EFFECT OF SURFACE TREATMENT BY HARD CHROMIUM FOR ENHANCING THE TRIBOLOGICAL PROPERTIES

Dr. N.Nandakumar
Assistant Professor
Department of Mechanical Engineering
Government College of Technology, Coimbatore, Tamilnadu, India

Abstract : ***The behavior of a material under relative motion significantly dependents upon the surface topography of a material, area of surface contact and the environment under which the material comes into function. Tribological behavior of surface coatings is influenced by various conditions, such as contact of materials, contact of microstructure, and composite coating on the substrate system. Surface wear and abrasion is one of the major problems to be considered for life span of the product, and wear is not enviable since it reduces the quality and failure of parts. In order to increase the wear resistance, certain surface treatment is to be done on the component. The spindle used for winding thick paper cone worn-out frequently due to friction between the paper and the spindle. In this work experimental investigation was done on EN8 carbon steel spindle shaft surface treated with hard chromium under different conditional parameters and it was validated for optimal wear resistance. By surface coating with hard chroming process, the surface wear rate is reduced and life span of the spindle shaft increases which has been tested and analyzed for wear measurement. The wear rate noticed in a particular time period has been studied and found that the life period of hard chromed spindle shaft has been increased.***

Index Terms - Tribological behavior, surface coating, hard chromium, wear resistance

I. INTRODUCTION

Serviceable engineering components not only rely on their bulk material properties but also on the design and characteristics of their surface. This is especially true in wear resistant components, as their surface must perform many engineering functions in a variety of complex environments. The behavior of a material is therefore greatly dependent on the surface of a material, surface contact area and the environment under which the material must operate. The surface of a metallic material is made up of a matrix of individual grains, which vary in size and bond strength depending on the means by which the material was manufactured and on the elements used to form those grains. The surface of these components may require treatment, to enhance the surface characteristics. Surface treatments that cause microstructure changes in the bulk material include heating and cooling/quenching through induction, flame, laser, and electron beam techniques, or mechanical treatments (one example is cold working).Surface treatments that alter the chemistry of a surface include carburizing, nitriding, carbo-nitriding, nitro-carburizing, chromizing and aluminizing. Hard facing is another form of surface treatment, where the bulk material's surface is given a protective layer of another material having more superior properties than those of the bulk material. An example of this is coating a turbine pump seal joint with a corrosive resistive material, to prevent salty water from eroding the pump. Each method of hard facing, examples of which are coating deposition, cladding or welding, causes particular physical and chemical effects on the bulk material, some beneficial, some detrimental environments have on these surfaces.

The surface shape or topology depends upon the process used for forming, be it moulding, casting, or cutting and abrading. This is often seen microscopically as a series of asperities rather than the flat surface seen macroscopically. The geometrical texture may be characterized by its surface profile and results from three different components of surface texture (roughness, waviness and error). Mitrovic et al. studied about the Cr hard coatings which are largely used in industry in metal cutting and cold forming processes. They worked on quantitative way represents improvement, in terms of wear resistance, which was obtained by depositing chromium by hard coating on foundation material. Testing was performed in conditions without lubrication at variable value of contact parameters (normal load, sliding speed). Hard chromium coatings in all contact conditions show smaller values of wear rate. Kinshuk dubey et al. analyzed the Tribological behavior of hard coating deposited by HOVF process. In that study the oxy-fuel process was applied to 4140 alloy steel. The Pin-on-Disc test was used to estimate the wear resistance of the different material-coating-parameters combinations. The data were analyzed and a statistical model, explaining the effect(s) of different parameters as well as their interaction, was obtained Kusinski et al. done the investigation of the life-time of drills covered with the anti-wear Cr(C,N) complex coatings, deposited by means of Arc-PVD technique. Hard chrome, also known as industrial/engineering chrome or electrolytic hard chromium is employed as a functional coating for the enhancement of surface performance in engineering applications requiring low friction, wear and corrosion resistance.

