Electroforming of Thin Walled Nickel Tubes

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The paper describes a method of electroforming thin walled nickel tubes (0.12-0.15 mm) which was difficult to fabricate by conventional procedures. An electroforming assembly of horizontal type has been designed and fabricated to electroform tubes of length upto 600 mm. Electroforming has been done both from Watts and sulphamate baths. The baths needed periodic purification and filtration. The tubes electroformed from sulphamate bath have better mechanical properties. Hydrogen relieved tubes exhibited excellent brazing characteristics. It was also possible to prepare groved nickel tubes.

elatively few metals are electroformed and nickel is the most important among these. This is mainly lue to its excellent properties, particularly its trength, toughness and corrosion resistance. Its echanical properties like hardness, ductility, nternal stress etc. can be varied significantly y varying the conditions of electrodeposition ike bath pH, temperature, current density and uitable addition agents in the bath. The success f electroforming depends on the choice of proper ath and precise operating conditions.

he paper discusses the electroforming of thin alled (0.12-0.15 mm, wall thickness) nickel tubes hich are difficult to fabricate by conventional etallurgical technique like extrusion and rawing. The process of electroforming offers the ost convenient, fast and reliable alternative echnique for making thin walled nickel tubes with etter mechanical properties. These tubes can be sed in the manufacture of mass flowmeters.

XPERIMENTAL

n the literature, numerous bath formulations are vailable based on nickel sulfamate olutions(1-5). In the present study, sulfamate ath was made from nickel sulfamate concentrate supplied by M/S. Grauer and Weil, Bombay) by dding required amounts of other reagents. lectroforming was also done from Watts Bath. ach bath was of 25 litre capacity. Details of omposition and conditions of operation of the ath are listed in Table 1.

he bath was mechanically agitated. The mandrel as rotated vertically (25-30 RPM). The cathodic ontact to the mandrel was made by a brass ushing. The bath was purified and filtered eriodically by adopting standard procedures 3). Polypropylene bagged titanium basket filled ith sulphur-depolarised nickel, was used as node. Electrolyte nickel sheet also performed ell in the Watt's bath.

TABLE 1

COMPOSITION AND OPERATING CONDITIONS FOR NICKEL BATHS

Current Density = 5-6 A/dm^2 pH = 4 - 4.4
Mechanical Agitation Temp: 52 - 56 °C

Watts Bath	Sulfamate Bath
Nickel Sulfate =300 g/l	Nickel Sulfamate =440 g/l
Nickel Chloride= 40 g/l	Nickel Chloride = 6 g/l
Boric acid = 40 g/l	Boric acid = 40 g/l
Antipit agent =0.15 g/l	Antipit agent =0.15 g/l
Anodes: Electrolytic Nickel or S-depolarised nickel shots in titanium basket.	Anodes: S-Nickel shots in Titanium basket.

Machined aluminium tube was used as mandrel. It was cleaned in dilute alkali followed by acid dip(6). After plating, the mandrel was dissolved out in cold 10% sodium hydroxide solution and the alkali smut was removed by dipping the nickel tube in 50% nitric acid. The electroformed nickel tubes were relieved by hydrogen by baking in vacuum at 300°C for 3-4 hours.

Internal stress measurements were carried out from purified solutions using a modified Brenner and Senderoff's spiral contractometer (gearless model) The helix was prepared according to standard procedure. . Stress (σ) was calculated using Equation:

$$\sigma = \left[\frac{(2K)}{pt}\frac{(D)}{d}\right]\left[1+\frac{(Eo)}{E}\frac{(d)}{t}\right]$$

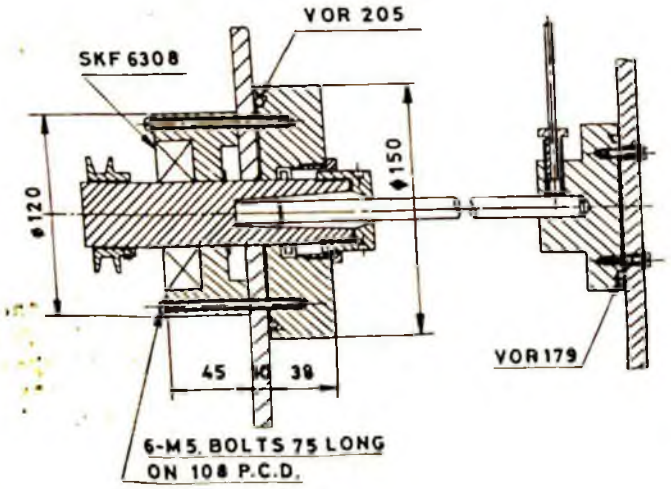
Where K is constant for helix, calculated using 1 Oz (by weight), p & t are pitch and thickness of helix respectively, D is the deflection in degrees

d due to internal stress the electro-
,d is the thickness of the deposit. Eo is
modulus of electroplated nickel and E is
ng's modulus of stainless steel.

cro-hardness of nickel was measured using
1 load.

