COMBINATION OF DIAMOND-ELECTROCHEMICAL HONING AND GALVANIC CHROME-PLATING

Popov, Alexander P., *Russian University of Transport, Moscow, Russia.*
Sviridenko, Danila S., *All-Russia Research Institute of Aviation Materials, Moscow, Russia.*
Komarov, Yuri Yu., *Russian University of Transport, Moscow, Russia.*

ABSTRACT

Electrochemical methods have found their greatest usefulness in the dimensional machining of surfaces of machine parts, based on complex processes of metal dissolution. The authors study the results of bench tribological tests of the results of application of the combined method of diamond electrochemical honing and galvanic chroming, creating high-strength surface layers, that showed the measure of intensity of wear, deviation from the optimum regimes, the causes and nature of emergence of coating defects. To fulfill the test conditions, appropriate equipment, technological equipment, tools were used, and an appropriate type of electrolyte medium was provided. The structure of the created equipment, in particular, included modernized vertical honing semi-automatic machines and mechanical devices. Based on the test results, the possibility of combining two methods of electrochemical metal surface treatment subject to high tribological load was confirmed.

Keywords: machine parts, tribology, combined treatment, electrochemical processing, diamond electrochemical honing, galvanic chroming, wear, dimensional machining.

Background. *To solve the technological problems of creating new equipment in the industry, it has become increasingly common to use and develop methods for processing materials based on the nonmechanical action of a tool on a workpiece. In most similar cases, electrochemical processing methods are used (ECP) [1–3].*

ECP prevails in the technologies of dimensional machining (shaping) of the working surfaces of machine parts using the processes of metal dissolution, but ECP control in comparison with the machining processes is a technologically difficult task. Moreover, ECP in the production of machines can improve the accuracy of machining of parts, and thereby raise the reliability of the product as a whole [4, 5].

Objective. *The objective of the authors is to consider the performance of the method of combination of diamond-electrochemical honing and galvanic chroming.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, evaluation approach.*

Results. *An example of the use of ECP is the combined method of diamond-electrochemical honing (DECH) and galvanic chroming, which was tested for steels 30HGSA, 30HN2MFA, 35HN2MFASH, 23HGS2MFALU, St. 50A [6, 7].*

The ranges of variation in roughness and macrogeometry were 0,2–0,3 μm and 0,01–0,02 mm, respectively. These results are formed in conditions of optimal values of current density, duration of operations, specific pressures of expansion of bars, varieties of tools [8]. The change in the hardness of the surface layer and the pattern of internal residual stresses confirms the regime ranges selected during the macro and microgeometric studies.

Suitable hardening growth ranges were obtained: 16,6–17,9 • 10^{-3} MPa. The nature of distribution of internal residual stresses in the superficial layer (0,1–0,4 mm) is determined by the variety of abrasive tools used. The greatest values of such stresses (–50...-400 MPa) are fixed when using bars of type 15AM50St1B. The choice of the type of abrasive tool determines the duration of sparking-out, the effectiveness of hardening of the surface layer. The duration of sparking-out is estimated at 6 to 8 seconds.

Bench tribological tests of combined DECH and galvanic chroming, creating high-strength surface layers, determined the intensity of wear 0,002–0,003 • 10^{-3} kg [9]. This range is performed under the conditions of the established combination of DECH modes at the established thickness of the galvanic coating. These studies, taking into account the analysis of fractograms, demonstrate the difference in the development of wear process.

The formed surfaces after the tribological tests are characterized by combinations of light-gray background with one-sidedly oriented microrelief, and also perfectly smooth parts with no traces of microcutting, nor of adhesion-cohesive setting in conditions of dry friction.

However, deviations in the work regime of application of the combined DECH method and galvanic chroming from the optimum modes create disturbances in stable tribological interaction, causing defects in the coating. Bench tests of the combined method's capabilities under conditions of alternating cyclic loading, as well as tests for estimating the impact elasticity values in general, confirm the choice of selected ranges of regime for certain level of the galvanic chrome coating layer. Thermocyclic tests have shown that it is possible to reliably operate parts at a temperature range of 1260–1280 °C. At higher temperatures, the surface of the sample is covered with a layer of oxide films.

In addition to the tests listed above, the friability of galvanic coating on the surface formed by the diamond-electrochemical honing method was assessed. The conducted evaluation showed that the established range of modes provides values of friability of 2–3 % and is a significant improvement in comparison with the possibilities of reaming and boring methods [10, 11].

To implement the combined DECH and galvanic chroming combined method appropriate equipment, technological equipment (devices), tools, relevant electrolytes, and optimized modes were used.

