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QUALITY IMPROVEMENT IN NICKEL PLATING PROCESS

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Abstract: Plating is one of the important process on metal surface to improve rigidity, strength, anti rusting and shinny finish of the product. Nickel plating is done over stain less steel, copper etc. In electronic Industry it is extensively used to improve surface finish and anti tarnishing properties. The surface finish, surface thickness of finish etc. depend upon chemical composition of the solution as well as application of electricity in the bath. Right combination of all these will provide durable, lustrous finish on the metallic surface.

Key words: Process flow diagram, CNX diagram, SN ratio.

1. **Introduction:** Substantial number of manufactured parts for Electronics projects are required for Nickel plating operation in Plating shop. Nickel plating is an important operation, high rejection at this stage often resulted in shortage of important parts. It is therefore necessary to control the Nickel plating process and contain the defects at the plating shop level itself [1].
   High level process flow diagram is shown in Fig 1.

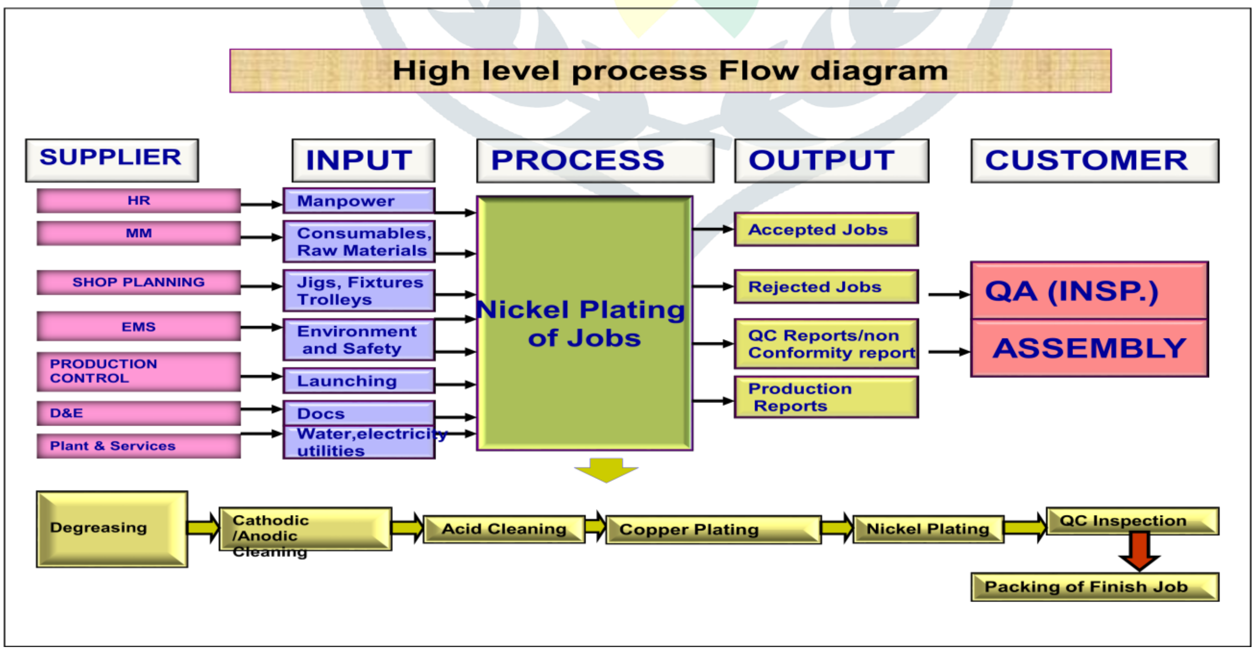


Fig 1: High level process flow diagram

Process flow diagram of Nickel plating is depicted in Fig 2.

