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RESEARCH ARTICLE OPEN ACCESS

Experimental Investigation of Chromium and Nickel Thin Sheets on EN8 Steel by Plating Technique

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Abstract-

Commonly electroplating is used to modify the surface of engineering materials to improve the mechanical properties such as hardness, wear and corrosion resistance to meet the functional requirements of the products in industries. Innumerous research works were carried out across the world to assess the suitability of the coating for industrial applications and it is interesting to note thatthemostoftheresearchersoptedplatingprocess for coating the substrate using electrolysis process. Meanwhile, few researchers expressed about the deterrenteffectofthedecarburizationonmechanical properties of the coating due to processing at high temperature in Plating process which increases the efficiencyoftheplatingprocess.Duetothenatureof the Plating process, residual stress builds up inthick deposits is a significant and a limiting problem. It follows that precise control of these phenomena is essential, if a thick deposit is to be plated. To overcome this metal electro plating technique is employed with Nickel and chromium is plated onthe substrate of material to improve the abrasive wear resistance.

In this research work, electroplating of chromium and nickel thin sheets over ASTM EN8 steel substrate through the process was considered to investigatetheeffectofintroducingthecarburization process on wear properties of the resultant coating. Thethicknessoflayersproducedbyionimplantation rangefromnanotomicrometers.Herecarburization is introduced on the substrate before plating to compensate the loss of carbon during spraying due to this there will be increase in the wear resistance and increase in the efficiency of the steel, an investigation on the wear behavior before and after the coating is carried out. The surface of the treated coating is examined by Hardness, Wear and corrosiontests.

I. INTRODUCTION

1.1 GENERAL

Serviceable engineering components not only rely on their bulk material properties but also on the design and characteristics of their surface. Thisisespeciallytrueinwearresistantcomponents, as their surface must perform many engineering functionsinavarietyofcomplexenvironments.The behaviorofamaterialisthereforegreatlydependent onthesurfaceofamaterial,surfacecontactareaand the environment under which the material must operate Surface engineering techniques can be used to develop a wide range of functional properties, including physical, chemical, electrical, electronic, magnetic,mechanical,wear-resistantandcorrosion-resistant properties at the required substrate surfaces..

1.2 SURFACEENGINEERING

Surface engineering can be defined as the branch of science that deals with methods for achievingthedesiredsurfacerequirementsandtheir behavior in service for engineering components. Engineering components must perform certain functions completely and effectively, under various conditions in aggressiveenvironments.

Improving the functionality of an existing productis the onlyaimofsurfaceengineering.New coatings and treatment processes may also create opportunities for new products which could not otherwise exist. For example, satellites could not function, nor could modern power plants operate safely, without the application of advanced surface engineering techniques.

1.3. STEEL

Steel is an alloy of iron and other elements, primarily carbon, widely used in construction and other applications because of its high tensile strength and low cost. The base metal, iron, is able to take on two crystalline forms, body centeredcubicandfacecenteredcubicdependingon its temperature. Carbon, other elements, and inclusions within iron act as hardening agents that preventthemovementofdislocationsthatotherwise occur in the crystal lattices of ironatoms.

1.4 EN8 STEEL

EN8 steel is one of the key material options that we have stocked here at Parkside Steel, taking the pride of place in our range of alloy steel and black carbon rounds as well as the alloy rounds and bright carbon.

The best applications of EN8 steel leads to those which have superior qualities to mild steel are required, but where the additional. Expense of alloy steel cannot be justified. The chemical compositionof this steel is also known as 080A42 which includes carbon, silicon, manganese, sulphur and phosphorus.

EN8 is a through-hardening medium carbon steel which is often used for making shafts, gears, and studs. EN8 steel bar or threaded steelbar is a hard and tough medium carbon steel which is usuallyusedfor makingshafts,gears,and studs. EN8 steel can be machined very simply. The small amount of carbon ranges from 0.16 to 0.3%. Carbon steel has more carbon, up to 2%, and this allows it to be hardened andtempered.

1.5 EN8 STEELPROPERTIES

EN8 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition. EN8 is suitable for the manufacture of parts such as general-purpose axles and shafts, gears, bolts and studs for suchapplications the use of EN8D (080A42) is advisable. It is also available in a free-machining version, EN8M (212A42)

Goodheattreatmentresultsonsectionslarger than 63mm may still be achievable, but it should be notedthata lossinmechanicalpropertieswouldbe apparent approaching the center of thebar

1.6 MECHANICALPROPERTIES

Property	Quantity	
Max Stress	700-850 n/mm^2	
Yield Stress	465 n/mm^2 Min	(up to 19mm LRS)
0.2% Proof Stress	450 n/mm^2 Min	(up to 19mm LRS)
Elongation	16% Min	(12% if cold drawn)
Impact KCV	28 Joules Min	(up to 19mm LRS
Hardness	201-255 Brinell	

1.7 CHEMICALCOMPOSITION

Component	Composition
Carbon	0.36-0.44%
Silicon	0.10-0.40%
Manganese	0.60-1.00%
Sulphur	0.050 Max
Phosphorus	0.050 Max
Chromium	-
Molybdenum	-
Nickel	-

1.8 INTRODUCTION TO CHROMEPLATING

Chrome plating also referred to as chrome which is a technique of electroplating a thinlayer of chromium onto a metal object. Sometimes, a less expensive imitator of chrome may be used for aestheticpurposes.

