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Defect Analysis of Hard Chrome Plating: A Case Study

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Various type of components in different shape & size are hard chrome plated . Some quality issues of chrome plated components such as:

i. Coating peeled off
ii. Coating chip off
iii. Insufficient coating thickness
iv. Absence of coating
v. Uneven coating thickness
vi. Rough coating deposition
vii. Dual color coating
viii. Scratches in coating
ix. Dent
x. Pitting

are observed. Aforesaid defects adversely impact on the image of organization. This report has prepared to reach the solution to remove aforesaid defects. I studied more than 2000 research papers, discussion with many technical expert in this field. I have done various trials in different parameters towards process approach, then after , I found some fruitful results. As per outcome after a lot of trials, I found that 70 % defects can be controlled by controlling the following parameters:

i. Improper selection of electrical parameter (specially for % ripple)
ii. Improper anode setting
iii. Usage of old/discarded anodes & fixtures
iv. Improper bath temperature selection
v. Poor chemical composition of bath
vi. Poor cleaning of parts & contact point prior to plating
vii. Improper/Insufficient pre & post heat treatment cycle
viii. Frequent fluctuation of power supply
ix. Too high machining
x. Quality of D.M. Water
xi. Lack of polishing
xii. Poor testing gauges/instruments/tools
xiii. Poor working condition of equipment
xiv. Negligence of worker & staff
xv. Poor Skill & knowledge of workman & staff
xvi. Insufficient measuring instrument
xvii. Negligence by Chemical Laboratory during testing of bath solution.

For rest 30 % defect's, it can be improved & to make quality as worldwide aspect we will have to go some new technological changes:

i. In place of conventional chrome salt, high accelerated chrome salt with efficiency up to26% can be used.
ii. Instruments such as HULL CELL, Spectrometer for thickness , Scanned electron microscope for surface image will be required.
iii. Pulsed technique for better coverage.
iv. Prior to plating, surface can be activated by Nickel chloride.

This report is based on totally practical approach. This work has been divided into following parts.

i. Trial has been completed in conventional chrome bath

ii. Trial has been completed in conventional chrome bath along with pulsed technique.
iii. Trial has been conducted in high accelerated chrome bath along with pulsed technique.
iv. Trials have been conducted in conventional chrome bath with Nickel chloride activation.
v. For removal of impurities of chrome bath, use of ion exchange method
vi. For removal of impurities of chrome bath, use of electro dialysis principle

I. MATERIAL AND MEHOD:

A. CONVENTIONAL CHROME PLATING PROCESS SEQUENE:

S.NO	OPERATION	PROCESS PARAMETER	REMARK IF ANY
01	S/R BEFORE ELECTROPOLISHING	TIME -- 2 HOURS TEMP. (^{O}C) -- 200	
02	ELECTROPOLISHING	CURRENT – 35AMP/dm^2(Each Barrel) TIME -- 2 MINUTES TEMP. (^{O}C) -- 75-80 SP. GRAVITY (^{O}Be) – 55-65	Current & time will vary as per components surface area
03	HOT WATER RINSING	3-4 DIP	
04	COLD WATER RINSING	3-4 DIP	
05	PASSIVATION	DIP FOR 30 SECOND	
06	CLEANING WITH HOT WATER & PULL THROUGH	BY APPLY PROPER BRUSH	
07	BORE INSPECTION		NO ANY WIRE MARK
08	CLEANIG WITH TCE & PULL THROW	ROOM TEMPERATURE	
09	ULTRA SONIC CLEANING	TIME -- 7 MINUTES TEMP. (^{O}C) -- 52 - 55	Time will vary as per components surface area
10	COMPONENT INSPECTION		COMPONENT SHOULD BE CLEAN
11	BATCH FORMATION		08 COMPONENTS FOR EACH BATCH WITH SAME GAUGE
12	ANODIC CLEANING	CURRENT – 20 AMP/dm^2(Each Barrel) TIME -- 10 MINUTES TEMP. (^{O}C) -- 55-60 SP. GRAVITY (^{O}Be) – 12 - 16	Current & time will vary as per components surface area
13	NEUTRALIZATION	TIME -- DIP FOR 30 SECOND TEMP. (^{O}C) -- 50 - 55	
14	ETCHING	CURRENT – 35 AMP/dm^2(Each Barrel) TIME -- 2 MINUTES TEMP. (^{O}C) -- 55-60 SP. GRAVITY (^{O}Be) – 21 - 22	Current & time will vary as per components surface area
15	CHROME PLATING	CURRENT – 35 AMP/dm^2(Each Barrel) TIME -- 2.20 HOURS(7.70 RUN) TEMP. (^{O}C) -- 55 SP. GRAVITY (^{O}Be) – 21 - 22	Current & time will vary as per components surface area
16	WATER RINSING	3-4 DIP	
17	S/R (DEHYDROGENATION)	TIME -- 18-20 HOURS TEMP. (^{O}C) -- 200	
18	Q.C INSPECTION		

B. +CHROME PLATING BATH COMPOSITION:

S.NO.	INGRADIENTS	CONCENTRATION
01	HEXA VALENT CHROME	225 - 275g/l
02	TRI CHROME	0 - 18g/l
03	SULPHATE	2.25 - 2.75g/l
04	IRON OXIDE	0 - 20 g/l

05	TOTAL OXIDE	0 - 38g/l

C. CHROME SALT QUALITY:

S.NO.	INGRADIENTS	UNIT	STANDARD
01	Alkaline Salt	%	0.000 – 0.015
02	Appearance		Flakes
03	Assay	%	99 - 100
04	Chloride	%	0.0000 – 0.0050
05	Colour		Dark red to purple
06	Insoluble	%	0.000 – 0.020
07	Solubility		25 % aq. Solution
08	Sulphate	%	0.00 – 0.10

D. Anodic Cleaner:

Appearance : Powder
Colour : White
Caustic Content : 60 -70%

E. ELECTRO POLISH CHEMICAL:

S.NO.	INGRADIENT	STANDARD
01	Appearance	Clear Liquid
02	Colour	Colourless
03	Specific Gravity	1.664 – 1.706
04	Assay %	85 – 88%
05	5 % aq. Solution	Clear
06	Imp. Iron % Max.	0.002
07	Imp. Lead % Max	0.002
08	Fluoride % Max.	0.010
09	Acetate % Max.	0.01

F. SULPHURIC ACID(H_2SO_4):

S.NO.	INGRADIENTS	STANDARD
01	Minimum assay(acidimetric)	97%
02	Wt. per ml @ 20^0C	1.834 – 1.836g
03	Non volatile matter	0.01%
04	Hydro chloric acid	0.0005%
05	Nitric Acid	0.001%
06	Arsenic	0.0002%
07	Iron	0.002%
	Lead	0.002%
	Reducing substances	0.02mlN/1%

G. HYDRO CHLORIC ACID (HCl):

Make : Qualigens; Specific Gravity: 1.18

S.NO.	INGRADIENTS	STANDARD
01	Assay	35.8-36%

H. Nickel Chloride:

- Chemical Formula : $NiCl_2.6H_2O$.
- Molecular Weight : 237.7
- Appearance : Light Green Powder.
- Grade : I.S. 1809 - 1979 Grade I.