ITAL ELECTROFORMING TANK ASSEMBLY

lectroforming nickel tubes of length more
)0 mm, difficulties were encountered in the
al type of electroforming cell. The main
ulty was the wobbling of mandrel during
on which increased with the increase of its
. An electroforming tank in which the
l is held horizontal was designed and
:ed. The tank was made of 10 mm thick
:x with arrangement for horizontal rotation
: mandrel at 25 to 30 rpm. The cpapcity of
ank was about 60 litres, with a length of
m. Only two-third of its capacity was filled
solution. The schematic diagram of the
)bly is shown in Fig. 1. The material of
:ruction for rotating assembly consisted of
n, teflon and perspex. No metal part was used
de the tank except for electrical contact to
rotating mandrel.



ig. 1' Horizontal Electroplating Assembly

he tank was fitted with oil seal and O-rings to
revent solution leakage. The mandrel was
moothly rotated through a ball bearing using a
eduction gear A/C motor.

hree polyprophylene bagged titanium baskets (each
00 mm x 150 mm x 25 mm,) filled with S-nickel
hots, were kept along the length of the tank.
hey were kept on one side of the mandrel.

mechanical stirring was carried out in the tank. during electroforming. Other parameters like pH, temperature, purification and filteration were similar as in the case of vertical cell. Electroforming in a horizontal cell has the following advantages i) comparatively lesser quantity of solution is required, ii) a better control in tube thickness can be achieved, iii) wobbling of mandrel is avoided, and iv) titanium anode basket of much smaller length can be used for electroforming of long tubes. Nickel sulfamate bath was used for electroforming of nickel tube in horizontal type of tank. Nickel tubes upto 600mm length were electroformed from this cell.

RESULTS AND DISCUSSION

Good quality nickel tubes varying in length from 250mm to 600mm having internal dia 10.00mm to 12.5mm and wall thickness 0.12 to 0.15mm, could be electroformed. Selecting mandrels free from surface pits and scratches and keeping the solution free from dust and suspended particles ensures integrity of the electroformed tube. Tubes formed in such cases are found to be free from pores.

Tensile strength and percent elongation were determined using 12.7 mm guage length tensile specimen, cut from flat nickel plates. Table 2

TABLE 2

MECHANICAL PROPERTIES OF NICKEL

Bath type	Hardness (VHN)	UTS MN/m²	% Elongation	Internal stress* MN/m²
Watts	180	453	25	163.9
Sulfamate	230	575	10	21.3

* Tensile stress, thickness of coating 60 um.
Electroplating conditions: C.D. 6A/dm²
pH=4-4.4, Temp: 52-56°C
Anode: S-Ni shots in titanium basket.

presents the data on mechanical properties and internal stress of nickel electroplated from both Watts and sulfamate baths. The mechanical properties compare well with the reported values in literature(7,8). The nickel tube electroformed from sulfamate has higher hardness and UTS values and lower internal stresses, hence it is better to use this bath for electroforming. Hydrogen pick up in nickel is more from Watts Bath compared to sulfamate bath [Table 3]. Hydrogen was baked out by heating the tubes in vaccum at 300°C for 3-4 hours. Nickel tubes had excellent brazing characterstics and thermal shock resistance, as tested by heating the tube with oxygen-acetylene flame and quenching in water; no distortion or

cracking of the tube was observed. Unbaked tubes cracked on brazing. In the intended application, need was felt to elctroform tubes having grooves (0.4mm deep, 0.2mm wide, pitch 1.5mm) on the surface. The mandrel was suitably prepared and electroforming done from sulfamate bath. The groove pattern was faithfully reproduced. Thickness within the groove was 62-65% of the tube thickness.

TABLE 3

ANALYSIS OF GASES IN ELECTROFORMED NICKEL

S.No	Plate Condition	Watts Bath		Sulfamate Bath	
		H	N	H	N
1.	As Electroplated	40	9	19	4
2.	Ni plated on Al and latter dissolved out	118	10	45	6
3.	Sample (2) annealed in vacuum at 300°C for 3 hours	40	10	28	0

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