ТЕХНИЧЕСКИЙ СЕРВИС В АПК

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Разработка технологического процесса фрикционного алитирования

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Аннотация. Финишная антифрикционная безабразивная обработка (ФАБО) является одним из высокоэффективных методов повышения триботехнических свойств деталей (износостойкость, задиростойкость). Отсутствие высокоэффективных технологических сред и устройств для обработки деталей, а также низкая коррозионная стойкость нанесенных медьсодержащих покрытий сдерживает применение ФАБО. Фрикционное алитирование, предлагаемое авторами, заключается в нанесении алюминийсодержащего защитного покрытия трением, за счет применения алюминиевого натирающего инструмента и разработанной технологической среды, включающей в себя соли алюминия. В качестве материала натирающего инструмента выбран технический сплав марки АД1 ГОСТ 4784-97, состоящий из 99,3% Al, Fe – 0,3%; Si – до 0,3%; Ti – не более 0,15%; Zn – до 0,1%; Mg – не более 0,05%; Cu – до 0,05%; марганца Mn – не более 0,025% и примесей – до 0,05%. В качестве обрабатываемой детали при отработке технологии использовались цилиндрические образцы. Разработанная авторами технологическая среда включает соли меди, олова и никеля, глицерин, глюкозу и воду с дополнительным содержанием солей алюминия. Установлено, что для качественного протекания фрикционного алитирования процесс должен осуществляться за 3…4 прохода на скорости скольжения натирающего инструмента 0,1…0,3 м/с и давлении натирающего инструмента в пределах 5…7 МПа. В массовом производстве технологический процесс алитирования должен, включать следующие операции: очистка до обработки, дефектация, фрикционное алитирование, очистка после обработки, контроль качества покрытия и при необходимости длительного хранения – консервация детали.

Ключевые слова: износостойкость, задиростойкость, антифрикционные свойства, финишная антифрикционная безабразивная обработка, ФАБО, технологическая среда, фрикционное алитирование, алюминийсодержащее покрытие.

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ORIGINAL PAPER

Developing the technology of friction alitising

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Abstract. Finishing anti-friction non-abrasive treatment (FANT) is one of the highly effective methods of increasing tribotechnical properties of parts (wear resistance and scoring resistance). The lack of highly effective technological media and devices for treating parts, as well as low corrosion resistance of the applied copper-containing coatings restrains the use of FANT. The technology of friction alitising, proposed by the authors, consists in the application of an aluminum-containing protective coating by friction, through the use of an aluminum rubbing tool and the developed technological medium, which includes aluminum salts. The technical alloy of AD1 grade GOST 4784-97, consisting of 99.3% Al, Fe – 0.3%; Si – up to 0.3%; Ti – not more than 0.15%; Zn – up to 0.1%; Mg – not more than 0.05%; Cu – up to 0.05%; manganese Mn – not more than 0.025% and impurities – up to 0.05% was chosen as a material of the rubbing tool. Cylindrical samples were used as the treated part during the elaboration. The technological medium developed by the authors includes salts of copper, tin and nickel, glycerine, glucose and water with additional content of aluminum salts. It has been established that qualitative friction alitising should be carried out in 3 to 4 passes at a sliding speed of the rubbing tool of 0.1 to 0.3 m/s and pressure of the rubbing tool within 5 to 7 MPa. For mass production, the technological process of alitising should include the following operations: cleaning before processing, defecting, friction alitising, cleaning after processing, quality control of coating and preservation of the part – if necessary for long storage.

Keywords: wear resistance, scoring resistance, antifriction properties, finishing antifriction non-abrasive treatment, FANT, technological environment, friction alitising (aluminising), aluminum-containing coating.

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Introduction. Finishing antifriction non-abrasive treatment (FANT), developed by D.N. Garkunov and V.N. Lozovsky, is one of the highly effective methods of increasing tribotechnical properties, such as wear resistance, scoring resistance, and coefficient of friction of new and reconditioned surfaces of rubbing joint parts [1-2].

The essence of the FANT process consists in the frictional coating of plastic (soft) metals on the contacting surfaces of parts of rubbing joints (cylinder liners, connecting rod and crankshaft main journals, supporting surfaces of camshafts, shafts, rods, and pins) in a special technological medium [1-2].

Based on the literature-and-patent review, the authors have established that FANT enhances increased scuff resistance, decreased wear intensity and friction losses in rubbing joints, in their subsequent operation after manufacturing or overhaul due to selective transfer processes occurring during friction (the Garkunov effect), consisting in formation of protective self-healing “servovitic” films on the friction surfaces [3, 4].

The wide application of various FANT technologies is constrained by the lack of highly effective technological media and devices for the treatment of various parts, as well as the low corrosion resistance of the applied copper-containing coatings [6, 7].

Purpose of the research: to develop the technology of friction alitising of friction surfaces of rubbing joint parts.

