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Methodology For Forming Innovative Anti-Corrosion Thinking Among Students

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Abstract: This article addresses the issues of developing innovative anti-corrosion thinking among students of higher education institutions. The relevance of corrosion processes and corrosion prevention measures in industry, particularly in the oil and gas and energy sectors, is substantiated. The study examines a methodology for developing students' creative and innovative competencies through the use of interactive teaching methods, project-based learning, research-oriented approaches, and the integration of digital technologies in the educational process.

Keywords: Corrosion, anti-corrosion protection, inhibitor, coating, oil and gas industry, innovative thinking, teaching methodology, interactive methods.

Introduction: At present, since metal structures constitute the main equipment of industrial enterprises worldwide, the demand for corrosion inhibitors that protect metals from corrosion has been steadily increasing alongside the development of industry and the national economy. In this context, reducing metal corrosion in the oil and gas, metallurgy, mechanical engineering, chemical industry, and other sectors in order to extend the service life of production processes, as well as developing new types of corrosion inhibitors and optimizing their compositions, is of great importance [1].

In the Republic and in various industrial sectors worldwide, corrosion of metal structures leads to significant economic losses and technogenic risks [2]. The corrosion problem is particularly acute in the oil and gas industry, chemical industry, and energy sector. Therefore, preparing future engineers and technologists who are capable of developing modern, environmentally safe, and innovative anti-corrosion solutions is one of the key objectives of the education system. It is not sufficient to form only theoretical knowledge among students; rather, it is necessary to develop their skills in analyzing problem situations, finding solutions based on innovative approaches, and fostering innovative thinking abilities [3].

Innovative Anti-Corrosion Thinking and Its Formation in the Educational Process. Innovative anti-corrosion thinking refers to a student's ability to deeply understand corrosion processes, critically evaluate existing protection methods, develop optimal ratios and operating conditions, and propose new materials, inhibitors, or technological solutions aimed at corrosion prevention. This type of thinking is not limited to theoretical knowledge but involves the application of scientific reasoning and creativity in solving practical engineering problems. In general, innovative anti-corrosion thinking includes the following structural components:

- a scientific and analytical approach;
- creative and critical thinking;
- interdisciplinary integration of knowledge;
- orientation toward solving real-world practical problems.

The Role of Teaching Methods in Developing Innovative Thinking. The formation of innovative thinking among students requires the use of modern teaching approaches alongside traditional lecture-based instruction. To achieve this goal, the following

methods are recommended.

Problem-based learning. Students are presented with problem-oriented questions based on corrosion issues encountered in real industrial facilities. For example, they may be asked to identify the causes of CO_2 or H_2S corrosion in pipeline systems and to propose effective protection and mitigation methods. This approach encourages analytical reasoning and the application of theoretical knowledge to practical situations.

Project-Based Learning (PBL). In this method, students work in small groups on applied projects such as "Development of an Environmentally Safe Corrosion Inhibitor" or "Technologies for Reducing Internal Corrosion in Oil Pipelines." Project-based learning enhances students' independent research skills, teamwork abilities, and competence in making innovative engineering decisions.

Case study method. The use of case studies based on real industrial scenarios helps students develop analytical and critical thinking skills. By analyzing actual corrosion-related failures and protection strategies, students gain experience in evaluating alternative solutions and selecting optimal approaches.

Innovative Approaches in Laboratory Training. Laboratory classes play a crucial role in the development of innovative anti-corrosion thinking. In addition to traditional experimental work, students are assigned tasks such as testing new corrosion inhibitors, determining corrosion rates using modern measurement techniques, and assessing the impact of environmental factors on corrosion processes. These activities foster experimental thinking and encourage students to adopt innovative approaches when interpreting results.

Moreover, the use of digital simulation and modeling tools, such as mathematical modeling of corrosion processes, significantly broadens students' scientific outlook and strengthens their ability to analyze complex systems.

Interdisciplinary Integration and Research-Oriented Activities. Corrosion-related problems are closely linked to chemistry, materials science, environmental science, and engineering technologies. Therefore, interdisciplinary integration in the educational process contributes to the formation of comprehensive and innovative thinking among students. Engaging students in research activities, encouraging them to write scientific articles, participate in startup projects, and collaborate with industrial enterprises has proven to be highly effective in developing their professional and innovative competencies.

RESULTS AND DISCUSSION

The implementation of the proposed methodology demonstrated positive outcomes in the development of students' innovative anti-corrosion thinking. The integration of interactive teaching methods, project-based learning, laboratory experimentation, and research-oriented activities significantly enhanced students' engagement in the learning process and improved their ability to analyze corrosion-related problems comprehensively. Students showed a deeper understanding of corrosion mechanisms, protection methods, and the practical applicability of inhibitors and protective technologies.

Project-based and problem-oriented tasks encouraged students to independently search for solutions, compare alternative approaches, and justify their decisions based on scientific reasoning. As a result, their creative potential and capacity for innovative problem-solving increased noticeably. Laboratory-based activities, particularly those involving modern corrosion testing techniques and experimental evaluation of inhibitors, strengthened the connection between theoretical knowledge and practical application. Moreover, interdisciplinary integration contributed to the formation of a systems-based perspective, enabling students to consider corrosion problems from chemical, material, environmental, and technological viewpoints.

Overall, the findings indicate that the proposed teaching approach effectively fosters analytical, creative, and innovative competencies that are essential for addressing real industrial corrosion challenges.

CONCLUSION

The formation of innovative anti-corrosion thinking among students is a vital component of modern engineering education. The harmonious combination of interactive teaching methods, project-based learning, laboratory practice, and research activities enhances students' creative potential and prepares them to solve real industrial corrosion problems using

innovative approaches. The proposed methodology contributes to improving the effectiveness of teaching corrosion-related disciplines in technical higher education institutions and supports the training of highly qualified specialists capable of developing modern, environmentally safe, and efficient anti-corrosion solutions.

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