

Review

official reviewer Zubko Vladyslav Mykolayovych, doctor of technical sciences, professor

for a dissertation **Du xin (Ду Сінь)**

«Technological support of strength and durability at the manufacture and repair of component parts for branch mechanical engineering»,

(«Технологічне забезпечення надійності та довговічності деталей загального машинобудування при їх виготовленні та відновленні»),

applied for the degree of Doctor of Philosophy,

from the field of knowledge **13 - «Mechanical engineering»,**

on specialty **133 - «Industrial engineering».**

1. Relevance of the dissertation topic.

In the design of general mechanical structures, wear cannot currently be predicted and avoided by mechanical design methods. The friction and wear of machine parts waste the global economy large amounts of money every year. Friction and wear occur on the contact surfaces of dynamic equipment components. Wear issues and improving the anti-wear of parts have been the most important areas of research. In order to extend the service life of machinery and equipment, parts that have expired need to be remanufactured. Remanufacturing engineering is the industrialization of high-tech repair of waste mechanical and electrical products. With remanufacturing technology, the quality and performance of products can reach or even exceed that of new products, and the cost can be saved. The U.S.

Department of Defense has also included "new remanufacturing technology" as a new focus in the defense industry.

In the dissertation, after some locking mechanisms were used for a period of time, the surface of pin shafts were worn and the friction increased. It caused the pin shaft to not rebound properly and the chassis quick-change battery box to not be fully fixed. Serious safety accidents may occur while electric vehicles were travelling. Therefore, the surface of the key parts of the locking mechanism needs to be repaired or manufactured.

Remanufacturing is closely related to surface restoration. Composite coatings can achieve multiple coating functions. The high strength and wear resistance of the coating are achieved thanks to the multi-layer combination. Use antifriction materials to reduce friction on coated surfaces. Surface repair technology has attracted major attention in remanufacturing engineering and involves a large number of technical issues that need to be solved. Compared with other methods, ESD technology has the advantages of lower cost, simple and convenient equipment, reduced material waste, and less environmental pollution. The ESD repair process is environmentally friendly and causes minimal pollution to the surrounding environment. It has low cost and easy operation.

The various process methods proposed in this dissertation to improve surface wear resistance have positive scientific significance. The author proposed the composite coating process to solve the design problems of electric vehicle companies, greatly improve the service life of the product, and reduce the maintenance cost of parts. The combined method of RC circuit and vibration and the

GO gel method are used to improve the surface quality and further promote the ESD surface performance. It has strong industrial practical value. It is worth promoting in similar process problems.

Du xin's dissertation work is dedicated to solving a practical scientific and technological problem in the field of mechanical engineering: to develop an innovative, energy-saving, and environmentally friendly technology, which is used to strengthen and repair the surface of key parts of general mechanical structures. The subject is considered relevant and has important scientific and practical significance.

2. Connection with scientific programs, topics, plans.

The dissertation is a fragment of scientific programs of research work of the Ministry of Education and Science of Ukraine "Scientific methodology of parts working surfaces maintenance properties providing by energy-efficient environmentally friendly methods" (№ 0116U002756).

3. Scientific novelty of the obtained results.

The analysis of the content of Duxin's dissertation work and the applicant's main scientific publications shows the most important theoretical and methodological provisions and conclusions, which prove the scientific novelty. The scientific novelty of the results obtained lies in the theoretical and experimental confirmation of the new method, namely:

1) For the first time, high-speed steel SKH51 was chose as a transitional coating. High-speed steel SKH51 has good wear resistance and impact toughness. During the deposition process, there are almost no microcracks on the surface. At

the same time, it has good compatibility with WC coating and can increase the thickness of the composite coating.

2) For the first time, abrasion width method was used to research the wear resistance of ESD coatings. Due to uneven micro-textures of the ESD coating, the abrasive particles can be easily embedded in the micro-texture, which will bring large errors to measure the wear quality of the coating. The wear width is measured by the microscope, which can measure values more conveniently and accurately.

