AP19578884 “Increase of wear resistance and improvement of tire punching machine tool design” – p.m. Musayev M.M.

Relevance: Global integration of domestic and foreign manufacturers has led to an increase in the use of foreign equipment in domestic industries. One of these pieces of equipment is the tire-piercing machine.

These machines, as well as the technological and tool accessories for them, are supplied by Russian and Chinese manufacturers. It has been identified that the tool used for piercing holes in tires wears out quickly and often fails. The worn-out tool is replaced with a new one, which is purchased from foreign manufacturers. The tool consumption is very high and negatively impacts the production cost of the manufactured products.

Research results have shown that the tool used for piercing holes in tires wears out quickly and often fails. The worn-out tool is replaced with a new one, which is purchased from foreign manufacturers. The tool consumption is very high and negatively affects the production cost of the manufactured products.

This problem highlights the need for the development of technology to improve the wear resistance and design of tools for tire-piercing machines. Scientific research aimed at solving this issue is highly relevant.

The goal of the project is to improve the wear resistance and enhance the design of the tool for the tire-piercing machine.

The objective of the project *is to increase the wear resistance and improve the tool design of the tire punching machine*

Expected and Achieved Results*:*

As a result of the project, a technology to increase the wear resistance of the working part of the tire-piercing tool will be developed. An experimental sample of the tire-piercing tool will be designed and manufactured.

The following results are expected from the project:

— 2 (two) articles and/or reviews in peer-reviewed scientific journals related to the scientific direction of the project, indexed in the Science Citation Index Expanded Web of Science database and/or with a CiteScore percentile of at least 35 in the Scopus database;

— 2 (two) articles or reviews in peer-reviewed foreign or domestic journals recommended by CQASHE;

— 1 patent of Kazakhstan for a utility model;

— 1 certificate of state registration of copyright;

— 1 monograph.

Based on the research, recommendations for using the technology to improve the wear resistance of the working part of the tire-piercing tool, as well as for manufacturing a new design of the tire-piercing tool, will be developed.

A doctoral dissertation (PhD) by Kassymbabina D.S. and two master's theses in the field of “Mechanical Engineering” will be defended on the topic of the project.

For 2024. It was experimentally established that to increase the wear resistance of the working surfaces of parts and tools operating under high thermodynamic loads, as well as under high contact and impact loads, it is possible to use the method of mechanized cladding in a shielding gas environment. As a result of calculations in the planning of the experiment, a multiple regression equation was obtained, determining the dependence of the hardness of the clad layer on the current, welding voltage and speed of movement of the welding torch.

As a result of the studies on the structure of the cladded layer, the feasibility of applying heat treatment to increase the durability and reliability of the tire-piercing tool was established, as well as to improve the mechanical properties of the cladded layer to ensure the necessary strength, wear resistance, toughness, and material structure. An analysis of existing heat treatment methods applied to improve the wear resistance and durability of cutting tools was conducted, with consideration of their advantages and disadvantages.

For cladding the working part of the tire-piercing tool, ESAB OK Tubrodur 35GM cladding wire with a diameter of 1.6 mm was used. This material is a low-carbon steel alloyed with Si, Mn, and Cr. The alloying elements increase strength, hardenability, and contribute to the formation of a fine-grained structure. The alloying additions of Si, Mn, and Cr dissolve in ferrite and strengthen

it. Considering the chemical composition of the cladding material, the heat treatment method selected was hardening.

With a carbon content of 0.2% (C=0.2%), the cladding material is classified as hypoeutectoid steel. According to the Fe-Fe3C phase diagram, with 0.2% carbon content, the hardening temperature range is 880–920°C (heated to 30–50°C above the A3 point). At this temperature, the material with an initial pearlite-ferrite structure acquires an austenitic structure, which, upon subsequent cooling at a rate above the critical rate, transforms into martensite.

The hardening of the working part of the tire-piercing tool was conducted in an electric furnace, heating the material to 900°C. Cooling was performed in mineral (oil) oil, with the temperature maintained in the range of 60–90°C for minimal oil viscosity.

To relieve internal stresses, low-temperature tempering was carried out (heating to 150–200°C). It is known that during tempering, hardened martensite transforms into tempered martensite, which increases strength. After tempering, the hardened surface achieves a hardness in the range of HRC 58–63. The tempering duration was approximately 1–2.5 hours. The work was completed according to the scheduled plan.

Computer simulation of the thermal treatment technology method to improve the wear resistance of the working part of the tire-piercing tool was performed. Specifically, using the MATLAB software package, optimal cladding parameters were determined. Response surfaces were constructed to determine the optimal cladding conditions, such as the dependence of cladded layer hardness on welding current and welding voltage, as well as the dependence of cladded layer hardness on welding current and welding torch speed. As a result, optimal cladding parameters were established, ensuring high-quality and strong coatings.

The computer simulation of the heat treatment (hardening) process was performed using the DEFORM 3D software. The modeling results revealed the patterns of how heating temperature during hardening affects phase transformations, grain growth, and decarburization of the surface layers of the cladding material. The patterns of how cooling regimes (rate, temperature) influence the formation of martensitic structure were also identified. Based on the results of the work, one article was published in a peer-reviewed scientific journal with a CiteScore percentile of at least 35 in the Scopus database, and one article in a domestic journal recommended by CQASHE, as well as one certificate of authorship was obtained.

