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CHARACTERIZATION ANALYSIS OF ZINC AND ALUMINIUM COATING FOR STEELS

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ABSTRACT

Characterization Analysis of Zinc and aluminium Coating For Steels. Coating is a covering that is applied to the surface of an object usually referred to as the substrate. The properties of metals and alloys can be controlled and improved by modifying their microstructure when using their pulse current. Analyzing the characterization of Zinc and Aluminium Coating For steels by Electroplating Method.

Keywords: Analysis of material, Characteristics of zinc and aluminium, Electroplating methodology.

1. INTRODUCTION

Steel is an alloy of iron with typically a few percent of carbon to improve its strength and fracture resistance compared to iron. Many other additional elements may be present or added. Stainless steels that are corrosion and oxidation resistant need typically additional 11% chromium. Because of its high tensile strength and low cost, steel is used in buildings, infrastructure, tools, ships, trains, cars, machines, electrical appliances, and weapons. Iron is the base metal of steel and it can take on two crystalline forms (allotropic forms): body centered cubic and face-centered cubic. These forms depend on temperature. In the body-centered cubic arrangement, there is an iron atom in the Centre and eight atoms at the vertices of each cubic unit cell; in the face-centered cubic, there is one atom at the Centre of each of the six faces of the cubic unit cell and eight atoms at its vertices. It is the interaction of the allotropes of iron with the alloying elements, primarily carbon that gives steel and cast iron their range of unique properties. The increase in steel's strength compared to pure iron is possible only by reducing iron's ductility.Steel was produced in bloomery furnaces for thousands of years, but its large-scale, industrial use began only after more efficient production methods were devised in the 17th century.

1.1 TYPES OF STEELS:

Steel is graded as a way of classification and is often categorized into four groups—Carbon, Alloy, Stainless, and Tool.

Carbon Steels: only contain trace amounts of elements besides carbon and iron. This group is the most common, accounting for 90% of steel production. Carbon Steel is divided into three subgroups depending on the amount of carbon in the metal: Low Carbon Steels/Mild Steels (up to 0.3% carbon), Medium Carbon Steels (0.3–0.6% carbon), and High Carbon Steels (more than 0.6% carbon).

Alloy Steels: contain alloying elements like nickel, copper, chromium, and/or aluminum. These additional elements are used to influence the metal's strength, ductility, corrosion resistance, and machinability.

Stainless Steels: contain 10–20% chromium as their alloying element and are valued for their high corrosion resistance. These steels are commonly used in medical equipment, piping, cutting tools, and food processing equipment.

Tool Steels: make excellent cutting and drilling equipment as they contain tungsten, molybdenum, cobalt, and vanadium to increase heat resistance and durability.

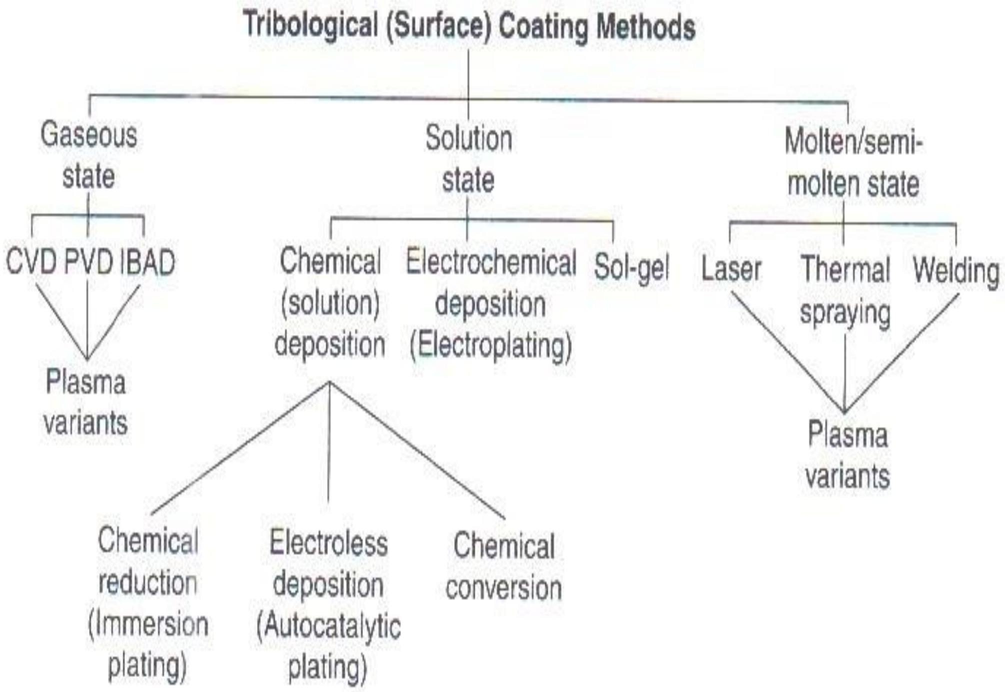
1.2 MILD STEEL (LOW CARBON STEEL):

Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as "low carbon steel." Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having carbon content from 0.30% to 2.0%. If any more carbon than that is added, the steel would be classified as cast iron.Mild steel is not an alloy steel and therefore does not contain large amounts of other elements besides iron; you will not find vast amounts of chromium, molybdenum, or other alloying elements in mild steel. Since its carbon and alloying element content are relatively low, there are several properties it has that differentiate it from higher carbon and alloy steels.Less carbon means that mild steel is typically more ductile, machinable, and weldable than high carbon and other steels; however, it also means it is nearly impossible to harden and strengthen through heating and quenching. The low carbon content also means it has very little carbon and other alloying elements to block dislocations in its crystal structure, generally resulting in less tensile strength than high carbon and alloy steels. Mild steel also has a high amount iron and ferrite, making it magnetic.The lack of alloying elements such as those found in stainless steels means that the iron in mild steel is subject to oxidation (rust) if not properly coated. But the negligible amount of alloying elements also helps mild steel to be relatively affordable when compared with other steels. It is the affordability, weldability, and machinability that make it such a popular choice of steel for consumers.

2.COATING

A coating is a covering that is applied to the surface of an object, usually referred to as the substrate. The purpose of applying the coating may be decorative, functional, or both. The coating itself may be an all-over coating, completely covering the substrate, or it may only cover parts of the substrate. An example of all of these types of coating is a product label on many drinks bottles one side has an all-over functional coating (the adhesive) and the other side has one or more decorative coatings in an appropriate pattern (the printing) to form the words and images.Functional coatings may be applied to change the surface properties of the substrate, such as adhesion, wettability, corrosion resistance, or wear resistance. In other cases, e.g. semiconductor device fabrication (where the substrate is a wafer), the coating adds a completely new property, such as a magnetic response or electrical conductivity, and forms an essential part of the finished product.A major consideration for most coating processes is that the coating is to be applied at a controlled thickness, and a number of different processes are in use to achieve this control, ranging from a simple brush for painting a wall, to some very expensive machinery applying coatings in the electronics industry. A further consideration for 'non-all-over' coatings is that control is needed as to where the coating is to be applied. A number of these non-all-over coating processes are printing processes.

2.2 COATING METHODS



The current research focuses on the objectives of the Surface engineering with the Nano Axis aiming improvements over improvement. This research concentrates on coating of Nickel Silicon Carbide on Mild steel which is used in piston rings and to test the mechanical properties under variant different parameters like duty cycle, current density and frequency.

2.3 COATING MATERIALS:

1. Zinc.
2. Aluminium

3. ELECTROPLATING:

Electroplating is the application of a metal coating to a metallic or other conducting surface by an electrochemical process. The article to be plated (the work) is made the cathode (negative electrode) of an electrolysis cell through which a direct electric current is passed.The article is immersed in an aqueous solution (the bath) containing the required metal in an oxidized form, either as an aquatic cation or as a complex ion.The anode is usually a bar of the metal being plated.Some of the purposes for which articles are electroplated are:

(1) Appearance

(2) Protection

(3) Special surface properties

(4) Engineering or mechanical properties.

4. ZINC AND ALUMINIUM

4.1 ZINC

Zinc is a chemical element with the symbol Zn and atomic number 30. Zinc is a slightly brittle metal at room temperature and has a blue-silvery appearance when oxidation is removed. It is the first element in group 12 of the periodic table. In some respects, zinc is chemically similar to magnesium: both elements exhibit only one normal oxidation state (+2), and the Zn^{2+} and Mg^{2+} ions are of similar size. Zinc is the 24th most abundant element in Earth's crust and has five stable isotopes. The most common zinc ore is sphalerite (zinc blende), a zinc sulfide mineral. Zinc is refined by froth flotation of the ore, roasting, and final extraction using electricity (electrowinning).

