ABSTRACT

thesis for the degree of Doctor of Philosophy (Ph.D.) in the direction of training: 8D071- "Engineering and Engineering"
educational program: 8D07101-"Mechanical Engineering"

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RESEARCH AND IMPROVEMENT OF MANUFACTURING TECHNOLOGY OF ROLLING STOCK COUPLER PARTS

Statement of the question and relevance of the study. Issues of railway engineering development are considered in the state program for the development of mechanical engineering in the Republic of Kazakhstan (2010-2014) and as part of the investment projects included in the "Map of industrialization" of Kazakhstan for 2010-2014, as well as the State Program of industrial and innovative development of the Republic of Kazakhstan (RK) for 2015-2019 and 2020-2025 years.

The Program for Development of Mechanical Engineering in Kazakhstan for 2010-2014 set the task of organizing large assembly factories with increasing the localization level through mastering the production of parts and components. The investment projects included in the Kazakhstan Industrialization Map for 2010-2014 provided for the implementation of projects for the organization of large assembly productions with an increase of localization level through mastering the production of parts and components, such as: "Production of passenger cars" and "Organization of production of electric locomotives." As a result, the LLP Electric locomotive assembly factory (Astana, Kazakhstan) was organized.

The analysis of the state of repair production of locomotive and car building industries has shown that there is a problem of increasing wear of locomotive and car parts, especially the automatic coupling part of the rolling stock. The high cost of spare parts and materials necessitates the development of repair and restoration facilities in Kazakhstan, capable of providing high-quality repair and restoration of rolling stock parts. It is known that up to 80% of the parts discarded during repair are suitable for further operation after restoration. As a rule, the weight loss of such parts does not exceed 2% of the original weight, while the metal strength of the products remains at the same level. For several names of the most metal-intensive and expensive products their secondary use is much more than the consumption of new spare parts. At the same time, the cost of restoration is 65-70% lower than the cost of new parts, and the consumption of materials is 15-20 times less than for manufacturing. LLP Electric locomotive assembly factory, in addition to producing KZ8A and KZ4A series freight and passenger electric locomotives, is also engaged in the repair and restoration of rolling stock parts and units. One such main unit subject to cyclic repair and restoration of parts is the automatic coupling device of the rolling stock.

The results of the study showed that the surfaces of the coupling device parts restored by cladding cannot withstand the original hardness of the cladding material and, as a result, are subjected to rapid wear and premature failure. This problem was

thought to be caused by the poor quality of the surfacing method. However, as a result of joint work on the research of the technology of repair and restoration of parts of the coupling device of rolling stock in the conditions of LLP Electric locomotives assembly factory, it was revealed that the premature failure of parts of the coupling device can affect not only the quality of surfacing technology but also the quality of machining after surfacing. Since the analysis of control data showed that it was not always possible to obtain the original hardness of the cladding material after surfacing or after machining. It was assumed that the reason for this could be the following: improper assignment of surfacing modes and thickness of the deposited layer; the thickness of the deposited layer after machining decreases and can transfer to a mixing layer, where the hardness has a lower value. This state of the matter dictated the need to conduct a study of the technological process (TP) of cladding worn surfaces and the technology of machining the clad surfaces of the parts of the coupling device. In this regard, the work aimed at researching and improving the technology of manufacturing parts of the automatic coupling device of rolling stock **is relevant**.

The aim of the work is to increase the wear resistance of the parts of the automatic coupling device of the rolling stock.

The object of study: Technology for restoring the worn surfaces of the parts of the coupling device.

The subject of study: Mechanical machining processes of clad surfaces of parts of the coupling device.

Methods of research: The following methods were used for the study: analysis of the technology of repair and restoration of loaded machine parts, experimental research, planning and processing of results, metallographic study, and computer modeling of the thermo friction milling process based on the finite element method.

Research objectives:

1. The study of the state of the problem and analysis of existing technologies of repair and restoration of parts working in heavy loads.
2. Study of the restoration technology of parts of the coupling device of the rolling stock under the conditions of LLP Electric locomotives assembly factory.
3. Experimental study of the machining process of clad surfaces of coupling device parts by thermal friction milling methods.
4. The study of temperature distribution in the contact "tool-workpiece" and hardness of the machined surface at different methods of thermo friction milling in the software package DEFORM 3D Machining.
5. Calculation of economic efficiency of the proposed technology and development of recommendations for production. Introduction into production.

The scientific novelty of the work is as follows:

1. The method of thermal friction milling of the clad surface of the parts of the coupling device has been developed.

2. It is established that after thermo friction milling the hardness of the machined surface with cladding increases up to 10%, which is HB 60.

