TO IDENTIFY CAUSES AND REMEDY OF CORROSION AND EROSION ON INJECTION SCREW OF PLASTIC MOULDING EQUIPMENT

Project:- IDP

Group No :- ME-04

Team ID :- 8775

Guided By :-

Prof. M. D. Patel

(Department of Mechanical)

Prepared By :-

Vaghela Mehulsinh B.(11ME58)
Prajapati Mehul M. (11ME71)
Prajapati Pratik P. (11ME70)
Patel Sagar C. (D12ME23)

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Introduction

Fig 1- Plastic injection molding machine [13]

- Injection Screw is part of Plastic Injection Moulding Machine.

- It is use for feed melt plastic raw material.

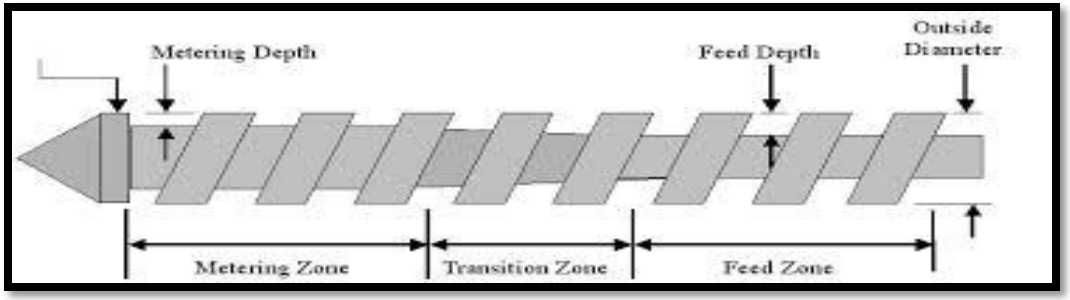


Fig-2 Injection screw [13]

Project Definition

- Injection screw is made of EN41B steel material.
- Nitriding on Injection screw.
- Corrosion & Erosion problem produce on Injection screw, when PVC raw material use in injection molding machine.
- When CPVC (Chlorinated polyvinyl chloride) material use then more corrosion & erosion problem produce on Injection screw.

Fig-3 corrosion part of injection screw.[15]

Fig- 4 corrosion part of injection screw.[15]

Objectives of the Present Investigation

- Reduce corrosion problem
- Reduce erosion problem
- Prevent function of Injection screw
- Prevent quality of plastic product

Causes of Corrosion and erosion on injection screw

- Temperature affect on steel.
- Acid is also affect on steel.
- Chlorine is more responsible corrosion Produce on steel- alloy. [11]

Ways of solution for reduce corrosion and erosion problem

1. HDPE Process

2. Suitable coating to resist corrosion and erosion

3. Heat treatment Process

HDPE (High Density Polyethylene) Process [12]

- There is many way to clean the screw after processing to protect its function.
- Out from that HDPE process is more efficient.
- The moulding machine's barrel zone temperature should be around 200º C to begin the purging process. Fractional melting High Density Polyethylene(HDPE) is used as a purging compound.
- By this Process to reduce store Chlorine on Surface of injection screw.

fig-5 Types of cleaning screw [12]