II. MATERIALS AND METHOD

Surface engineering, including surface treatments and coatings, is one of the most effective and flexible solutions for tribological problems. Surface coatings change the tribological characteristics by inducing residual compressive stresses, decreasing the coefficient of friction, increasing the surface hardness, varying the surface chemistry and roughness. The spindle is get worn-out quickly after certain no of parts produced due to the compressed drawing force by the belt and the pulling force required to pull all the papers from their respective reels. The spindle is stationary and the papers those joined are moving in spiral path along the spindle. The belt tension and the pulling force required to pull the papers from respective reels gives the compressed binding force and belt motion gives the feed of the tube produced. When spindle gets the wear, the tolerance limit fixed to the internal diameter of the tube gets reduced and it will not fit into the shaft where it has to be mounted. Surface Coating is applied to the surface of an object usually referred to as the substrate. In many cases coatings are applied to improve surface properties of the substrate, such as appearance, adhesion, weldability, corrosion resistance, wear resistance, and scratch resistance. Hard chroming is a process that involves the electroplating of a thin veneer of chromium onto an underlying metal. Sometimes used

for decorating purposes, chrome plating can also serve as a layer of protection as well. Often, chrome plating is applied to metal objects when there is an increased opportunity for corrosion to occur. The plating process involves bonding a metal onto a surface through electrolytic means. The part is placed in a bath of a solution called an electrolyte, in the case of chrome plating, the electrolyte is primarily chromic acid (CrO3) along with other additives (SO4 and F) which help as catalysts and can affect coating post-plate. Electro-deposited Chrome is extremely hard, with typical values of 850 - 1050 HV (63 – 70HRc), hence the term "Hard" Chrome. This makes it an excellent coating for wear resistant and abrasion resistant applications.

III. RESULTS AND DISCUSSION

The spiral paper core spindle is coated with hard chroming process of 0.1mm thickness. The spindle of both materials was mounted on the paper core machine for the trial run production for eight weeks. The diameters of both the spindle at the end of every week was observed. The diameter change reflects the wear rate of both spindles. Comparison of observation on diameter depreciation was done. Hardness of the spindles after the hard chroming is found 900 BHN. The observation of spindle diameter reduction is a measure of wear rate. If the diameter reduces significantly, then it reveals that high wear rate. From the table 1. we concludes that the hard chromed spindle wear rate very much is lesser than the spindle which is not hard chromed.

Table 3. 1 Wear observation on spindle

Sl .No	Test Run Duration	EN8 Spindle Diameter (mm)	Hard Chromed Spindle Diameter (mm)
1	End of one week	100	100
2	End of two weeks	99.80	100
3	End of three weeks	99.65	100
4	End of four weeks	99.49	100
5	End of five weeks	99.32	100
6	End of six weeks	99.20	100
7	End of seven week	99.04	99.96
8	At the end of eight weeks	98.70	99.92

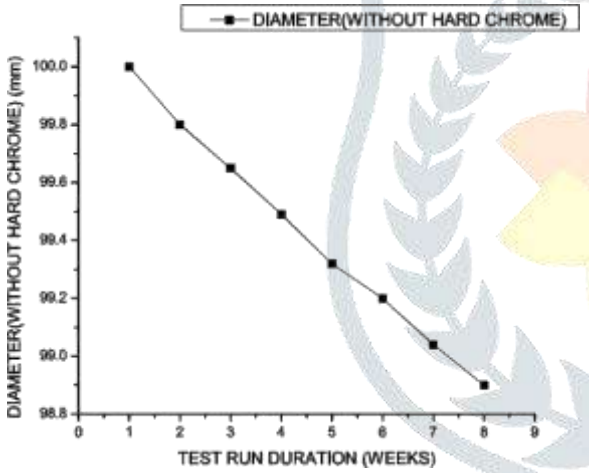

Fig. 3.1 Test Duration and Diameter (Without Chrome)

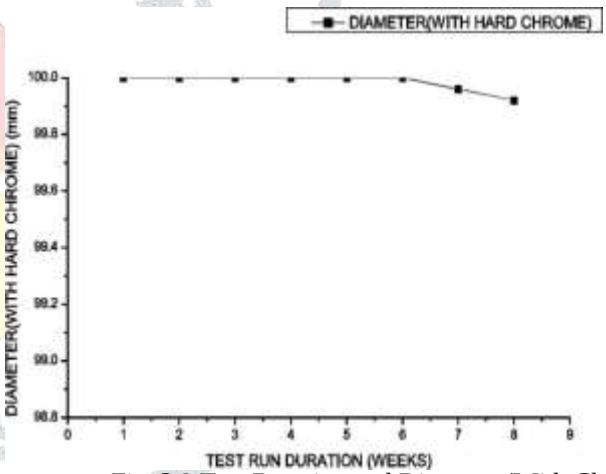

Fig. 3.2 Test Duration and Diameter (With Chrome)