Process:

Chrome plating a component typically includes these stages:

- Degreasing to remove heavy soiling
- Various pretreatments depending on thesubstrate
- Placement throughthechromeplatingis allowed to warm to solutiontemperature

- Application of plating current for the required time to attain the desiredthickness

1.9 APPLICATION

Atfirstglance,chromeplatingmayappearto beapurelyaestheticfinish.Whilechromeplatingdoes offer an attractive finish for a wide range of products and hard chrome surfaces which is ideal for a multitude of other industrial applications, including:

- Hydraulic cylinders andpistons
- Automotive and mechanicalcomponents
- Rolls, molds, dies, screws and other forming surfaces
- Press punches andtooling
- Shafts and rotors for pumpapplications
- Components used in textiles andprinting

1.10 INTRODUCTION TO NICKELPLATING

Electroless nickel plating is a form of alloy treatment designed to increase resistance and hardness in a metal or plastic. The electroless nickel plating process is simpler than its counterpart electroplating. Electric current is not required to pass through the chemical bath solution in order to initiate the plating process. Instead, the metal surface goes through a series of cleaning and auto-catalytic reactions, which Electro-Coatings have perfected.

1.11 TYPES OF NICKELPLATING

There are many products on the market that incorporate a type of nickel plating in the manufacturing process.

- Bright nickelplating
- Electroless nickelplating
- Dull nickelplating

There are a variety of advantages and disadvantages for each coating and each one more suitable for some items than others.

1.12 ELECTRO PLATED NICKEL(BRIGHT)

1.12.1 PROPERTIES

To add bright nickel plating to an item, it must be submitted to an electric current. Bright mirror like finish produced by Bright Nickel plating due to its elevated sulphur content. However, it produces high Leveling properties to hide polishing lines and any other imperfections of the surface of a material.

1.12.2 APPLICATION

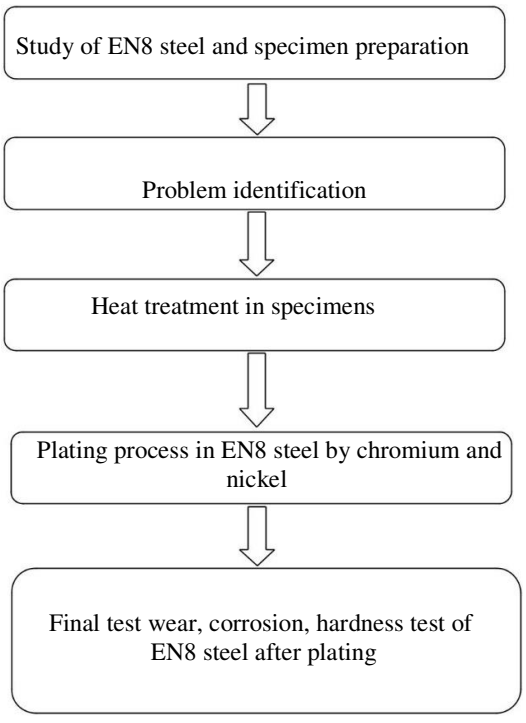
Bumpers, rims, exhaust pipes and trims for cars, and bikes as well as plumbing and also ideal for restoring any machinery mechanisms that are worn.

II. PROBLEM IDENTIFICATION

2.1 PROBLEM DEFINITION

- MediumcarbonsteelEN8steeliswidelyusedin heavy industrial applications such as valves and joints of pipelines.
- However, the material loss due to corrosion reduces the efficiency and life time of the material.
- Duetothiswearresistanceandefficiencyarenot been effective in the low carbonsteel.

III. METHODOLOGY



IV. EXPERIMENTALDETAILS

4.1 PLATING PROCESS ONMEDIUM CARBON STEELPLATE

Steel is commonly considered carbon steel when no minimum content is specified for any alloyingelement(forexample,aluminium,chromium, nickel, molybdenum, vanadium, etc.) or any other element is being added in obtaining a desired alloy effect. The manganese does not exceed 1.65%, the specified minimum for copper in about less than 40% orexceed
.60% and silicon does not exceed .60%. Alro stocks ASTM A-36 carbon hot rolled steel, the most commonly used mild/hot-rolled steel in sheet and plate.