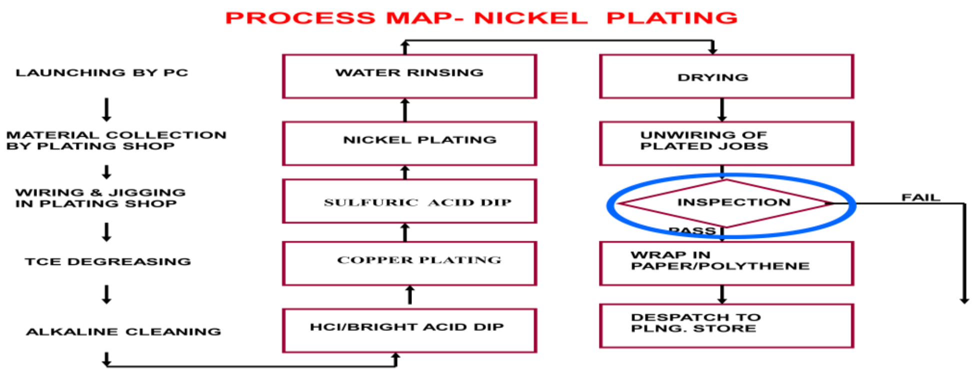


Fig 2: Process Flow Diagram of Nickel Plating

2. **Problem:**

Data were collected for a month about Zinc plating, Tin plating and Nickel plating from plating plant. Among these three types of plating defect analysis were done. It was observed that among these three types of plating, Nickel plating has maximum no of defects. Details is shown in Fig 3.

INSPECTION DATA FOR PLATING JOBS (AUG'20)

Type of Plating	Qty Plated	No of defects	% of Defects
1. Chromate Conversion	3915	0	0.00%
2. Zinc Plating	529	1	0.2%
3. Nickel Plating	711	83	11.6%
4. Tin Plating	998	12	0.012%

Fig 3: Data of Plating Shop

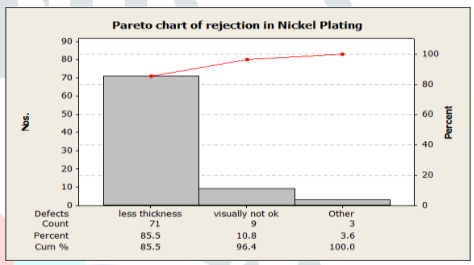


Fig 4: Fault spectrum

Failure data was analysed thoroughly and individual fault was identified. It was found that out of 83 rejected items , less thickness case was 71, which was maximum. Detail is shown in Fig 4. Inspection data in lot wise defect spectrum is shown in Fig 5.

INSPECTION DATA FOR NICKEL PLATING JOBS (AUG'20)

SL.NO	QTY PLATED	QTY PASSED	QTY RW	% Rework
1	59	53	6	10.1
2	91	78	13	14.2
3	81	73	8	9.8
4	85	78	7	8.2
5	75	65	10	13.3
6	80	67	13	16.2
7	70	63	7	10.0
8	90	80	10	11.1
9	30	26	4	13.3
10	50	45	5	10.0
Total	711	628	83	11.6

Fig 5: Inspection data for Nickel plating

Characteristic	Defects	Units	Opps	TOP	DPU	DPO	PPM	Z
Pass/Fail	83	711	3	2133	0.116	0.03891	38912	3.3
Total	83	711	3	2133	0.116	0.03891	38912	3.3

ZST (INITIAL) =3.3

Fig 6: Process Calibration

Process calibration was calculated and Zst was 3.3. Calculation is shown Fig 6.

3. **Analysis:** All operators of Plating shop was called and a brainstorming season was conducted. They were told to find out reasons of failures. Based on the discussion cause and effect diagram of failure was drawn [2]. Diagram is shown in Fig 7:

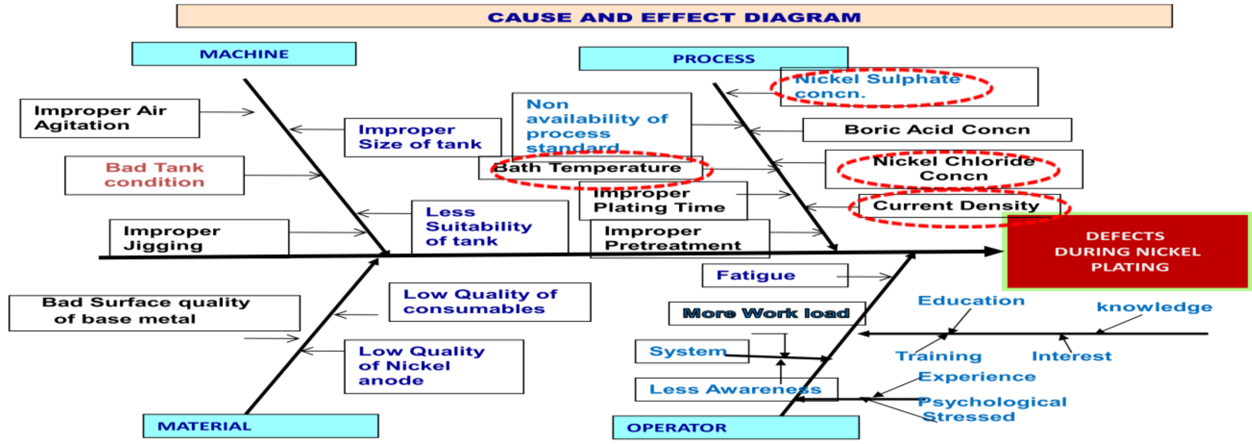


Fig 7: Cause and Effect diagram

The main reason for defects were pointed out;

1. Bath Temperature
2. Current Density
3. Nickel Sulphate concentration
4. Nickel Chloride concentration

It was decided to draw CNX diagram[3] to identify noise , constant and variable parameter. parameters were taken from cause & effect diagram only. CNX diagram is shown in Fig 8.

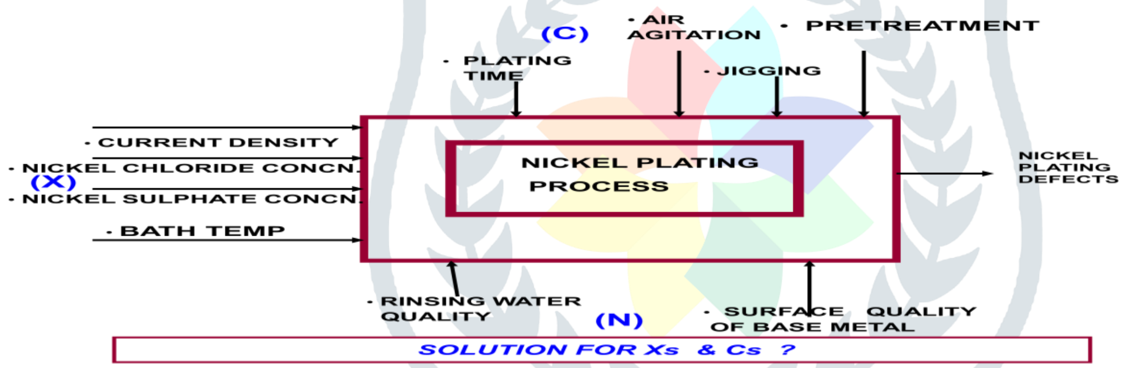


Fig 8 : CNX Diagram X factors level were set to conduct design of experiment

Using Taguchi method[4] for finding out significant factors in Nickel plating process as per process standard was Factor = 4 and Level = 2. For finding optimum value of four experimental factors, Taguchi test was conducted. Taguchi L8 chart is shown in Fig 9 and 'X' factor chart is shown in Fig 10.

TAGUCHI L8 DESIGN

BATH TEMP.	CURR. DENSITY	NICKEL SULPHATE	NICKEL CHLORIDE
1	1	1	1
1	1	2	2
1	2	1	2
1	2	2	1
2	1	1	2
2	1	2	1
2	2	1	1
2	2	2	2

USING MINITAB 17

'X' - FACTOR	LOW LEVEL (-1)	HIGH LEVEL (+1)
NICKEL SULPHATE CONC.	230 G/L	290 G/L
NICKEL CHLORIDE CONC.	30 G/L.	40 G/L.
CURRENT DENSITY	2 A/Sq.dm.	6 A/Sq.dm.
BATH TEMPERATURE	44 DEG CEL	60 DEG CEL

CURRENT LEVEL OF OPERATION IS AT LOW LEVEL (-1)

Fig 9: L8 chart of Taguchi **Fig 10: 'X' factor level**

In terms of Actual parameter of Nickel plating, Taguchi L8 design is shown in Fig 11. 'Y' responses for each set of reading was recorded and similarly 5 set of reading were taken. 'Y' response data is shown in Fig 12.