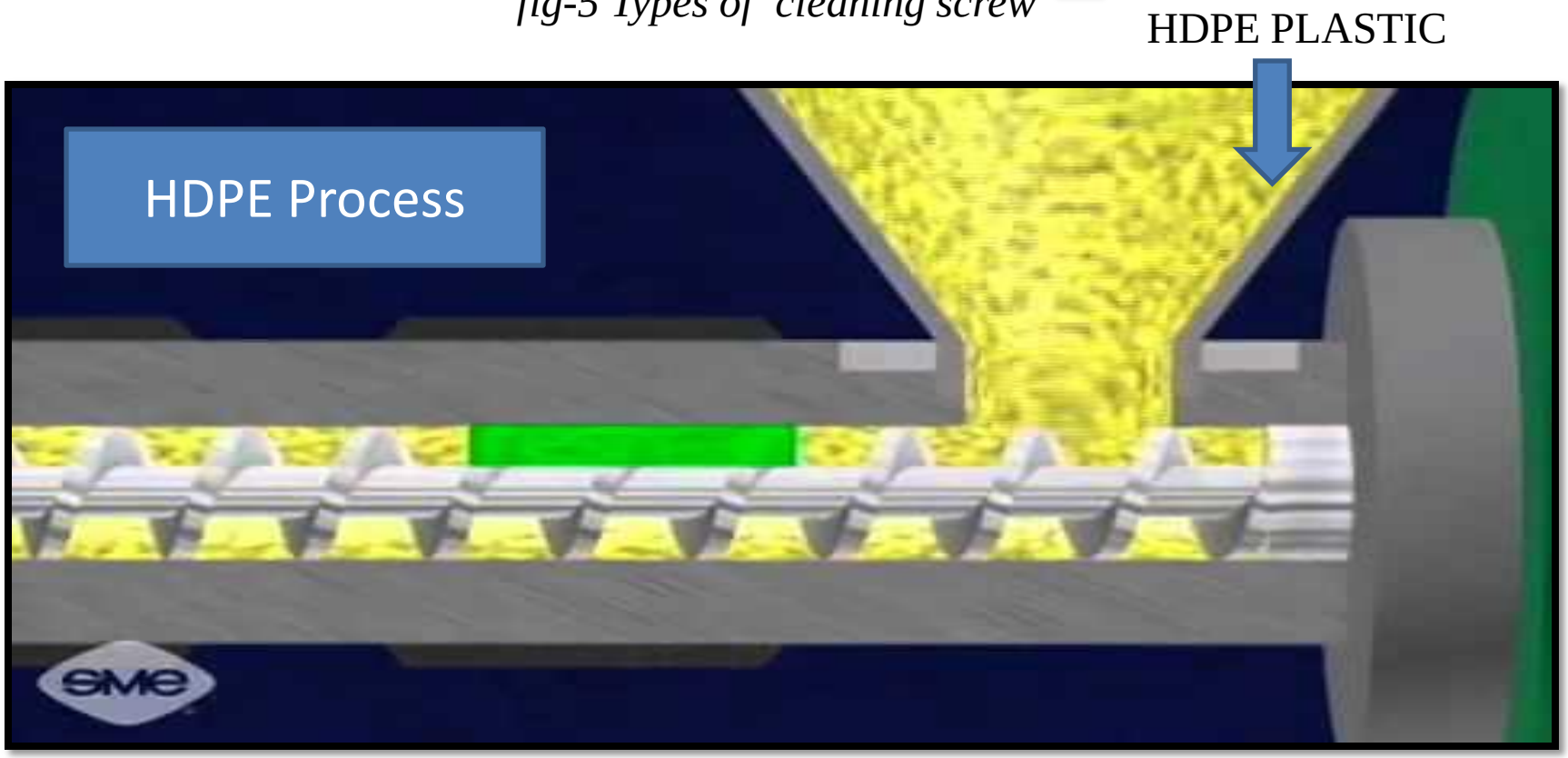


fig-6 HDPE process for cleaning screw [16]

Types of coating [3]

- There are many types of coating available.
- But, for both wear and corrosion resist coating is