SPECIFICATIONS

- Nickel and Cobalt combined (as Ni + CO) percent by weight → Min.23.7 %
- Cobalt (as CO), percent by weight, → Max.0.5 %
- pH of aqueous solution, not less than → 3.5
- Acid insoluble matter, percent by weight, → Max. 0.05 %
- Sulphate (as SO_4), percent by weight → ——
- Copper (as Cu), percent by weight, → Max.0.002 %
- Lead (as Pb), percent by weight → Max. 0.002 %
- Iron (as Fe), percent by weight. → Max 0.01 %
- Zinc (as Zn), percent by weight. → Max Max 0.002 %

I. Demineralized Water:

PH	:	6.5 – 7.5
Conductivity	:	0-4µS
Turbidity	:	Nil

J. MEASURING INSTRUMENT:

S.NO	INSTRUMENT	RANGE	PURPOSE
01	Digital Thermometer	-40 to 300^0C	For measurement of Bath Temperature
02	Digital AC/DC Clamp meter		For measurement of D.C./A.C. Current
03	Digital EC/TDS /TEMP Meter	0 to 9990µS/8560ppm/0 to 80^0C	For measurement of conductivity & dissolved solid of D.M. Water
04	Digital PH Meter	0 to 14	For measurement of PH of D.M. Water
05	Digital ripple meter		For measurement of ripple %
06	Hydro Meter	1.000 to 2.000	For measurement of Bath Specific gravity

K. METALLURGICAL MICROSCOPE:

NOMENCLATURE: Computer based non contact measuring microscope(As per IS 4163: 2004 for NMIR testing)
Measuring Range: X, Y & Z(200 X 200 X 200 MM & ABOVE)
Surface Illumination: Halogen Lamp along with intensity control system
Analysis Range(Micro Analysis):
C1 R1 S1 TO C5 R5 S5
Inclusion : 0.5 to 2.5 micron
Case Depth : 0.05 to 1mm
Accuracy: 4 +L/200micron

L. Test piece Specification:

i. Dimension

Shape: Circular
Diameter: 45.01dm
Thickness : 5.098mm

ii. Chemical Composition:

S.No	Ingradient	%
01	C	0.35-0.45
02	Mn	0.70-1.0
03	S(Max.)	0.02
04	P(Max)	0.02
05	Mo	.15-.35
06	Si	0.10-.35
07	Cr	0.90-1.5

iii. Chemical Composition(LAB Report):

S.No	Ingradient	%
01	C	0.402
02	Mn	0.809
03	S(Max.)	0.0074
04	P(Max)	0.0095
05	Mo	0.163
06	Si	0.027
07	Cr	1.099
08	Ni	0.024
09	Al	0.015
10	Cu	0.0082

M. Pulse type rectifier(Polarity Reversal Unit):

Make: HIND RECTIFIERS LTD, MUMBAI PLANT

Introduction: Polarity Reversal Unit designed by Hirect are intended for use in electrochemical process /application such as plating bath, electrolysis etc. It gives flexibility to user for setting various modes of operation along with wide range of pulse ON & OFF timing. The unit is designed to be connected to a D.C. power supply & can output various pulse profiles as listed further.

Specification:

S.No.	Parameters	Values			Units
		MIN	TYP	MAX	
01	Input Voltage(Vin)		12		V DC
02	Out put Voltage(Vout)		12		V DC
03	Out put Current (Iout)		300		A DC
04	Process Time	1 sec		9 hrs.	
05	Forward process time	1 sec		9 hrs.	
06	Reverse process time	1 sec		9 hrs.	
07	Forward Pulse ON/OFF Time	1 ms		999ms	
08	Reverse Pulse ON/OFF Time	1 ms		999ms	
09	Dead Time	1 ms		999ms	
10	Ambient Temperature			50	^{0}C
11	Duty Class			100	%

II. RESULT & DISCUSSION

1. CONVENTIONAL CHROME PLATING PROCESS:

Trial No.	TANK NO.	TANK COMPOSITION	CURRENT	TIME	PROCESS SEQUENCE	PICTURE TEST PIECE SIDE 1 & 2	DATE	OBSERVATION
01	B-14(3)	Hex. Chrome: 236.72g/l Sulphate : 2.34g/l Total oxide : 15.50g/l Iron oxide : 3.92g/l Trivalent: 5.54g/l	50 Amp	11:40 to13:40hrs	1.Polishing 2.Ultra Sonic Cleanig 3.Chrome plating	Fig: A	22/01/2019	
02	B-14(2)	Hex. Chrome: 266.72g/l Sulphate : 2.37g/l Total oxide : 15.50g/l Iron oxide : 3.92g/l Trivalent: 5.54g/l Electropolish: Sp. Gravity: 58^{0}Be Temp: 80^{0}C Time : 03 Minutes Current : 30Amp	40 Amp	16:00 to17:15hrs	1.Polishing 2.Ultra Sonic Cleanig 3.Electropolish 3.Chrome plating	Fig: 2	30/01/2019	40 Amp

03	B-14(1)	Hex. Chrome: 223.37g/l Sulphate : 2.35g/l Total oxide : 18.50g/l Iron oxide : 7.92g/l Trivalent: 8.54g/l Electropolish: Sp. Gravity: 56^0Be Temp: 80^0C Time : 07 Minutes Current : 30Amp	25 Amp	13:40 to14:40hrs	1.Polishing 2.Ultra Sonic Cleanig-5 min. 3.Electropolish 4.Hot Rinse- 4 times 5.Anodic Cleaning - 55^0C,without current,5minute 6. Neutralization- 2 dip, 55^0C 7.Chrome plating	Fig: C	07/02/2019	25 Amp
04	B-14(2)	Hex. Chrome: 231.71g/l Sulphate : 2.36g/l Total oxide : 15.50g/l Iron oxide : 3.92g/l Trivalent: 5.54g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 02 Minutes Current : 30Amp	40 Amp	11:00 to12:40hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 5min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: D	12/02/2019	40 Amp
05	B-14(2)	Hex. Chrome: 243.38g/l Sulphate : 2.36g/l Total oxide : 17.50g/l Iron oxide : 5.92g/l Trivalent: 12.54g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 02 Minutes Current : 30Amp	40 Amp	11:00 to12:20hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 5min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: E	15/02/2019	40 Amp
06	B-14(2)	Hex. Chrome: 243.3g/l Sulphate : 2.36g/l Total oxide : 15.50g/l Iron oxide : 3.92g/l Trivalent: 5.54g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 02 Minutes Current : 30Amp	40 Amp	11:00 to12:40hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 5min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: F	22/02/2019	
07	B-14(3)	Hex. Chrome: 231.71g/l Sulphate : 2.36g/l Total oxide : 15.50g/l Iron oxide : 3.92g/l Trivalent: 5.54g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 03 Minutes Current : 30Amp	40 Amp	11:00 to12:40hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 5min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: G	27/02/2019	40 Amp
08	B-14(2)	Hex. Chrome: 265.05g/l Sulphate : 2.65g/l Total oxide : 18.50g/l Iron oxide : 9.92g/l Trivalent: 5.54g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 03 Minutes Current : 25Amp	35 Amp & 25 AMP	12:00 to14:40hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 10min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: H	17/03/2019	35 Amp & 25 AMP
09	B-14(2)	Hex. Chrome: 260.05g/l Sulphate : 2.12g/l Total oxide : 35.00g/l Iron oxide : 4.85g/l Trivalent: 6.76g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 03 Minutes Current : 25Amp	40 Amp	11:00 to12:30hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 10min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: I	03/07/2019	Ripple : 6.1% Send to CQAE(MeT)

10	B-13(4)	Hex. Chrome: 260.00g/l Sulphate : 2.12g/l Total oxide : 14.00g/l Iron oxide : 4.85g/l Trivalent: 6.75g/l Electropolish: Sp. Gravity: 58^0Be Temp: 80^0C Time : 03 Minutes Current : 25Amp	40 Amp	10:00 to11:30hrs	1.Polishing 2.Ultra Sonic Cleanig - 5min. 3.Electropolish 4.Anodic Cleaning 10min,56^0C(without current) 5.Neutralization - 56^0C(2 dip) 3.Chrome plating	Fig: J	05/07/2019	Ripple: 0.00%

SUMMERY:

S.NO.	TRIAL NO.	DATE	OBSERVATION
01	01	22/01/2019	1.Test piece had not electropolished 2.Large no. of pin holes(uncovered surface)are developed 3.Trees like structures are formed at corner 4.current is 50 AMP & time is 2:00 Hours.
02	02	30/01/2019	1.Test piece had electropolished before chrome plating, surface shining increased. It is fruitful , it will implement for all trial 2.less of pin holes(uncovered surface)are developed as comparison of trial-01. 3.Trees like structures are formed at corner 4.current is 40 AMP & time is 1hours15 minutes.
03	03	07/02/2019	1. Current reduced to 25 amp. & time given 1:00 hrs. 2. Pin holes are developed grater than Trial-02 ,but less than Trial -01. 3.Less Trees like structures are formed at corner. 4. Dull plating in comparison of Trial -01 & 02.
04	04	12/02/2019	1. Current given 40 amp for 1hrs 40 minutes. 2.Pin holes are dispersed at the whole surface area 3. Shining is good. 4. Trees like structures are formed at corner 5. Some places large size of pin holes are developed.
05	05	15/02/2019	1. Current given 40 amp for 1hrs 20 minutes. 2.Pin holes are dispersed at the whole surface area 3. Shining is very good. 4. Trees like structures are formed at corner 5. More organized surface are formed as per microscopic view.
06	06	22/02/19	1. Current given 40 amp for 1hrs 40 minutes. 2. Number of pin holes are decreased. 3. shining is good 4. Trees like structures are formed at corner 5. One batch of eight numbers of MAG barrels are chrome plated in same bath , all are tight in gauge from muzzle end side.
07	07	2702/19	1. Current given 40 amp for 1hrs 40 minutes. 2. Number of pin holes are increased & some places large size pin holes are developed. 3. shining is good 4. Trees like structures are formed at corner. 5. . One batch of eight numbers of MAG barrels @ 40 amp. are chrome plated in same bath , all are O.K. in gauge after plating.
08	08	17/03/2019	1. Current given 25amp for 1hrs 40 minutes(for test piece -01 &35 amp. For test piece -2. 2. Large size of pin holes are developed in test piece-01& Test piece-02 3. Trees like structures are formed at corner. 4. shining is good.
09	09	03/07/19	1. Current given 40 amp for 1hrs 30 minutes. 2. Large size of pin holes are developed at some places. 3. Trees like structures are formed at corner. 4. shining is good. 5. Sample send to CQAE(Met.) for testing.
10	10	05/07/2019	1. Current given 40 amp for 1hrs 30 minutes. 2. Add 400ml Organic catalyst in bath(ripple-0.00%) 2. After plating, etched the chrome plated test piece for 20second & then microscopic view. 3. Pin holes are developed but very small in number. 4. Very good result 5. It gave idea to use organic catalyst with high accelerated chrome salt & pulsed electro deposition technique.

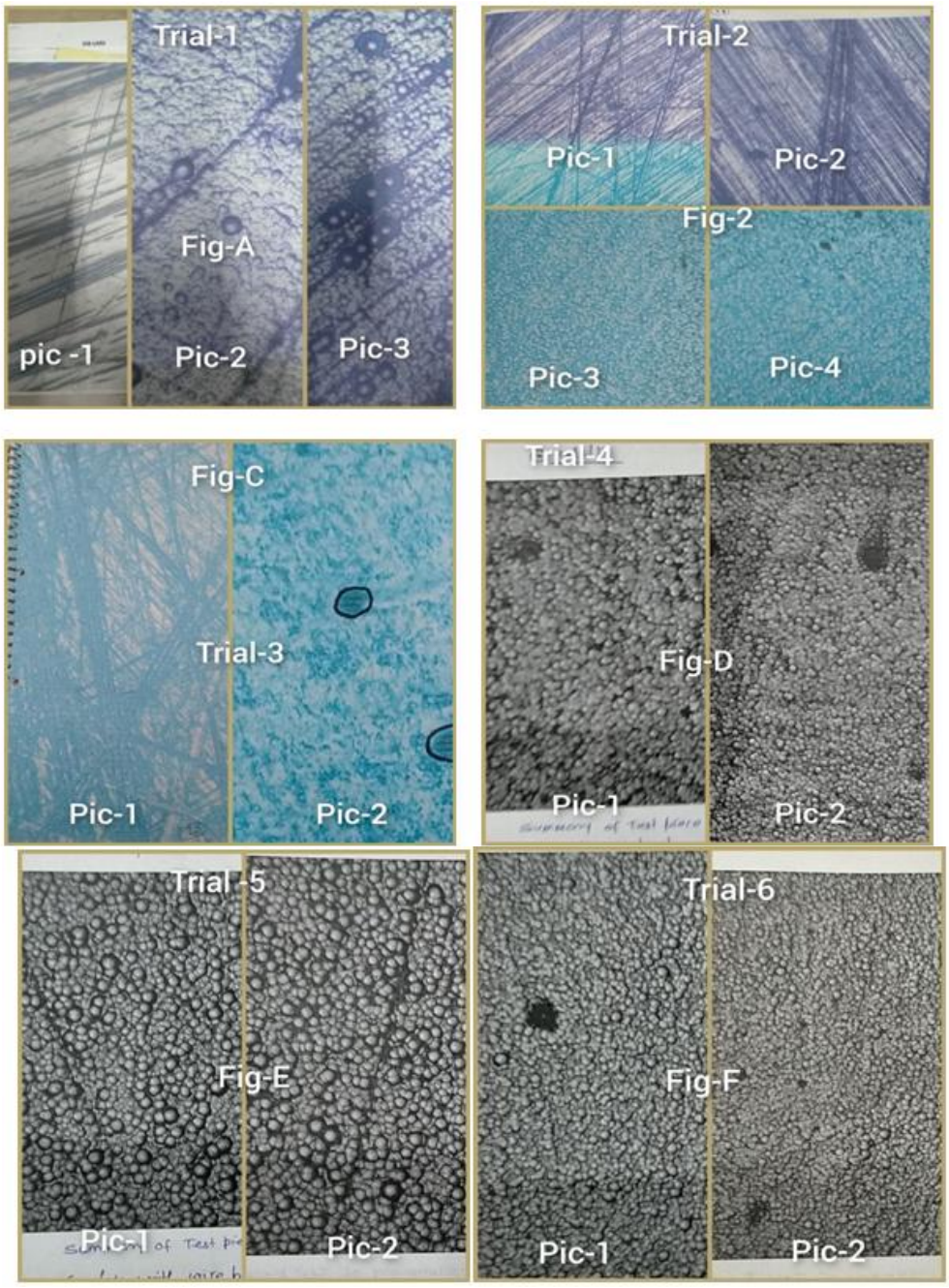
Trial-1
Fig-A
pic -1
Pic-2
Pic-3
Trial-2
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Fig-2
Pic-3
Pic-4
Fig-C
Trial-3
Pic-1
Pic-2
Trial-4
Fig-D
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Pic-2
Trial -5
Fig-E
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Pic-2
Trial-6
Fig-F
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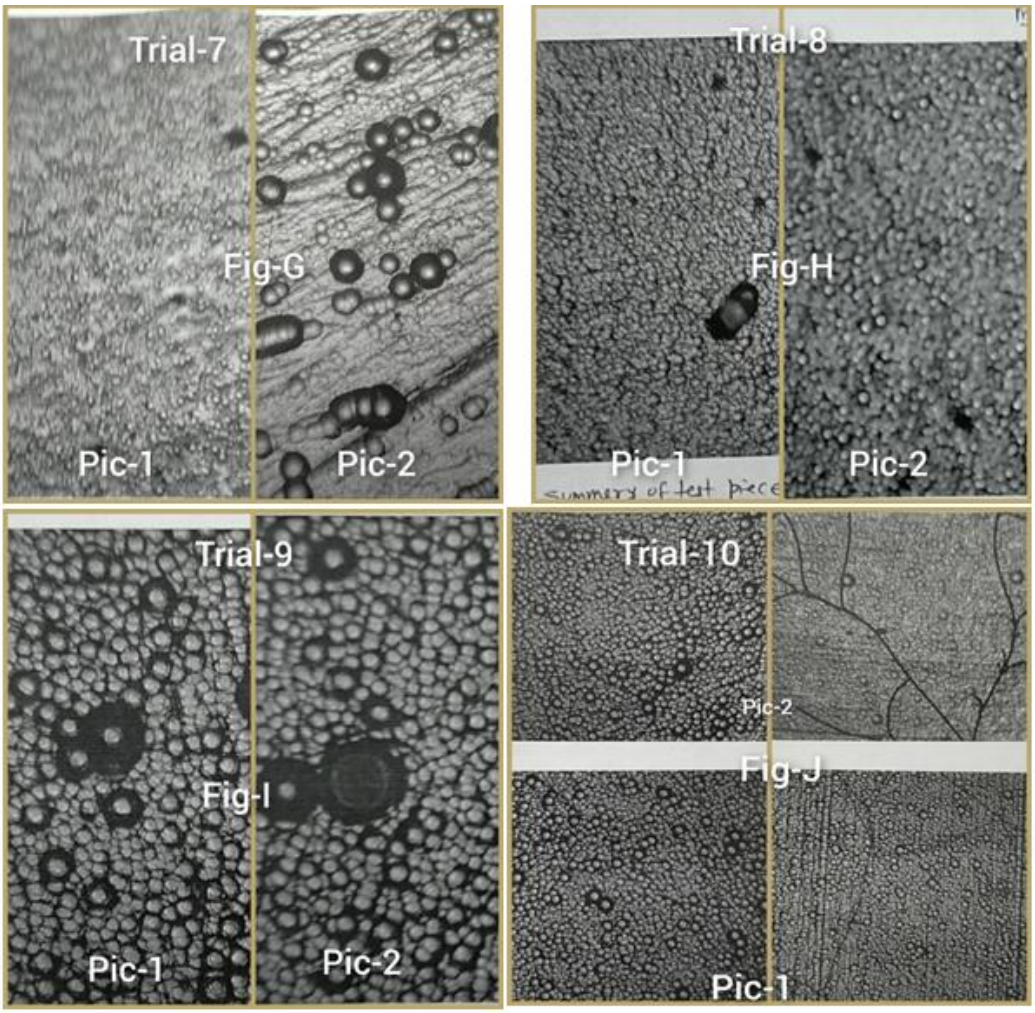


