Low Temperature/Low Concentration Bright Nickel Plating

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BRIEF description of various nickel plating processes like dull, semibright, bright, micro-porous etc. is given. The corrosion resistance of these coatings is compared. Efforts for obtaining low temperature nickel plating using certain additives are cited from literature.

The development of a low temperature low concentration bright nickel plating bath in the Authors' R and D Centre is narrated. A comparison of the above new bath with other proprietory compositions is made. The material and energy savings by this process is highlighted.

ONE of the established processes of metal finishing is nickel plating over which Chromium is deposited. The historical development starting from 1840 is available in popular books by Brugger[1], Lowenhein[2] etc. Watts[3] entered the arena in 1914 and introduced the most famous solution which has stood the test of time. Since bright plate can directly be achieved, post plating like polishing are rarely needed.

Earlier bright plating baths could not give levelled deposit and other surface defects could not be eliminated and the brightness depended mainly on the substract. At this stage organic compounds with specific groups were commercially introduced to obtain fully bright, levelled deposits with negligible stress.

Due to the introduction of sulphur containing organic compounds, the bright deposits were found to be less corrosion resistant compared to dull nickel mechanically polished plates. To overcome this draw back various commercial baths have been introduced. Duplex Nickel, is one such where an undercoat of sulphur free semi-bright nickel plating is first given over which bright nickel and Chromium are successively given and this Duplex coating is found to be better corrosion resistant. The sulphur free layer being more noble than bright nickel, confines the corrosion current to bright nickel only resulting in lateral distribution than vertical corrosion. Trinickel plating process has three layer system where the bottom layer is semibright, the thin central layer has high sulphur content and the top layer essentially bright nickel. Usually the highly activated nickel layer is less than 10% of the total nickel thickness.

Attempts to improve corrosion resistance of nickel-chromium plating have also led to development of micro-porous chromium, where the chromium top coat is deliberately made discontinuous. The under coat of nickel deposit contains fine non-metallic inclusions over which chromium is plated thus achieving discontinuity.

The present emphasis internationally is to conserve materials and lower temperature of operations wherever possible. The pollution of environment also cause concern in addition to energy crisis as well as raw material shortage. Having this in mind a project on Low Temperature Low Concentration Bright Nickel Plating was undertaken in the Authors' R and D Centre. This paper gives the details about the new development achieved.

Though efforts towards this objective have been there from very early days, still fully bright nickel plating were not achieved earlier[4], Albo Process[5] a low temperature low concentration is one such system. Many of the earlier processes could have a low plating rate. High chloride baths have been attempted to increase anode corrosion and limiting current density. The diffusion coefficient of nickel ion is increased where by higher limiting current density almost double that of a sulphate bath is achieved[6]. Due to better electrical conductivity, the metal distribution over the cathode is also better. These are a few reasons because of which attempts have been made abroad

TABLE 1

	A		B		Conventional
	Range g/l	Optimum g/l	Range g/l	Optimum g/l	Watts g/l
Nickel metal	30-40	35.5	34.5-64.4	45	71
Nickel Chloride hexa hydrate	100-130	110	90-120	112.5	63
Nickel Sulphate Septa hydrate	20-50	40	60-150	75	275
Boric acid	45-55	50	49-67.5	56	44

to develop new commercial composition with high chloride for low concentration low temperature bright nickel processes.

In Table 1 two such bath compositions are given.

EXPERIMENTAL

Hull cell studies followed by 2 litre beaker scale experiments were first done in the laboratory. 20 litre trial in a rubber lined tank exactly as a replica of a commercial bath was done at Authors' laboratory as well as at TI Cycles of India, after satisfactory results in the previous lab scale experiments. Commercial nickel sulphate, Nickel Chloride and Boric acid were used to prepare the the bath and conventional purification techniques adopted.

The 320 ml. standard Hull cell used, had facility for air agitation. A host of Organic additives resembling commercially known Class I and Class II brightner levelling and wetting agents were synthesised in our R and D Centre from chemicals available indegenously. Extensive trials with polished M.S. as well as Brass sheets were conducted and optimum composition was decided through these studies, The cost of the brighter system was always borne in mind while these studies were on. The 20 litre trials were conducted for determining the thickness, corrosion resistance of the nickel plate, chrome acceptability, stress, levelling, cathode efficiency etc.

Encouraged by these results, two foreign commercial brightner systems which work satisfactorily on low concentration low temperature conditions, were imported for comparative studies. Similar trials at hull cell level and 2 litre volumes were conducted.

The Table below gives the operating conditions and other details for the two foreign systems as well as our bath.

Conditions	A	B	C
Current density (range)	1-8 A/dm^2	2.2-10.8A/dm^2	1-8 A/dm^2
Current density (optimum)	4-6 A/dm^2	5.4-7.5 A/dm^2	4-6 A/dm^2
Air agitation	yes	Yes	yes
Temperature (optimum)	45-50°C	43°C	40 ± 1°C
Solution pH	3.8	4	4
Stress	present	negligible	absent
Thickness for 20 min. plating by BNF jet	16.2 microns	16 microns	16 microns
Burning effect	No	observed at high C.D.	No
Brightness	Fully bright	Fully bright	Fully bright
Cathode efficiency	97%	> 95%	> 95%
Chrome acceptability	good	good	good
Corrosion resistance (15 micron nickel + 0.3 to 0.5 micron Chrome subjected to 24 hour acetic acid salt spray test at 35°C)	passed	passed	passed

Cost Saving : Our new Low Temperature Low Nickel System offers the following savings :

1. Lesser chemical make up and maintenance cost.
2. Lesser energy for heating the bath.
3. Lesser effluent treatment expenses.

The cost saving calculations are based on 5000 gallons nickel bath operating 16 hrs/day and 5 days a week. The cost of the brightner system is comparable to any commercial brightner system available in India. It is emphasised that imported brightners are costlier to the commercial brightners available in their countries themselves. The cost saving for initial makeup comes to Rs. 86,000. The drag out loss is calculated to be 0.2% of solution volume per week. Hence with the New Low Concentration Bath, the saving per annum due to lesser drag-out loss is Rs. 90,000. Though silica immersion electrical heaters are extensively used, our calculation for the energy saving is based on steam heating. This amounts per annum to Rs. 63,000. The effluent treatment expenses are also reduced considerably due to lower concentration of nickel thus resulting in minimising pollution.

CONCLUSION

This indegenous effort is a humble contribution towards energy saving and material conservation from our R and D Centre which is hoped to be commercially employed soon.

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