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STUDIES ON BIPOLAR ELECTRODE FOR PREFERENTIAL DEPOSIT BUILD UP ON INTRICATE SHAPED ARTICLE

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Current and metal distribution plays a major role in electroplating/electroforming in deciding the uniformity of electrodeposit obtained on intricate shaped objects. Special cell and electrode designs are to be adopted to enable uniform deposition. Shields, baffles, auxiliary or conforming anodes are utilized to promote uniform deposition [1-3]. A slightly different condition was met with, while doing nickel deposition, where the thickness of the deposit required on a recessed area of an intricate shaped object was very high compared to the remaining portions. Special electrode design based on bipolar electrode was adopted and the results obtained are presented in this paper.

Keywords: Bipolar electrode, electroplating and electroforming

INTRODUCTION

During nickel plating, the anode provides electrical contact with the solution and distributes the current to the work being plated. In most cases, the plate uses nickel metal anodes which dissolve as the current flows and thereby replace the nickel ions discharged at the cathode, maintaining the concentration of nickel salts dissolved in the plating solutions.

Small insoluble anodes made by titanium with a thin coating of platinum have been used to increase the current directed into recesses on a shaped part but such anodes give rise to other problems, such as exfoliation of the platinum deposit in presence of chloride ions, the replacement of depleted metal ions and the cost of the platinised electrode etc. These problems can be overcome by using soluble nickel auxiliary anodes on electrical circuits separated from the main anodes.

Another way of directing current into the recess is to use a short nickel rod which has no external electrical connection but points into the recess. Since nickel is a metallic conductor, it acts as a low resistance path for the current. Current from the main anode travels to the nearer end of the rod, through the rod and then across the short distance, through the solution to the surface of the recess in the work. In consequence, nickel metal is deposited on the end of the rod near to the anode and dissolved from the end near the cathode. An incidental advantage of such bipolar anodes is that if they are accidentally pushed against the work, there is no short circuiting since the bipolar anode is not electrically connected to any of the electrodes.

During our work on electroforming of cryogenic rocket engine thrust chamber, preferential thickness building at a recessed portion became essential to minimise the loss due to nodular growth at the projections and subsequent post machining operations. The section of the recessed portion to be electrodeposited with nickel, is shown in Fig. 1.

This paper describes the effect of the bipolar anodes positioned at four different angles, namely 90°, 45°, 30° and 20° with reference to the anode on the metal distribution in the recessed shaped cathode.

EXPERIMENTAL

The cathodes were prepared by pressing 1mm thick brass sheets on a stainless steel mandrel so as to get the conforming shape. The cathodes of 100 x 60 mm size have a bend of 170° at a distance of 20 mm, the depth being 6 mm. The cathodes were mechanically polished electrocleaned, pickled, washed and introduced into the nickel sulphamate plating electrolyte. The purified sulphamate nickel bath has the following composition:

Nickel shlphamate	240 g/l
Nickel chloride	10 g/l
Boric acid	45 g/l

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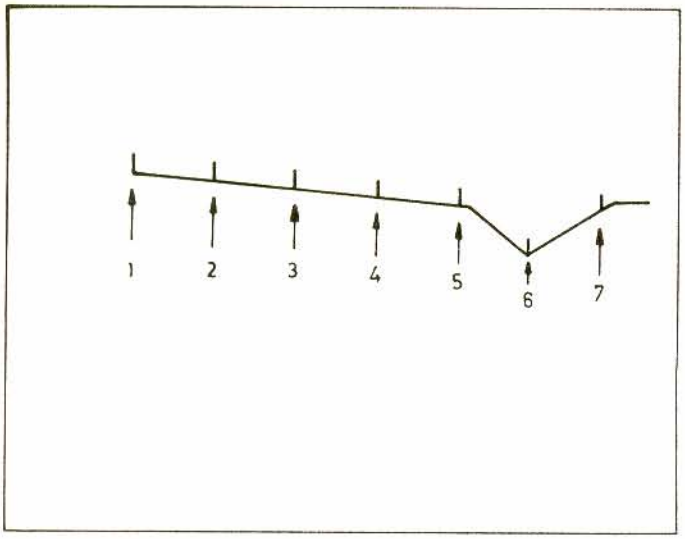

Fig. 1: Different location of intricately shaped cathode for thickness measurement

Deposition was carried out at a current density of 2A/dm^2 at an electrolyte *p*H of 3.5.

Electrolytic nickel anodes were used both as the regular anode and the bipolar anode. The anode was placed parallel to the cathode and the bipolar anode was positioned between the two electrodes at different angles of inclination namely 90°, 45°, 30° and 20° relative to the anode. The distance between the cathode and the end of the bipolar electrode was maintained. Deposition was carried out for 1 hour. The cathode was divided into 7 sections and the thickness at each point was measured using nickelascope.

RESULTS AND DISCUSSION

Table I shows the 6 different points on the specimen where thicknesses of the nickel deposits, were tested. These points were selected in such a way as to include all the points, where maximum or minimum current densities are expected and also at the neck of the recess, where high thickness build up is expected. It is observed that when the bipolar electrode was positioned perpendicular to the anode, points 1,2,3 and 6 received almost the same current as it was without the electrode whereas points 4 and 5 received higher currents (Fig. 2).

The thickness values obtained at these points, given in Table I also show that only at point 5, noticeable increase in thickness could be observed.

When the bipolar electrode was positioned at an angle of 45° to the anode, from the thickness data obtained, it could be inferred that points 4,5 and 6 received higher thicknesses whereas the other points received the same current. Hence it follows that the electrode still functions as a bipolar electrode.