3. An equation for evaluating the hardness of the clad surface after thermal friction milling is derived.

4. For the first time simulation of the machining process of the clad surface by different methods of thermo friction milling using DEFORM 3D Machining software package was performed and it was established that during thermo friction milling with a smooth friction cutter:

- the depth of temperature propagation deep into the workpiece is up to 3.8 mm, and the thickness of the hardened layer of the clad surface after processing is 1.62 mm.

Provisions made for the defense:

1. Method of thermofriction milling of the clad surface of the parts of the coupling device.

2. The results of the experimental study of the machining process of the clad surfaces of the parts of the coupling device by thermal friction milling.

3. Equation for evaluation of hardness of the clad surface after thermosetting milling.

4. Results of simulation of hardfacing surface machining process by different methods of thermofriction milling using DEFORM 3D Machining software package.

The validity and reliability of scientific statements, conclusions, and results are confirmed by the correctness of the problem statement, and the adequacy of theoretical and experimental research. The patents of the Republic of Kazakhstan (RK) for the method of thermal friction plane processing and friction disc design, as well as for the design of a circular saw have been obtained. The certificate of state registration of intellectual property rights of the Republic of Kazakhstan on the method of determining the temperature distribution in the "tool-workpiece" contact at various methods of thermo friction milling has been obtained.

The practical significance lies in the development of the method of thermo friction machining of the plane and special design of friction disc, as well as the method of determining the temperature distribution in the contact "tool-workpiece" at various methods of thermo friction milling and recommendations for production.

The author's contribution consists in setting tasks and developing research methods; developing and manufacturing special designs of friction mills, determining optimal machining modes, and organizing and conducting experimental studies of thermo friction milling of clad surfaces.

Dissertation work is aimed at fulfilling the main tasks of the State program of industrial-innovative development of RK for 2015-2019 and 2020-2025 years and is performed within the initial theme of the department "Technological equipment, machine building and standardization" (TEM&S) "Development of thermal friction processing technology at low speeds". Also, the main results of the dissertation are implemented in the production of LLP Electric locomotives assembly factory and the educational process of NJSC "Karaganda Technical University named after. A. Saginov Karaganda Technical University" (KarTU named after A. Saginov) when training bachelor and masters in mechanical engineering.

Work approbation. The main provisions of the doctoral dissertation were reported and discussed at the meetings of the Department of TEM&S of A. Saginov KarTU (2019-2022), at the meeting of the Department of "Technology of Mechanical Engineering" of Navoi State Mining Institute (2021), at a meeting of the scientific seminar at KarTU named after A. Saginov (2022), as well as at conferences of international level and working meetings of machine-building enterprises:

- International scientific-practical conference "Integration of science, education, and production - the basis for implementing the Plan of the Nation" (Saginov readings #12), (Karaganda, 2020);
- at the technical meeting of Electric locomotives assembly factory LLP (Astana, 2020).

Publications

According to the results of the doctoral dissertation 14 works were published in Russian, Kazakh, and English languages, including 3 articles in the international scientific editions, according to Clarivate or included in the base Scopus, 5 articles in the editions recommended by the Committee for Quality Assurance in Education and Science of Kazakhstan. The reports of the presented work were reviewed at 3 international conferences. 2 patents of RK for useful models and 1 certificate of state registration of rights on the object of copyright were received.

The volume and structure of the work. The doctoral dissertation consists of an introduction, 5 chapters, and a conclusion stated on 150 pages of typewritten text which are explained with 75 figures, 16 tables, a list of 135 references, and 11 appendices.

Research results and main conclusions. During the performance of the dissertation work, the complex research aimed at solving the problem of ensuring the wear resistance of the parts of the rolling stock coupling device in the conditions of the LLP Electric locomotives assembly factory was carried out. As a result, the following was achieved:

1. The method of thermal friction milling of the clad surface allows to increase in the initial hardness of the processed surface by up to 10%, which amounts to HB 60 is developed.

2. It is established that during thermo friction milling an increase in cutting depth t and feed rate S have a positive effect on the hardness of the machined surface after surfacing, and an increase in feed rate S and cutting speed n_m have a negative effect. Taking into account ensuring the minimum consumption of surfacing material the following optimal milling modes were selected: S = 300 mm/min; t = 0.5 mm; n_m = 1000 rpm.

3. The equation for estimating the hardness of the deposited surface after thermo friction milling was derived: HB=265.18-0.013-V+0.063-S+36-t.

4. At modeling of the process of processing a clad surface by thermo friction milling with the use of a smooth friction milling cutter on program complex DEFORM 3D Machining it has been established that:

- the depth of temperature propagation deep into the workpiece is up to 3.8 mm, and the thickness of the hardened layer of the clad surface after machining is 1.62 mm.

5. The results of the study are implemented in the production of LLP Electric locomotives assembly factory (Astana, Kazakhstan). The annual economic effect from the use of the proposed tool (smooth friction cutter) is 5390994 tenge.