TAGUCHI L8 DESIGN

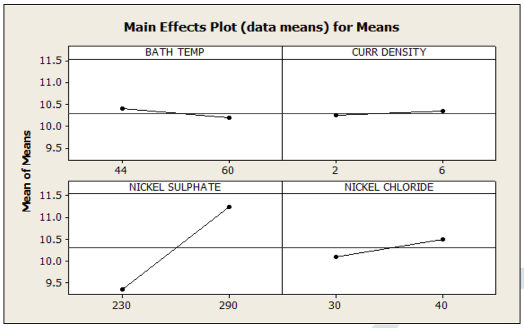
BATH TEMP.	CURR. DENSITY	NICKEL SULPHATE	NICKEL CHLORIDE
44	2	230	30
44	2	230	40
44	6	290	40
44	6	290	30
60	2	290	40
60	2	290	30
60	6	230	30
60	6	230	40

Fig 11: Actual L8 Parameter

TAGUCHI ANALYSIS BASED ON THICKNESS (Y) AS RESPONSE FOR BATCH OF 08 EXPERIMENTS. ONLY MAIN EFFECT IS CONSIDERED. INTERACTION EFFECT IS IGNORED.

BATH TEMP	CURR DENSITY	NICKEL SULPHATE	NICKEL CHLORIDE	Y1	Y2	Y3	Y4	Y5
44	2	230	30	9	10	10	9	9
44	2	290	40	11	12	12	11	11
44	6	230	40	9	10	10	11	10
44	6	290	30	12	11	10	10	11
60	2	230	40	8	9	9	10	9
60	2	290	30	12	11	11	12	10
60	6	230	30	9	9	10	8	9
60	6	290	40	13	12	10	11	12

Fig 12: 'Y' Responses



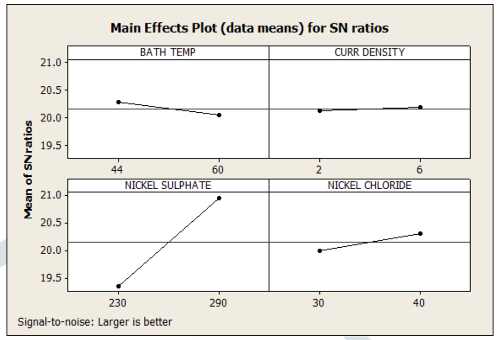


Fig 13: Main effect plot for means **Fig 14: Main effect plot for SN ratio**

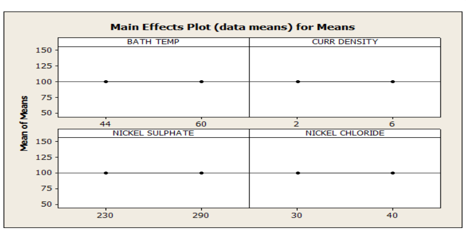
Analysing delta values and main effect graphs it indicates that larger the better (signal to noise ratio)[5]. Main effect plot for means and main effect plot for SN ration are shown in Fig 13 and fig 14 respectively. It can conclude that the optimum parameters are given below:

PARAMETER	OPTIMUM VALUE
1. Nickel Sulphate	290 Gm/Ltr
2. Nickel Chloride	40 Gm/Ltr
3. Bath Temperature	44 Deg.Cel.
4. Current Density	6 Amp/Sq.Dm

TAGUCHI ANALYSIS BASED ON FTP AS RESPONSE (DUE TO POOR ADHESION AS CAUSE OF REJECTION) FOR TOTAL 08 EXPERIMENTS. ONLY MAIN EFFECT IS CONSIDERED. INTERACTION EFFECT IS IGNORED.

BATH TEMP	CURR DENSITY	NICKEL SULPHATE	NICKEL CHLORIDE	FTP
44	2	230	30	100
44	2	290	40	100
44	6	230	40	100
44	6	290	30	100
60	2	230	40	100
60	2	290	30	100
60	6	230	30	100
60	6	290	40	100

When less thickness (< 10 micron)is the cause) of rejection. Similarly responses were taken for factors having rejections due to poor adhesion[6]. Main effect plot for means and main effect plot for SN ratio are shown in Fig 15 and Fig 16 respectively.



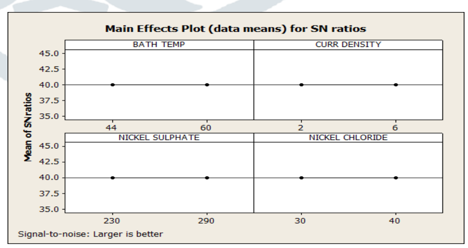


Fig 15 : Main effect response for means **Fig 16: Main effect response for SN ratio**

When poor adhesion was the main cause of rejection, as per theory, larger the better but in these case graphs were straight lines, hence it can be concluded that there was no effect on adhesion in these parameter[7][8].

