

An Experimental Investigation Analysis on Zinc Coated Chain Sprocket

M. Sankarapandian¹, Leenus Roger Benny C², Logeshwar H³, Manikandan M⁴, Srigiri R⁵

Assistant Professor, Department of Mechanical Engineering, TRP Engineering College, Tiruchirapalli, India¹

UG Scholars, Department of Mechanical Engineering, TRP Engineering College, Tiruchirapalli, India^{2,3,4,5}

ABSTRACT: A Zinc multilayer is deposited onto the surface of Sprocket to enhance the Wear rate, Fatigue life and Hardness of Sprocket under Physical Vapor Deposition Process (PVD). By using Analysis software to analysis the fatigue life. Based on analysis report we conduct experimental test on Zinc coated Sprocket to find Wear rate and Hardness by using Tribometer and Vickers test. Both the results shows that the Zinc coated Sprocket has less wear rate, more hardness and fatigue limit the normal Sprocket

I. INTRODUCTION

1.1 Sprocket:

A sprocket or sprocket-wheel is a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly, and differs from a pulley in that sprockets have teeth and pulleys are smooth.

Types of Sprocket:

- Type A: Plain Plate Sprockets
- Type B: Hub on One Side
- Type C: Hub on Both Sides
- Type D: Detachable Hub

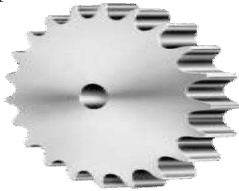


Fig 1.1 Type A: Plain Plate Sprocket

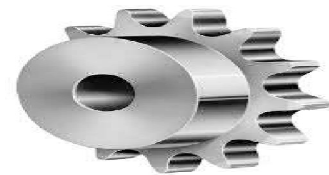


Fig 1.2 Type B: Hub on side



Fig1.3 Type C: Hub on Both Side



Fig 1.4 Type D: Detachable Hub

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

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other side has one or more decorative coatings in an appropriate pattern (the printing) to form the words and images. Paints and lacquers are coatings that mostly have dual uses of protecting the substrate and being decorative, although some artist paints are only for decoration, and the paint on large industrial pipes is presumably only for the function of preventing corrosion. Functional coatings may be applied to change the surface properties of the substrate, such as adhesion, wet ability, corrosion resistance, or wear resistance. 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. Many industrial coating processes involve the application of a thin film of functional material to a substrate, such as paper, fabric, film, foil, or sheet stock. If the substrate starts and ends the process wound up in a roll, the process may be termed "roll-to-roll" or "web-based" coating. A roll of substrate, when wound through the coating machine, is typically called a web.

1.2.1 TYPES OF COATING:

- Metal and Non-metal Coatings
 - Non-Metallic Coatings
 - Metallic Coatings
- Electroplating
- Electroforming
- Galvanizing
- Anodizing
- Organic Coatings

II. LITERATURE REVIEW

From the sprocket components based on heat transfer mechanism. Mainly the results of convective heat transfer coefficient & radiative heat transfer coefficient are compared with practical values. This paper concludes that the material has large influence on convective & radiative heat transfer & to avoid thermal cracks temperature should be within optimum range.

Amol A. Apte and H. Ravi has analyzed finite element prediction on thermal performance of sprocket & stresses in a sprocket system. Validation of sprocket design is carried out through CAE/FEA. The procedure for prediction of thermal performance of sprocket is developed & it correlate with test data available for the recently available design & it applied to the new sprocket design. **M.Rama Narasimha Reddy, K.Harshavardhan Reddy, N.Balaji Ganesh** has analyzed structural & thermal analysis of sprocket. In this work they compare the results for stainless steel & carbon steel & result obtained is that both the materials has stress value less than yield stress but thermal gradient of carbon steel is more than stainless steel so carbon steel is better than stainless steel. **O.S.I. Fayomi , O.O. Joseph a, M.P. Mubiayi c, B.M. Durodola d, O. Gabriel** has analyzed the effect of Zn-MgO deposition prepared through direct electrolytic co-deposition on mild steel. The experiment was conducted at current density between 0.5 and 1A/cm⁻². The morphologies of the coated surfaces were characterized using Atomic Force Micro- scope (AFM), high resolution Nikon Optical Microscope (OPM) and Scanning Electron Microscopy attached with Energy Dispersive Spectrometer (SEM/EDX). The corrosion behavior was studied using linear potentio- dynamic polarization method in 3.5% simulated environment. The phase change was evaluated using X-ray Diffract gram (XRD). **Y. ReyesVidal a,1, R. Suarez-Rojas a, C. Ruiz a, J. Torres, Alia Méndez b, G. Trejoa** has analyzed The safety of heavy equipment is directly determined by the quality of heavy-duty sprocket which is a basic component transmitting motion and power. However, local overheat of tooth surface, non-homogeneous hardness and micro cracking are observed due to the skin effect, corner effect, and annular effect during traditional induction hardening of sprockets with conventional circular coil. **M. Szociński, K. Darowicki** has analyzed that polyvinyl zinc-rich coating exposed to 97% relative humidity atmosphere for 40 days. Condition of the coating and evolution of its protective properties were determined with the novel AFM-based approach capable of providing surface profiles, local dc current maps as well as local impedance

