Synthesis and Characterization of Pulse Electrodeposited Zn-Ni Alloys

Prabhu Ganesan, Swaminatha P. Kumaraguru and Branko N. Popov
Department of Chemical Engineering
University of South Carolina,
Columbia, SC 29208

Ziinc is widely used as sacrificial coatings for the protection of steel substrates. Zinc is a very active material and corrodes easily due to its lower standard electrode potential (E^0 = -0.76 V *vs*. normal hydrogen electrode). To achieve the desired levels of corrosion protection, very thick zinc coating (~25 μm) is needed. However, use of thicker coating leads to poor formability and weldability[1]. To overcome the problems associated with Zn coating and to have superior corrosion protection property, Zn alloys are under extensive research. Zn is alloyed with iron, nickel and cobalt to enhance the corrosion and mechanical properties. Studies have shown that Zn-Ni alloys with a nickel content of 12-14% offers 4-5 times better corrosion resistance than for pure Zn[1, 2]. Despite increase in corrosion properties, the corrosion potential of Zn alloys is closer to zinc and the wide potential difference between the Zn alloy coating and steel substrate remains unchanged. Zinc-Ni deposition is classified as anomalous behavior due to the inhibiting nature of zinc towards Ni deposition.

In the present study, pulse deposition of Zn-Ni alloy was done using acidic bath[3] with a pH of 4.7 at three different temperatures. The aim of this study is to achieve higher nickel content in the final deposit. To achieve this, the pulse deposition was performed with different parameters such as duty ratio ($\theta = T_{on}/T_{on}+T_{off}$), the peak current density (J_p) and average current density (I_{ave}). The effect of pulse parameters on the Zn-Ni composition and the corrosion property are discussed. SEM and EDAX were used to study the surface morphology and composition of the alloy.

Results and Discussions

The thickness of the Zn-Ni deposits obtained from three different temperatures is about 12 μm for a 30 minutes deposition time. At room temperature, the Zn-Ni composition has been found to be 86:14 wt% whereas at 40 ^oC, the composition is 37:66 wt.%. Highest nickel content of nearly 70% is achieved at 55 ^oC. It was observed that at lower average current density (I_{ave}) higher nickel wt.% was achieved at all the three temperatures and it decreased with increasing I_{ave}.

The duty ratio (θ) has also marked effect on the Zn-Ni alloy composition. The T_{off} time was fixed at 12 ms and the T_{on} was varied between 0.5 and 8 ms (Fig.1). It was observed that very high nickel content of up to 75.65 wt.% could be achieved at a duty ratio of 0.04. The Ni content decreased with the increase in duty cycle. Higher Zn content of 71.83 wt.% was achieved at a duty ratio of 0.4.

The corrosion characteristics of Zn-Ni alloy plated samples were tested in 0.5 M Na_2SO_4 and 0.5 M H_3BO_3 buffer solution at pH 7. A representative sample area of 1 cm^2 was chosen for testing. A three-electrode setup was used to study the corrosion behavior of Zn-Ni pulse deposited samples. Platinum mesh served as the counter electrode. All the measurements taken in this study are referred with respect to saturated calomel electrode (SCE) filled with saturated KCl solution.

Results indicated that by changing the pulse parameters, the composition of Zn-Ni alloy could be altered. Preliminary corrosion studies indicated that the Zn-Ni deposit with higher nickel content showed highest polarization resistance.

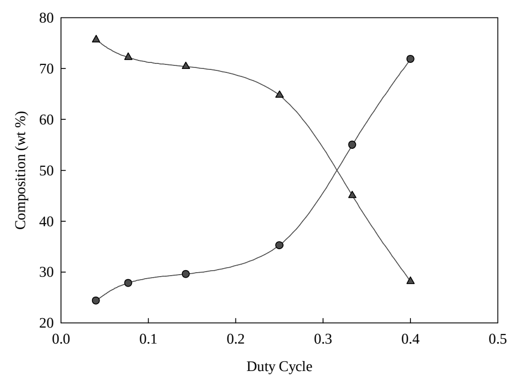

Fig1. Variation in Zn-Ni composition with duty cycle.

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