  1.WC(Tungsten carbide) coating

  2.CrN(chromium nitride) coating

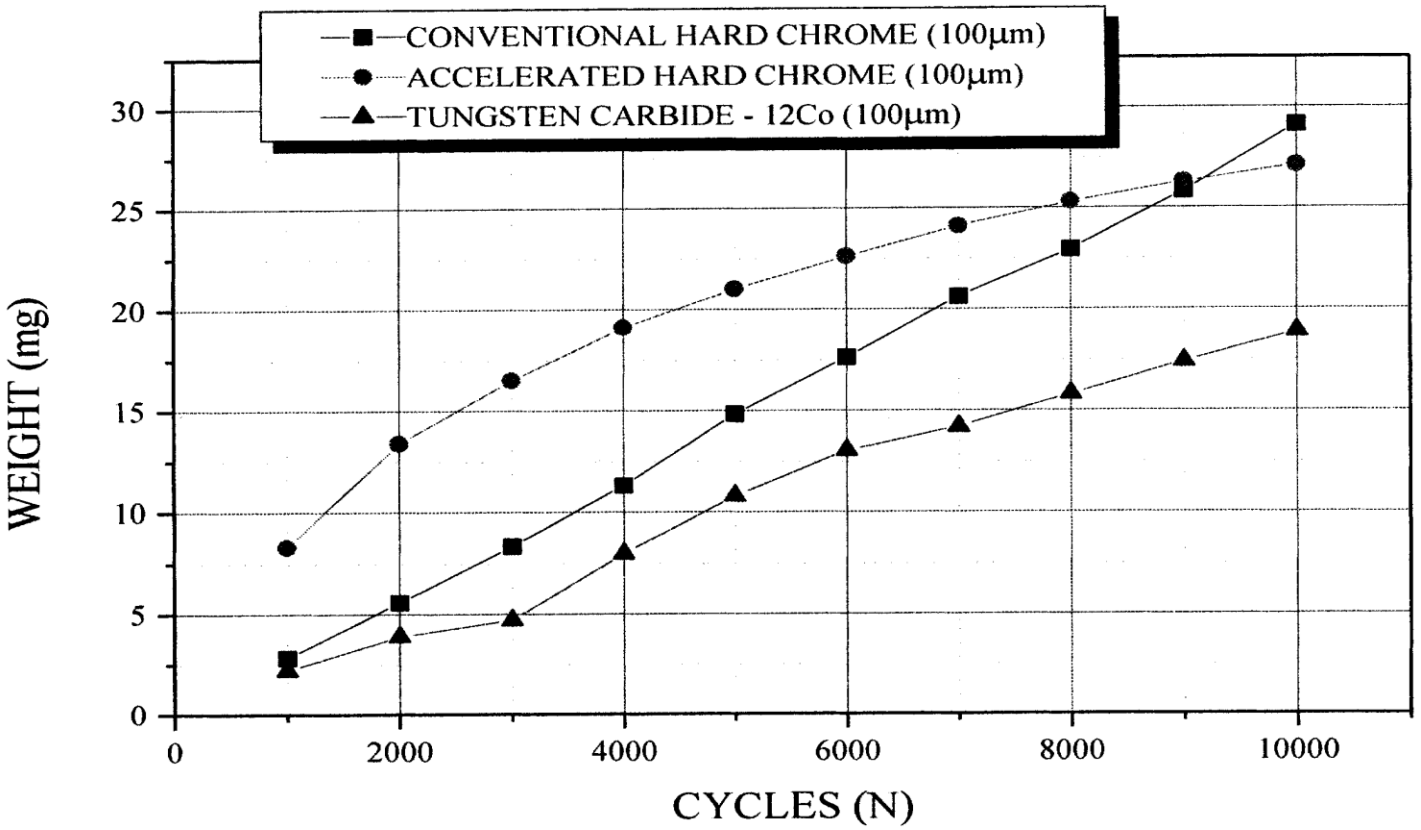
  3.Hard chrome plate coating

  4.Ceramic coating

WC(Tungsten carbide) coating [2]

- The coatings have very high bond strengths, fine as-sprayed surface finishes and low oxide levels.
- The highest level of micro hardness achieve by WC coating.
- The wear resistant strongly depends on the internal micro-structure of coatings. The nanometric features contributes to the increase of surface smoothness of coatings and increase the resistance against the wear.

[3]



•The weight loss per cycles on surface of material is less in tungsten carbide.

•Tungsten carbide coating is more resist for wear or erosion and corrosion.

[5]