2. CONVENTIONAL CHROME PLATING WITH PULSE ELECTRODEPOSITION:

i. Chrome plating Tank composition as per LAB Report:

S.NO	INGRADIENT	VALUE IN g/l
01	Sulphate	2.41
02	Total Oxide	0.00
03	Iron Oxide	0.00
04	Trivalent chrome	0.00
05	Hexvalent chrome	276.73

II. Trial Report:

S.NO	TRIAL NO.	MODE	SPECIFIC VALUE	REMARK
01	00	CONVENTIONAL ROOT	CURRENT : 40AMP. TIME :2.00 HRS	FIG. 1 &2 10/11/2019
02	01	RF - NP	FWD CURRENT TIME: 30 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5mS TOTAL TIME:2.00HRS. CURRENT : 80AMP	FIG. 3 &4 11/11/2019(F/N)
03	02	RF - NP	FWD CURRENT TIME: 30 MIN. REVERSE CURRENT: TIME:10SEC DEAD TIME : O5mS TOTAL TIME:2.00HRS. CURRENT : 80AMP	FIG. 5 &6 11/11/2019(A/N)
04	03	RF - NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:10SEC DEAD TIME : O5mS TOTAL TIME:1.30HRS. CURRENT : 50AMP	FIG. 7 &8 12/11/2019(F/N)
05	04	RF - NP	FWD CURRENT TIME: 20 MIN.	FIG. 9 &10

			REVERSE CURRENT: TIME:20SEC DEAD TIME : O5mS TOTAL TIME:1.30HRS. CURRENT : 40AMP	12/11/2019(A/N)
06	05	RF-NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : 10mS TOTAL TIME:1.30HRS. CURRENT : 25AMP	FIG. 11 &12 13/11/2019(A/N)
07	06	RF-NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5mS TOTAL TIME:2.00HRS. CURRENT : 25AMP	FIG. 13 &14 14/11/2019(F/N)
08	07	RF-NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : 10mS TOTAL TIME:1.30HRS. CURRENT : 30AMP	FIG. 15 &16 14/11/2019(F/N)
09	08	RF-NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5mS TOTAL TIME:1.30HRS. CURRENT : 30AMP	FIG. 1 7&18 14/11/2019(A/N)
10	09	RF-NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5mS TOTAL TIME:2.00HRS. CURRENT : 40AMP	FIG. 19 &20 15/11/2019(F/N) TREES LIKE STRUCTURE ON CORNER
11	10	RF-NP	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5mS TOTAL TIME:1.30HRS. CURRENT : 50AMP	FIG. 21, 22 &23 15/11/2019(A/N) TREES LIKE STRUCTURE ON CORNER
12	11	RF-P	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5Ms FWD ON: 10mS REV ON: 02Ms Ref: OFF: 000mS TOTAL TIME:1.30HRS. CURRENT : 30AMP	FIG. 24 &25 15/11/2019(A/N) NO RESULT
13	12	RF-P	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5Ms FWD ON: 10Ms FWD OFF: 10mS REV ON: 10Ms Ref: OFF: 000mS TOTAL TIME:1.30HRS. CURRENT : 30AMP	FIG. 26 &27 16/11/2019(F/N) NO RESULT
14	13	RF-P	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5Ms FWD ON: 10Ms FWD OFF: 00mS REV ON: 10Ms Ref: OFF: 000mS TOTAL TIME:1.30HRS. CURRENT : 30AMP	FIG. 28 &29 17/11/2019(F/N)
15	14	RF-P	FWD CURRENT TIME: 20 MIN. REVERSE CURRENT: TIME:20SEC DEAD TIME : O5Ms FWD ON: 10Ms FWD OFF: 00mS REV ON: 00Ms Ref: OFF: 000mS TOTAL TIME:1.30HRS. CURRENT : 30AMP	FIG. 30 &31 18/11/2019

SUMMERY:

S.NO.	TRIAL NO.	DATE	OBSERVATION
01	00	10/11/19	1.Conventional bath 2.current given 40 amp. For 2:00 hrs. 3. Pin holes are developed. 4. Good shining. 5. Trees like structure are formed a corner.
02	01	11/11/19(F/N)	1.RF-NP 2. Current given 80 amp. For 2:00 hrs. 3.FWD:30min,REV:20Second,DEAD time:05mS 4.Pin holes are developed 5. Uniform surface area but dull plating. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8.Uniform plating on the perimeter of test piece which cannot be observed in normal plating. It is advantageous.
03	02	11/11/19(A/N)	1.RF-NP 2. Current given 80 amp. For 2:00 hrs. 3.FWD:30min,REV:10Second,DEAD time:05mS 4.Large size pin holes are developed 5. Uniform surface area but dull plating. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8.Uniform plating on the perimeter of test piece which cannot be observed in normal plating. It is advantageous.
04	03	12/11/19(F/N)	1.RF-NP 2. Current given 50 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS 4. size of pin holes are reduced. 5. Uniform surface area ,shining is better. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8.Uniform plating on the perimeter of test piece which cannot be observed in normal plating. It is advantageous.
05	04	12/11/19(A/N)	1.RF-NP 2. Current given 40 amp. For 1:30 hrs. 3.FWD:20min,REV:20Second,DEAD time:05mS 4. Size of pin holes are reduced more than of Trial No.-03. 5. Uniform surface area, shining is better. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8. Uniform plating on the perimeter of test piece which cannot be observed in normal plating. It is advantageous.
06	05	13/11/19(A/N)	1.RF-NP 2. Current given 25 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:10mS 4. More pin holes are developed after increasing dead time. 5. Uniform surface area ,dull plating. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8. Uniform plating on the perimeter of test piece which cannot be observed in normal plating. It is advantageous.
07	06	14/11/19(F/N)	1.RF-NP 2. Current given 25 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS 4. Large size of pin holes are developed.. 5. Uniform surface area ,shining is better. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8. Uniform plating on the perimeter of test piece which cannot be observed in normal plating. It is advantageous. 9. For better result following parameters to be maintained: FWD:20min.,REV:20second,DEAD time 05mS
08	07	14/11/19(F/N)	1.RF-NP 2. Current given 30 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:10mS 4. Large size of pin holes are developed.. 5. Uniform surface area, shining is better. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8. When dead time is 10mS, result is not better so next trial dead time will be 05mS. 9. Uniform plating on the perimeter of test piece which cannot be observed in normal

			plating. It is advantageous. 10. For better result following parameters to be maintained: FWD:20min.,REV:20second,DEAD time 05mS
09	**08***	14/11/19(A/N	1.RF-NP 2. Current given 30 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS 4. very low numbers of pin holes are developed 5. Uniform surface area, shining is better & good finishing. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased. 8. so, it is very fruitful & Next trial Point No. 2 & 3 will be constant.
10	**09***	15/11/19(F/N)	1.RF-NP (for recheck the process by increasing current density) 2. Current given 40 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS 4. **After increasing current from 30 amp to 40 amp, it observed that chrome plating deposited layer by layer but not cover pin hole areas.** 5. Uniform surface area, shining is better & good finishing. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased.
11	**10***	15/11/19(A/N)	1.RF-NP 2. Current given 50 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS 4. **After increasing current from 40 amp to 50 amp, it observed that chrome plating deposited layer by layer but not cover pin hole areas.** 5. Uniform surface area, shining is better & good finishing. 6. No trees like structure are formed at corner. 7. Coverage of chrome plating surface are increased.
12	11	15/11/19(A/N)	1.RF-P 2. Current given 30 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS FWD ON: 10mS,FWD OFF:02mS,REV ON: 10mS,REV OFF:00mS 4. No result
13	12	16/11/19(F/N)	1.RF-P 2. Current given 30 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS FWD ON: 10mS,FWD OFF:10mS,REV ON: 10mS,REV OFF:00mS 4. No result
14	13	17/11/19(F/N)	1.RF-P 2. Current given 30 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS FWD ON: 10mS,FWD OFF:00mS,REV ON: 10mS,REV OFF:00mS 4. Result improve but not satisfactory. 5. More large size pin holes are developed.
15	14	18/11/19(F/N)	1.RF-P 2. Current given 30 amp. For 1:30 hrs. 3.FWD:20min,REV:10Second,DEAD time:05mS FWD ON: 10mS,FWD OFF:00mS,REV ON: 00mS,REV OFF:00mS 4. Better result than trial no. -13. 5. More study are required to operate pulse mode.