TABLE I: Thickness of nickel deposit on the intricately shaped cathode with different angles

Point on the cathode	Without bipolar electrode	Electrode angle 20°	30°	45°	90°
			Thickness µm		
1	5.50	3.62	4.12	6.00	5.25
2	5.62	4.50	5.00	6.25	6.00
3	5.92	5.00	5.50	7.00	6.25
4	6.50	6.00	7.75	9.00	7.02
5	8.62	7.50	10.52	11.62	9.50
6	10.62	10.50	13.12	13.50	11.00

At the angle of 30°, only points 5 and 6 showed higher thickness, and point 4 exhibited a marginal increase whereas points 1,2 and 3 showed a marked decrease in thickness. The increase in thickness observed in points 4,5, and 6 however were lower than those obtained with the bipolar electrode at 45°. When the electrode was positioned at an angle of 20°, the thickness values obtained at all the points were lesser than the other four cases (Fig. 3).

It could be understood that the bipolar effect diminished as the angle of positioning of the electrode was decreased.

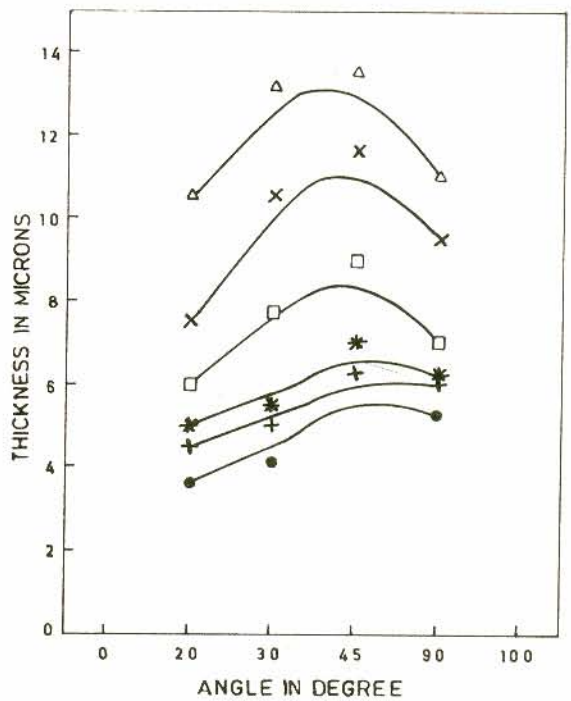

Fig. 2: Thickness of nickel deposit on intricately shaped cathode
W#ithout BPE *45 Degree* *20 Degree* *90 Degree* *30 Degree*

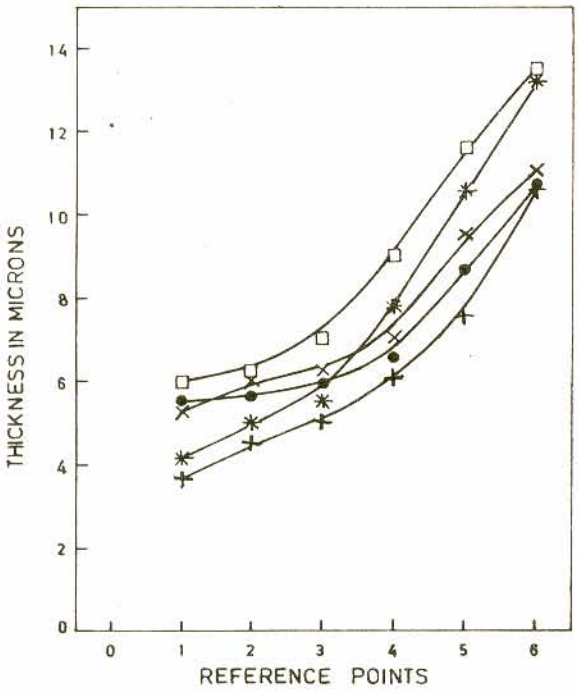

Fig. 3: Thickness of nickel deposit on intricately shaped cathode
Series 1 *Series 2* *Series 3*
Series 4 *Series 5* *Series 6*

When the bipolar electrode was positioned at 90°, current lines concentrated on the end which was close to the anode and the other end being far off from this, received negligible current hence turned anodic to the cathode surface as expected in any bipolar electrode system. However, when the electrode was kept in an inclined position, the above type of end to end bipolarity gradually decreased with decreasing angle, and the whole surface facing the anode acted as the cathode while the other side turned to be the anode. This in turn caused increased resistance reducing the current. At 45° angle, both type of bipolar influences should have been prevalent, leading to higher thickness at all points tested. At 30 and 20°, the electrode created additional resistance for deposition and points 1,2 & 3 in the former and at all points in the latter. Table II shows the potentials at different locations of the intricately shaped cathode with the inclinations of the bipolar electrode with respect to the saturated calomel electrode.

TABLE II: Potential at different locations of the intricately shaped cathode wih the inclinations of the bipolar electrode with respect to the saturated calomel

Sl. No.	Without bipolar electrode	30°	45°	90°
1.	-0.377	-0.350	-0.558	-0.410
2.	-0.350	-0.369	-0.532	-0.396
3.	-0.340	-0.371	-0.536	-0.371
4.	-0.325	-0.397	-0.556	-0.360
5.	-0.320	-0.420	-0.545	-0.465
6.	-0.380	-0.396	-0.516	-0.345

CONCLUSION

From the above study it appears that positioning the bipolar electrodes at an angle of 45° and 30° to the anode is more effective in building up thickness at the recessed point of the complicated shaped cathode.

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