steel 40 R_a = 0.5 µm, from cast iron R_a = 0.85 µm.

When burnishing samples of steel 40 and high-strength cast iron VCh 75-50-03 for all 3 studied burnishing cycles, an extreme relationship between the roughness of the treated surface and the force on the smoother is observed [8].

It has been established by experiments that the minimum values of the roughness of the processed surface in terms of Ra occur at P = 210 N/mm for steel 40 and at P = 410 N/mm for VCh 75-50-03 cast iron, regardless of the number of burnishing cycles. This pattern suggests that the formation of the roughness of the treated surface is influenced by the processing time and pressure on the surface to be smoothed, therefore, the reason lies in the mechanism of plastic deformation [9].

In Fig. 1, a shows the obtained experimental dependence of the surface roughness of a part made of steel 45 on the length of the path traveled by the tool for tool materials: composite 05IT, leucosapphire, niborite, and in Fig. 1, b - dependence of the surface roughness of a part made of VCh 65-50-03 cast iron on the length of the path traveled by the tool made of composite 05.



a **b**

Fig. 1. Dependence of the roughness of the sample during smoothing on the length of the path traveled by the tool made of various materials

As a result of the studies, it was found that the superhard material niborite (tomal 10) has the greatest resistance when processing steel 45, its resistance is 6.3 km. Resistance for other materials when processing steel 45 is 2.3 km for leucosapphire, and 4.4 km for composite 05IT.

The choice of a specific tool material must be made for economic reasons for each material of the workpiece.

Experiments have also shown that the performance of the smoother is increased when using a hard alloy with a reduced dispersion of the carbide phase [10]. The application of wear-resistant coatings, performed in this work, did not give a tangible increase in the durability of carbide tools.

A two-factor experiment was carried out in production conditions, which simulated the joint and interrelated influence of the burnishing force and the number of loading cycles on the quality of processing of the gland journals of crankshafts made of ductile iron. The results turned out to be adequate to the patterns established in the laboratory.

Comparison of the results of experimental studies and calculations using the energy model of wear. A comparative assessment of the data on the sizes of the wear areas of the working surfaces of smoothers made of various tool materials was performed, which were obtained experimentally and by calculation using the energy wear model.

In Fig. 2 shows the dependence of the area of wear on the distance traveled by the tool during processing. Curves 1 and 3 were obtained experimentally according. The critical value of the wear area Scritich was determined as the state of the tool that was not able to provide the required roughness during machining (with the required $R_a = 0.4$ µm, $S_{critical} = 2.5$ mm^2).

Curve 2 was obtained by a theoretical method when solving the energy model presented in the second chapter, while the empirical coefficient of resistance K resistance = $0.375 \cdot 10^{-2}$).

Curve 3 was obtained theoretically using the energy model for a new group of tool materials H10F after introducing the necessary empirical coefficients into it when plotting curve 2. It can be seen from the graphs that the error between the experimental and calculated wear areas is not large (less than 20%), while the curves wear corresponds to the classical, and consist of three main stages: running-in, normal operation, catastrophic wear [11].

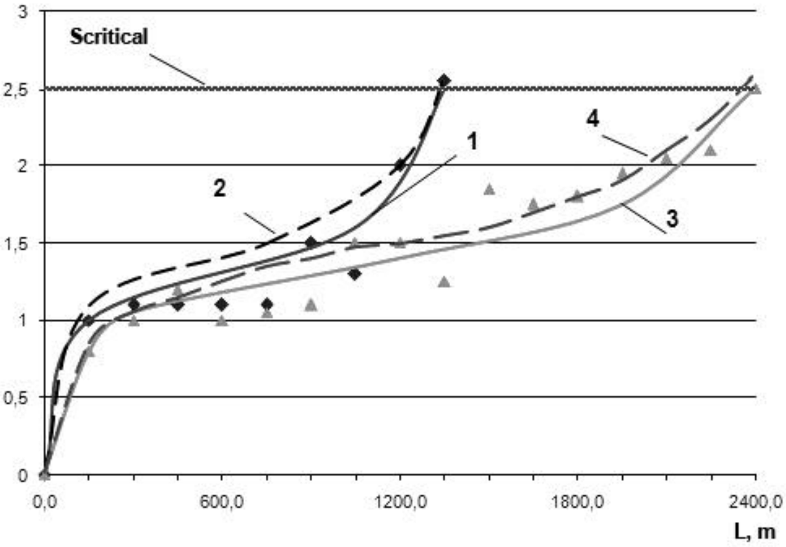
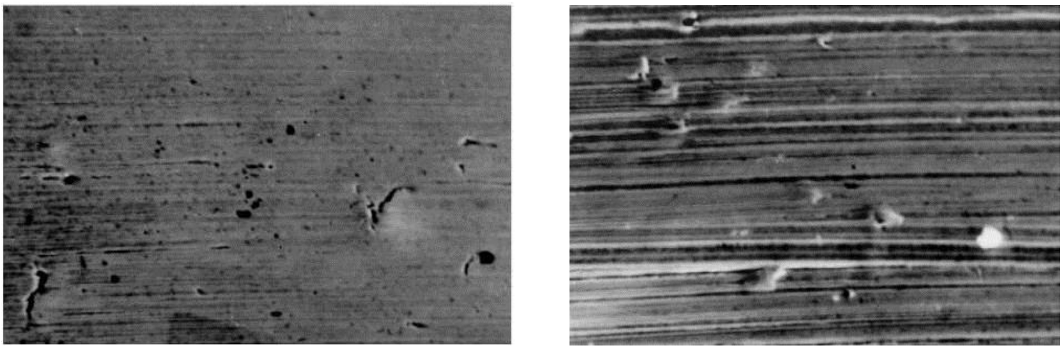