CrN(Chromium nitride) coating

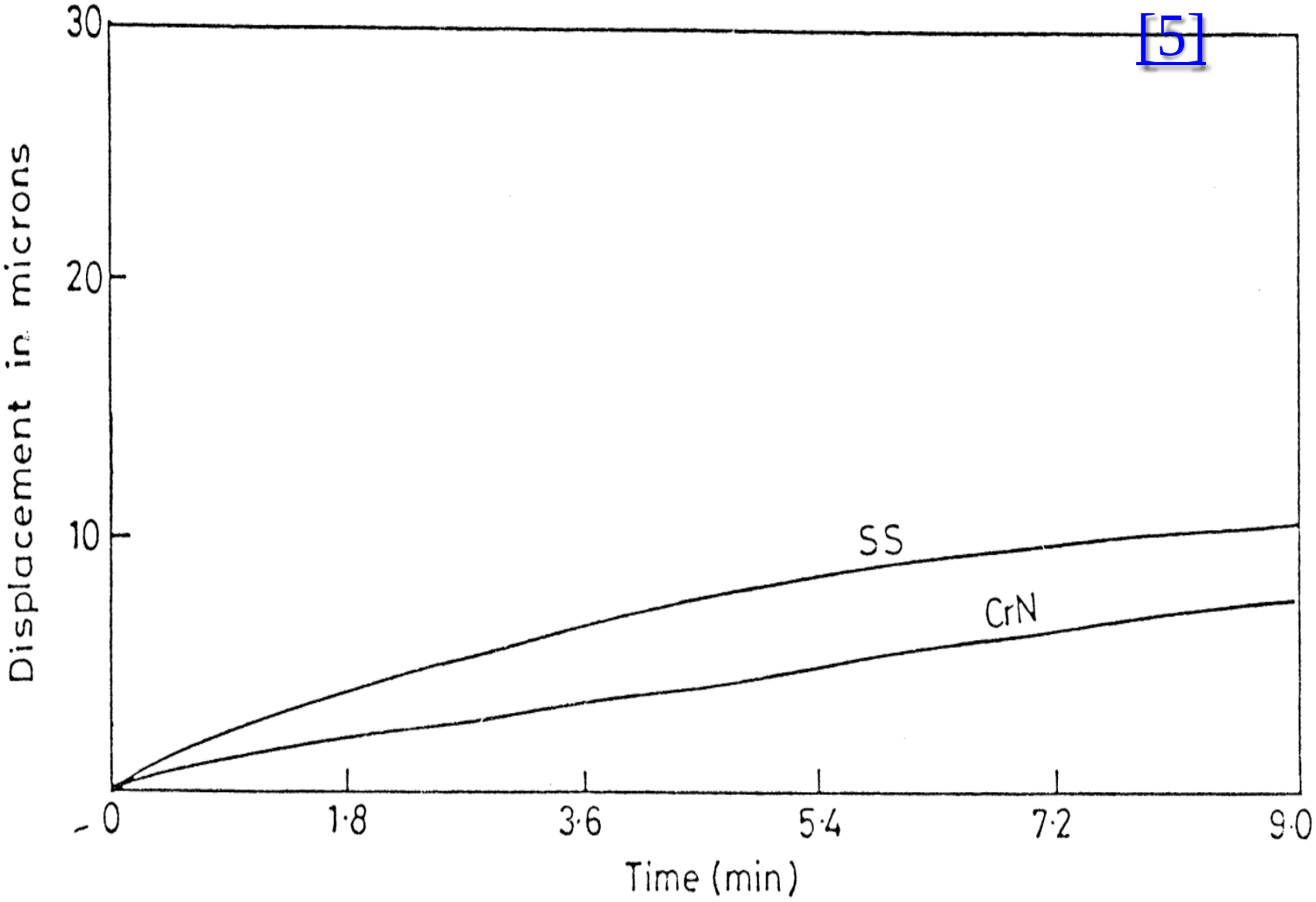
- The material with important consideration CrN has shown to be a promising coating for higher hardness, good adhesion and wear protection.

- The Cr-N composite due to higher hardness, wear resistance and anticorrosion characteristics is widely used in cutting tool, aero space and industrial fields.

- Chromium nitride-coated stainless steel substrate showed that the chromium nitride coating is uniform.

- In CrN coating stainless steel Corrosion rate is low compare than simple stainless steel.

[5]



Wear trend for SS and CrN coating. loads0.5 kg, Velocity 0.5 m/s.

Induction Hardening [8]

- Induction hardening is one of the Heat Treatment process. Induction hardening are generally use for the families of steels carbon alloy.

- Part to be hardened need to be heated. induction hardening is generally used for very heavy cases in the range of approximately 1.2 to 6 mm.

- In the induction heater, the specimen is pre-heated first, and then heated and quenched by water spray to form a hard case. Then the hardness and micro-structures are evaluated and compared at various levels of operations.

[9]

- In induction hardening , the hardness value is Rc57 with the case of depth 2mm (Rockwell Hardness in C-Scale).which is higher compare to hardness value Rc34 in forging.

- For achieving higher hardness, minimum air gap between job and coil, and subsequent super cooling is required.

- It is essential to mention that the electromagnetic induction is a method of heating of electrically conductive materials, as during heat treatment of metals. It is quick, easy, quite safe, clean, time saving, material saving, energy saving method of heating process.

Literature Review

Sr.	Title	Investigator	Remarks
1	Oxidation resistance of TiN, CrN, TiAlN and CrAlN coatings deposited by lateral rotating cathode arc	Y.C. Chim , X.Z. Ding , X.T. Zeng, S. Zhang. [1]	• With the incorporation of TiAlN and CrAlN coatings showed better oxidation resistance as compared to TiN and CrN on stainless steel.
2	The wear resistance of thermal spray the tungsten and chromium carbides coatings	M.W. Richert. [2]	•The wear mechanisms also depending on the roughness of the coating face. •The nanometric features contributes to the increase of surface smoothness of coatings and increase the resistance against the wear.

