International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 2, No. 2, April 2013

Research Paper

TO STUDY THE EFFECTS OF WEAR RESISTANT COATING ON BEARING ALLOY STEEL (E52100) BY PLASMA SPRAY METHOD

Sumit Singh[1]*, Preetkawal Singh[2], Ashwani Kumar[1] and Sukhminderbir Singh Kalsi[1]

**Corresponding Author: Sumit Singh,* ✉ *sumit2virdi@yahoo.com*

In a textile mill the spinning machine's ring frame comprises of a ring and a traveller. The yarn is twisted with the help of a traveller and is winded on the bobbin with the dual support of a ring and the traveller. The traveller is dragged along behind by the spindle even though it doesn't have a drive on its own. During winding the centrifugal force generates high contact pressure between the ring and the traveller. This pressure results in the internal surface degradation of the ring which further affects its working life. The main aim of this study was to augment the working life of the ring in order to depreciate the idle time required to restore the rings on the spindle repeatedly during spinning. The objective was accomplished by the means of thermal spray coatings, where the effect of the coatings on the ambit of the wear and wear characteristics of the rings were inspected. In this study the plasma sprayed coatings, namely Cr_3C_2NiCr was analyzed on E52100 of the ring. ATSMG99 standards were used for performing wear tests on Pin-on-Disc for both the uncoated and coated samples of E52100. The wear behavior of the coated as well as uncoated bearing alloy steel is interpreted with the result of wear data generated. The result exhibit that Cr_3C_2NiCr has been profitably deposited on E52100 grade of bearing alloy steel by plasma spray process. In comparison to bare E52100 the coated E52100 have shown considerably less wear loss. The accruing volume loss for plasma sprayed coatings increases with the increase in load. The Cr_3C_2NiCr coating has sustained minimum wear. The Cr_3C_2NiCr-E52100 coating-substrate combination has shown minimum wear.

Keywords: Wear resistant coating, Bearing alloy steel, Plasma spray method

INTRODUCTION

Wear occurs as a natural consequence when two surfaces with a relative motion interact with each other. Wear may be defined as the progressive loss of material from contacting surfaces in relative motion. Scientists have

[1] Department of Mechanical Engineering, ACET, Amritsar, India.
[2] Department of Mechanicala Engineering, BCET, Gurdaspur, India.

developed various wear theories in which the Physico-Mechanical characteristics of the materials and the physical conditions (e.g., the resistance of the rubbing body and the stress state at the contact area) are taken in to consideration. Wear of metals is probably the most important yet at least understood aspects of tribology. It is certainly the youngest of the tri of topics, friction, lubrication and wear, to attract scientific attention, although its practical significance has been recognizes throughout the ages.

METHODS TO CONTROL WEAR

There are many types of wear, but there are only four main types of wear systems (tribosystems) that produce wear and six basic wear control steps. The four basic tribosystems are: Relatively smooth solids sliding on other smooth solids, Hard sharp substances sliding on softer surfaces, Fatigue of surfaces by repeated stressing (usually compressive), Fluids with or without suspended solids in motion with respect to a solid surface. Various design features can also considered reducing wear. The various traditional techniques applied to materials to deal with wear produced in the preceding tribosystemsinclude: Separate conforming surfaces with a lubricating film. Lubrication is the most important factor for wear consideration. The main objective of lubrication is to reduce the severity of friction and wear in addition to performing other functions. Make the wearing surface hard through the use of hard facing, diffusion heat treatments, hard chromium plating, or more recently developed vapor deposition techniques or high-energy processes. Make the wearing surface resistant to fracture. Many wear processes involve fracture of material from a surface; thus toughness and fracture resistance play a significant role in wear-resistant surfaces. The use of very hard materials such as ceramics, cemented carbides, and hard chromium can lead to fracture problems that nullify the benefits of the hard surface.

COATINGS

Coating is a covering that 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, wetability, corrosion resistance, wear resistance, and scratch resistance.It can also be defined as a layer of material, formed naturally or deposited artificially on the surface of an object made of another material, with an aim of obtaining required technical or decorative properties (Burakowski and Wierzchon, 1999). It is a fact of life that many components are deemed to be worn out when their surfaces have degraded beyond a predetermined limit. However, the useful life of many components may be extended by coating with a material tailored to resist the particular environment in which the component is working. Coatings can vary from a few to several hundred microns and be deposited by different means.