The composition of the set of equipment for the implementation of the combined method included modernized vertical honing semi-automatic models 3M83, 3K82U, 3821, special tools and devices were used, the designs of which are unified and interchangeable.

A honing tool with a mandrel was also used. The main design value for the design of a honing tool is length of its cathode section. The greatest durability belongs to mechanically fixed insulators made of plastics that do not change their properties in the electrolyte: caprolon, fluoroplastic. The insulating coating made of thermosetting material AG-4V based on feyoolformaldehyde resin and glass fiber as a filler is also of great strength. The coating is applied by injection molding. The gap limiters from the viewpoint of the theory of friction and wear should preferably be made of materials of high hardness. However, attempts to apply gap limiters made of oxide ceramics or poly-crystalline superhard materials proved to be unsuccessful, since when limiters contacted the surface being treated, scratches formed and roughness worsened [12, 13]. Therefore, the honing tools were equipped with plastic limiters.

The efficiency of a honing tool depends on the accuracy of production and the materials used. Power elements (body, expansion collar, wedge blocks) were made of heat-treated (hardened with low tempering) steel 30H13, and the landing of movable joints were made according to 7–8 accuracy standards [14].

The accessories for diamond-electrochemical honing are mechanical and are designed taking into account the peculiarities of their operation. During idle time salts are deposited in the gaps of mobile compounds. In order to keep the mobility, the devices do not use precise landing, and the interface surface area is assumed to be minimal. As testing has shown, the contact surface «current lead–workpiece», located in the electrolyte, is subject to anodic dissolution [15].

Therefore:

1) supply of current to a workpiece is carried out by means of an easily replaceable special contact element, which is part of a device;

2) flow of current in the areas of coupling of a device with a workpiece is excluded, especially on the basis surfaces.

If the workpiece had holes or slits that intersect with the surface being treated, then the devices use plugs that eliminate leakage of the electrolyte [16].

Conclusions.

As a result of the tests, it should be noted:

– a high level of macro- and microgeometric accuracy – 0,01–0,03 mm and 0,2–0,4 μm, respectively was achieved;

– compressive character of the internal residual stresses is formed, the maximum values of which are within the range of 100–400 MPa at a hardness value of 16,6–17,9 • 10^{-3} MPa and a surface layer value of 0,1-0,4 mm;

– structural and phase particularities in the formation of the surface layer in comparison with the main material were not revealed;

– bench tribological tests showed an increase in wear resistance by 5–10 % regarding to the combined mechanism of cohesion-adhesive wear;

– tests in the conditions of cyclic alternating loading form a certain increase in longevity (8–10 %) with provision for specifically selected intervals of values of impact elasticity of samples, at the same time the adhesive strength of the galvanic coating grows at the values of friability of 2–3 %;

– thermal cyclic tests have shown reliable serviceability of parts surfaces at temperatures up to 930°C;

– based on the results of the studies, the following ranges of regimes of DECH method were obtained:

- *current density 20–30 A/cm²;*
- *specific pressure of a honing tool 0,4–0,5 MPa;*
- *electrolyte pressure 0,6–0,8 MPa;*
- *voltage 14–20 V;*
- *duration 90–200 s;*
- *electrolyte 10–15 % solution, TMS-31;*
- *ratio of the rates of reciprocating and rotational movements of 0,2–0,3;*

– violation of the operation mode of the method of diamond-electrochemical honing causes cracks and breakdown of the superimposed galvanic coating.

REFERENCES

1. Usov, S. V., Vyacheslavova, O. F. [*et al*]. Nontraditional methods of processing of machine parts, created on the basis of information technology [*Netradicionnye metody obrabotki detalej mashin, sozdannye na osnove informacionnyh tehnologij*]. Podolsk, Slavyanskaja shkola publ., 2010, 150 p.

2. Ryabtseva, A. V., Evstratov, S. V., Sviridenko, D. S. Foundations of forming small diameter holes using electrotechnological processing and their control [*Osnovy formirovanija otverstij malyh diametrov primeneniem elektrotehnologicheskoj obrabotki i ih kontrol'*]. *Informacionnye tehnologii v proektirovanii i proizvodstve*, 2015, Iss. 4, pp. 55–57.

3. Popov, A. P., Popova, T. A. Optimization of Technological Processes. *World of Transport and Transportation*, Vol. 13, 2015, Iss. 5, pp. 16–25.