Sr.	Title	Investigator	Remarks
3	Effects of tungsten carbide thermal spray coating by HP_HVOF and hard chromium electroplating on AISI 4340 high strength steel	Marcelino P. Nascimento, Renato C. Souza, Ivancy M. Miguel, Walter L. Pigatin, Herman J.C. Voorwald.[3]	•Both(WC-co & hard chromium) coatings completed the test (salt spray test) of 72 h with full corrosion. For the HVOF tungsten carbide coating, a better corrosion resistance was observed after sealing application before testing.
4	Influence of tungsten carbide particle size and distribution on the wear resistance of laser clad WC/Ni coatings	K. Van Acker, D. Vanhoyweghen, R. Persoons, J. Vangrunderbeek.[4]	•The wear resistance reaches a maximum for the highest concentration of WC carbides and is more than 200 times better than the pure Ni matrix coating.

Sr.	Title	Investigator	Remarks
5	Effect of chromium nitride coating on the corrosion and wear resistance of stainless steel	Jacek Jagielski, A.S. Khanna, Jacek Kucinski, D.S. Mishra, P. Racolta. [5]	•Hardness of the chromium nitride-coated material are higher than the base steel material. It is interesting to note that corrosion rate was 4000 times less than the base alloy.
6	Effect of nitrogen flow rate on properties Of CrN films Prepared by HCD-gun	A.J. Novinrooz, H. Seyedi. [6]	•The micro hardness behaviour of CrN compound was affected by nitrogen gas flow rate. •The wear resistance test was accomplished by allowing the grinding wheel scratch and removes the surface. It was found the high flow rate of nitrogen, leads to higher value of wear resistance.

Sr.	Title	Investigator	Remarks
7	Introduction to Surface Hardening of Steels	Michael J. Schneider. [7]	•Flame and induction hardening are generally limited to certain families of steels, such as medium-carbon steels, medium-carbon alloy steels, some cast irons, and the lower-alloy tool steels. •The benefits of induction hardening are faster process, energy efficiency, less distortion.
8	Development of induction surface hardening process for small diameter carbon steel specimens	Daisuke Suzuki, Koji Yatsushiro, Seiji Shimizu, Yoshio Sugita. [8]	•Result of heat treatment for 6mm in diameter specimens, the hardened zone depth was about 0.4mm and hardness value was about 55Rc near the surface.

Sr.	Title	Investigator	Remarks
9	Effect of induction hardening On high carbon steel forgings	Subir Danda. [9]	•Thus a case induction hardening with hardness 57 Rc is the ultimate result. It is quick, easy, quite safe, clean, time saving, material saving, energy saving method of heating process yield higher production rates. •Hence in near future, the induction hardening is going to be the most superior heat treatment process rather than the others.
10	Synthesis of Commercial-Scale Tungsten Carbide-Cobalt (WC/Co) Nanocomposite Using Aqueous Solutions of Tungsten (W), Cobalt (Co), and Carbon (C) Precursors	T. Danny Xiao, Xinglong Tan, Maozhong Yi. [10]	•The WC grains in the consolidated parts are being ~200 - 300 nm average, with Co phase uniformly distributed in the WC grain boundaries.

Experimental Reading of test

- Material of EN41B stainless steel alloy
- Induction hardening
- WC(Tungsten carbide) coating
- Corrosion testing

Material of EN41B stainless steel alloy

- Three Rounds bar EN41B Stainless steel material
- Dimension- φ50mm dia. And 50mm length.
- Cutting and Turning Operation done on EN41B specimen.