When poor appearance is the cause of rejection, in these cases both graphs for main effect plot for SN and main effect plot for means were straight lines[9]as shown in Fig 17, Fig 18 and Fig 19. It indicates that there was no effect of different parameters on visual appearance[10].

TAGUCHI ANALYSIS BASED ON FTP AS RESPONSE (DUE TO VISUAL INSPECTION AS CAUSE OF REJECTION) FOR TOTAL 08 EXPERIMENTS. ONLY MAIN EFFECT IS CONSIDERED. INTERACTION EFFECT IS IGNORED.

BATH TEMP	CURR DENSITY	NICKEL SULPHATE	NICKEL CHLORIDE	FTP
44	2	230	30	100
44	2	290	40	100
44	6	230	40	100
44	6	290	30	100
60	2	230	40	100
60	2	290	30	100
60	6	230	30	100
60	6	290	40	100

Fig 17 : Factor for responses (Rejection due to Visual rejection)

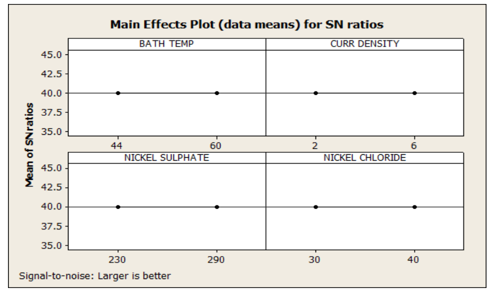


Fig 18: Main effect plot for SN ratio

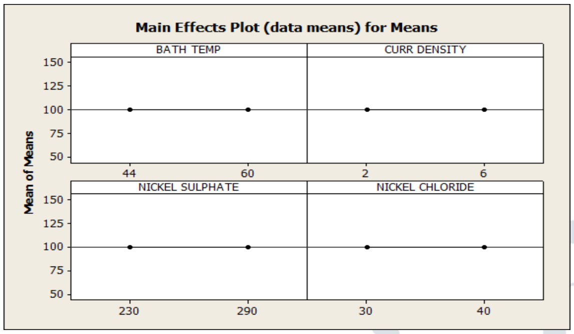


Fig 19: Main effect plot for means

After all the experiments , result-1 combination provided the best results. The optimum parameter were as follows:

Sl No	Parameter	Values
1.	Nickel Sulphate	290 Gm/Ltr
2.	Nickel Chloride	40 Gm/Ltr
3.	Bath Temperature	44 Deg.Cel.
4.	Current Density	6 Amp/Sq.Dm

4. **Result:** As outcome of experimentations, a set of values for each parameter was obtained. These parameter values are called optimum value of the experimentation. Nickel plating parameters were set as per the said values. After that Nickel plating operation was done. The outcome is mentioned in Fig 20.

AFTER IMPLEMENTATION OF IMPROVEMENT

INSPN. DATA FOR NICKEL PLATING JOBS (01st JAN'2021- 15th JAN 2021)

SI.No	PERIOD	QUANTITY PLATED	QUANTITY PASSED	QUANTITY REJECTED
1.	01-01-21 TO 15-01-21	326	325	01
TOTAL		326	325	01

Fig 20: Data after implementation of improvement

Process parameter was calculated with the help of Minitab 17. Zst after incorporation of improvement parameter was 4.58. Detail is shown in Fig 21.

Process Parameter

Characteristic	Defects	Units	Opps	TOP	DPU	DPO	PPM	Z
Pass/Fail	01	326	3	978	0.0030	0.0010	1022	4.58
Total	01	326	3	978	0.0030	0.0010	1022	4.58

Z(AFTER IMPROVEMENT) =4.58

Fig 21: Improved process parameter.

Initial Zst of the process was 2.3. After incorporation of optimum value, the process zst was become 4.58. the optimum parameter value is depicted in Fig 22.

Optimum parameter for Nickel Plating process

S.No	PARAMETERS	RECOMMENDED
1	NICKEL SULPHATE	290±1 g/l
2	NICKEL CHLORIDE	40±1g/l
3	CURRENT DENSITY	6±0.1 Amp/dm²
4	BATH TEMP.	44± 1 °C

Fig 22: Optimum parameter for Nickel Plating process

5. Conclusion:

The following benefits were obtained by optimizing Nickel plating parameters;

1. On time delivery of item.
2. Quality of the product improved.
3. Customer satisfaction.
4. Less quality cost.

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