PLASMA SPRAY COATINGS

Plasma spraying is one of the most widely used thermal spraying technique which finds a lot of applications due to its versatility of spraying a wide range of materials from metallic to non metallic. An arc is created between tungsten tipped copper cathode and an annular copper anode (both water cooled).

Plasma generating gas is forced to pass through the annular space between the electrodes. While passing through the arc, the gas undergoes ionization in the high temperature environment resulting plasma. The ionization is achieved by collisions of electrons of the arc with the neutral molecules of the gas. The plasma protrudes out of the electrode encasement in the form of a flame. The consumable material, in the powdered form, is poured into the flame in metered quantity. The powders melt immediately and absorb the momentum of the expanding gas and rush towards the target to form a thin deposited layer. After that next layer strikes on it and the coating builds up.

CASE STUDY

Degradation of materials by wear is a very common problem, e.g., in wear of Rings, lappet hooks, traveler in case of textile machinery, bearings, etc. Sowear problem of Ring Traveller (E52100) selected as case study in the present work. Due to abrasive wear of Ring, they require frequent repair and replacement; it increases the idle time of the machine to reinstate it, which ultimately results in production loss. It has been decided to use surface coatings on their surfaces to solve the problem. After a comprehensive literature review, Plasma Spray coating technique was selected to deposit coatings (Chromium Carbide-Nickel Chromium Cr_3C_2-NiCr) on this material. The wear data will be helpful to study the wear kinetics for the uncoated as well as the coated bearing alloy steel (E52100) and to explain the role of the coatings to affect the wear phenomenon of the bearing alloy steel.

EXPERIMENTAL PROCEDURE

Selection of the substrate material for the present study has been made after consultation with engineer. To know the composition and grade of the substrate material, it (substrate material) was sent to laboratory test for spectroscopic analysis test at Central Tool Room, Ludhiana, Punjab. After getting the report, it was found that the grade of steel was E52100,which is used for the manufacturing of ring of ring traveller. The substrate material (E52100) which was used to prepare small cylindrical pins having circular cross-section of diameter equal to 5 mm and length equal to 30 mm. A total of 8 pins were prepared. The pins were prepared on lathe machine and their end faces (to be coated) were ground on cylindrical grinding machine. Grinding was followed by polishing with 1/0, 2/0, 3/0, and 4/0 grades polishing papers.the wear tests were conducted with the help of Pin-On-Disk wear test rig on coated as well as uncoated surfaces. Different experimental readings were obtained from the machine under varying load conditions. These readings were helpful to study the wear kinetics for the uncoated as well as the coated E52100 and to compare the role of the coatings to reduce the wear of E52100.

RESULTS

Wear Behavior of Chromium Carbide Nickel Chromium (Cr_2C_3-NiCr) coatings v/s E52100:

The samples of coating, i.e., Chromium Carbide Nickel Chromium (Cr_2C_3-NiCr) on E52100 were subjected to wear on Pin-On-Disc wear test rig at normal loads of 30 N, 40 N and 50 N respectively. Three samples of E52100 substrate were also subjected to wear on Pin-On-Disc wear test rig at the same loads. The wear data was collected and shown in Tables 1 and 2. Figure 1 shows the graphical representation of the cumulative volume loss for Chromium Carbide Nickel Chromium (Cr_2C_3-NiCr) and E52100 with time. Table 1 shows cumulative volume loss with increase in load for bearing alloy steel (E52100). Table 2 shows cumulative volume loss with increase in load for Chromium Carbide Nickel Chromium (Cr_2C_3-NiCr) on E52100. It is observed from the results (Figure 1) that the coating; Chromium Carbide Nickel Chromium (Cr_2C_3-NiCr) have shown better wear resistance as compared to E52100 substrate material. The wear rate of Cr_2C_3-NiCr is very little as compared to bare E52100, which is shown by a flat curve.

