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ANALYSIS OF THE IMPACT OF CORROSION ON THE OPERATIONAL RELIABILITY OF TRANSPORT-TECHNOLOGICAL MACHINES

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Abstract: The article analyzes the corrosion processes occurring in automobile body components, as well as the impact of corrosion on elements such as the body, doors, and frame of transport-technological machines. It also examines the metrological instruments used in body manufacturing, issues related to the use of anti-corrosion coatings, and their practical application. The study discusses the decline in economic efficiency resulting from body corrosion. Furthermore, several proposals are presented concerning the use of modern models of measuring instruments that enable the assessment of corrosion levels on body surfaces and their broad implementation in practice.

Keywords: metrology, corrosion, mechanical wear, anti-corrosion material, body, TTM (transport-technological machine), detonation, frame, tire, inhibitor.

Introduction

During the operation of automobile body components, various factors such as climatic and road conditions cause corrosion, while vibration and noise levels increase, leading to a significant reduction in service life. Corrosion primarily affects the lower parts of the body, joints, and the frame of trucks. In automobile manufacturing plants, such factors are taken into account during material selection, and anti-corrosion coatings are applied to the body depending on the expected operating conditions.

The complexity and curvature of mountain road profiles influence the operating modes and energy load of the vehicle's braking systems. When driving on mountainous roads, the number of braking instances per kilometer can reach 10–19. In certain sections of these routes, the surface temperature of the friction components rises to 460–490°C in the rear brakes and 270–290°C in the front brakes [1]. During uphill movement, the driving wheels transmit large torque forces, while frequent braking during prolonged descents and numerous small-radius turns cause intensive tire wear.

The condition of the road network and the complexity of its profile negatively affect vehicle reliability. As a result, the engine, brakes, and other systems experience greater loads, leading to reduced reliability. Frequent loosening and misalignment of fasteners occur, causing accelerated wear of components and assemblies, material fatigue, and ultimately failure.

In mountainous regions, especially in subtropical climates, high air humidity accelerates corrosion in vehicle electrical connectors, components, assemblies, and aggregates—particularly in the cabin, body, fenders, and joints. All these factors demonstrate the need for special attention to the technical condition of vehicles operated in mountain and desert environments.

One of the main objectives of this study is to examine methods, technologies, and practical approaches used in laboratories to determine the degree of body corrosion, as well as to define procedures, criteria, and recommendations for corrosion evaluation.

Main Part

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The article presents the results of research on the corrosion of metals used in the transport sector. According to ISO 9227, corrosion resistance is tested by exposing samples to a 5% NaCl solution nebulization environment for 72 to 240 hours. The advantage of this method lies in its simplicity and cost-effectiveness, allowing rapid observation of corrosion initiation and propagation on the surface.

In electrochemical tests, it is possible to measure the degradation of coatings over time, as well as to determine corrosion current and rate. Compared to the salt spray method, electrochemical testing offers higher sensitivity and a better understanding of the metal’s corrosion mechanism.

In climatic tests, continuous and cyclic testing is carried out at 40°C and 95% relative humidity (RH). These tests identify corrosion resistance under condensation and humidity conditions. Additionally, mechanical tests, metallographic, and microscopic analyses are employed to study the corrosion behavior in detail.

All tests are performed in accordance with ISO 9227, ASTM B117, ASTM G31, ASTM D610, ISO 4628, ASTM D3359, and ISO 4624 standards. Furthermore, all automobile body components are produced and tested according to the manufacturer’s internal plant standards. Samples, typically 50×150 mm in size, are cut from corroded areas and tested under specific environmental categories in the laboratory. The obtained results are documented in an official test report.

In some cases, corrosion points on vehicle bodies are assessed through visual inspection during operation. By studying the climatic conditions of operation and identifying corrosion-causing factors, it becomes possible to collect essential data for further research.

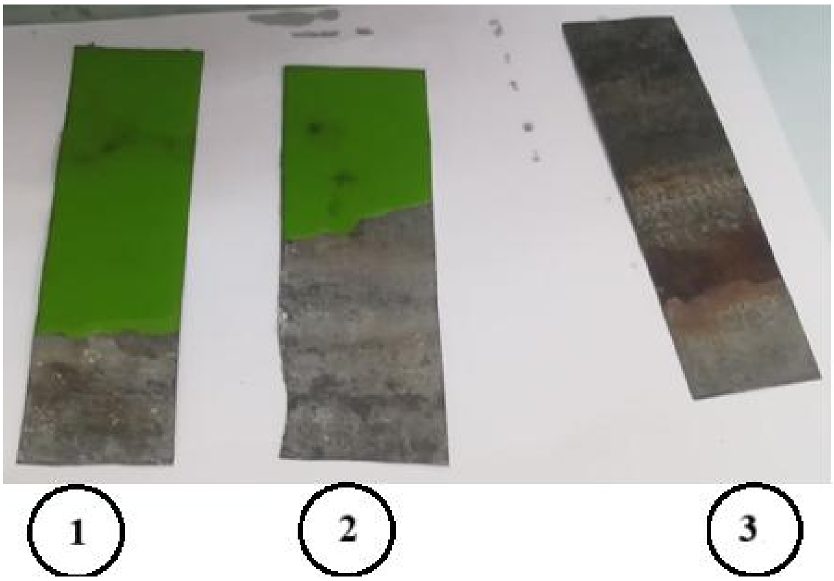

Figure 1. Metal Samples Prepared for Laboratory Testing

1. Surface coated with standard automotive paint.
2. Surface coated with a 50% epoxy–polyurethane-based layer.
3. Surface treated with a composite coating based on epoxy–polyurethane material.