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spectra. The proposed technique allowed insight into the local changes of coating topography and electrical Properties accompanying a transition from purely electrochemical to barrier mechanism of protection.

III. PROBLEM IDENTIFICATION

A coating serves many purposes. Some of these are presented as Protection of steel structures from the environment by acting as a barrier between the substrate and the aggressive environment, such as the marine and industrial environments. Control of solvent losses. Control of marine fouling; certain constituents in coating control the growth of marine fouling in seawater. Reduction in friction (coating reduces friction between two contacting surfaces). Pleasant appearance; certain types of coatings provide a pleasant appearance and produce attractive surroundings. Change in light intensity; by selection of appropriate coatings the light intensity in rooms and buildings can be varied as desired. Visibility; many combinations of colors because of their visibility from large distances are used on television and radio towers to warn aircraft. Modification of chemical, mechanical, thermal, electronic and optical properties of materials. Application of thin coatings on low-cost substrates results in increased efficiency and cost savings.

IV. METHODOLOGY

SURFACE PREPARATION

Surface preparation is the most important factor in determining the success of any protective coating system. It affects the performance of the coating more than any other variable. In other words, if the surface preparation is poor, coating performance is invariably going to be poor. If the surface preparation is good, then the coating applied over it is likely to perform well.

4.1.1 Significance of surface preparation

If the coating system has an improper foundation (i.e. poor surface preparation) it may fail during its design life. The prime objective of surface preparation is to ensure proper adhesion of a coating with the substrate. While adhesion is the key to coating effectiveness, it also determines whether it has become an actual part of the substrate. Adhesion is even more critical for coating subjected to corrosive or immersion environments. Proper surface preparation is extremely necessary for the service life and overall effectiveness of a Coating-substrate system. The purpose of surface preparation is twofold: (i) To roughen the substrate surface so as to provide increased surface area for mechanical interlocking of the coating with the substrate. This roughening, commonly known as anchor pattern or anchor profile is essentially a pattern of peaks and valleys etched into the surface. This pattern may usually be achieved with abrasive blast cleaning although certain power tools, which simultaneously clean and roughen the surface, may also be employed (ii) To clean the surface for chemical adhesion of a coating with the substrate. A coating applied over a substrate contaminated with soluble salts, rust, grease, wax (iii) Surface preparation involves removing all loose coating and rust, so that only tightly adhering rust and coating are left. Mechanical pretreatments, such as needle-gun and wire brush, can remove loosely bound rust and dirt but do not provide either the cleanliness or the surface profile required for recoating the steel. Conventional dry abrasive blasting is the most commonly used pretreatment; however, wet abrasive blasting and hydro jet cleaning are excellent treatment methods that are also gaining industry acceptance.

4.1.2 Common methods of surface preparation

There are many tools, techniques and methods for preparing a steel surface for coating. There are also a number of standards for various types and degree of surface preparation. The degree of cleaning required for a given steel substrate depends on a number of factors, among which the service environment of the coating system is perhaps the most important. Cost is another factor in selecting degree of surface preparation, generally speaking, the more rigorous the degree of cleaning, the more expensive it is. Different types of surface preparation methods are solvent cleaning, hand tool cleaning, power tool cleaning, low & high pressure water jetting, chemical stripping, dry and wet abrasive blast cleaning etc. These are briefly discussed as follows

4.1.2.1 Solvent cleaning

Solvent cleaning removes detrimental foreign matter such as oil, grease, soil, drawing and cutting

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compounds, and other contaminants from steel surfaces with the help of solvents, emulsions, cleaning compounds, steam cleaning

4.1.2.2 Hand-tool cleaning

It is a technique to prepare the substrate surface by using non-power hand tools so as to remove loose mill scale, rust, coating and all other loosely attached contaminants. It is a slow process and may not be used for preparation of large surfaces. It will also not generate the surface roughness required for most industrial protective coatings. Hand-tool cleaning may only be undertaken after solvent cleaning has been accomplished. Some of the common hand-tool cleaning equipment are wire brushes, non-woven abrasive pads, scrapers, chisels, knives, and chipping hammers.