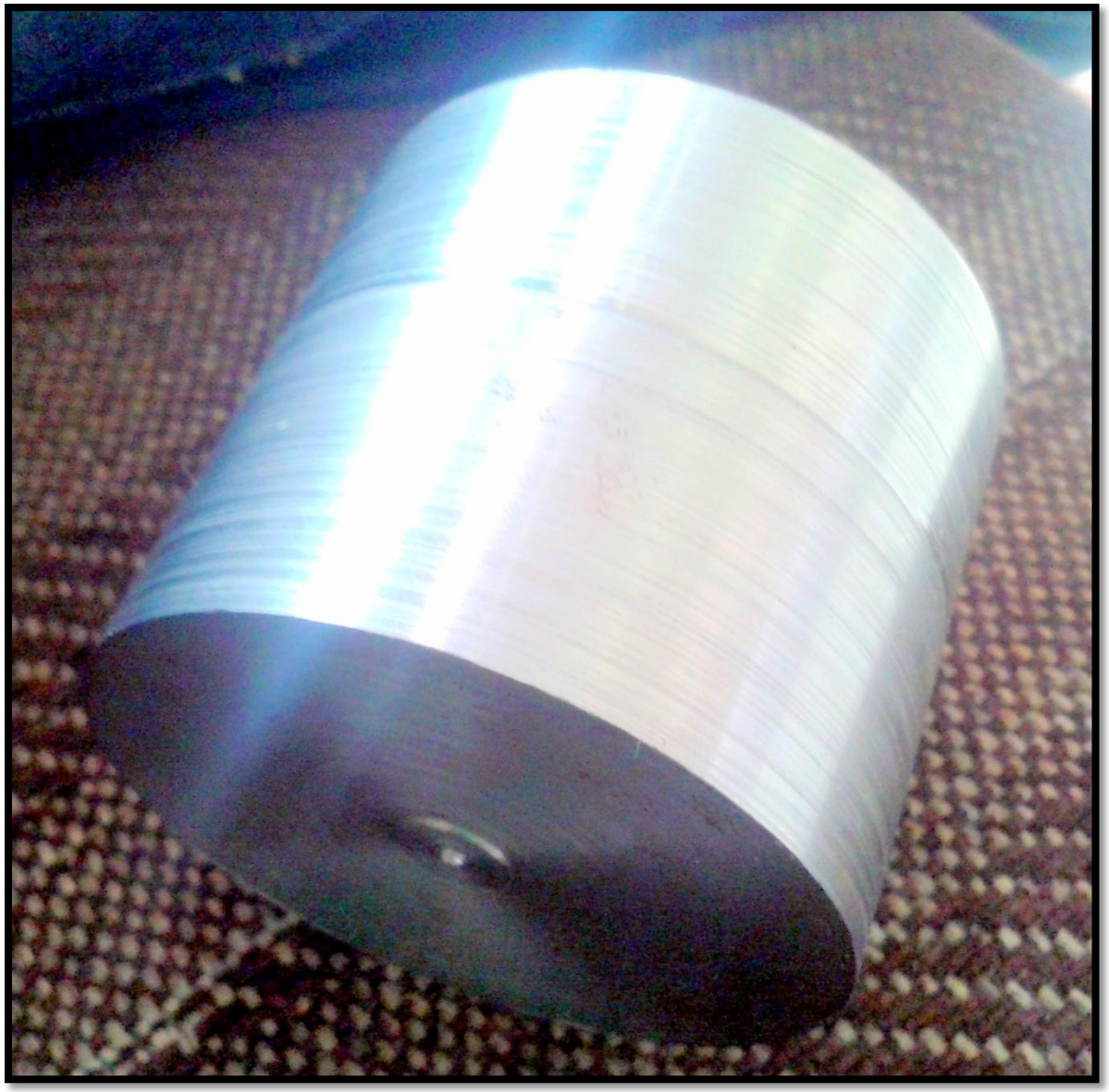


Fig-9 After turning process EN41B Specimen

Induction hardening

- Induction hardening is apply on one specimen.
- Induction hardening is applying 3mm depth on surface of EN41B specimen. Simple specimen has hardness 20 to 22 Rc(Rockwell hardness C-scale)

➢ Heat treatment condition

- Dip Quenching- water cooled
- After, Hardness measure- 45 to 50 Rc(Rockwell hardness C-scale).

[16]

Fig-10 Induction Hardening Machine UM-Series

Fig-11 Induction Hardening EN41B specimen

WC(Tungsten carbide) coating

- After, WC coating is apply on induction hardening EN41B specimen and simple EN41B specimen.

- Coating layer thickness- 250μm to 300 μm.

- WC coating is applying by HVOF(high velocity oxygen fuel) method.

Fig-12 Induction Hardening and WC coating EN41B specimen

Fig-13 WC coating EN41B specimen

Corrosion testing

- After that corrosion test apply on all three EN41B specimen.
- **ASTM B117 Salt Spray Testing** corrosion test.