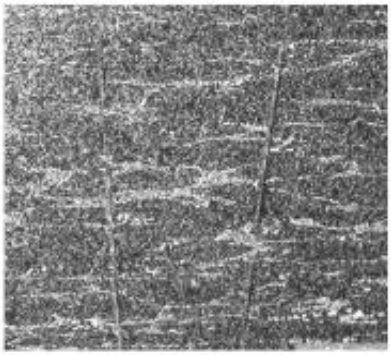

Figure 1 – Microstructure of the base metal, consisting of sorbitic pearlite and ferrite phase (300x), hardness 38HRC.

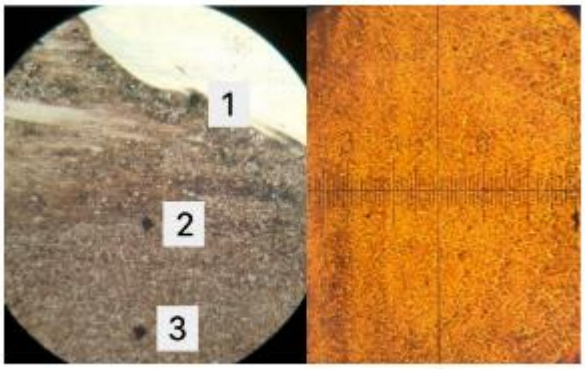

Figure 2 – a – Microstructure of the cladded layer surface; b – Microstructure of the cladded layer with surface hardness impressions.

Research Group

Mussayev Medgat Muratovich – Scientific Supervisor, PhD, Associate Professor at the Department of TEME&S

Hirsch Index – 4; TEME&S

Researcher ID: AAR-6997-2020;

ORCID: 0000-0001-9875-8159;

Scopus Author ID: 57220743851

Donenbayev Bakytzhan Serikovich – Responsible Executor, PhD, Senior Lecturer at the Department of Mechanics

Hirsch Index — 4,

Researcher ID: Y-2178-2018,
ORCID: 0000-0001-6923-3476,
Scopus Author ID: 57193404717

Abdugaliyeva Gulnur Baymurzaevna – Executor, PhD, Associate Professor at the Department of TEME&S
Hirsch Index – 3;
Researcher ID: AAN-2968-2021;
ORCID: 0000-0003-3469-3901;
Scopus Author ID: 57200327289

Tussupova Sayagul Oralovna – Executor, PhD, Senior Lecturer at Toraighyrov University
Hirsch Index – 5;
Researcher ID: AGX-8685-2022;
ORCID: 0000-0002-8920-4901;
Scopus Author ID: 57210194689

Karsakova Nurgul Zholaevna – Executor, Doctoral Student in group MSD-20 at the Department of TEME&S
Hirsch Index – 4;
ORCID: 0000-0003-4524-5135;
Scopus Author ID: 57219115360

Kassymbabina Kassymbabina Dana Saylauovna – Executor, Doctoral Student in group MSD-22 at the Department of TEME&S
Hirsch Index – 1;
Scopus Author ID: 57882320800

List of publications

1. Mussayev, M., Sherov, K., Kassymbabina, D., Abdugaliyeva, G., Donenbayev, B., Kardassinov, S., Karsakova, N., Tussupova, S. Research of wear and increasing wear resistance of the working part of busbar punching tools by surfacing method // Journal of Applied Engineering Science, 2024, Iss. 22, Vol. 3, pp. 654-664 https://doi.org/10.5937/jaes0-51175

2. Mussayev, M.M., Donenbaev, B.S., Sherov, K.T., Kassymbabina, D.S., Aman, I.M. Research and analysis of the wear characteristics of busbar punching tools // Science and Technology of Kazakhstan, Pavlodar: Toraighyrov University Publishing, 2023. No. 2. – pp. 48-56.

3. Mussayev, M.M., Sherov, K.T., Kassymbabina, D.S., Abdugaliyeva, G.B., Bobeev, A.B. Metallographic Study of Samples of Busbar Punching Tool Material Clad with ESAB OK Tubrodur 35GM Wire // Science and Technology of Kazakhstan, Pavlodar: Toraighyrov University Publishing, 2024. No. 3. – pp. 52-65 https://doi.org/10.48081/PLNE2708

4. Certificate No. 37787 of inclusion in the state register of rights to objects protected by copyright. Research and analysis of the wear characteristics of busbar punching tools / Kassymbabina, D.S., Mussayev, M.M. Published on 04.07.2023.

5. Certificate of state registration of copyright No. 50538, 17.10.2024

Information for Potential Users:

The potential consumers of the developed technology are domestic industrial enterprises that have punching machines. The developed technology for increasing the wear resistance of the working part of busbar punching tools, as well as the combined design of the busbar punching tool, have a high level of commercialization.

Scope of application:

Machining industry of mechanical engineering.

Date of Information Update: 08.11.2024