4.1.2.3 Power-tool cleaning

It is same as hand-tool cleaning but removes loosely adhered rust, coating, mill scale etc. with the help of pneumatic and/or electrically operated tools.

4.2 Purposes of a Coating:

A coating serves many purposes. Some of these are presented as below (i) Protection of steel structures from the environment by acting as a barrier between the substrate and the aggressive environment, such as the marine and industrial environment (ii) Control of solvent losses. (iii) Control of marine fouling; certain constituents in coating control the growth of marine fouling in seawater. (iv) Reduction in friction (coating reduces friction between two contacting surfaces). (v) Pleasant appearance; certain types of coatings provide a pleasant appearance and produce attractive surroundings. (vi) Change in light intensity; by selection of appropriate coatings the light intensity in rooms and buildings can be varied as desired.(vii) Visibility; many combinations of colors because of their visibility from large distances are used on television and radio towers to warn aircraft. (viii) Modification of chemical, mechanical, thermal, electronic and optical properties of materials. (ix) Application of thin coatings on low-cost substrates results in increased efficiency and cost savings.

4.3 PVD COATING PROCESS

Physical vapor deposition (PVD) is fundamentally a vaporization coating technique, involving transfer of material on an atomic level. It is an alternative process to electroplating. The process is similar to chemical vapor deposition (CVD) except that the raw materials/precursors, i.e. the material that is going to be deposited starts out in solid form. The current version of physical vapour deposition was completed in 2010 by NASA scientists at the NASA Glenn Research Center in Cleveland, Ohio. This physical vapour deposition coating is made up of thin layers of metal that are bonded together through a rig that NASA finished developing in 2010. In order to make the coating, developers put the essential ingredients into the rig, which drops the surrounding atmospheric pressure to one torr (1/760 of our everyday atmosphere). From there, the coating is heated with a plasma torch that reaches 17,540 degrees Fahrenheit or 9,727 degrees Celsius. NASA's PS-PVD is one of only two such facilities in the USA and one of four in the world. In the automotive world, it is the newest alternative to the chrome plating that has been used for trucks and cars for years. PVD processes are carried out under vacuum conditions. The process involved four steps:

- Evaporation
- Transportation
- Reaction
- Deposition

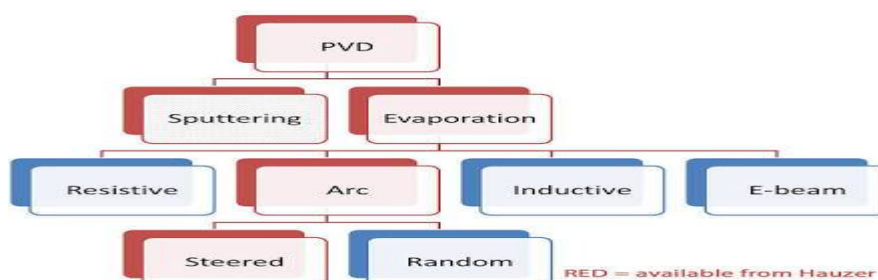


Fig 4.2 PVD Process Steps

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a) Evaporation

During this stage, a target, consisting of the material to be deposited is bombarded by a high energy source such as a beam of electrons or ions. This dislodges atoms from the surface of the target, 'vaporizing' them. Stage. For the above examples, the reactive gases may be oxygen, nitrogen and methane.

b) Transport

This process simply consists of the movement of 'vaporized' atoms from the target to the substrate to be coated and will generally be a straight line affair.

c) Reaction

In some cases coatings will consist of metal oxides, nitrides, carbides and other such materials. In these cases, the target will consist of the metal. The atoms of metal will then react with the appropriate gas during the transport stage. For the above examples, the reactive gases may be oxygen, nitrogen and methane. In instances where the coating consists of the target material alone, this step would not be part of the process.

d) Deposition

This is the process of coating build up on the substrate surface. Depending on the actual process, some reactions between target materials and the reactive gases may also take place at the substrate surface simultaneously with the deposition process.