Hardness, trial run wear results showed that the values for the respective tests for the coated specimen were much better, in comparison to EN8 steel without hard chroming. It improves the hardness of the metal in mechanical sense with good Tribological properties. From trial run wear test and hardness test, hard chroming coating process of spindle proved to be good replacement for EN8 steel spindle without coating. Due to the hard chroming the Hardness of the hard chromed spindle is higher than the EN8 spindle, it has good wear resistance. The trial test readings and graph results on the diameter wear rate of the hard chromed spindle is very less when compared with the EN8 spindle without hard chroming .Hence the spindle total life will be is increased. The hard chromed spindle is advisable to use this application to improve the life of spindle so that reducing the tool replacement cost and improve the productivity.

REFERENCES

[1] Ganesh, B.K.C. 2012. Effect of Surface Treatment on Tribological Behavior of Ti-6Al-4V Implant Alloy. Journal of Minerals and Materials Characterization and Engineering, 11, 735-743,

[2] Essa, FA. 2018. Enhancing the Tribological and mechanical properties of M50 steel using solid lubricants – A detailed review. Proc I Mech E Part J: J Engineering Tribology, 232(5), 619–642.

[3] Zhecheva. A. 2005. Enhancing the microstructure and properties of titanium through nitriding and other surface engineering methods, Surface Coatings and Technology, 200, 2192-2207.

[4] Sahoo. P. 2011. Tribology of electroless nickel coatings - A review. Materials and Design, 32, 1760-1775

[5] Vernhes. L. 2013. Alternatives for hard chromium plating: Nano-structured coatings for severe-service valves. Materials Chemistry and Physics, 140, 522-528

[6] Basu. B. 2011. Tribology of ceramics and composites - A material science perspective. Hoboken, New Jersey: John Wiley & Sons, Inc.

[7] Choi. Y.I. 2014. Mechanism for the formation of black Cr-Co electrodeposits from Cr3+ solution containing oxalic acid, J. Electrochem. Soc. 161, 713–718.

[8] Huang. C.A. 2009, Role of nickel undercoat and reduction-flame heating on the mechanical properties of Cr–C deposit electroplated from a trivalent chromium based bath., Surf. Coat. Technol. 203, 2921–2926.
[9] Zeng.Z. 2008. Electrodeposition and tribological behavior of amorphous chromium-alumina composite coatings, Surf. Coat. Technol. 202, 2725–2730.
[10] Marwah. M.S. 2011. Morphological changes during annealing of electrodeposited NiCr coating on steel and their effect on corrosion in 3% of NaCl solution, J. Iron. Steel Res. Int. 18, 72–78.
[11] Saravanan.G. 2012. Structure, composition and corrosion resistance studies of Co–Cr alloy electrodeposited from deep eutectic solvent (DES), J. Alloys Compd. 522, 162– 166.
[12] Ahmed. R. 2013. Influence of Re-HIPing on the structure–property relationships of cobalt-based alloys, Tribol. Int. 57,8–21.
[13] Li. M. 2011. Electrodeposition of NiCo-Fe2O3 composite coatings, J. Cent. South Univ. Technol. 17 (2010) 708−714.
[14] Kenneth. R. 2002. Newby, Industrial hard chromium plating, in: ASM Handbook Online, Vol. 5, Surface Engineering, ASM International.
[15] Hones, P. 1999. Characterization of sputter-deposited chromium oxide thin films. Surface and Coatings Technology, 120: p. 277-283.
[16] Mitrovic.S 2012. Tribological potential of hybrid composites based on zinc and aluminium alloys reinforced with SiC and Graphite particles. Tribology in Industry, 34(4): p. 177-185.
[17] Wank.A. 2006. Comparison of hard metal and hard chromium coatings under different tribological conditions, Surface & Coatings Technology, Vol. 201, No. 5, pp. 1975–1980