# Influence of Ni-Co Coating on Steel-A Review

**M.Senthil Kumar, S.Bharath Priya Dharshan, D.Bharath, T.Anish Infant Raj, M.Dhanasakar**

Department of Mechanical Engineering, Sona College of Technology. Salem-5.

msksona@gmail.com,
priyadharanarun17@gmail.com,
bharathwayne007@gmail.com,
anishinfantraj@gmail.com,
sahardhana@gmail.com

## ABSTRACT

Metallic coating of nickel-cobalt can improve the surface properties of the substrate. The coating surfaces have been developed to increase the wear resistance, hardness or corrosion resistance for industrial applications. In this review paper, the study is related to nickel–cobalt alloy coating on EN8 steel by pulse plating. Electro deposition of Ni-Co alloy on EN8 steel was performed in an acid chloride bath. The influences of electro deposition parameters such as current density, temperature, pH value, cobalt sulphate and saccharin concentration on composition and current efficiency were investigated in detail. Scanning electron microscopy and energy dispersive spectrometry were used to investigate the coating microstructures, surface morphology. The hardness of plating layers was measured. The morphology and the microstructure of deposits were analyzed by SEM and XRD respectively.

**Keywords**: Electro deposition, EN8 steel, pulse plating, chloride bath, Ni-Co alloy, SEM, XRD.

## I.INTRODUCTION

The best applications of EN8 steel tend to be those for which superior qualities to mild steel are required, but where the additional expense of alloy steel cannot be justified. The chemical composition of this steel - also known as 080Mn40 or 080Mn42-includes carbon, silicon, manganese, sulphur and phosphorus**.**

The property of the material is:

1. High strength
2. Rigidity
3. Impact resistant
4. Heat and oxidation resistance
5. Resistance to corrosion and wear

### A. Nickel-Cobalt Coating

Nickel electroplating on low carbon steel are used in many industrial application due to its improving corrosion fatigue life. Coating thickness improvement provides good protection against corrosion but in other hand reduces fatigue life.6 μ m thickness of electroplated Nickel improved fatigue life of low carbon steel specimen in corrosive environment and exposed to cyclic load.**[2]**

Nickel coatings are most attractive due to their low porosity content and high corrosion resistance. However, improving these properties seems to be necessary for special purposes which can be achieved through pulse plating.**[3]**

## B. BATH COMPOSITION

| | | oz./gal. | g./L |
|---|---|---|---|
| Nickel sulfate | $NiSO_4.6H_2O$ | 32 | 240 |
| Nickel chloride | $NiCl_2.6H_2O$ | 6 | 45 |
| Sodium formate | $NaCHO_2$ | 4.6 | 35 |
| Boric acid | $H_3BO_3$ | 4 | 30 |
| Cobalt sulfate | $CoSO_4.7H_2O$ | 2 | 15 |
| Ammonium sulfate | $(NH_4)_2SO_4$ | 0.3 | 2.5 |
| Formaldehyde | HCHO | 0.12 | 1 |

