ELECTROLESS NICKEL-PHOSPHORUS (EN) COATINGS ON MAGNESIUM AND MAGNESIUM ALLOYS

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Abstract

Magnesium (Mg) and its alloys are being used as structural components in industries because of their high strength-to-weight ratio and relatively high stiffness. A shortcoming of Mg alloys is poor corrosion and wear resistance that have hindered its widespread applications. Corrosion can be minimized by using high purity alloys, rapid solidification, and surface treatment or coatings. Of these techniques, electroless nickel-phosphorus (EN) coating is one of the most effective methods to combat the problems. The objective of this research is to understand the relationships of processing, microstructure and properties of EN coatings on Mg alloys, and therefore to develop uniform, well-adhered, pore-free EN based coatings.

In the first stage of the work, three types of EN coatings, namely, low, medium, and high phosphorus, were deposited on Mg and its alloy substrates. In the second stage of this research, EN coatings containing superfine Al_2O_3 particles and a novel plasma electrolysis assisted EN plating processing were developed on Mg alloys. XRD, SEM, TEM, EDX, XPS, and some corrosion and mechanical testing methods were implemented to evaluate and characterize the above EN-based coatings. The effects of various alloy substrates and plating bath parameters on coating deposition rate, porosity, phosphorus content, and properties, were studied in detail. Furthermore, the effect of post heat treatment on the properties of EN coatings was also investigated.

The results of this study show that the properties of EN coatings are directly related to the phosphorus content and porosity of the coatings, and various Mg alloy substrates. EN coatings with low phosphorus content are nano-crystalline, hard and ductile. As a result, they have superior adhesion strength. EN coatings with medium phosphorus content have an amorphous structure with better corrosion and wear resistance. Especially, the medium phosphorus EN coatings produced by novel plasma electrolysis assisted processes provide superior corrosion resistance and higher adhesion strength. The novel EN technique is also an environmental friendly processing. Direct high phosphorus EN coatings show the least kinetic coefficient of friction and good wear resistance under dry sliding friction because of the self-lubricating nature of phosphorus element. However, the porosity is severe within the direct high phosphorus coatings, which is detrimental to its corrosion property. Adhesion strength and wear resistance of EN alumina composite coating on Mg alloys are improved significantly. It has also been demonstrated that the adhesion strength of EN on Mg alloys is strongly

related to several parameters including coating thickness, hardness, internal stress, nucleation density, and the substrate's chemical and physical nature.

In conclusion, this research has made good progress on producing a series of uniform, well-adhered, and pore-free EN-based coatings through better understanding of the relationships of processing, microstructure and properties. The EN-based coatings can provide adequate corrosion and/or wear resistance to Mg and Mg alloys.

Dedication

I would like to dedicate my thesis to my family especially my parents whose unbelievable endurance, unconditional love, and untouchable devotion have been monumental. Also, I would like to dedicate this work to anyone who has ever taught me anything. Finally, I would like to dedicate this work to all those who have devoted their lives to bring the faded light of ambiguity to the complete shininess of clarity.

"You shall know the truth, the truth set you free"

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May God bless them All.

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