According to the results of laboratory tests, steel samples coated with a **composite epoxy–polyurethane coating** demonstrated a **3–4 times** reduction in corrosion rate compared to uncoated steel.

A field study was also conducted to examine the corrosion processes affecting vehicle body components during operation**.** The research involved transport-technological machines of Qamchiqavtoyo‘l IYFUK DM and service vehicles of the Republican Scientific Center for

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Emergency Medical Care – Karakalpakstan Branch, particularly those used in rural family clinics.
The study noted that the Karakalpakstan region exhibits relatively high soil salinity, while in the Qamchiq mountain pass**,** salt mixtures are frequently applied to roads during the autumn–winter season to prevent icing. Despite regular cleaning and maintenance of the vehicle bodies, it was observed that corrosion increased significantly in joints and closed sections where dirt and salt residues accumulated.
In cases where timely cleaning was neglected, severe damage to body panels and surface coatings was recorded, indicating the critical importance of proper maintenance for corrosion prevention in vehicles operating under such environmental conditions.

Figure 2. Corrosion "Hotspots" on Ambulance Vehicles

Corrosion occurs not only on body components but also on wheel rims. A corroded or mechanically deformed wheel rim causes improper friction between the tire and the road surface during motion, which significantly reduces the tire's service life. In some cases, corrosion can be mitigated through driver skill and careful operation.

The study identified the corrosion boundaries of vehicles and the external influencing factors responsible for rust formation. As a solution, the body areas surrounding the wheels were classified as high-risk zones for corrosion. It is therefore recommended that, during the manufacturing process, these specific regions be made from high-quality, chromium-alloyed steels.

Examples of such corrosion-resistant steels include SAF 2304 and TP316L, which exhibit superior durability and protection against environmental and mechanical corrosion effects.

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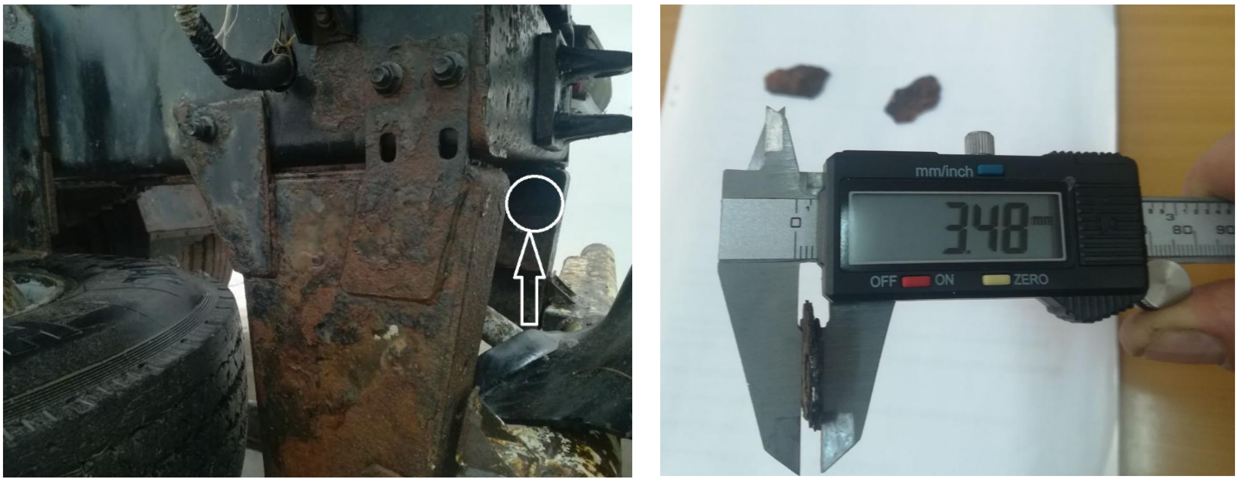

Figure 3. Corrosion "Hotspots" on Transport-Technological Machines

The study revealed that the corrosion depth on metal surfaces reached up to 3.48 mm. The findings indicate that corrosion has a significant impact on the service life of transport-technological machines operating in severe climatic conditions, emphasizing the necessity of regular treatment with anti-corrosion coatings.

Conclusion

This article presents a study on the corrosion levels of automobile body components. It emphasizes the need for careful consideration of corrosion issues during the body preparation and assembly stages in automobile production. It is recommended to use high-quality steel grades when selecting materials and to ensure effective application of anti-corrosion coatings during the painting process.

An analysis of vehicles operated by Qamchiqavtoyo‘l IYFUK DM and the Republican Scientific Center for Emergency Medical Care, Karakalpakstan Branch, particularly service vehicles of rural family clinics, showed that corrosion significantly affects their operational lifespan.

Laboratory tests conducted in accordance with the ISO 9227 standard confirmed that steel samples coated with composite epoxy–polyurethane coatings demonstrated a 3–4 times lower corrosion rate compared to uncoated steel.

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