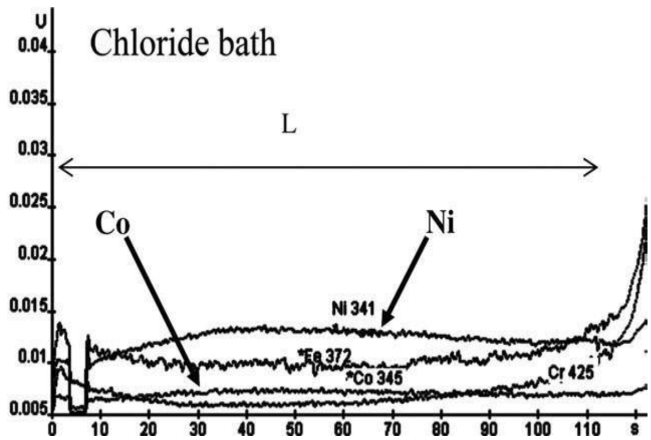


**Figure.1.Chloride bath. Ordinates: intensity signal in Vs. sputtering time deposition**

## C. CURRENT DENSITY

The influence of current density at 22˚C, pH 2 on the cobalt weight percent in the Ni-Co alloy foils and the cathodic current efficiency is shown in Figure.2. It is observed that the Co weight percent in the deposits increases significantly as current density increases and eventually reaches a maximum of 35.7 wt% at about 4 $A/dm^2$. With a further increase in the current density, the weight percent of Co decreases gradually. The solution gave smooth and bright deposit with super hardness and ductility over current density range between 3 to 4 $A/dm^2$, whereas the deposit was undesirable in other current density range. When the current density was lower than 3 $A/dm^2$, the deposits were brighter, but their toughness decreased. When the current density was higher than 5 $A/dm^2$, the deposit at the edge was burnt. Especially when the current density increased to 6 $A/dm^2$, the obtained deposits was dull with green attachments appeared on the surface and it was seriously burnt at high current density region.

It is also noticed that the current efficiency decreases with current density, which indicates an increase in the rate of hydrogen discharge. At 3 $A/dm^{2,}$ the current efficiency is 57.6%, and it decreases to 31.5% at 5 $A/dm^2$. Over the current density range of 5 $A/dm^2$ to 7 $A/dm^2$, the current efficiency does not change much.

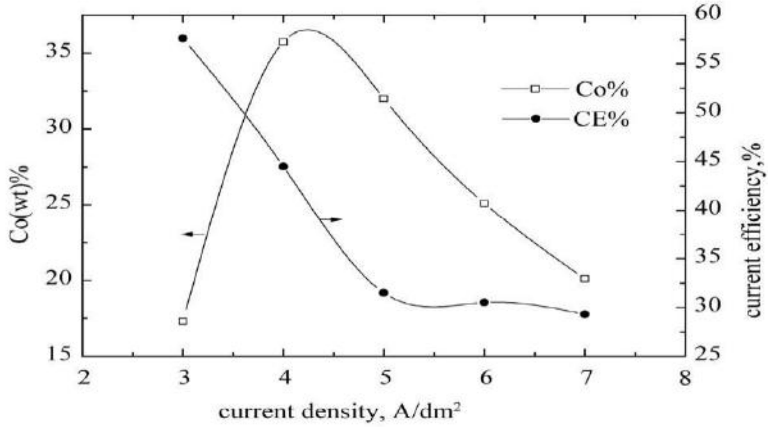


**Figure.2.** **Influence of Current Density on Ni-Co alloy electrodeposition at pH2, 22°C**

# D. TEMPERATURE

The influence of bath temperature at pH 2 and current density 4 A/dm$^2$ on the composition of Ni-Co alloy deposits and the current efficiency is shown in Figure.3.It is found that the Co content in the deposits is lower at the low temperature. And the Co content in the deposit is only 23.3 wt% at temperature of 20˚C. With increasing temperature, the Co content in the deposit increases rapidly and reaches a maximum value of 34.1 wt% at temperature of 30˚C. It is noticed that there is a steady increase in current efficiency with gradual increase in temperature. At 20˚C, the current efficiency is 27.6%, and it increases to 33.8% at 60˚C. In the mean time, the brightness of the deposits improves, the hydrogen evolution reaction weakens, the quality of the deposits is good and the thickness of the deposits increases. At temperature higher than 50˚C, the brightness of the deposit decreases and its compactness is worse. At 60˚C, the deposit is dull grey and brittle, accompanied by phenomenon of charred black with a large number of bubbles produced on the surface. So the optimum temperature range is 40 - 50˚C, at which the obtained deposits are bright and smooth.

