Int. J. Mech. Eng. & Rob. Res. 2013

International Journal of Mechanical Engineering and Robotics Research

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

Research Paper

INVESTIGATING THE EFFECTS OF WEAR RATES ON MSEN-8 BY THERMAL SPRAY COATING

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A lappet hook is part of ring frame of a spinning machine in a textile mill. The lappet hook imparts twist to the yarn. The lappet hook help to wind the yarn on the bobbin. High contact pressure (upto 35 N/square mm)is generated between the thread and surface of lappet hook during winding, mainly due to centrifugal force. This pressure leads to degradation of internal surface of the hook, which significantly affects its working life. The objective of this study was to enhance the working life of the hook in order to decrease the idle time required to reinstate the lappet hook on the spindle periodically during spinning. The objective was carried out by means of thermal spray coatings, where the effect of the coatings on the extent of wear and the wear characteristics of the rings were examined. Detonation gun sprayed coatings, namely WC-Co, was compared in this study on MSEN8 of the lappet hook. The objective was carried out by means of hard coatings, where the effect of the coatings on the extent of wear and the wear characteristics of the lappet hook were examined. The study compared thermal spray coatings, namely D-GUN sprayed WC-Co on MSEN8. Wear tests were performed on Pin-On-Disc apparatus using ASTM G99 Standard for the uncoated and coated samples of high tensile steel. The result of coating experimental wear data generated, of the worn samples is used to analyze the wear behavior of coated as well as uncoated high tensile steel. The results show that WC-Co coatings have been successfully deposited on MSEN8 grade of high tensile steel by Detonation Spray Process. The coated MSEN8 has shown significantly less wear loss as compared to bare MSEN8. The cumulative volume loss for detonation sprayed coatings increases with increase in load. The WC-Co coating has undergone minimum wear. The WC-Co-En14B coating-substrate combination has shown minimum wear.

Keywords: Wear rates, Thermal spray coating, Lappet hook

INTRODUCTION

Wear is erosion or sideways displacement of material from its “derivative” and original position on a solid surface performed by the action of another surface. Wear is related to interactions between surfaces and more

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specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface.

Wear is a process of removal of material from one or both of two solid surfaces in solid state contact, occurring when two solid surfaces are in sliding or rolling motion together (Bhushan and Gupta, 1991). The rate of removal is generally slow, but steady and continuous Under normal conditions, the wear-rate normally changes through three different stages:

Primary stage or early run-in period, where surfaces adapt to each other and the wear-rate might vary between high and low.

Secondary stage or mid-age process, where a steady rate of ageing is in motion. Most of the components operational life is comprised in this stage. Tertiary stage or old-age period, where the components are subjected to rapid failure due to a high rate of ageing.

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 tribosystems include: 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.

THERMAL SPRAY TECHNOLOGY

Thermal spraying techniques are coating processes in which melted (or heated) materials are sprayed onto a surface. Characteristics of Thermal Spray Coatings:

Hardness: Thermal spray coatings are often used because of their high degree of hardness. Their hardness and erosion resistance make them especially valuable in high-wear applications. The hardness and density of thermal spray coatings are typically lower than for the feedstock material from which the coatings were formed. In the case of thermal spray metallic coatings, the hardness and density of the coating depend on the thermal spray material, type of thermal spray equipment, and the spray parameters. Corrosion resistance. Metallic thermal spray coatings may be either anodic or cathodic to the underlying metal substrate. Because corrosion occurs at the anode, anodic coatings will corrode in corrosive environments and the cathode will not. Anticorrosive coating systems are generally designed such that the coating material is anodic to the substrate metal. Anodic coatings will corrode or sacrifice to protect the substrate. Adhesion. Thermal spray coatings may have very high adhesion. Special coatings, used for wear resistance, that are applied by thermal spray processes with very high particle velocity can have greater tensile adhesions.

FORMULATION OF PROBLEM

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. So wear problem of lappet hook (MSEN-8) selected as case study in this thesis work. Due to abrasive wear of lappet hook, 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, detonation spray coating technique was selected to deposit three coatings (viz.; Tungsten Carbide-Cobalt WC-CO) on this material. It has been learnt from the literature that these coatings can provide better resistance to wear.