[18]

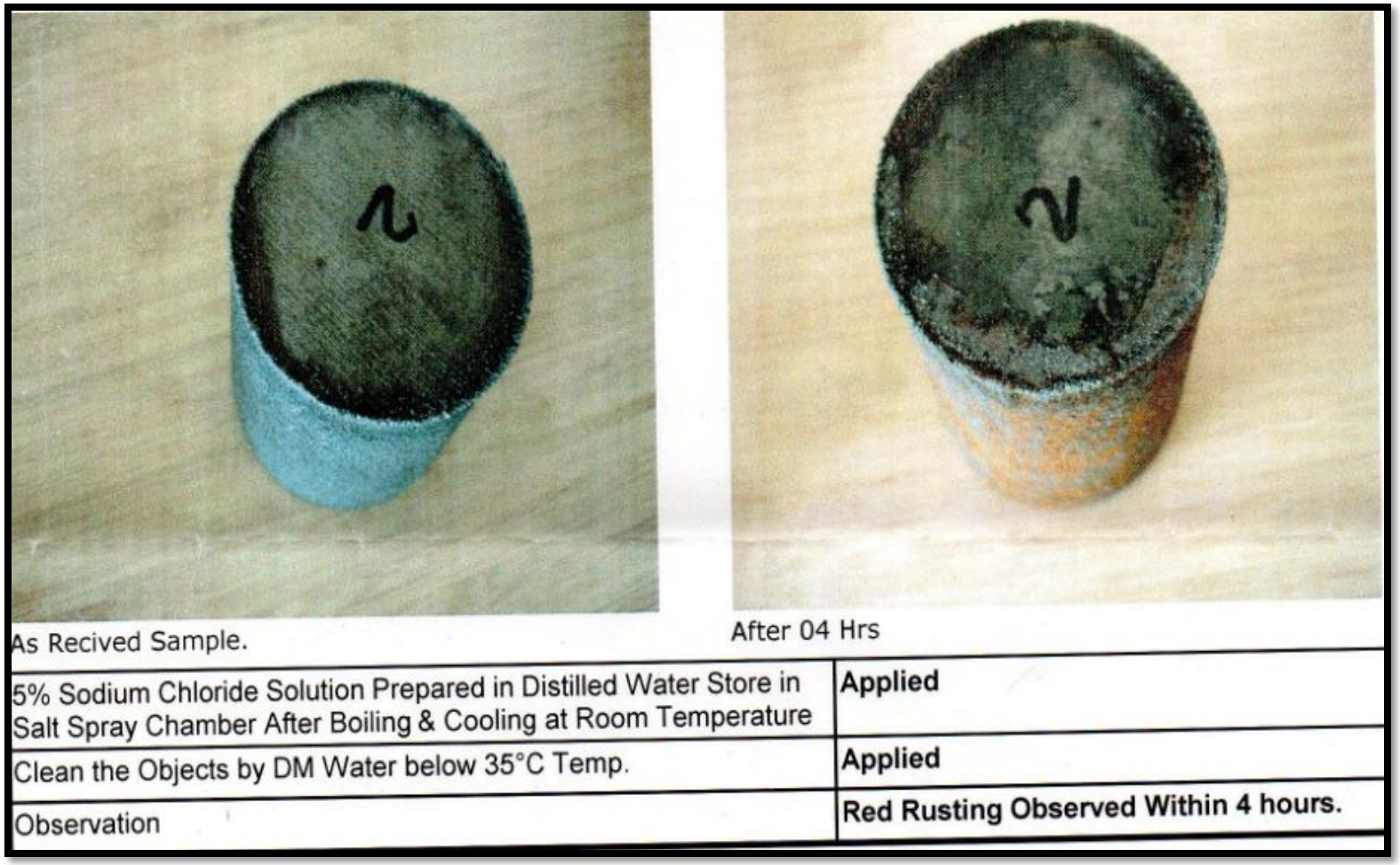
Fig-14 ASTM B117 Salt Spray Testing Machine

As Recived Sample.

After 04 hrs.

5% Sodium Chloride Solution Prepared in Distilled Water Store in Salt Spray Chamber After Boiling & Cooling at Room Temperature	**Applied**
Clean the Objects by DM Water below 35°C Temp.	**Applied**
Observation	**Red Rusting Observed Within 4 hours.**

Fig 15 Simple EN41B Round bar



As Recived Sample.

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5% Sodium Chloride Solution Prepared in Distilled Water Store in Salt Spray Chamber After Boiling & Cooling at Room Temperature	**Applied**
Clean the Objects by DM Water below 35°C Temp.	**Applied**
Observation	**Red Rusting Observed Within 4 hours.**

Fig 16 WC Coated EN41B Round bar

As Recived Sample.

After 04 Hrs.

5% Sodium Chloride Solution Prepared in Distilled Water Store in Salt Spray Chamber After Boiling & Cooling at Room Temperature	**Applied**
Clean the Objects by DM Water below 35°C Temp.	**Applied**
Observation	**Red Rusting Observed Within 4 hours.**

Fig 17 Induction Hardened WC Coated EN41B Round bar

Result and calculation

1. Simple EN41B Round bar

- Surface Area A1 =2πrh=2*π*28*48=8444.60 mm²
- Corrosive area A2 =5729.6 mm²
- Percentage of corrosion = [A2/A1]*100=67.84%per 4hour.