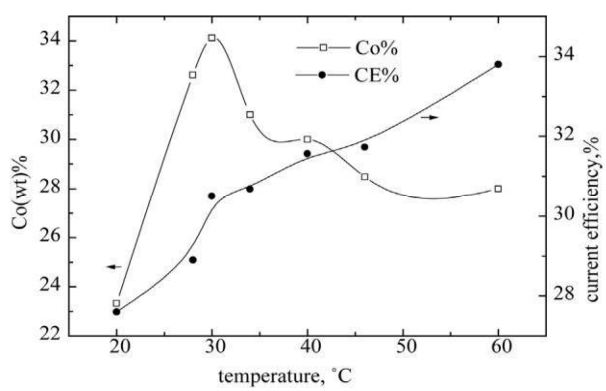


**Figure.3.** **Influence of Temperature on Ni-Co alloy electrodeposition at pH2, 4 A/dm$^2$**

## E. MORPHOLOGY AND PHASE STRUCTURE OF NI–CO ALLOYS

Typical cross-sections of Ni–Co alloys deposited from chloride bath is shown in Figure.4

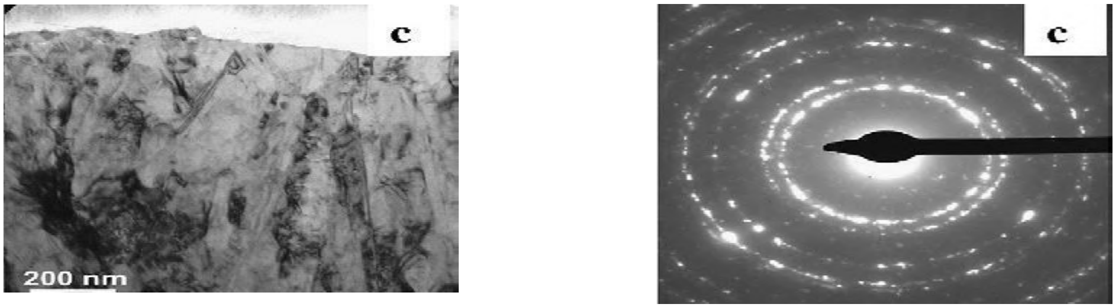


Figure.4.Bright field TEM images and the corresponding diffraction pattern of the Ni–Co alloys deposited from a chloride bath.

## F. SEM ANALYSIS

Figure.5 shows the SEM micrographs of the Ni-Co alloy foils with different cobalt contents. The morphology shows uniform spherical fine-grain nodules which are characteristic of cobalt alloy deposits. Hydroxide particles are not observed and all the deposits are bright, metallic and smooth. Obvious grain boundary can be found on the deposit. Compared (a) and (b), it can be seen that the crystal size of the deposit with higher Co content is much smaller.

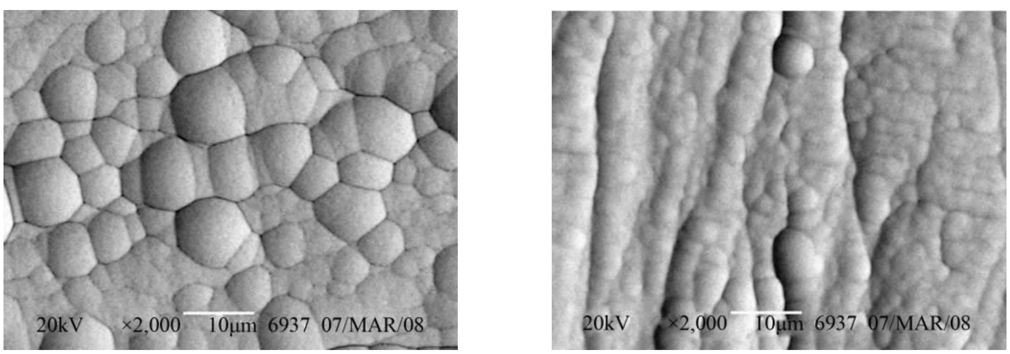


Figure.5. **SEM micrographs of Ni-Co alloy deposit (a) 35.6 wt% Co, (b) 41.5 wt% Co.**