III. Trial Report for CURVED SHAPE COMPONENT:

S.NO	TRIAL NO.	MODE	SPECIFIC VALUE	REMARK
01	01	RF - NP	FWD TIME: 20MIN. REV TIME : 20 SECOND TOTAL TIME: 3:00HRS CURRENT : 30AMP BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 19/11/19
02	02		FWD TIME: 20MIN. REV TIME : 20 SECOND TOTAL TIME: 3:00HRS CURRENT : 30AMP BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 20/11/19
03	03		FWD TIME: 20MIN. REV TIME : 20 SECOND TOTAL TIME: 3:00HRS	DATE: 21/11/19 SOME AREA IN INTRICATED PART ARE UNCOVERED, REWORK

			CURRENT : 30AMP BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	
04	04		FWD TIME: 20MIN. REV TIME : 20 SECOND TOTAL TIME: 3:00HRS CURRENT : 32AMP BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 22/11/19 SOME AREA IN INTRICATED PART ARE UNCOVERED, REWORK
05	05		FWD TIME: 20MIN. REV TIME : 20 SECOND TOTAL TIME: 4:00HRS CURRENT : 40AMP STRIKE: 10MIN. @50AMP. TIME: 3HRS50MIN.@40 AMP BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 23/11/19 IMPROVEMENT, UNCOVERED AREA REDUCED
06	06		FWD TIME: 20MIN. REV TIME : 20 SECOND TOTAL TIME: 4:00HRS CURRENT : 40AMP STRIKE: 10MIN. @50AMP. TIME: 3HRS05MIN.@40 AMP TIME: 45MIN.@45 AMP BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 2511/19 ALL AREA ARE COVERED

SUMMERY:

From trial no.-08 (14/11/19(A/N)) ,I got some important result such as: FWD Time: 20min.,REV time: 20second, Dead time: 05mS, so these parameters will constant in next all trials.

S.NO.	TRIAL NO.	DATE	OBSERVATION
01	01	19/11/19(F/N)	1.CURVED SURFACE COMPONENT 2.Current -30amp., ripple-0.00%RF-NP,Total time :03.00hrs. 3. very good result. 4. Some intricate areas are covered which was not possible in normal plating. 5. Components were not hanged in fixture , hanged by copper wire.
02	02	20/11/19(F/N)	1. CURVED SURFACE COMPONENT 2. Current -30amp., ripple-0.00%RF-NP,Total time :03.00hrs. 3. very good result. 4.Some intricate areas are covered which was not possible in normal plating. 5.Components were not hanged in fixture , hanged by copper wire.
03	03	21/11/19(F/N)	1. CURVED SURFACE COMPONENT 2. Current -30amp., ripple-0.00%RF-NP,Total time :03.00hrs. 3. very good result. 4.Some intricate areas are covered which was not possible in normal plating. 5.Components were not hanged in fixture , hanged by copper wire. 6. Some uncovered area in curve part is seen. 7. After rework desire output obtained.
04	04	22/11/19(F/N)	1. CURVED SURFACE COMPONENT 2. Current -32amp., ripple-0.00%RF-NP,Total time :03.30hrs. 3. very good result. 4.Some intricate areas are covered which was not possible in normal plating. 5.Components were not hanged in fixture , hanged by copper wire. 6. Some uncovered area in curve part is seen (same as trial-03). 7. After rework desire output obtained.
05	05	23/11/19(F/N)	1. CURVED SURFACE COMPONENT 2. Current -40amp., ripple-0.00%RF-NP,Total time :04.00hrs. Strike: 10 min.@50amp 3. Introduce a new anode to increase anode surface area of both side. 4. very good result. 5.Some intricate areas are covered which was not possible in normal plating. 6.Components were not hanged in fixture , hanged by copper wire. 7. Uncovered areas are decreased . 8. After rework desire output obtained.

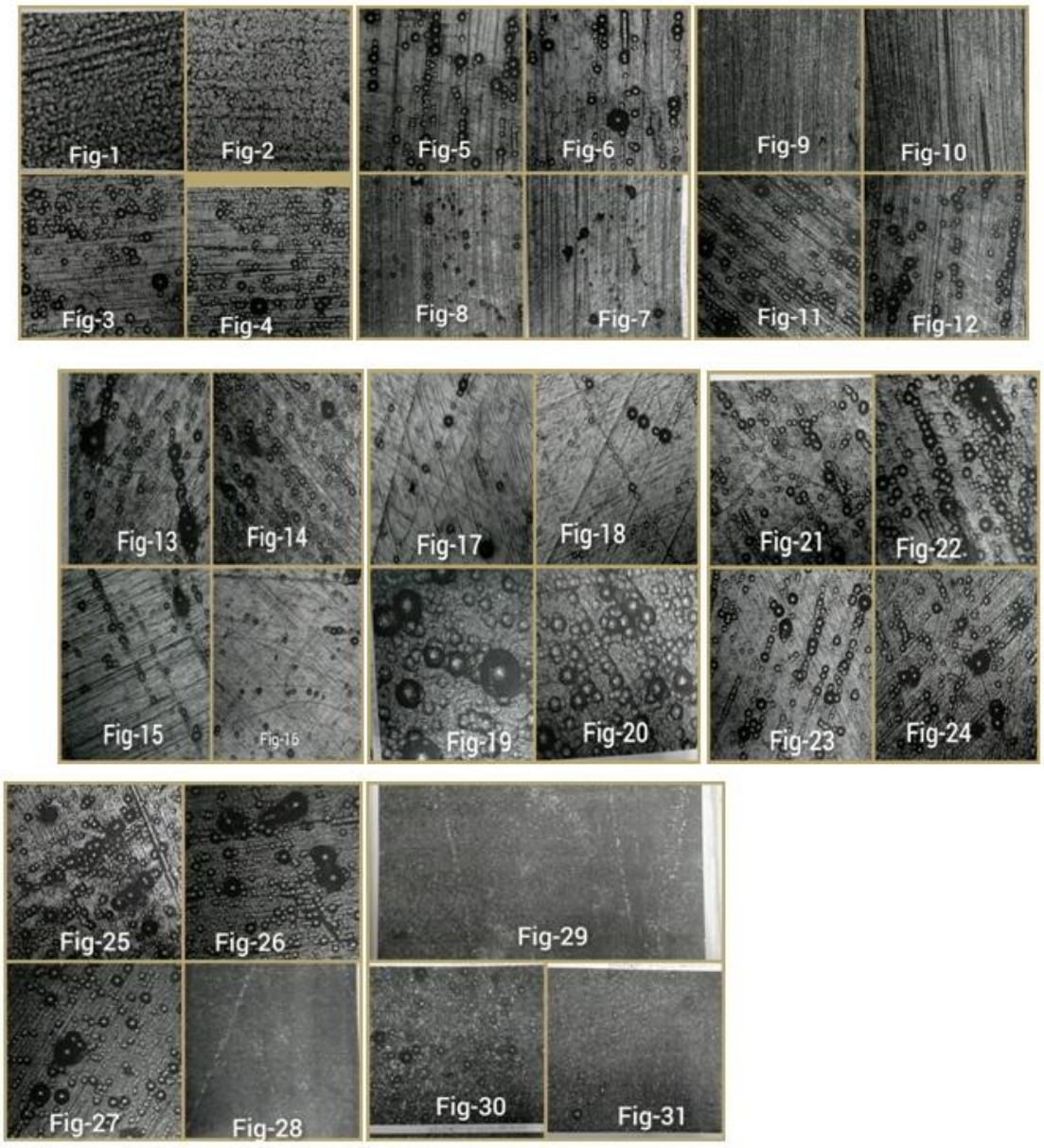
06	06	25/11/19(F/N)	1. CURVED SURFACE COMPONENT 2. Current -40amp., ripple-0.00%RF-NP,Total time :04.00hrs. Strike: 10 min.@50amp,then 3:05hrs@40amp.& finally 45 minutes@45amp 3. Introduce a new anode to increase anode surface area of both side. 4. very good result. 5.Some intricate areas are covered which was not possible in normal plating. 6.Components were not hanged in fixture , hanged by copper wire. 7. No uncovered area found 8. No need to rework.