4.3.1 PVD USES:

PVD coatings are deposited for numerous reasons. Some of the main ones are:

- Improved hardness and wear resistance
- Reduced friction
- Improved oxidation resistance

V. RESULT AND DISCUSSION

CHEMICAL COMPOSITIONS:

zinc is alloyed with copper and titanium to produce a material with optimum mechanical and physical characteristics for building applications, particularly with regard to mechanical resistance and creep resistance . It is composed of very high quality zinc Z1 (99,995% pure zinc), as defined by the EN 1179 standard, to which titanium and copper are added. Copper increases the mechanical resistance of the alloy, making it harder and stronger. Titanium increases creep resistance permitting greater thermal expansion and contraction, of the material without causing metal fatigue.

5.2 PHYSICAL PROPERTIES OF ZINC:

Phase	Solid
Density (near r.t.)	7.14 g.cm ⁻³
Liquid density at m.p.	6.57 g.cm ⁻³
Melting point	692.68 K (419.53°C, 787.15°F)
Boiling point	1180 K (907°C, 1665°F)
Heat of fusion	7.32 kJ.mol ⁻¹
Heat of vaporization	123.6 kJ.mol ⁻¹
Heat capacity	(25°C) 25.390 J.mol ⁻¹ .K ⁻¹

Table 5.1 Physical Properties of Zinc

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5.3 WITHOUT ZINC COATING

Material	Wear rate ($\times 10^{-6} \text{ mm}^3 / \text{Nm}$)
ZINC	2.10

Table 5.2 without Coating Wear rate

5.4 WITH ZINC COATING

Material	Wear rate ($\times 10^{-6} \text{ mm}^3 / \text{Nm}$)
SS	2.30

Table 5.3 with Coating Wear rate

5.5 DIFFERENCE OF KNOOP HARDNESS BETWEEN NORMAL SPROCKET AND ZINC COATED SPROCKET

Table 5.4 Knoop Hardness

MATERIAL	KNOOP HARDNESS
SS	735
ZINC	895

5.6 GRAPHS

5.6.1 Wear rate of Without Zinc Coat vs. zinc Coated

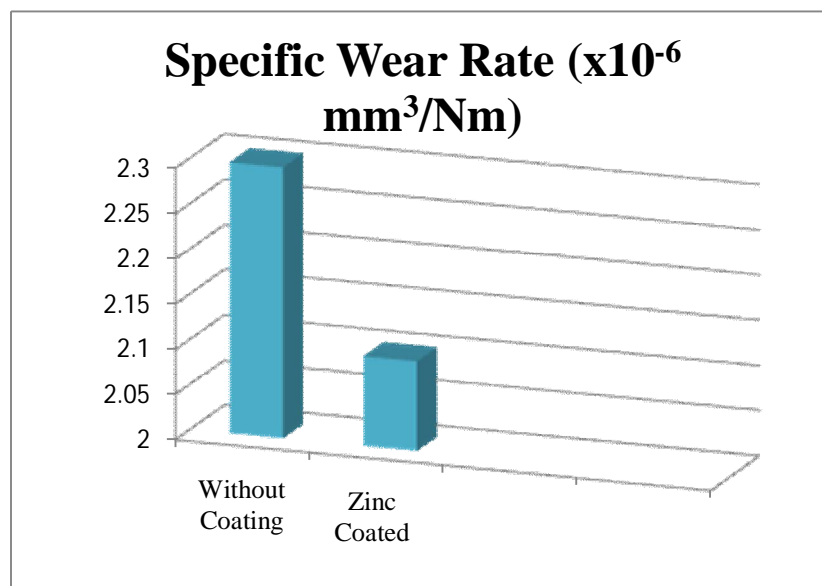


Fig 5.1 Wear rate of without Zinc coat vs. Zinc Coated

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5.6.2 S-N Curve without Coating Sprocket