Materials and methods. To improve the FANT technology by increasing the anticorrosive and tribotechnical properties of the treated parts it is advisable to use aluminum alloys with enhanced anticorrosive properties, high plasticity, as well as a new technological medium containing, along with salts of other plastic metals, aluminum salts as a material of the rubbing tool. The technological processis proposed to be called "friction alitising (aluminising)", by analogy with the previously known methods of friction brass plating and bronze plating.

The technical alloy of AD1 grade GOST 4784-97, consisting of 99.3% Al, Fe – 0.3%; Si – up to 0.3%; Ti – not more than 0.15%; Zn – up to 0.1%; Mg – not more than 0.05%; Cu – up to 0.05%; manganese Mn – not more than 0.025% and impurities – up to 0.05% was chosen as a material of the rubbing tool.

To work out the modes of friction alitising, the authors used a 1K62 lathe and a screw-cutting machine with a special device installed in its toolholder (Fig. 1, 2). Cylindrical samples were used as workpieces.

To carry out the process of friction alitising, the authors applied the developed technological medium (invention application No. 20233122292 dated August 28, 2023) containing copper, tin and nickel salts, glycerine, glucose and water, the peculiarity of which is the additional content of aluminum salts.

Results and discussion. Based on literature and patent analysis, theoretical studies in the field of tribology and laboratory tests, the authors have formulated the main requirements for developing technological fluids by identifying the influence of various components on the application process and the resulting properties of aluminum-containing coatings [5, 6].

It was found that the total content of salts of plastic metals below 1.0% does not ensure the formation of coatings with high tribotechnical properties. The total content of salts more than 5.0% leads to an increase in the corrosive effect of the composition on the treated surface and to the overconsumption of active components of this medium.

Presence of aluminum salts in the composition enhances increased anticorrosive and scoring-resistant properties of the obtained coatings.

The content of glycerine in the amount of 30 to 40% provides optimal viscosity of the composition and the necessary concentration of surfactants formed as a result of glycerine tribodegradation.

The concentration of glucose below 6% does not fully ensure the recovery of sufficient amount of metal from the composition. The content of reducing agent more than 10% does not improve the properties of the coating and does not lead to a significant increase in the coating process productivity. At the same time, it leads to the overconsumption of the composition.

Water and glucose have a cooling effect, good solubilising ability in relation to other components of the composition, and significantly reduce viscosity. Due to the latter fact, the composition can be used in the systems of supplying the technological medium of the machine tool.

Steel and cast iron parts are coated at a sliding speed of the rubbing tool of 0.1 to 0.3 m/s. Decreasing the speed of processing reduces the process performance. On the other hand, the increase in speed leads to a decrease in the quality of coating and subsequently scoring-resistant properties. The pressure of the rubbing tool providing uniform coating of reddish colour is within 5 to 7 MPa. These modes require 3 to 4 passes of the rubbing tool to obtain continuous and uniform coatings.

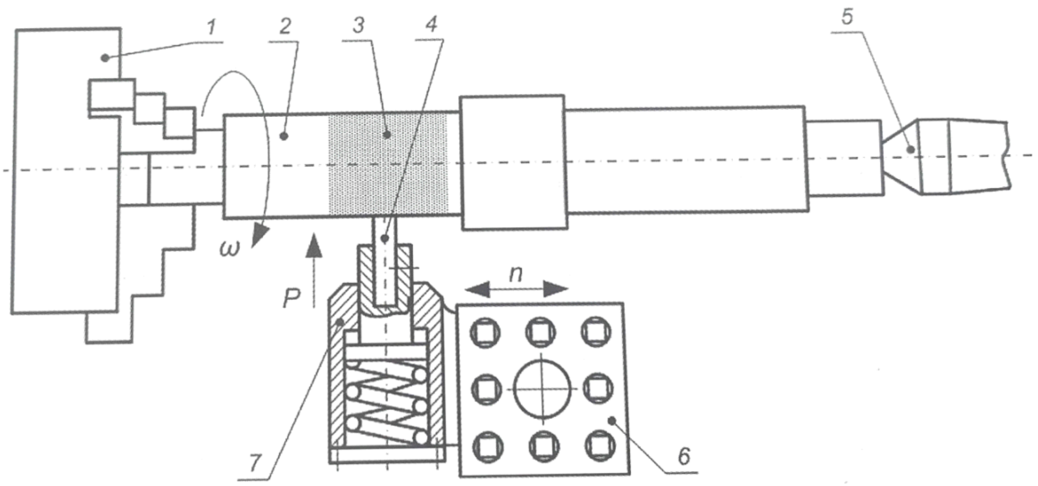

Fig. 1. Principal scheme of friction alitising:
1 – machine rotation drive; 2 – workpiece; 3 – aluminum-containing coating;4 – aluminum rubbing tool; 5 – moving center of the tailstock; 6 – toolholder; 7 – FANT device; P – pressure force of the rubbing tool; *n* – longitudinal feed of the machine toolholder; ω – angular velocity of the workpiece