Carbon levels are divided as follows:
Low carbon = .06% to .25% carbon content (mild steel)
Medium carbon = .25% to .55% carbon content (medium steel)
High carbon = >.55% to 1.00% carbon content (hard steel)
Carbon grades are available in the following grade series:
10XX = non-resulpherized carbon steel, with manganese 1.00% maximum (for example 1018, 1045 and 1050).
11XX=resulpherizedcarbonsteel(forexample1117, 1141 and1144).
12XX = rephosphorized and resulpherized carbon steel (for example 12L14 and 1215).

4.2 HEATTREATMENT

Heat treatment process effect on material structure and grains. Most carbon steels and carbon alloy steels can be heat treated for the purpose of improving mechanical properties such as tensile and yield strength

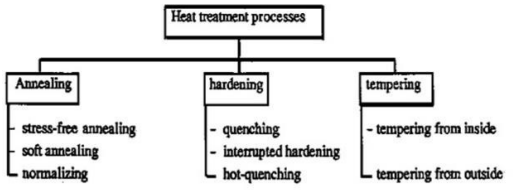


Figure .1 Heat Treatment Process

4.10 ELECTROPLATING PROCESS STEPS

4.3 HEAT TREATMENT OFFERROUS METALS

All heat-treating operations involve the cooling and heating of metals and the common types of heat treatment for ferrous metals are hardening, tempering, annealing, normalizing, and case hardening.

4.4 HARDENING

A ferrous metal is normally hardened by heating a metal to the required temperature and it is cooled rapidly by inserting the hot metal into a quenching medium, such as oil, water, orbrine.

4.5 TEMPERING

Steelisusuallyharderthannecessaryand too brittle for practical use after being hardened. Severe internal stresses are set up during the rapid cooling of themetal.

4.6 NORMALIZING

Ferrous metals are normalized to relieve the internal stresses produced by machining, forging, or welding. Normalized steels are harder and stronger than annealed steels.

4.7 CASEHARDENING

Case hardening is an ideal heat treatment for parts which require a wear-resistant surface and a tough core, such as gears, and so forth. The most common case-hardening processes are carburizing and nitriding.

4.8 SOLUTION HEATTREATMENT

The tensile strength of many nonferrous alloyscanbeincreasedbycausingthematerialswithin thealloytogointoasolidsolutionandthencontrolling the rate and extent of return to an altered mechanical mixture. This operation is called solution heat treatment

4.9 ELECTRO PLATINGPROCESS

The electroplating is depositing a superior or more noble metal on a base metal by help of electrolysis.
For example, metals like iron are coated with deposits of nickel or chromium by electroplating to protect it from corrosion. Picture frames and machinery parts are often chromium-plated to protect them from corrosion and at the same time to give them a goodappearance

In an electroplating process, the object to be electroplated is made the cathode in the solution of a salt of the coating metal.

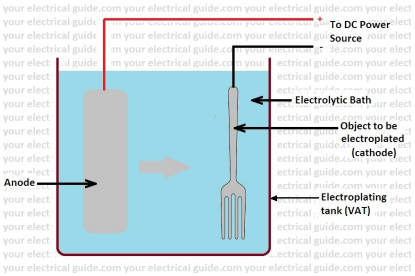


Figure.2 Plating Process

When DC is applied to the electrodes, current starts flowing through the electrolyte. The metal ion moves towards the article and it get deposited on it. The voltage requirement is small usually about the order of 1 - 16 volts only.

4.11 ELECTROLYTICBATH

The electrolyte used in electrolytic bath depends on the nature of the metal which has to be deposited. The electrolytic deposits provided by electroplating are crystalline in nature. The temperature should also be maintained at a proper level. By experiments, a certain optimum value of current density and temperature has been worked out for each electrolyte. The optimum values of current densities and temperatures for different electroplating processes are shown in the table.

4.12 EN 8 STEEL

Figure.3 EN 8 steel

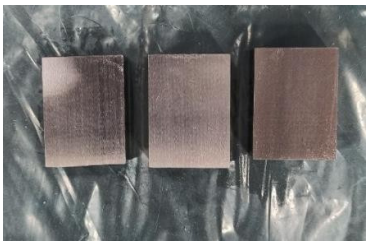


Figure.4 EN 8 steel machined sample

Figure.5 Plated samples (a) Nickel (b) Chromium

V. RESULTS ANDDISCUSSIONS

5.1 CORROSIONTEST

The salt spray test is a standardized and popular corrosion test method, used to check corrosion resistance of materials and surface coatings Salt spray testing is an accelerated corrosion test that produces a corrosive attack to coated samples inorder to evaluate the suitability of the coating for use as a protective finish. Test duration depends on the corrosionresistanceofthecoating;generally,themore corrosionresistantthecoatingis,thelongertheperiod of testing before the appearance of corrosion/ rust. ASTM B117 was the first internationally recognized salt spray standard, originally publishedin 1939. Other important relevant standards are ISO9227, JIS Z 2371 and ASTM G85.