4. Gavrish, A. P., Roik, T. A., Zigulya, S. M. New schemes of diamond honing of high-alloy composites of friction parts of printing machines [*Novye shemy almaznogo honingovanija vysokolegirovannyh kompozitov detalej trenija poligraficheskih mashin*]. *Vestnik Hmel'nic'kogo Nacional'nogo universitetu. Tehnichni nauki*, 2014, Iss. 6, pp. 39–43.

5. Popov, A. P., Popova, T. A., Komarov, Yu. Yu. Methods for increasing reliability [*Metody povyshenija nadezhnosti*]. *Vestnik Moskovskogo gosudarstvennogo otkrytogo universiteta. Serija «Tehnika i tehnologija»*, 2013, Iss. 4, p. 32.

6. Usov, S. V., Polyakov, S. V. [*et al*]. Scientific basis for creating progressive methods for processing machine parts [*Nauchnye osnovy sozdanija progressivnyh metodov obrabotki detalej mashin*]. Podolsk, Slavyanskaja shkola publ., 2011, 209 p.

7. Usov, S. V., Sviridenko, D. S. Electrochemical methods of machining of machine parts: Study guide. [*Elektrohimicheskie metody obrabotki detalej mashin. Ucheb. posobie*]. Podolsk, Saturn-S publ., 2007, 122 p.

8. Bakhvalov, V. A. A way of honing deep holes and a tool for its realization [*Sposob honingovanija glubokih otverstij i instrument dlja ego realizacii*]. *STIN*, 2006, Iss. 4, pp. 39–40.

9. Usov, S. V., Sviridenko, D. S., Smolentsev, E. V., Belyakin, A. S. Study of the influence of combined treatment methods on the tribological characteristics of the surface layer of machine parts [*Issledovanie vlijanija kombinirovannyh metodov obrabotki na tribologicheskie harakteristiki poverhnostnogo sloja detalej mashin*]. *Vestnik Voronezhskogo gosudarstvennogo tehnicheskogo universiteta*, 2012, Iss. 5, pp. 138–141.

10. Domnin, P. V., Timofeeva, A. A. Influence of various methods of surface treatment in deep holes on the roughness index [*Vlijanie razlichnyh sposobov obrabotki poverhnostej v glubokih otverstijah na pokazatel' sherohovatosti*]. *Sovremennaja tehnika i tehnologii*, 2016, Iss. 3, pp. 16–20.

11. Zvontsov, I. F., Ivanov, K. M., Serebrenitsky, P. P. [*et al*]. Technological methods of quality management in the manufacture of parts with deep holes [*Tehnologicheskie metody upravlenija kachestvom v proizvodstve detalej s glubokimi otverstijami*]. *Metalloobrabotka*, 2016, Iss. 4, pp. 11–25.

12. Smolentsev, V. P., Boldyrev, A. A. Application of magnetic-rheological fluids in metalworking [*Primenenie magnitno-reologicheskih zhidkostej v metalloobrabotke*]. Non-traditional methods of processing: interuniversity collection of scientific works. Iss. 9, part 3. Moscow, Mashinostroenie publ., 2010, pp. 120–129.

13. Bilgi, D. S., Jain, V. K., Shekhar, R., Mehrotra Sh. Electrochemical deep hole drilling in super alloy for turbine application. *Journal of materials processing technology,* Vol. 149, Iss. 1-3, 2004, pp. 445–452.

14. Pa, P. S. Electrode form design of large holes of die material in ultrasonic electrochemical finishing. *Journal of materials processing technology,* Vol. 192–193, 2007, pp. 470–477.

15. Kuzovkin, A. V., Smolentsev, V. P. Dimensional shaping of complex profile parts with the use of solid current-carrying filler [*Razmernoe formoobrazovanie slozhnoprofil'nyh detalej s primeneniem tverdogo tokoprovodjashhego napolnitelja*]. Voronezh, Publishing House of VSTU, 2000, 176 p.

16. Zvontsov, I. F., Serebrenitsky, P. P. Electrodiamond honing of deep holes [*Elektroalmaznoe honingovanie glubokih otverstij*]. [Electronic resource]: http://mirprom.ru/public/elektroalmaznoe-honingovanie-glubokih-otverstiy.html. Last accessed 22.11.2017.

Information about the authors:

Popov, Alexander P. – Ph.D. (Eng), associate professor of Russian University of Transport , Moscow, Russia, pap60@bk.ru.

Sviridenko, Danila S. – Ph.D. (Eng), associate professor of All-Russia Research Institute of Aviation Materials, Moscow, Russia, d_sviridenko@mail.ru.

Komarov, Yuri Yu. – senior lecturer of Russian University of Transport, Moscow, Russia, yk5@ya.ru.

Article received 22.11.2017, accepted 17.02.2018.