Wrocław University
of Science and Technology

Faculty of Mechanical Engineering

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REVIEW OF THE FOREIGN SCIENTIFIC CONSULTANT

for the dissertation thesis of Maulet Meruyert

***"Regularities of formation of structure and properties of detonation coatings of Ni-Cr-Al System"*,**

submitted for the degree of Doctor of Philosophy, Ph D,
on speciality 8D05301 - Physics.

The extension of the service life of components that operate at high temperatures in various industrial sectors remains a highly relevant issue. Among the most effective heat-resistant coatings are those based on the Ni-Cr-Al system. The high protective properties of these coatings are ensured by the formation of an Al_2O_3 layer during oxidation. Therefore, the long-term durability of the coatings is determined by maintaining an adequate level of aluminium in their surface layer. In Maulet Meruyert's dissertation, this issue is addressed by forming a gradient structure through the detonation spraying method, enhancing the aluminium distribution from the substrate to the surface layer of the Ni-Cr-Al coating. This proposed solution is protected by the Utility Model Patent of the Republic of Kazakhstan No. 8922 titled "Method of Obtaining Functional Gradient Coating", published on March 7, 2024.

The dissertation investigates the formation regularities of the structure and properties of Ni-Cr-Al-based coatings during detonation spraying. The technological regimes of the detonation method have been determined to ensure an adequate level of aluminium necessary for the formation of an Al_2O_3 layer on the coating surface. According to the analysis of the X-ray phase, when the detonation barrel was filled with an oxygen-acetylene (O_2/C_2H_2) explosive gas mixture of 40 % and 50 %, only the $CrNi_3$ phase was detected. However, when the volume of the explosive gas mixture was reduced to 30 % and 25 %, the phases Al, $CrNi_3$ and NiAl were identified. It was established that an aluminium content of 6-15 % in the Ni-Cr-Al composite powder does not significantly affect the structure and phase transformations of the coating, with 20 % being the optimal aluminium content. Extensive high-temperature studies were conducted on both gradient and homogeneous Ni-Cr-Al detonation coatings. After high-temperature tests, protective oxides of Al_2O_3 and Cr_2O_3 formed on the surface of the gradient-structured coating, enhancing the heat resistance of the 12Kh1MΦ steel used as a substrate. According to the results obtained, the gradient-structured Ni-Cr-Al coating exhibited lower porosity, higher

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adhesive strength, improved heat resistance, and superior mechanical and tribological properties compared to the homogeneous structured coating.

Modern research methods were applied in the dissertation, including scanning electron microscopy, X-ray phase analysis, Auger electron spectroscopy, and tribological testing methods. Furthermore, Ni-Cr-Al coatings were tested for high-temperature oxidation and hot corrosion using Na_2SO_4/NaCl salts and under the conditions of heating systems in thermal power plants. Based on the research results, recommendations for using gradient-structured Ni-Cr-Al coatings as protective layers were provided for components operating at high temperatures.

The main content of the dissertation is presented in 17 publications, including 7 articles in peer-reviewed scientific journals recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan, 2 articles in journals indexed in the Scopus and Web of Science databases, 8 articles in materials of international conferences. A significant part of the research was carried out within the framework of projects funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, including: AP08957765 "Development of functional gradient coatings based on Ni-Cr-Al for corrosion protection of high-temperature thermal power equipment components"; AP22688426 "Improving the protective properties of detonation coating based on NiCrAl" and BR24992876 "Development and approbation of surface treatment technologies and obtaining composite protective coatings to improve the operational properties of tools machine parts and equipment".

The dissertation is conducted at a high level, is of scientific and practical significance, and represents a thoroughly researched scientific work. I consider that Maulet Meruyert fully deserves to be awarded the degree of Doctor of Philosophy (PhD) in the specialty "8D05301 – Physics".

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