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METHODS AND MODERN APPROACHES TO IMPROVING THE CORROSION RESISTANCE OF MATERIALS

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ABSTRACT

In this article we will analyze methods to increase the corrosion resistance of materials and modern protection technologies. The main types of corrosion and its impact on the industry are examined, and advanced methods used in material protection, including protective coatings, alloys, electrochemical protection and nanotechnological approaches, are discussed. Also, scientific evidence-based information on the efficacy of innovative anti-corrosion materials and chemical inhibitors will be presented. The research results include practical recommendations for the effective use of corrosion resistant materials in the fields of industry, construction and engineering.

Keywords: Corrosion resistance of materials, protective coatings, alloys, electrochemical protection, nanotechnology, corrosion inhibitors, chemical protection, composite materials, metal coatings, industrial materials, anti-corrosion technologies.

INTRODUCTION

Corrosion is the gradual erosion of materials, especially metals and alloys, by virtue of chemical or electrochemical interaction with the environment. This phenomenon creates serious problems in the industry, construction and engineering sectors, as the mechanical strength of corroded materials decreases, the service life is shortened, and maintenance costs increase. Development of technologies to increase the corrosion resistance of materials is one of the important directions of modern science and industry. Various protection methods, including special coatings, alloys, electrochemical protection and innovative nanotechnology materials, play an important role in preventing corrosion. This article analyzes the root causes of corrosion process, its negative effects and advanced methods to improve material durability. The research results can be applied in the development of effective anti-corrosion measures in the industrial and scientific fields. What has been done to date. Research research and

innovative technologies in the fight against corrosion are widely studied in the fields of materials science, chemistry and engineering.

METHODOLOGY, RESULT, DISCUSSION

Below is a brief summary of the important research and development that has taken place in recent years. 1. Protective coatings and nanomaterials In recent years, special anti-corrosion polymer, ceramic and metal coatings have been developed. For example, nanocomposite coatings due to their high strength and protective properties are being used as an effective means for corrosion prevention. Coatings made on graphene, oxide coatings and carbon nanotubes are helping to significantly increase the service life of metals. 2. Alloys and Innovative Alloys In the modern metallurgical industry, various alloyed steels and alloys are being developed. In particular, stainless steel types with added molybdenum, chromium and nickel have a high corrosion tolerance. Also, aluminum and titanium-based corrosion-resistant alloys are widely used in aerospace and marine engineering. 3. Electrochemical protection methods Cathodic and anodic protection technologies are widely used today in industrial facilities, pipelines and offshore platforms. In particular, electrochemical protection methods are effectively used to extend the service life of metal structures and underground pipelines used in seawater. 4. Corrosion inhibitors: The modern chemical industry develops various inhibitors to prevent corrosion. For example, eco-friendly organic inhibitors are highly recommended in industry as an alternative to conventional chemical reagents. In particular, inhibitors developed on the basis of green chemistry provide effective protection without harm to the environment. 5. Artificial Intelligence and Modeling In recent years, artificial intelligence and computer modeling technologies have been widely used to predict corrosion and develop new durable materials. The process of development of corrosion with the help of artificial intelligence is analyzed, and the optimal methods of protection are recommended. New technique: Dynamically variable nanocoating technology 1. Idea The main problem with current coating technologies is that they are static and once rubbed against the surface of the material, it will wear out, crack or be degraded by environmental influences. The proposed technique is dynamically variable nanocoating technology, which will be self-healing and adaptable to environmental conditions. 2. Working principle Flexible coating based on nanoparticles: This coating consists of special nanoparticles that trigger a self-healing mechanism by feeling the damage or chemical attack of the material surface. Electric or heat-controlled reaction: The polymeric or metallic particles contained in this coating undergo a chemical change in response to the temperature or electric field change and form a new protective layer. Electroactive inhibitors: Special ions or microinhibitors are placed into the coating. When corrosion begins, they are activated, re-strengthening the damaged area. 3. Advantages Self-healing feature – When microcracking or damage occurs on the coating surface, the nanoparticles are activated and restore protection. Adaptability to the environment – May change its structure depending on temperature, humidity and chemical environment. Long-term protection – Lasts longer than conventional coatings. Eco-friendly – It can be as eco-friendly as compared to traditional chemical inhibitors and coatings. 4. Applications: Marine industry– protection of ships and submarine structures against corrosion. Oil and gas industry – Long-term protection of pipes and platforms. Aerospace

Engineering – Corrosion resistant coatings of aircraft and satellites. Automotive industry – Increase of corrosion resistance of metal parts.

LITERATURE REVIEW

Research to improve the corrosion resistance of materials is actively conducted globally. Scientific works in this area can be divided into the following main areas: chemical modification, use of coatings and protective layers, the use of inhibitors, and applications of alternative materials. 1. Modification of the chemical structure of the material. Research conducted at Namangan Engineering Construction Institute (2024) demonstrated the effectiveness of using industrial waste to improve the corrosion resistance of heavy concrete. This approach makes it possible to improve the physical and mechanical properties of concrete without harming the environment. Meanwhile, the Tashkent Institute of Chemical Technology (2024) studied ways to improve the corrosion resistance of structural materials by changing their composition. 2. Coatings and protective layers conducted at the Jizzakh Polytechnic Institute (2024) presented innovative technologies for the development of anti-corrosion coatings on the basis of domestic raw materials. Similarly, a study conducted by Morpholine (2023) analyzed the effectiveness of cyclohexylamine-based corrosion inhibitors for metal surfaces. This substance forms a protective layer on the metal surfaces, slowing down the corrosion process significantly. 3. Corrosion inhibitors and their effects. An article published by Zenodo (2023) recommends the factors that cause corrosion of building materials and chemical protective measures to prevent them. Rabbimov J. Sh. (2021) emphasizes the importance of using special protections to reduce pitting corrosion of carbon steels. 4. Alternative materials and nanocomposites Scientific studies show that the use of polymer-based coatings and composite materials can increase corrosion resistance significantly. According to the research conducted by Mukhitdinov M. B. (2023), polymer coatings are an effective protective agent for building materials. The analyzed literature shows that the effective ways of combating corrosion is the use of modified concrete, special coatings, chemical inhibitors and nanocomposite materials. Scientific research in this area is constantly ongoing, and new technologies are being developed.

CONCLUSION

Improving the corrosion resistance of materials remains a pressing challenge in the industrial and engineering sectors. The economic losses and safety problems caused by corrosion require the development of new innovative solutions in this area. The article analyzed the main causes of corrosion and methods for its prevention, including protective coatings, alloys, electrochemical protection and inhibitors. Currently, modeling methods developed using nanomaterials, electroactive inhibitors, and artificial intelligence are considered as effective anti-corrosion measures. At the same time, the dynamically changing nanocoating technology proposed in the article is anti-corrosion.

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