Chapter 64
Teaching "Design-for-Corrosion" to Engineering Undergraduates:
A Case Study of Novel Ni-B Coatings for High Wear and Corrosive Applications

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ABSTRACT

This chapter briefly describes the challenges and developments in the field of corrosion focusing on the subject of materials science. A brief introduction was provided on corrosion damage and the importance of its prevention. The fundamentals of corrosion and different forms of corrosion were presented to understand the basics of the subject. By presenting novel Ni-B coatings as a case study, innovative, effective instructional approaches to deal with corrosion were illustrated. After going through this chapter, readers are guided on how to develop student understandings of the fundamentals of materials selection, coating design, and their characterization to combat corrosion. Finally, the chapter also described how the use of modern characterization tools such as AFM and TEM could be innovative powerful tools used in the class/training sessions to build real and clear concepts about materials.

INTRODUCTION

Material sciences and corrosion protection technology have a great impact on quality of human life, sustainable development and competitiveness of industry. Therefore, it is essential to enhance the innovation of basic materials science and corrosion protection. The innovations in materials science demonstrate the history of breakthroughs in materials science starting with the Stone Age. Materials have greatly enabled

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the building of modern civilization, providing a pathway to innovation in industry, energy, agriculture, national security, health, and information technology. Advances in materials science have significantly enabled technological revolution (U.S. Department of Energy, 2010).

Corrosion is everywhere and metals, ceramics, glasses, polymers, aggregates, composites, and other materials corrode when exposed to environments. The components in plants are subjected to high corrosion and wear. Owing to these deleterious processes, the gradual deterioration of metallic surfaces occurs which usually results in loss of plant efficiency and sometimes a shutdown of the whole plant. The combined effects of wear and corrosion aggravate material damage (American Society for Metals [ASM], 2001). The cost associated with corrosion is estimated to be 3.1 percent of the U.S. gross domestic product (GDP). This estimate is similar to other countries. The work of Abdulhameed Al Hashem and his colleagues at Kuwait Institute of Scientific Research (KISR) indicates the cost of corrosion in the Middle East is about 5% of GDP, somewhat higher than the cost in the U.S. (Al Hashem, 2011).

In many applications, the surface of the component is subjected to vigorous mechanical forces and solvent attack. Therefore, in such cases, modifying surface properties is an appropriate choice rather than improving the bulk properties. Synthesis of multifunctional, nanostructured and composite coatings are becoming popular to improve the properties of materials used in a range of applications (Erdemir et al., 2006). Ni-B coatings possess very attractive properties like high hardness, high wear resistance and decent anti-corrosion properties and thus are potential candidates for a range of industrial applications.

The use of innovative instructional methods is very popular in recent years (Hooper & Rieber, 1995). An encouraging variety of innovative instructional methods are currently being used in higher education and are not limited to computer assisted instruction, computer managed instruction, audio-tutorial etc. These are all replacements for traditional lecture methods. In addition, the use of advanced surface characterization techniques such as Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), and Transmission Electron Microscopy (TEM) in the classroom may also greatly help the student to build clear concepts about materials structure without relying on their imagination and visualization.

This chapter describes the challenges and developments in the field of corrosion focusing on the subject of materials science. By presenting novel Ni-B coatings as a case study, innovative, effective instructional approaches to deal with materials science and corrosion are illustrated. A comprehensive literature review included here will enable the reader to understand fundamentals of corrosion, design of experiment, material selection and coating design to combat corrosion. By applying the existing knowledge on Ni-B coatings and different innovative approaches introduced, they will be able to develop novel different alloy and composite coatings for more challenging requirements.

In addition, this chapter describes how the use of modern characterization tools such as AFM, TEM can be innovative powerful tools in class/training sessions for building real and clear concepts. This chapter will also enable the readers to understand the importance of corrosion protection and the role of corrosion education to make engineering graduate well conversant with the technology of corrosion protection. Readers will also learn the use of advanced characterizing techniques and approaches used for monitoring corrosion. In this way they will be educated enough to practically implement corrosion concepts to combat corrosion. We believe this chapter will provide a strong base to motivate engineering graduates' interest in corrosion protection and further their corrosion education.

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