4.1.1 PROPERTIES OF ZINC:

PROPERTY	**Zn-Ni**
Appearance	Gray solid in various forms
Melting point	875c
Solubility in H2O	Insoluble
Density	200-250mA/cm2

4.2 ALUMINIUM:

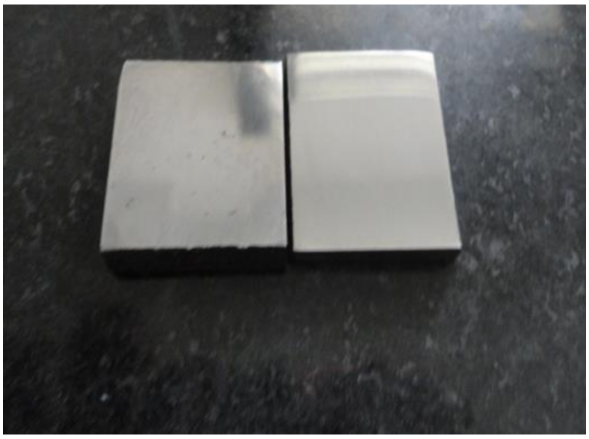
Aluminium oxide is a chemical compound of aluminium and oxygen with the chemical formula Al_2O_3. It is the most commonly occurring of several aluminium oxides, and specifically identified as aluminium (III) oxide. It is commonly called alumina and may also be called aloxide, aloxite, or alundum depending on particular forms or applications. It occurs naturally in its crystalline polymorphic phase α-Al_2O_3 as the mineral corundum, varieties of which form the precious gemstones ruby and sapphire. Al_2O_3 is significant in its use to produce aluminium metal, as and abrasive owing to its hardness, and as a refractory material owing to its high melting point. Al_2O_3 is an electrical insulator but has a relatively high thermal conductivity (30 $Wm^{-1}K^{-1}$) for a ceramic material. Aluminium oxide is insoluble in water. In its most commonly occurring crystalline form.

4.2.1 PROPERTIES OF AL2O3:

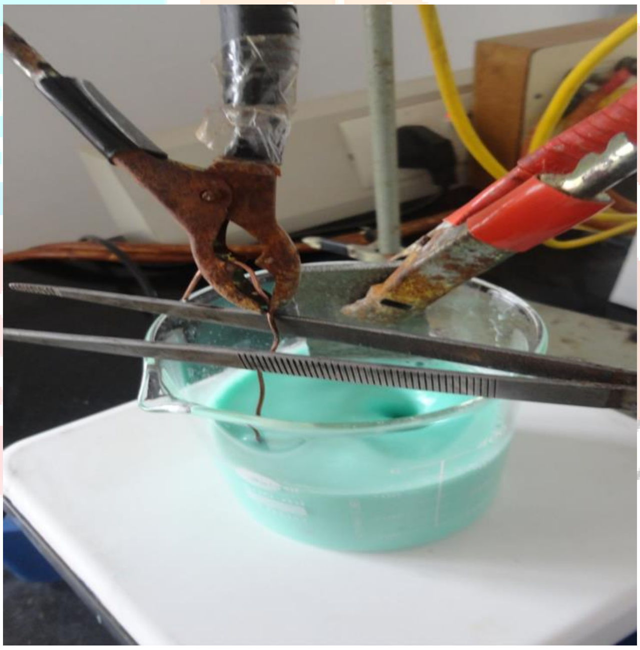
Al_2O_3 is an electrical insulator but has a relatively high thermal conductivity (30 $Wm^{-1}K^{-1}$) for a ceramic material. Aluminium oxide is insoluble in water. In its most commonly occurring crystalline form, called corundum or α-aluminium oxide, its hardness makes it suitable for use as an abrasive and as a component in cutting tools. Aluminium oxide is responsible for the resistance of metallic aluminium to weathering. Metallic aluminium is very reactive with atmospheric oxygen, and a thin passivation layer of aluminium oxide (4 nm thickness) forms on any exposed aluminium surface in a matter of hundreds of picoseconds.[better source needed][9] This layer protects the metal from further oxidation. The thickness and properties of this oxide layer can be enhanced using a process called anodising. A number of alloys, such as aluminium bronzes, exploit this property by including a proportion of aluminium in the alloy to enhance corrosion resistance. The aluminium oxide generated by anodising is typically amorphous, but discharge assisted oxidation processes such as plasma electrolytic oxidation result in a significant proportion of crystalline aluminium oxide in the coating, enhancing its hardness.