IV. Trial Report for Cylindrical shape(Inside plating):

S.NO	TRIAL NO.	MODE	SPECIFIC VALUE	REMARK
01	01	RF NP	FWD TIME: 20MIN. REV TIME : 20 SECOND DEAD TIME: 05mS TOTAL TIME: 1:00HRS15 MIN CURRENT : 144AMP STRIKE: 10MIN. @240AMP. BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 26/11/19 BARREL NO.: J-09-19: Component NO. 4154 4160 4051 4130 4059 3998 4000 4055 CURRENT 18.1 18.3 18.0 18.5 18.0 18.2 18.0 17.9 BORE SIZE: 5.60 NOT GO OUTPUT: 08 Components REMARK ROUGHNESS SEEN INSIDE THE BORE
02	02	RF NP	FWD TIME: 20MIN. REV TIME : 20 SECOND DEAD TIME: 05mS TOTAL TIME: 1:00HRS20 MIN CURRENT : 144AMP STRIKE: 10MIN. @240AMP. BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE: 27/11/19 Component NO.: J-09-19: Component no. 4054 4110 4206 **4133** 4032 4193 4155 4177 CURRENT 18.5 18.0 18.2 17.8 18.0 18.7 18.0 18.2 BORE SIZE: 5.61NOT GO(BE), 5.60 NOT GO(ME) OUT PUT: 07 NOS. REMARK ROUGHNESS SEEN INSIDE THE BORE
03	03	FR NP	FWD TIME: 20MIN. REV TIME : 20 SECOND DEAD TIME: 05mS TOTAL TIME: 1:00HRS20MIN CURRENT : 144AMP STRIKE: 10MIN. @240AMP. BATH TEMP.(^{O}C): 55 RIPPLE : 0.00% UNIT : B-14(4) SPECIFIC GRAVITY(^{0}Be): 21	DATE:28/11/19 Componet NO.: J-09-19: Component NO. **3887*** 4115 4119 4291 **4116** **4139** 3947 4101 CURRENT 18.0 18.7 18.0 18.5 17.6 18.0 18.3 18.0 BORE SIZE: 5.60 NOT GOOUT PUT: 07 NOS. OUTPUT: 05 *WIRE MARK REMARK:ROUGHNESS REDUCED QUALITY IMPROVE

SUMMERY:

S.NO.	TRIAL NO.	DATE	OBSERVATION
01	01	26/11/19(F/N)	1.08 Nos. of Cylindrical component inside plating 2. Current -144amp., ripple-0.00%RF-NP,Total time :01.15hrs. Strike: 10 min.@240amp 3. Batch of 08 components(5.60 not go),output: 08Nos. 4. Roughness seen inside the bore
02	02	27/11/19(F/N)	1.08 Nos. of Cylindrical component inside plating 2. Current -144amp., ripple-0.00%RF-NP,Total time :01.20hrs. Strike: 10 min.@240amp 3. Batch of 08 components (5.61 not go from Breech end & 5.60 not go from muzzle end),output: 07Nos. 4. Roughness seen inside the bore
03	03	28/11/19(F/N)	1.08 Nos. of Cylindrical component inside plating 2. Current -144amp., ripple-0.00%FR-NP,Total time :01.20hrs. Strike: 10 min.@240amp 3. Batch of 08 components(5.60 not go),output: 05Nos. 4. No roughness seen inside bore 5. For barrel plating FR-NP mode is effective.



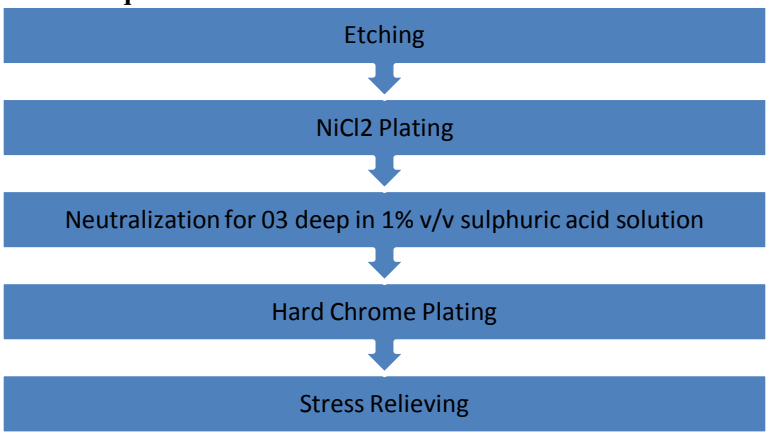
3. Conventional Chrome bath with Nickel Chloride activation:

i. Chrome plating Tank composition as per LAB Report: B14(4)

S.NO	INGRADIENT	VALUE IN g/l	REMARK
01	Sulphate	2.65	Tank No. – B14(3) 11/LAB/SAF DTD.: 20/01/21
02	Total Oxide	5.00	
03	Iron Oxide	1.40	
04	Trivalent chrome	3.30	
05	Hexvalent chrome	260.39	

II. Trial Report:

Process Sequence:



NiCl2 Plating:

i. Bath Capacity: 05 Litre

ii. Bath Composition :

NiCl2 : 200g/l

HCl(Conc.) : 100g/l

Make up in water

iii. Process Parameter:

Temperature : Room Temperature

Current : 8 – 10 Volt

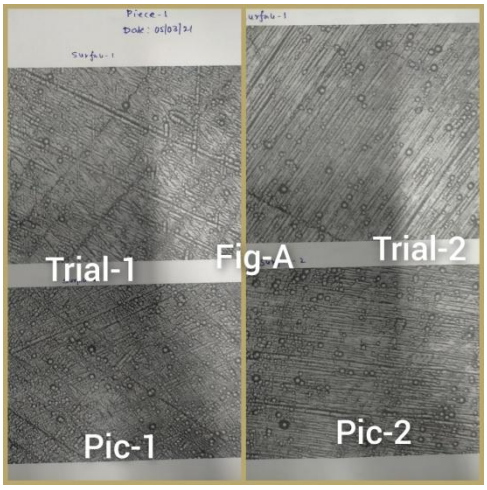
Time : 1 – 1.5 Minutes

iv. Component

Test Piece circular in shape

v. Hard Chrome Plating:

S.NO	TRIAL NO.	MODE	SPECIFIC VALUE	REMARK
01	01	CONVENTIONAL ROOT	CURRENT : 35AMP. TIME : 01 hrs30minutes	FIG. (a)1 05/03/2021
02	02	CONVENTIONAL ROOT	CURRENT : 35AMP. TIME : 01 hrs30minutes	FIG. (b)1 05/03/2021



SUMMERY:

S.NO.	TRIAL NO.	DATE	OBSERVATION
01	01	05/03/21	1.Conventional bath 2.current given 35 amp. For 1:30 hrs. 3. Pin holes didn't develop. 4. Good shining. 5.No any trees like structure are formed a corner.
02	02	05/03/21	1.Conventional bath 2.current given 35 amp. For 1:30 hrs. 3. Pin holes didn't develop. 4. Good shining. 5.No any trees like structure are formed a corner.

4. Practical trial of resin for removal of

(i) Tri chrome & Iron impurities from chrome solution

(ii) Removal of iron impurities from phosphating solution

By ion exchange method.

PRINCIPAL:

A. Purolite ion exchange chromic acid recovery process: The rinse water is first pumped through purolite INC11106PPH resin in the hydrogen form (RH) to remove metallic impurities (M^{+++}) such as chromium (Cr^{+++}) & iron(Fe^{+++}). This is necessary to avoid precipitation of metallic hydroxide in the subsequent anion exchange bed.