3) For the first time, the evaluation model of normalization method was used for comprehensive evaluation of ESD coating. Deposition quality, coating thickness, roughness, Vickers hardness and wear-resistant width were normalized. Corresponding weighting factors were determined and the total score of each candidate solution was obtained. The test solutions were evaluated to arrive at the optimal solution to the task.

4. Theoretical significance of the dissertation.

The dissertation inherits traditional relevant research theories and makes certain theoretical innovations. When the technology development of new process and the improvement of the old process was carried, it gets new theoretical guidance, such as:

1) A wear resistance evaluation model for ESD coatings was established, and the wear scar width was used to compare the wear resistance performance. Due to the large roughness value of the ESD coating surface, the original wear resistance evaluation method will produce large errors. The wear volume method was used to deduce the relationship between the wear scar width and volume. This method is

relatively simple and can truly reflect the wear resistance, which has positive theoretical significance.

2) Use high-speed steel as a coating to improve the wear resistance of ordinary carbon steel. This is an attempt and can be studied especially as a CO-free wear-resistant material. At the same time, it ensures that the coating has both wear resistance and good impact toughness. It can be studied as an intermediate coating for WC coating.

3) Comprehensive evaluation of ESD coatings from a transition coating perspective. Thus, the performance of ESD coating can be evaluated more scientifically.

4) The surface wear resistance of 45 steel is increased by using spark carburizing method. At the same time, a comprehensive analysis of the wear resistance of the surface-cured graphite coating was conducted. Orthogonal experimental methods can be used to optimize the deposition coating process. The orthogonal experimental method reduces the sample interval and quickly obtains the optimal value.

5) Using composite coating technology, the best deposition solution for SKh51+WC+B83 coating was obtained. The concept of SKH51+WC gradient coating is used to increase the thickness of the coating and increase the impact resistance toughness of the coating. B83 coating is used to form an anti-friction layer to reduce friction and solve lubrication in open environments.

6) By changing the electrode vibration frequency and amplitude, and controlling the discharge gap, the B83 material is continuously deposited through

the RC discharge circuit. Improve soft metal surface deposition quality and deposition efficiency.

7) Using the bonding process, GO gel is deposited on the ESD deposition surface to improve the agglomeration problem of lubricating particles and improve surface accuracy. Utilize graphene oxide to improve coating quality.

5. Practical significance of the results of the dissertation.

On the basis of fundamental and applied research, anti-wear coating processes are continuously being improved. Among them, the SKh51+WC+B83 composite coating has the best performance. Not only can the problem of the core parts of the electric vehicle battery box locking mechanism be repaired, but its lifespan can also be greatly extended. It can meet the actual needs of enterprises. In view of the low wear life of surface materials, the proposed solution can achieve ultra-long life and reduce the company's maintenance costs. In addition, this coating can solve the problem of strong fluidity of lubricants in open environments, which can reduce friction and achieve a stable friction state. It is also a new process application. Controlling the continuous deposition of soft metals, GO gel wear-resistant coating has positive industrial value and has great market prospects in remanufacturing projects. This technical solution is expected to save the enterprise 115 thousand hryvnia every year (much money).

6. The main results obtained personally by the author

Evaluating the main results of the thesis submitted for defense, it is necessary to emphasize their theoretical validity and the orientation of the acquirer Du Xin to a clear formulation of his own position.

The main provisions of the dissertation are scientifically substantiated, clear logical conclusions are made, and practical recommendations are provided for the introduction of the developed technology into production. The work contains all the necessary theoretical, methodological, methodical and analytical studies, properly covered in the relevant sections.

The scientific validity and reliability of the results presented in the dissertation work is ensured by the creative use of scientific approaches, systematic study and generalization of the results of scientific developments by scientists in the world branch of mechanical engineering.

An analysis of the plagiarism check report for the presence of textual borrowings (Unicheck program) was carried out. The reviewers came to the conclusion that Du Xin (Ду Сінь) «Technological support of strength and durability at the manufacture and repair of component parts for branch mechanical engineering», («Технологічне забезпечення надійності та довговічності деталей загального машинобудування при їх виготовленні та відновленні») is the result of independent research of the acquirer and does not contain elements of plagiarism and borrowing in accordance with the resolution of the CMU dated 12.01.2022 No. 44, paragraph 9. The used ideas, results and texts of other authors have a link to the corresponding source.

