Chapter VI

6 Summary and Conclusion

All the three experiments were designed with a view to study and develop coatings to prevent the substrate from corrosion. Two different metallic coatings and a non-metallic coating were studied. Owing to the commercial importance and acceptance of zinc-nickel and zinc-cobalt alloys, these two coatings were studied under metallic coatings. Under non-metallic coatings mixed oxide of zinc and iron was studied. These two oxides were chosen because of the existence of zinc and iron oxides in the paint technology as anti-corrosive pigments.

The objective of this study was to select well-known and established plating bath formulations and modify the process to improve the efficiency of the formulation, hence the coating. By doing this, a more economical method of coating can be anticipated. This would also lead to a coating with better performance. The mixed oxide coating was studied in order to develop a new way of coating material for corrosion prevention.

6.1 Zinc-Nickel deposition

X-ray analysis of the zinc nickel coating obtained under sonicated conditions, show that the coating obtained under this condition follows different crystal growth kinetics. The cluster size calculated using the X-ray data show that the grain size of the Zinc-Nickel coating obtained under sonicated condition is smaller than the deposits obtained under air agitation.

EDAX analysis of the Zinc-Nickel deposit obtained under sonicated condition has high nickel content than the deposit obtained under air agitated condition, for the same current density. This analysis highlights the technological importance of the modification done to the existing method. The importance can be either of the two ways (1) it is possible to derive a new formulation with low nickel concentration in the bath or (2) it is possible to operate with the existing formulation at low plating current density.

SEM analysis results show that the deposits obtained under sonication has even distribution of particle size and the crystal faces became apparent with increase in plating current density. AFM analysis shows that the sonicated Zinc-Nickel deposits are more uniform compared to the deposits obtained under air agitated condition.

Open circuit potential measurements show that the Zinc-Nickel deposits obtained under air agitated condition offers more protection. This could be because of the high nickel content in the deposits obtained under sonicated, as a separate phase in the deposit, making it more noble. This draw back could be over come by choosing optimum plating current density and plating bath composition. The results of X-ray, EDAX, SEM and AFM analysis were presented and discussed in chapter 3.

6.2 Zinc-Cobalt

Like Zinc-Nickel, Zinc-Cobalt is also a binary alloy. The major difference between the two coatings arises because of the required concentration of the noble metal in the deposit. The concentration of nickel in Zinc-Nickel deposits for optimum performance was found to be 10%, whereas in the case of Zinc-Cobalt the required cobalt concentration range from 0.8-1%. Thus making it more economical. This is the reason for the popularity of Zinc-Cobalt coatings.

X-ray analysis of the deposit obtained under sonicated condition is found to be different from the air agitated deposits. Under sonicated condition and at lower plating current densities the X-ray diffractogram shows the presence of zinc metal as a separate phase. This trend changes with increase in plating current density.

EDAX analysis of the Zinc-Cobalt deposits show a decrease in concentration of cobalt when compared with the deposits obtained under air agitated condition. This could be because of the anomalous deposition, which is discussed in chapter 4. The high concentration of cobalt in the deposit fluctuates with changes in plating current density and sonication leads to decrease in concentration of cobalt. SEM micrograph of deposits obtained below 3 A/dm^2 show crystal faces for air agitated deposits. Sonication results in coating with particles of nodular shape. At high plating current density needle shaped crystals were seen in the deposits obtained under sonication. AFM analysis show that the Zinc-Cobalt deposit obtained under sonication results in flakes in the direction perpendicular to the substrate. Open circuit potential measurement show that the deposits obtained under sonicated condition lead to a coating less noble than the air agitated coating. Thus sonication results in increased protection. Coatings obtained under sonicated conditions at high current densities failed to protect the substrate. These results were discussed in chapter 4. Optimization of the plating bath formulation and the other parameters would result in an innovative method of electrodeposition and thus that could be suggested as the future work.

6.3 Mixed oxide coating

Mixed oxides of zinc and iron were obtained together on mild steel substrate. The starting material was zinc nitrate and ferric chloride. The mixture as fine droplets was fed through a zone of high temperature. The fine particles of oxide thus obtained were carried onto a mild steel substrate by the carrier gas. The coatings were obtained at various temperatures, and the coatings were analyzed for their crystalline nature, morphology, composition and protection against corrosion.

The X-ray analysis of the coating show that the coating obtained at 400° is zinc ferrite, a mixed oxide of zinc and iron. Increasing the temperature results in increase in crystallinity. EDAX analysis shows increase in oxygen concentration with increase in processing temperature. The concentration of iron in the deposit was found to increase with increase in temperature. The increase in iron content indicates the oxidation of the substrate; also it highlights the formation of oxides of iron in the interface layer. SEM analysis shows uniform sphere shaped deposits at lower temperatures. At high temperature this spherical nature disappears and the coating is found to be more uniform.

Impedance analysis of the coatings show that the deposits obtained at low temperature offers more protection compared to the deposits obtained at high temperature. The coating obtained at 500°C did not show any protection, the probable reason is attributed to the formation of hard coatings at the surface of the sphere leaving soft, loose material at the core.