Fig. 2. Curves of the dependence of the area of wear on the traveled path of the tool in the process of wide burnishing

According to the results of a comparative assessment of the data obtained by calculation and experiment, one can recognize their agreement as good. For example, if we compare the sizes of the wear areas of the working surface of smoothers made of various tool materials, calculated according to the energy model of wear and obtained by measuring in real conditions of smoothing, then the difference between them does not exceed 25%, averaging 9.3% according to the results of measurements in 5 different smoothing modes.

Technological features of smoothing of ductile iron with spheroidal graphite. The technological features of the process of wide burnishing of high-strength cast iron with spheroidal graphite (for example, VCh 75-50-03 cast iron), which is characterized by low plasticity, increased hardness and a narrow range of deformation stresses from elastic deformation to its destruction, are revealed [12, 13].

In fig. 3 shows photomicrographs of the machined surface of a ductile iron crankshaft after wide burnishing and polishing with an abrasive belt. From the point of view of the microgeometry of the surface and the need for its running-in at the initial stage of wear, smoothing treatment turned out to be more preferable than polishing.



a **b**

Fig. 3. Surface after smoothing (a) and polishing (b) x300

Under the selected burnishing conditions, the surface layer of parts made of high-strength cast iron has a slight hardening - in terms of the degree of work-hardening, an increase of up to 10% at a work-hardening depth of 4 ... 6 μm.

Investigation of the wide burnishing process on specimens of hardened case-hardened steel 18KhGT. It was found that for smoothing parts made of case hardened 18KhGT steel, it is advisable to use smoothers with a working part made of polycrystalline plates of composite 05 with a radius of 2 mm, which, under optimal loading conditions, provides a roughness of the processed surface to R_a = 0.05 μm without signs of over-hardening. In the case when the initial surface roughness increases before smoothing, it is necessary to increase the pressure on the tool.

Conclusions

The criterion of tool durability is determined by its functional purpose of smoothing as a method of predominantly improving the roughness of the workpiece surface being processed. If the specified requirements for the height of microroughnesses on the machined surface (for example, the value of the R_a parameter) are not met, the smoothing tool is recognized as unsuitable for further work.

The process of tool wear in the work is considered as a transformation of the microgeometric topography of its working surface as a result of the adhesive interaction of two metal bodies under conditions of dry sliding friction using the application effect. The essence of this effect lies in the imposition of the microrelief of the working surface of the smoother when rolling on the workpiece surface with the accompanying process of plastic flow of the surface layer, which allows predicting the tool life.

Comparative evaluation of the data on the sizes of wear areas of the working surfaces of smoothers made of various tool materials, which were obtained experimentally and by calculation using the energy wear model, showed good coincidences of the wear area of the smoother: the maximum difference is 25% with an average error of 9.3%.

Revealing the thermal pattern of wide burnishing allows you to develop technological restrictions on the processing process in terms of two factors. First, to prevent possible negative structural and phase transformations in the surface layer of the burnished part with a subsequent decrease in its quality and operational reliability. And, secondly, to reduce the intensity of tool wear, especially in the absence of a beneficial effect of lubricating cooling process fluids.