RESOURCES REQUIRED:

1. Resin for chrome solution
2. Resin for phosphating solution
3. Burrate (02 Nos.)
4. Glass wool
5. Beaker
6. Chrome solution to be treated
7. Phosphating solution to be treated
8. PPES for safety

LAB Report before trial -01 (11/LAB/SAF , dtd: 05/02/2020)

Chrome Solution (B-11)

S.No.	Ingredients	Range(g/l)	Result(g/l)
01	Sulphate	2.25 – 2.75	2.30
02	Total oxide	0 – 38	13.0
03	Iron oxide	0 – 20	4.20
04	Trivalent	0 - 18	5.55
05	Hexavalent	225 - 275	236.71

LAB report ofPhosphating Solution(T-1, 11/LAB/SAF dtd: 04/02/2020):

S.NO.	Ingradients	Range	Result
01	Normality	0.35N – 0.45N	0.19N
02	Iron Content	0.056 – 0.3 g/l	0.14g/l
03	PH	--	3

OUR REQUIREMENT:

1. Iron & trivalent chrome contents to be removed without changing other ingredients.
2. Iron content to be removed without changing other ingredients.

Practical trial-01 : (06/02/2020,F/N)

A. Sequence for Chrome solution:

I. Took two nos. of burret & fix it into stand. Glass wool has been inserted into it for tightly packing of lower side.

II. Fill the resin in both burret and marked it as stage-01 & stage-02

III. For stage -01

a. Pass the D.M. water from the top of the burret for cleaning , repeat it 2 to 3 times.

b. Put a empty beaker(Marked stage-01) beneath the bottom of the burret & pass the chrome solution very slowly.

c. After collection of output in beaker send it for testing.

IV. For stage -02

a. Pass the D.M. water from the top of the burret for cleaning , repeat it 2 to 3 times.
b. Put a empty beaker(Marked stage-02) beneath the bottom of the burret & pass the chrome solution of the output of stage-01 very slowly.
c. After collection of output in beaker send it for testing.

LAB Report of Stage -01(11/LAB/SAF dtd: 10/02/2020):

S.No.	Ingredients	Range(g/l)	Result(g/l)
01	Sulphate	2.25 – 2.75	4.28
02	Total oxide	0 – 38	14.0
03	Iron oxide	0 – 20	3.21
04	Trivalent	0 - 18	6.93
05	Hexavalent	225 - 275	250.05

LAB Report of Stage -02(11/LAB/SAF dtd: 10/02/2020):

S.No.	Ingredients	Range(g/l)	Result(g/l)
01	Sulphate	2.25 – 2.75	5.75
02	Total oxide	0 – 38	.05
03	Iron oxide	0 – 20	0.14
04	Trivalent	0 - 18	0.43
05	Hexavalent	225 - 275	141.69

B. Sequence for Phosphating solution:
V. Took one nos. of burret & fix it into stand. Glass wool has been inserted into it for tightly packing of lower side.
VI. Fill the resin in burret and marked it as Phosphating solution
VII. Phosphating solution
a. Pass the D.M. water from the top of the burret for cleaning , repeat it 2 to 3 times.
b. Put a empty beaker(Marked Phosphating solution) beneath the bottom of the burret & pass the Phosphating solution very slowly.
c. After collection of output in beaker send it for testing.

LAB report ofPhosphating Solution(11/LAB/SAF dtd: 07/02/2020):

S.NO.	Ingradients	Range	Result
01	Normality	0.35N – 0.45N	0.17N
02	Iron Content	0.056 – 0.3 g/l	0.0056g/l
03	PH	--	3

Figure 1 : Chrome solution (left side);Phosphating solution (right Side)

4. ELECTRODYALISIS METHOD FOR REMOVING IMPURITIES OF CHROME SOLUTION BATH:

Chrome Purifying system is a unique electrolytic separation technique based on electro-dialysis using diaphragm for the removal of impurities (such as iron, copper, nickel, aluminum, Trivalant Chrome and zinc etc.) and also re-oxidize trivalent chrome from all types of chrome plating solutions including hard chrome and decorative chrome plating baths. The main advantage of this chrome purifier is that it can be operated continuously with the plating process thereby allowing continuous removal of metallic impurities and oxidation of Cr (III). Therefore, there is no need to dump the Chrome solution for reducing the impurities as the impurities are continuously removed.

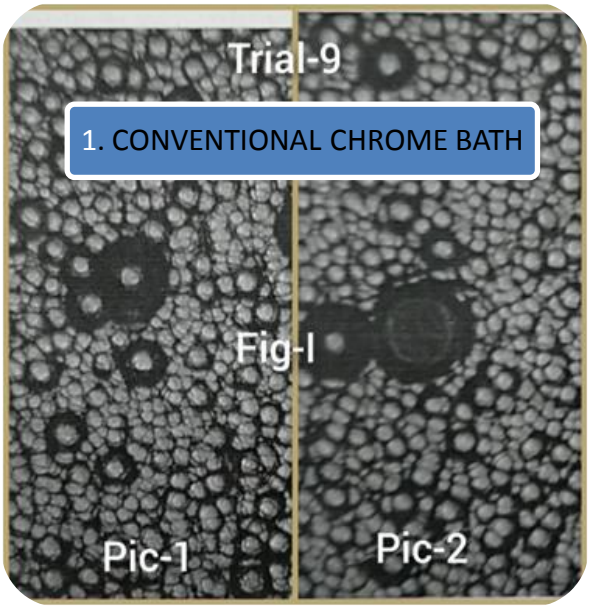
Technology: Metallic impurities such as Fe , Cu compartment. Cations are reduced at the cathode and hydrogen evolution occurs, raising the pH of the catholyte. As the concentration of hydroxyl ion (OH) increases inside the diaphragm resulting into the metal hydroxides to precipitate in the cathode chamber.

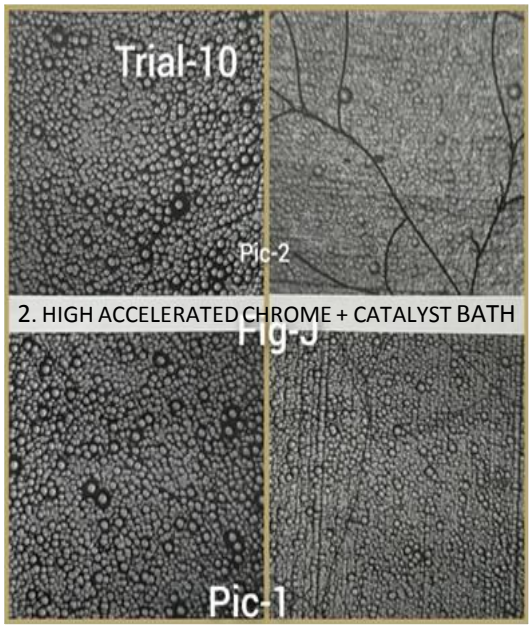
Problems faced when the level of metallic impurities gets too high.

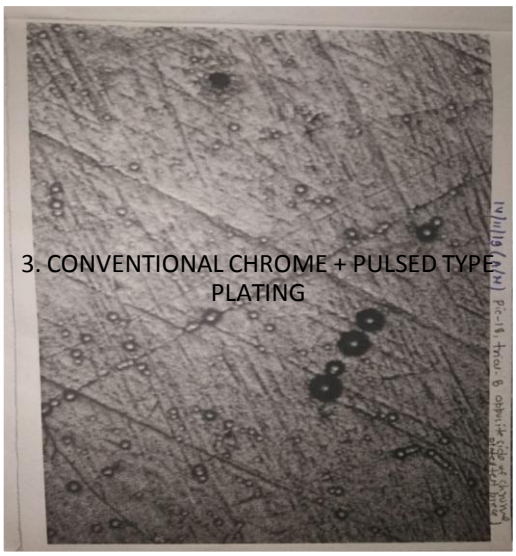
1. Rough or Nodular deposit.
2. Reduction in Cathode Efficiency.
3. Deposit Dull.
4. Reduction in plating rate.
5. Increase of electricity consumption as high voltage is required to give the desired Amps.
6. Reduction of Bright Range.
7. Reduction in covering power.
8. More variation in deposit thickness (Dog-bone Effect).
9. Tendency of peeling off.
10. Increased tendency for burning.
11. Pitted deposit.

III. CONCLUSION

1. For comparison of four pictures (Pic-1,2,3 & 4 given below)it is observed that Ni- Cr plating is much better than other , less pin hole has been created.