5.2 CORROSION TEST PARAMETERS

Table 5.1Corrosion testParameters

SALT SPRAY TEST AS PER ASTM B117-19			
SL.NO	**TEST CONDITION**	**REQUIREMENTS**	**ACTUAL**
1	Chamber Temperature	35+2°C	34.3 – 35.6 °C
2	pH of solution	6.5 to 7.2	6.3
3	Air Pressure	12 to 18psi	15psi
4	Concentration of sodium chloride	5%	5.0%
5	Collection of solution Per Hour	1 to 2 ml	1.2 ml
	Test Hours	24hrs	24hrs

5.3 CORROSION TEST SAMPLES

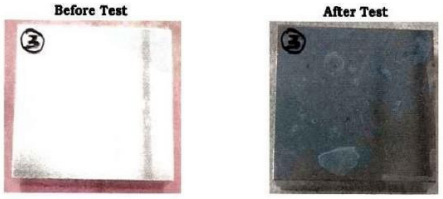


Figure.6 Chromium sample

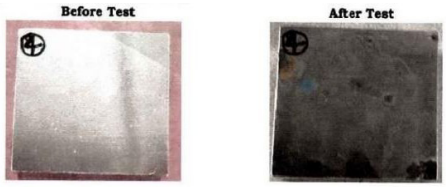


Figure.7 Nickel sample

5.4 ROCKWELL HARDNESSTEST

The Rockwell scale is a hardness scale based on indentation hardness of a material. The result is a dimensionless number noted as HRA, HRB, HRC, etc., where the last letter is the respective Rockwell scale.

5.5 ROCKWELL HARDNESSTEST

Load on indenter (kg): 100 kg

Diameter of indenter (mm): 2.5mm

5.6WEAREXAMINATION

Material Specification

Dimension = 50mm x 30mm

Length =50mm

PIN-ON-DISC TEST

The pin was held against the counter face of arotating discwithweartrackofsquare12×12mm.Thepinwas loaded against the disc through a dead weight loading system. The test procedure is asfollows:

- Initially, pin surface was made flat such that it will support the load over its entire cross-section called first stageRun-in-wear was performed in the next stage/ secondstage
- Final stage/ third stage are the actual testing called constant/ steady state wear.

Figure.8 Pin on Disc setup

Table 5.2 Wear test result for EN8

	Time in Minutes	Frictional force (N)	Coefficient of friction	Wear in Microns
EN8 STEEL	0	3.34	0.133	38.37
	5	3.83	0.153	115.53
	10	3.80	0.152	211.83
	15	3.70	0.148	306.79
	20	3.68	0.147	401.62
	25	3.68	0.147	498.45
	30	3.65	0.146	591.20

Table 5.3 Wear test results for Chromium

	Time in Minutes	Frictional force (N)	Coefficient of friction	Wear in Microns
CHROMIUM	0	3.24	0.133	28.37
	5	3.73	0.133	90.53
	10	3.81	0.132	176.83
	15	3.70	0.138	201.79
	20	3.66	0.133	222.62
	25	3.65	0.147	290.45
	30	3.62	0.146	331.20

Table 5.4 Wear test results for Nickel

	Time in Minutes	Frictional force(N)	Coefficient offriction	Wear in Microns
NICKEL	0	3.32	0.133	18.37
	5	3.73	0.123	85.53
	10	3.77	0.122	161.83
	15	3.72	0.128	186.79
	20	3.58	0.122	201.62
	25	3.61	0.137	288.45
	30	3.62	0.136	301.20

VI. CONCLUSION

Thedetailedliteraturesurveyrevealedtheexistenceof a research gap related to addressing of the effects of corrosion of medium carbon steel during high temperatureapplication.Theresearchworkconducted under this background with an aim of improving the corrosion properties of the resultant coating through the introduction of high temperature applicationscope to bridge the research gap. In this research work, coating of on EN8 steel through Plating process was undertaken for the study of corrosion properties. Analysis is made after plating process.Microstructure by Corrosion test, Hardness test and Wear Test is analyzed.

- In corrosion test spots was clearly observed, nocorrosionisobservedinNickelsamplei.e. no red and white spots is observed. In chromiumPlateonlyredspotisobserved.By comparing Nickel sheets are well suited for EN8 steel plating.
- RockwellHardnesstestforEN8Steel,Nickel Plated and Chromium Plated was taken, by comparing the results hardness for Nickel plated sample is increased thanchromium.

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