Рис. 1. Принципиальная схема фрикционного алитирования:
1 – привод вращения станка; 2 – деталь; 3 – алюминийсодержащее покрытие; 4 – алюминиевый натирающий инструмент; 5 – подвижный центр задней бабки; 6 – резцедержатель; 7 – устройство для ФАБО; *P* – сила прижатия натирающего инструмента; *n* – продольная подача резцедержателя станка; ω – угловая скорость детали

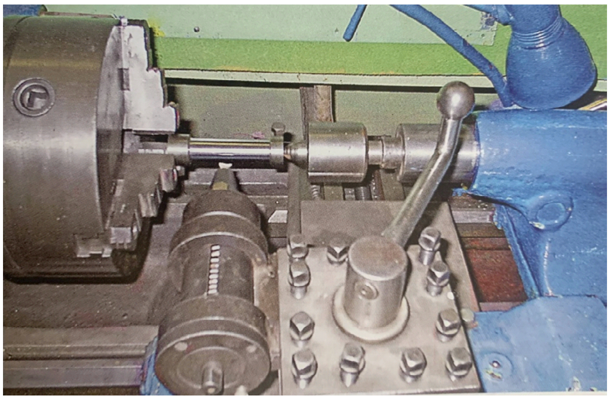

Fig. 2. External view of the device for elaborating the modes of friction coating

Рис. 2. Внешний вид устройства для отработки режимов нанесения покрытий трением

As a result of processing with the proposed composition, the resulting coating is a composite material enriched with aluminum near the free surface.

To use the described method in serial and mass production, we propose a technological process including several main operations: cleaning before processing, defecting, friction alitising, cleaning after processing, quality control of the coating, and preservation of the part if necessary for long-term storage.

Before applying protective coatings by friction alitising it is advisable to degrease the surface with monoethanolamine TU6-02-915-79 or white spirit GOST 3134-78 to remove particles of oil lubricating and cooling process media left after the machining of parts.

The machined part is installed in the holders of lathe, screw-cutting, boring, honing or other machine prepared for friction alitising.

For serial and mass friction alitising of parts, it is necessary to develop and test special fixtures, for example, devices for friction-mechanical coating of crankshafts or special heads for cylinder liners.

The surface of the part to be treated is wetted with the developed process fluid. The rubbing element of the device is brought into contact with the surface to be treated, pressed down with a predetermined force. Then the rotating device is switched on and the cross-feed of the device along the sample is performed. A sharp whistling sound indicates that coating is in progress.

The literature-and-patent analysis gives grounds to consider that the quality coating depends in a certain way on the activation of four activation channels of treated surfaces: mechanical, chemical, thermal, and vacancy-dislocation channel. During coating, besides chemical activation of the surface by chemical components contained in the process medium, additional activation of the process is provided by triggering the mechanical channel (destruction of oxide films in the contact zone and plastic deformation (riveting) of subsurface layers), as well as the thermal channel due to intensive heating of the contacted areas of the treated surface by the rubbing tool [5, 8].

The most complete activation of channels and intensification of the process of composite antifriction coating application is provided by tribocoating at optimal loading and speed modes of processing and effective composition of the technological medium.

Processing is carried out in several passes until obtaining a uniform coating without uncoated spots and large particles of the transferred metal.

After coating, the machine drive is switched off and the processed part is removed from the machine. To reduce the aggressiveness of substances in the water, the treated surfaces are washed with a 1% solution of glycerine GOST 6259-75 in water GOST 2874-82.

The treated parts is dried first with compressed air according to GOST 11882-73 at a pressure of 0.1 to 0.2 MPa using a blowing tap type 9693-1108, and then dried in the open air at a temperature not lower than 20°C.

Quality control of coatings (colour and continuity) is carried out by external inspection on the ORG 1 168-01-080A inspector's table with the help of a magnifying glass LP-4x GOST 25705-83. Then, if necessary for long-term storage, the parts are covered with a thin layer of preservative grease and sent to the warehouse.

The analysis of literature sources gives grounds to assume that for long-term preservation of high antifriction properties of treated parts in the subsequent operation of rubbing joints it is advisable to use lubricants with metal-cladding additives containing chemical compounds of aluminum [3, 5, 9].

Conclusions

1. The article considers a new technology of application of anti-wear coatings by friction – friction alitising (aluminising), which is a kind of FANT and consists in the application of aluminum-containing protective coatings by friction, due to the use of aluminum rubbing tools and a new technological medium including aluminum salts.

2. Based on laboratory studies the authors have established that the formation of continuous and uniform coatings by friction alitising is achieved for 2 to 3 working passes of the rubbing tool at a sliding speed of 0.1 to 0.3 m/s and pressure within 5 to 7 MPa.

3. The technological process of friction alitising of parts includes the following main operations: cleaning before processing, defection, friction alitising, cleaning after processing, quality control and coating preservation of if necessary for long-term storage.

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Д.В. Добряков – визуализация, создание черновика рукописи.

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Authors' contribution

V.I. Balabanov – conceptualization, methodology, draft finalizing (reviewing) and editing;

D.V. Dobryakov – visualization, original draft preparation

A.Y. Alipichev – English translation

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