5.EXPERIMENTAL SETUP:

5.1 NICKEL PLATE:



5.1.2 BATH PREPARATION:



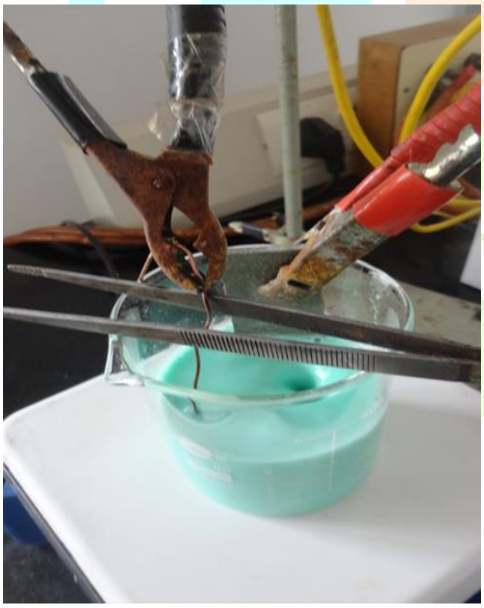
Developments on bright electro deposition of nickel Silicon Carbide are based upon Watt's compositions. Electroplating is generally preferred because of the ability to control

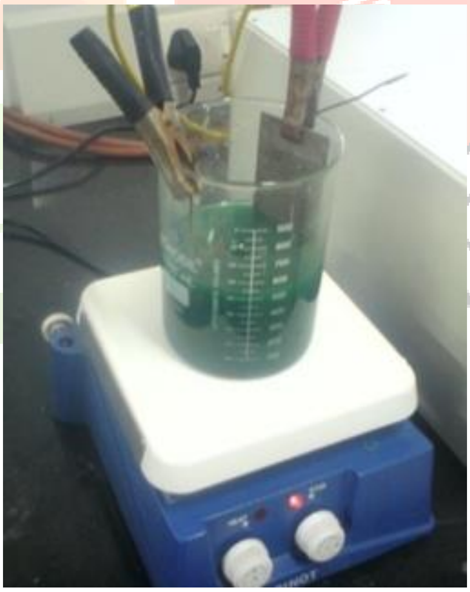
- ✓ The bath
- ✓ Thickness of deposits and
- ✓ The other properties of deposits.

Mostly electrodeposited composites are smooth, refined and uniformly oriented.Out of the different nickel plating baths, modified Watts bath was chosen as the electrolyte due to its capability in achieving various mechanical properties. The composition of the modified watts bath is given in table

PROPERTY	NiSO4	NiCl2	Acetone	Boric acid
Appearance	Yellow solid	Green	Colorless	Green
Melting point	>100C	1001C	-95.4C	170C
Boiling point	840C	1690C	56.53C	300C
Density	4.01g/mol	3.55g/mol	0.791g/mol	1.435g/mol
Molar mass	154.75g/mol	129.593 g/mol	58.08g/mol	61.83g/mol-1
Solubility in water	Soluble	Soluble	Soluble	Soluble

Bath for composite coating (Ni-Zn) and (Ni-Al2O3)





The nickel salts are the principal source of nickel ions and chloride ions increase anode dissolution and conductivity, while boric acid helps produce smoother, more ductile deposits and increases the current density range. Out of all these advantages additive free modified watts bath are chosen and shown in table 3.1.

The nickel content and pH will rise as the bath is used. pH, is the most easily controlled, this continuously changes in spite of the solution being buffered and the difference between the cathode and anode efficiency results in a gradual increase in pH of the solution. The rise in pH is counteracted by an addition of acid usually sulfuric acid. It can be increased with the help of nickel carbonate. After the bath has been freshly prepared it is readily kept in magnetic stirrer and is to be agitated for 24 hours before plating operation.

