Studies on Electrodeposited Zn-Ni-X (X=Cu, Cd, and Sn) Coatings as a Replacement for Cadmium Coatings

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Cadmium has been favored as a sacrificial coating for the protection of steel owing to its excellent corrosion resistance and engineering properties[1]. However, its toxicity has triggered the development of alternate coatings that can replace cadmium effectively. Zn-Ni alloy coatings have been suggested as a suitable replacement for Cd coatings. The Zn-Ni alloy provides good corrosion protection to steel, superior formability and improved weldability. Although nickel is nobler than zinc, the co deposition of Zn-Ni is anomalous and the content of Zn in the Zn-Ni alloy is very high (84%). The mechanism for this preferential deposition has been discussed in literature[2]. Hence the Zn-Ni alloys are more electronegative like the Zn coatings. The wide difference in the potentials of the coatings and the substrates leads to the high rate of dissolution when compared to that of cadmium. Hence the objective of the work is to bring down the sacrificial potential of the Zn-Ni alloy.

In the current work, a new Zn-Ni-X plating process was developed which offers a unique way of controlling the Zn-Ni ratio. The Zn-Ni-X alloys are electrodeposited from alkaline sulfate electrolytes in the presence of additives and complexing agents. The ratio of the zinc and nickel was effectively controlled by alloying with a ternary element, X (Cu, Cd, Sn). The electrodeposited Zn-Ni-X alloy has an increased content of nickel as compared to the conventional Zn-Ni alloy. The coatings have a Zn to Ni ratio of 1.3:1. The increase in the nickel content accounts for the decreased corrosion potential of the Zn-Ni-X coatings. The corrosion potential of the Zn-Ni-X alloy is –0.69 V (vs. SCE), which is still electronegative when compared to steel and offers sacrificial protection to steel. The coatings have superior corrosion resistance and barrier properties when compared to conventional Zn-Ni and cadmium coatings. Polarization studies and electrochemical impedance analysis on Zn-Ni-X coatings show a barrier resistance that is higher than the conventional Zn-Ni coatings by an order of magnitude (Fig.1). The composition of the coatings was analyzed by EDX. The surface morphology of the coatings was studied using SEM (Scanning Electron Microscope). Also, by alloying with the ternary element X, we expect to modify the rate of hydrogen evolution reaction, the hydrogen proton recombination and the adsorption kinetics at the surface to impede completely the proton permeation in the alloy. This decreases the hydrogen embrittlement. The decrease in the hydrogen embrittlement is characterized as per the ASTM F 519 standards. Corrosion data as per the ASTM B117 standards will also be reported

References:

1. K.R Baldwin and C.J.E Smith, *Trans.Inst.Met. Finish.*,**74**, 202 (19196)

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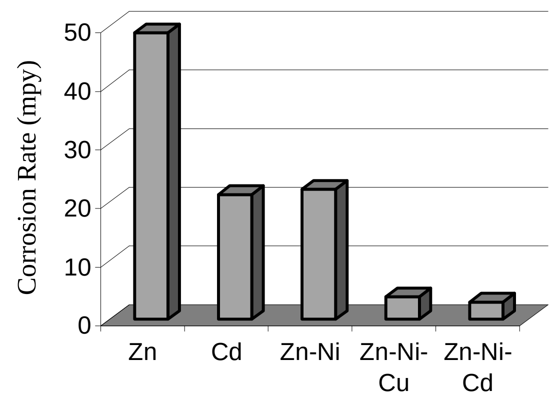

Fig.1. Comparison Chart of Corrosion rates for different coatings.