2. WC Coated EN41B Round bar

- Surface Area A1 =2πrh=2*π*29*55=10021.68 mm²
- Corrosive area A2 =4300 mm²
- Percentage of corrosion = [A2/A1]*100=42.90% per 4hour.

3. Induction Hardening and WC coating EN41B Round bar

- Surface Area A1 =2πrh=2*π*24.5*50=7696.90 mm^2
- Corrosive area A2 =600mm^2
- Percentage of corrosion = [A2/A1]*100=20% per 4hour
- In 4 hour corrosion rate is as follow:

➢ Simple EN41B Round bar>WC Coated EN41B Round bar> Induction Hardening and WC coating EN41B Round bar.

Conclusion

- Corrosion and erosion problem on injection screw is reduce by

1. **HDPE(**High Density Polyethylene**)**

- HDPE process is resist to store chlorine and impurity on surface of injection screw.
- So, Chlorine is not chemical reaction with injection screw material and not produce corrosion(Fecl2) on injection screw.

2. Induction Hardening

- Induction hardening is provide more hardness up to more depth of surface on Injection screw.

- Due to injection hardening injection screw surface become hard and smooth.

- So, Reduce Material wear rate on surface of injection screw.

3. WC (Tungsten carbide) coating

- Induction hardening is apply on injection screw then apply WC coating on injection screw.
- WC coating material is anti corrosion and anti erosion. So, WC coating injection screw is resist corrosion and erosion.

4. CrN (Chromium nitride) coating

- CrN coating material is also anti corrosion and anti erosion. Also, CrN coating is able to reduce corrosion and erosion on injection screw surface.

Methodology

PROBLEM IDENTIFICATION

LITERATURE REVIEW

ANALYSIS OF PROCESS PARAMETER

FIND THE ROOT CAUSES

FIND THE PARAMETER OF PROBLEM

FIND THE MAIN CAUSES

ABOUT HDPE PROCESS

ANALYSIS OF HEAT TRETMENT OR HARDENING PROCESS

SLECTION OF INDUCTION HARDENING TO RESIST EROSION

ANALYSIS OF SUITABAL COATING FOR RESIST CORROSION AND EROSION

SELECTION OF COATING TO PREVENT CORROSION AND EROSION

ANALYSIS OF BOTH INDUCTION HARDENING AND WC(TUNGSTEN CARBIDE) COATING TO REDUCE CORROSION AND EROSION ON INJECTION SCREW

APPLY INDUCTION HARDING AND WC(TUNGSTEN CARBIDE) COATING ON EN41B SS MATERIAL SPECIMEN

APPLY CORROSION TEST ON COATING SPECIMEN AND TAKE CORROSION RATE TEST READING

Progress Report

Sr. No	Topic	Jan-15				Feb-15				March-15			
		W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4
(1)	Industrial visit												
(2)	Research paper												
(3)	Analysis And Selection HDPE Process												
(4)	Analysis And Selection Induction Hardening, WC And CrN Coating												
(5)	Induction Hardening apply on 50mmDia and 50mm length En41B material one specimen.												

Continuous…

Sr. No	Topic	March-15			April-15				May-15			
		W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4
(6)	After WC coating is apply both Induction hardening specimen and without hardening specimen.											
(7)	Apply corrosion test on coating EN41B specimen and simple EN41B specimen and take corrosion rate test reading											
(8)	Report Writing and Presentation											

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13.FIG.1.HTTP://WWW.PLASTICIMPEX.COM/PRICING/IMSBM1500MLPETBOTTLESPRODU-TION.HTML

14.FIG.2.HTTP://CR4.GLOBALSPEC.COM/THREAD/20439/INJECTION-MOLDING-SCREW

15.FIG.3&4.HTTP://WWW.PTONLINE.COM/ARTICLES/HOW-TO-SPEC-SCREWS-BARRELS-FOR-RUNNING-CORROSIVE-MATERIALS.

16.FIG.6.HTTP://WWW.HDPE PURGING PROCESS

17.FIG.10.HTTP://WWW. *INDUCTION HARDENING MACHINE UM-SERIES.*

18.FIG.14 HTTP://WWW.WMTR.COM/EN.ASTMB117.HTML

Thank You