References

1. Hrushhev M.M. Jeksperimental'nye osnovy teorii abrazivnogo iznashivanija / M.M. Hrushhev, M.A. Babichev // Vestnik mashinostroenija. – 1964. – №6. – S. 56 – 62.

2. Kashheev V.N. Abrazivnoe razrushenie tverdyh tel: Avtoref. dis. … doktora fiz. mat. nauk / V.N. Kashheev. – Tomsk, 1963. – 45 s.

3. Tenenbaum M.M. Iznosostojkost' konstrukcionnyh materialov i detalej mashin pri abrazivnom iznashivanii / M.M. Tenenbaum. – M.: Mashinostroenie, 1966. – 332 s.

4. Shkol'nik L.M. Tehnologija i prisposoblenija dlja uprochnenija i otdelki detalej nakatyvaniem / L.M. Shkol'nik, V.I. Shahov. – M.: Mashinostroenie, 1964. – 184 s.

5. Matalin A.A. Tehnologicheskie metody povyshenija dolgovechnosti detalej mashin / A.A. Matalin. – Kiev: Tehnika, 1971. – 144 s.

6. Marchenko D.D. Improving the contact strength of V-belt pulleys using plastic deformation / D.D. Marchenko, K.S. Matvyeyeva // Problems of Tribology. – Khmelnitsky, 2019. – Vol 24. – No 4/94 (2019) – S. 49–53. DOI: https://doi.org/10.31891/2079-1372-2019-94-4-49-53.

7. Butakov B.I. Usovershenstvovanie processa chistovogo obkatyvanija detalej rolikami / B.I. Butakov // Vestnik mashinostroenija. – 1984. – № 7. – S. 50 – 53.

8. Marchenko D.D. Investigation of wear of a contact pair of friction "rope block - rope" / D.D. Marchenko // Problems of Tribology. – Khmelnitsky, 2019. – Vol 24. – No 2/92 (2019) – S. 82–87. DOI: https://doi.org/10.31891/2079-1372-2019-92-2-82-87.

9. Dykha A.V. Study and development of the technology for hardening rope blocks by reeling. ISSN 1729–3774 / A.V. Dykha, D.D. Marchenko, V.A. Artyukh, O.V. Zubiekhina–Khaiiat, V.N. Kurepin // Eastern–European Journal of Enterprise Technologies. Ukraine: PC «TECHNOLOGY CENTER». – 2018. – №2/1 (92) 2018. – pp. 22–32. DOI: https://doi.org/10.15587/1729-4061.2018.126196.

10. Dykha A.V. Prediction the wear of sliding bearings. ISSN 2227–524X / A.V. Dykha, D.D. Marchenko // International Journal of Engineering and Technology (UAE). India: "Sciencepubco–logo" Science Publishing Corporation. Publisher of International Academic Journals. – 2018. – Vol. 7, No 2.23 (2018). – pp. 4–8. DOI: https://doi.org/10.14419/ijet.v7i2.23.11872.

11.Marchenko D.D. Analysis of the influence of surface plastic deformation on increasing the wear resistance of machine parts / D.D. Marchenko, V.A. Artyukh, K.S. Matvyeyeva // Problems of Tribology. – Khmelnitsky, 2020. – Vol 25. – No 2/96 (2020) – S. 6–11. DOI: https://doi.org/10.31891/2079-1372-2020-96-2-6-11.

12. Aulin V. Wear resistance increase of samples tribomating in oil composite with geo modifier KGMF-1 / V. Aulin, A. Hrynkiv, S. Lysenko, O. Lyashuk, D. Velykodnyi, Y. Vovk, D. Holub, A. Chernai // Tribology in Industry. – Vol. 41, No. 2 (2019). – S. 156 – 165.

13. Aulin V. Exploring a possibility to control the stressed-strained state of cylinder liners in diesel engines by the tribotechnology of alignment / V. Aulin, S.A. Hrynkiv,Lysenko, A. Dykha, T. Zamota, V. Dzyura // Eastern-European Journal of Enterprise Technologies. – 2019. – Vol. 3 (12-99). – P. 6 – 16. DOI: 10.15587/1729-4061.2019.171619.

Марченко Д.Д., Матвеева К.С. Исследование износостойкости инструмента при выглаживании деталей.

В статье рассмотрен метод поверхностного пластического деформирования стальных деталей выглаживанием. Установлено положительное влияние этого метода на износостойкость исчтрумента в условиях интенсивного изнашивания и при обильной смазке.

Ключевые слова: износ, стойкость, инструмент, поверхностная пластическая деформация, пара трения, выглаживание.