Figure 1: Cumulative Volume Loss with Time for Cr_2C_3-NiCr and E52100

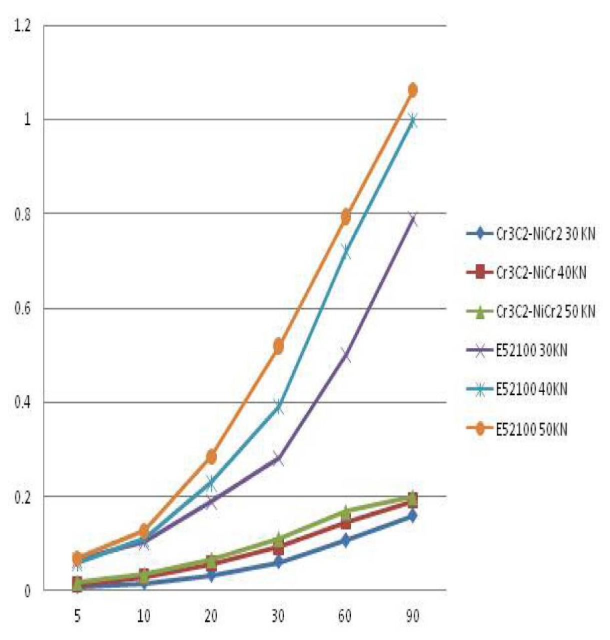

Table 1: Cumulative Volume Loss with Load for E52100

Material (E52100)	Load kN	Time (min)	Initial WT (gm)	Final WT (gm)	Cum Vol. Loss (mm³)
1	30	5	4.6658	4.6608	0.632911
	30	5	4.6608	4.6578	0.379747
	30	10	4.6578	4.6523	0.696203
	30	10	4.6523	4.6442	1.025316
	30	15	4.6442	4.6325	1.481013
	30	15	4.6325	4.6275	0.632911
	30	30	4.6275	4.6154	1.531646
2	40	5	4.9330	4.9298	0.405063
	40	5	4.9298	4.9245	0.670886
	40	10	4.9245	4.9155	1.139241
	40	10	4.9155	4.9030	1.582278
	40	15	4.9030	4.8915	1.455696
	40	15	4.8915	4.8778	1.734177
	40	30	4.8778	4.8566	2.683544

Table 1 (Cont.)

Material (E52100)	Load kN	Time (min)	Initial WT (gm)	Final WT (gm)	Cum Vol. Loss (mm^3)
3	50	5	5.0270	5.0234	0.455696
	50	5	5.0234	5.0149	1.075949
	50	10	5.0149	5.0052	1.227848
	50	10	5.0052	4.9872	2.278481
	50	15	4.9872	4.9728	1.822785
	50	15	4.9728	4.9662	0.835443
	50	30	4.9662	4.9456	2.607595

Table 2: Cumulative Volume Loss for Cr_2C_3-NiCr

Coating Cr_2C_3-NiCr	Load kN	Time (min)	Initial WT (gm)	Final WT (gm)	Cum Vol. Loss (mm^3)
1	30	5	4.6117	4.6115	0.074074
	30	5	4.6115	4.6113	0.074074
	30	10	4.6113	4.6109	0.148148
	30	10	4.6109	4.6102	0.259259
	30	15	4.6102	4.6097	0.185185
	30	15	4.6097	4.6091	0.222222
	30	30	4.6091	4.6078	0.481481
2	40	5	4.6665	4.6662	0.111111
	40	5	4.6662	4.6658	0.148148
	40	10	4.6658	4.6651	0.259259
	40	10	4.6651	4.6642	0.333333
	40	15	4.6642	4.6635	0.259259
	40	15	4.6635	4.6629	0.222222
	40	30	4.6629	4.6615	0.518519
3	50	5	4.6154	4.6150	0.148148
	50	5	4.6150	4.6146	0.148148
	50	10	4.6146	4.6138	0.296296
	50	10	4.6138	4.6127	0.407407
	50	15	4.6127	4.6120	0.259259
	50	15	4.6120	4.6113	0.259259
	50	30	4.6113	4.6105	0.296296

The cumulative volume loss for bearing alloy steel (E52100) is comparatively high as compared to Cr_2C_3-NiCr coatings. It has been observed that with increase in load on Chromium Carbide Nickel Chromium (Cr_2C_3-NiCr) wear increases. The observation is same for Bearing alloy steel (E52100) in which also wear increases with increase in load. The uncoated material curve shows that in the time during the initiation stage of wear, the wear rate is almost constant. But after that there is rapid increase in wear rate. Whereas in case of coated materials, there is almost constant wear rate. From the Figure 1 it is clear that the life of coated material is enhanced by five to six times as compared to uncoated material.

CONCLUSION

- Plasma sprayed Cr_3C_2NiCr coatings has successfully been deposited on E52100 grade of high tensile steel.
- The Plasma sprayed Cr_3C_2NiCr coatings coated on E52100 specimens showed significantly lower cumulative volume loss as compared to uncoated E52100 substrate.
- Cumulative volume loss for plasma sprayed Cr_3C_2NiCr coated as well as uncoated E52100 specimens increases with increase in load.
- The cumulative volume loss for Cr_3C_2NiCr coating was observed to be minimum in the present study.

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