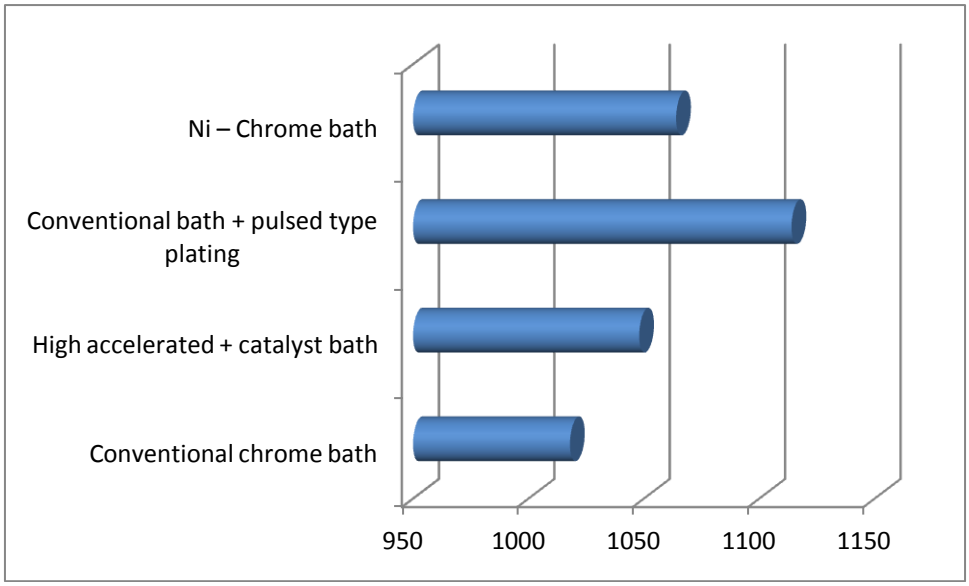


i. Comparison of microstructure

S.No.	Process	Microstructure
01	Conventional chrome bath	More nos.& large size pin holes are developed
02	High accelerated + catalyst bath	Comparatively less nos. & small size pin holes are developed
03	Conventional bath + pulsed type plating	Very less nos.& very small size pin holes are developed
04	Ni – Chrome bath	Very, very less nos. & dot type size pin holes are developed

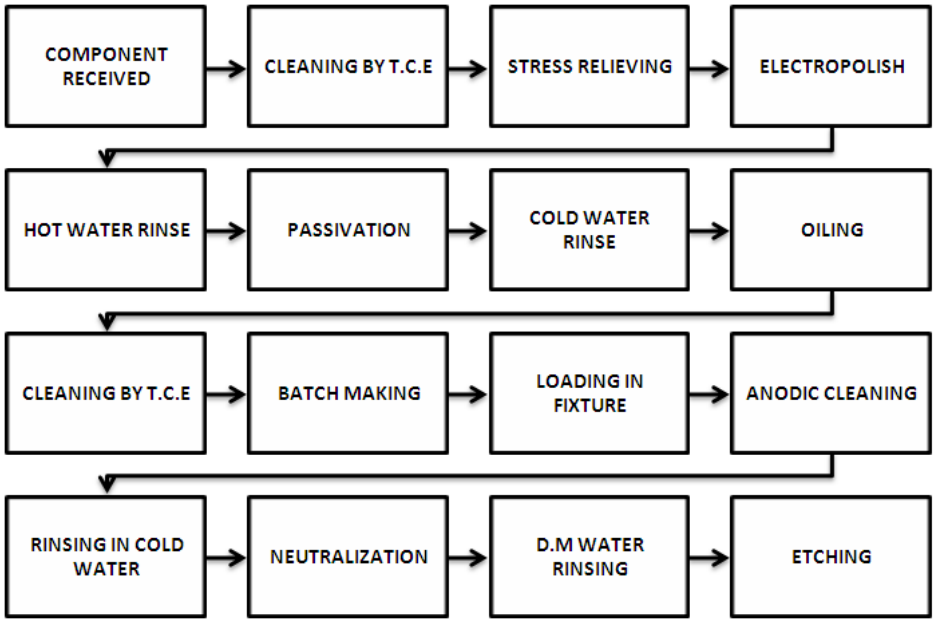
2. Hardness:

S.No.	process	Hardness(Average Micro Vickers Hardness on Chrome plating in HV0.1 Kg; as per IS:1501;Pt-1:2013)
01	Conventional chrome bath	**1018**
02	High accelerated + catalyst bath	**1048**
03	Conventional bath + pulsed type plating	**1114**
04	Ni – Chrome bath	**1064**

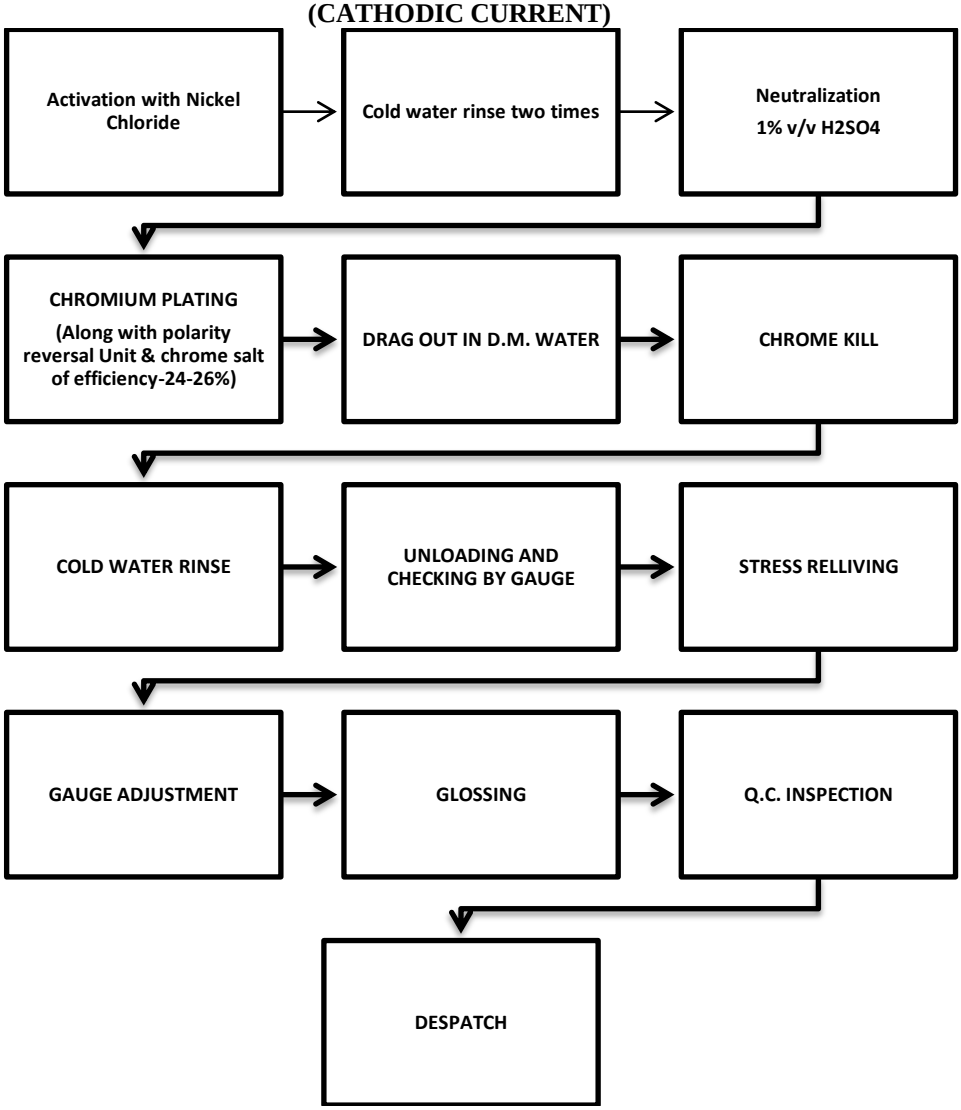


3. Following process sequence should be used as given below.

BLOCK DIAGRAM
(ANODIC CURRENT)



BLOCK DIAGRAM:
(CATHODIC CURRENT)



4. To minimize impurities in chrome solution tank, purifier based on electrodyalisis method should be used. Ion exchange method (resin based) doesn't give fruitful result.

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