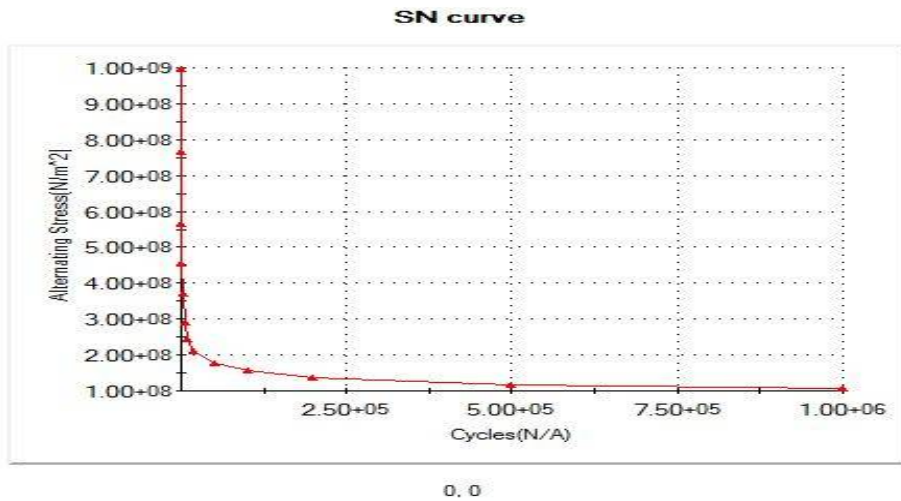


Fig 5.2 S-N Curve for without Coating Sprocket

5.6.3 S-N Curve with Zinc Coated Sprocket

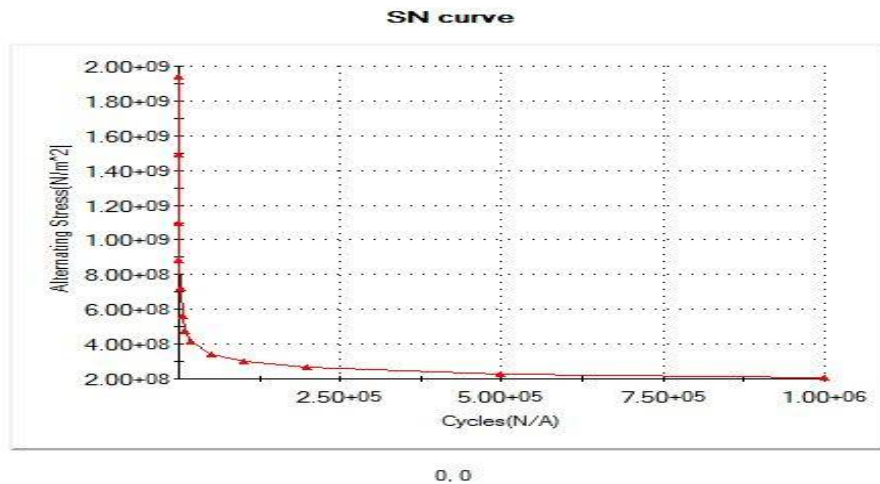


Fig 5.3 S-N Curve for Zinc Coated Sprocket

5.6.4 Hardness test:

Work Piece	Surface Treatment	Knoop Hardness	Thickness(10 ⁻³ mm)
SS	None	745	None
SS	Zinc	847	25
SS	Zinc	895	40
SS	Zinc	835	50

Table 5.5 Knoop Hardness for varies Thickness

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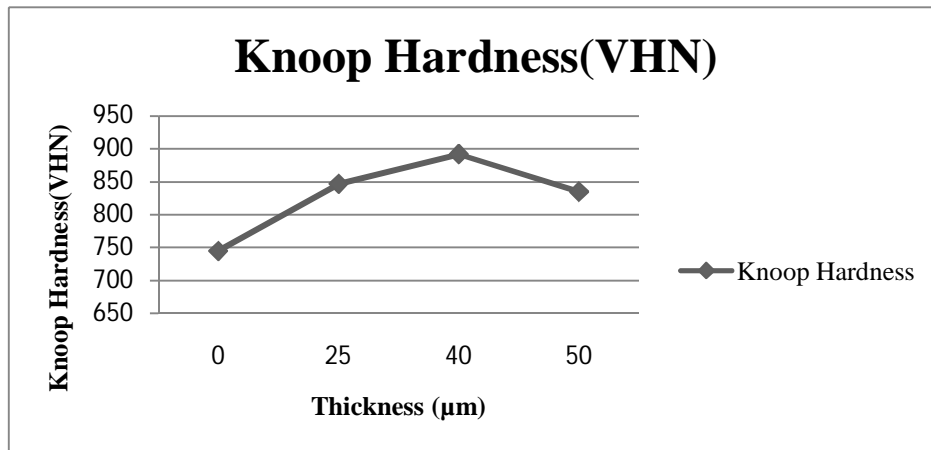


Fig 5.4 Knoop Hardness vs. Thickness (µm)

VI. CONCLUSION

Proper electro deposition of mild steel using zinc particle was carried out. The micro hardness and wear rate behavior of the resultant deposition were investigated with the following deductions: Increasing of zinc percentage causes decreasing the wear rate. The average increase in micro hardness of the Sprocket Plate substrate was 60 HVN to deposited sample Zn was 85 HVN. Also resists the corrosion of sprocket plate by zinc plating. Zinc is a corrosion resistance. Increases the life of the materials. Hardness no: 327-412 mpa. Sprocket life is 6000hr(bc)-7000hr(ac). Reduction of cost on replacement by mass production.

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