5.1.3 VAPOUR DEGREASING

Cleaning is very important step in the process of metal deposition. This process involves the use cleaners, either with or without the application of current and frees the surface from dirt, oil, grease and so on. After mechanical polishing the next stage was the vapor degreasing. The substrate was immersed in acetone and kept in an ultrasonic stirrer for ten minutes. This was done to clean the sample of any impurities like oil, grease, dirt and etc, present. Then it was washed in distilled water.

Vapor degreasing setup

5.1.4 PULSE RECTIFIER SPECIFICATION

Pulse Rectifier	
Specification	
Make	Dynatronix,USA
Model	Micro Star Pulse Series DPR 20-30-100
Input power	110-120VACSinglePhase50-60hz
Output rating	0-20V,30Aavg,100Apeak
Pulsed output wave	Bi-polar square wave -50µec rise max,
Output resolution	20.0V/ 99.9A
Meter resolution	20.0V/ 30.0A
Size	432mmX222mmX584mm
Weight	18.4kg

Pulse rectifier specifications

The substrate was then immersed in the watts bath solution using a holding device. Dynatronix pulse rectifier as shown in fig 3.24 is used to supply pulse current at various duty cycles and various current densities. Three different experiments were done keeping the parameters viz duty cycle, frequency and current density respectively constant. Four trials were carried out under each experiment varying the other parameters.

Dyanatronix Pulse Rectifier and plating setup

In the conventional DC plating there is only one parameter namely current density (I), which can be varied. But in pulse electrode position (PED) there are three independent variables, viz, (1) ON- time (T_{ON}), (2) OFF-time (T_{OFF}) and Peak current density (I_P).In pulse current the duty cycle corresponds to the percentage of total time of a cycle and given by (Pulse Mathematics in Appendix A.1)

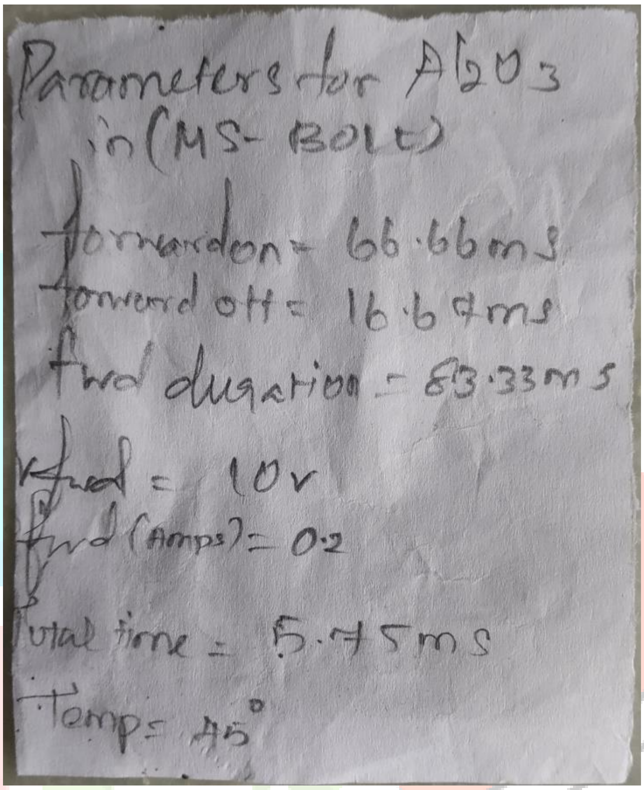
Duty cycle = $(T_{ON}) / (T_{ON} + T_{OFF})$

Total Time = $T_{ON} + T_{OFF}$

I_A = (I_P) * duty cycle

I_P = Peak current density * Surface Area

The pulse current will deposit metal at the same rate as direct current provided the average pulse current density (I_A) equals the latter.



Parameters used in Pulse Rectifier Setup for Aluminium coating on Mild Steel

6.FINISHED MATERIAL:

6.1 Zn-Ni MATERIAL:

6.2 Ni-Al2O3 MATERIAL:

7.CONCLUSION:

The first part of this paper identify the materials, and experimental conditions of the coating is finished and coated. Pure Zinc is not suitable for the process of electroplating,hence it cannot be used.The aluminium is perfectly suited for the electroplating process, and to be perfectly coated.

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