7. Number of scientific publications.

According to the results of research, 21 scientific papers were published, including: 4 articles in professional editions of Ukraine, 11 collections of conference papers, 4 articles in the Scopus or WOS scientific-metric publication and 2 articles

in other scientific editions. The structure and number of all publications meet the established requirements. They adequately reflect the main content of the dissertation. In scientific works published as co-authors, only the ideas and provisions proposed by the authors are used in the paper. The published works sufficiently reflect and confirm the conducted research.

8. The degree of validity of scientific provisions.

The main provisions and conclusions of the dissertation work are the result of the generalization of the theoretical and experimental material by the authors, and the reliability of the results of the conclusions of the dissertation is ensured by the use of a variety of modern methods of research, including the high-tech methods of electron microscopy, X-ray analysis, energy-spectral analysis, and roughness assessment. The validity of the conclusions is confirmed by the harmonization of the theoretical provisions and conclusions of the dissertation with the results of the experimental research, as well as by the results of the pilot tests and the recommendations for the implementation of the proposed technological solutions in production.

9. The structure and content of the dissertation, its completeness and compliance with the established requirements for design.

The structure of the dissertation consists of eight parts, including: Abstract, Introduction, Chapter 1 (Literature review, the purpose and the tasks of research in electro-spark deposition repair process), Chapter 2 (Basic theory and methodology of research on electro-spark deposition), Chapter 3 (Experiment research results and analysis), Chapter 4 (Industrial applications of composite coatings), Conclusions and

a list of used literary sources and appendices. The thesis is presented on 152 pages of the main text, including 40 tables, 70 figures and appendices.

In the dissertation work, the rules of planning and conducting scientific research are followed, and modern methods of research and processing of experimental results are used. The scientific novelty of the results of the work is based on comprehensive research, which was used at the appropriate level with the use of generally recognized research methods.

The style and presentation of the work is logical, consistent and meets the requirements for printed works. The content of the work presents the results of scientific research and their approbation in practice. When presenting the text, modern scientific and lexical terminology is mainly used.

10. Discussion clauses, comments and wishes regarding the content.

There are still some issues that have not been analyzed in detail in the paper.

1) Different electrode diameters result in different deposition processes. In the electro spark deposition study, it was not found that the analysis of the influence of electrode diameter on the deposition process.

2) Only one material, WC-10Co, was analyzed for the WC coating. Other components of WC coating can also be analyzed comparatively.

3) Research needs quantitative analysis of corrosion. The corrosion resistance of B83 coatings can be measured through electrochemical experiments and quantitatively compared with the base material.

4) The B83 soft metal coating was analyzed. Can this method be extended to other materials such as In, Zn, Sn, etc.?

Shows of remarks and wishes do not reduce the overall positive impact of the dissertation work.

General conclusion

Dissertation work Du Xin (Ду Сінхь) «Technological support of strength and durability at the manufacture and repair of component parts for branch mechanical engineering», («Технологічне забезпечення надійності та довговічності деталей загального машинобудування при їх виготовленні та відновленні»), which was submitted for defense to the specialized academic council for obtaining the degree of Doctor of Philosophy in the field of knowledge 13 – Mechanical Engineering with a specialty 133 – Industrial Engineering according to its relevance, scientific and theoretical level, main results of validity, main provisions and results published in professional publications, the novelty of the statement and practical significance meet the requirements of the order of the Ministry of Education and Culture of Ukraine No. 40 of January 12, 2017 "On approval of requirements for the preparation of a dissertation" and Resolution of the Cabinet of Ministers of Ukraine of January 12, 2022 No. 44 "On approval of the Procedure for awarding the degree of Doctor of Philosophy and cancellation of the decision of the one-time specialized academic council of a higher education institution, scientific institution on awarding the degree of Doctor of Philosophy" with changes introduced in accordance with Resolution of the Cabinet of Ministers No. 341 dated 03/21/2022.

Reviewer,

Doctor of Technical Sciences, Prof.

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ЗАСВІДЧУЮ
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