## G. XRD ANALYSIS

Figure.6 shows the XRD patterns of the electrodeposited Ni-Co alloy foils with 37 wt% Co and 35.6 wt% Co content, respectively. Two sharp peaks in each XRD pattern at the 2θ of around 44. 46˚ and 51.8˚ are observed clearly. Their main textures are (111) and (200). These high peaks suggest that the Ni-Co alloy deposits may be considered as crystalline in structure. With increase of Co content, the intensity of the main peaks increase, and the peak width is broader for deposit with higher Co content indicates decrease in grain size of the deposit. The deposit can be identified as Ni solid solution with a face centred cubic (fcc) structure.

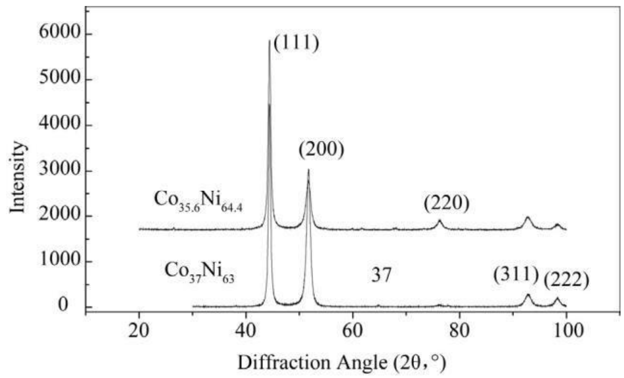


Figure.6. **XRD patterns of Ni-Co alloy deposits**

# II.CONCLUSION

The pulsed electro deposition of nickel cobalt at various duty cycles improved the hardness of the material deposited from a Watts-type bath. The bright deposits were obtained without burnt deposit under pulse condition at room temperatures. The hardness of nickel deposited by pulse plating was higher than obtained by direct current. The crystallographic structure of Ni-Co deposited steel is the FCC in Ni solid solution. The deposit is uniform fine grained. The deposit shows good toughness and low residual stress. From the literature survey we observed that Wear resistance, Tensile strength, Corrosion property, Hardness and Fatigue life of steel can be improved.

# REFERENCES

1. M.Senthil Kumar 2016, Investigation of Surface Coating On Wear, Corrosion And Fatigue Behavior Of Steel, Advance in Natural and Applied Science.

2. Yu-Fang Yang, Bin Deng, Zhao-Hui Wen , Preparation of Ni-Co Alloy Foils by Electrodeposition.
3.M. Srivastava, V. E. Selvi, V. K. W. Grips and K. S. Rajam, "Corrosion Resistance and Microstructure of Electrodeposited Nickel–Cobalt Alloy Coatings," Surface & Coatings Technology, Vol. 201, 2006, pp. 3051-3060.
4. Peter, J. Padar, E. Toth-Kadar, A. Cziraki, P. Soki, L. Pogany and I. Bakonyi, "Electrodeposition of Co–Ni–Cu/ Cu Multilayers 1. Composition, Structure and Magnetotransport Properties," Electrochimica Acta, Vol. 52, 2007, pp. 3813-3821.

5. A. N. Correia and S. A. S. Machado, "Electrodeposition and Characterisation of Thin Layers of Ni-Co Alloys Obtained from Dilute Chloride Baths," Electrochimica Acta, Vol. 45, 2000, pp. 1733-1740.
6. W. H. Safranek, The Properties of Electrodeposited Metals and Alloys, 2nd ed., American Electroplaters and Surface Finishers Society, Orlando, FL (1986).
7. S Nigam, S K Patel, S S Mahapatra, N Sharma and K S Ghosh. Nickel coating on high strength low alloy steel by pulse current deposition.4
8. B. Stein, P. Jaeger and C. Przybyla, Mechanical Properties of Electroformed Nickel Cobalt Alloys