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 MSEN-8, which is used for the manufacturing of lappet hook. The substrate material (MSEN-8) 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 16 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.

Wear behavior of tunsten carbide and cobalt coatings vs. MSEN-8:

The samples of coating, i.e., WC-Co on MSEN-8 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 MSEN-8 substrate were also subjected to wear on Pin-On-Disc wear test rig at the same loads. Figures 1 shows the graphcal representation of Cummulative volume loss for tungsten carbide (WC-Co) and MSEN-8 with time. Table 1 shows the cumulative volume loss with increase in load for bare MSEN-8. Table 2 shows cumulative volume loss with increase in load for tungsten carbide (WC-Co) on MSEN-8. It is observed from the results (Figure 1) that the coating; WC-Co have shown better wear resistance as compared toMSEN-8 substrate material. The

Figures 1: Cummulative Volume Loss for WC-Co and MSEN-8

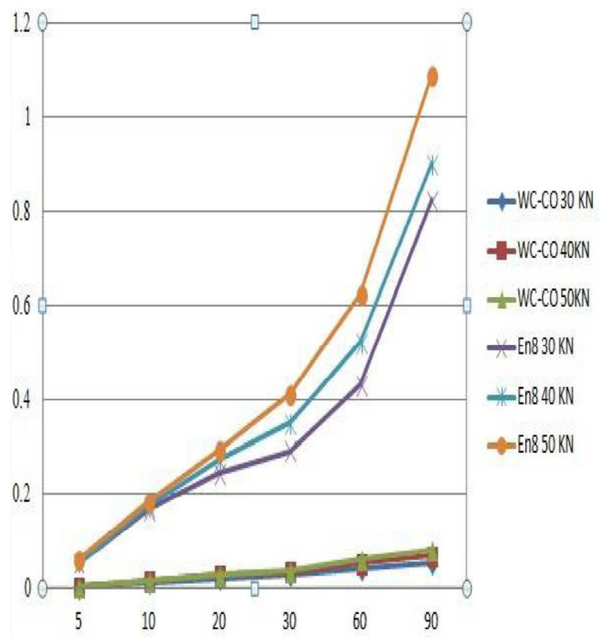

Table 1: Cummulative Volume Loss for MSEN-8

Material (MSEN-8)	Load kN	Time (min)	Initial WT (gm)	Final WT (gm)	Cum Vol. Loss (mm^3)
1	30	5	5.1430	5.1401	0.053
	30	5	5.1401	5.1388	0.053
	30	10	5.1388	5.1368	0.1648
	30	10	5.1368	5.1356	0.2433
	30	15	5.1356	5.1344	0.2904
	30	15	5.1344	5.1320	0.4317
	30	30	5.1320	5.1220	0.824
2	40	5	5.0461	5.0455	0.053
	40	5	5.0455	5.0440	0.053
	40	10	5.0440	5.0433	0.173
	40	10	5.0433	5.0420	0.2733
	40	15	5.0420	5.0365	0.3504
	40	15	5.0365	5.0315	0.5217
	40	30	5.0315	5.0321	0.902

Table 1 (Cont.)

Material (MSEN-8)	Load kN	Time (min)	Initial WT (gm)	Final WT (gm)	Cum Vol. Loss (mm^3)
3	50	5	5.1560	5.1548	0.059
	50	5	5.1548	5.1530	0.059
	50	10	5.1530	5.1520	0.183
	50	10	5.1520	5.1503	0.294
	50	15	5.1503	5.1420	0.41
	50	15	5.1420	5.1365	0.623
	50	30	5.1365	5.1280	1.09

Table 2: Cumulative Volume Loss for WC-Co

Coating WC-Co	Load kN	Time (min)	Initial WT (gm)	Final WT (gm)	Cum Vol. Loss (mm^3)
1	30	5	5.1733	5.1730	0.056604
	30	5	5.1730	5.1728	0.037736
	30	10	5.1728	5.1725	0.056604
	30	10	5.1725	5.1722	0.056604
	30	15	5.1722	5.1720	0.037736
	30	15	5.1720	5.1717	0.056604
	30	30	5.1717	5.1711	0.113208
2	40	5	4.9884	4.9880	0.075472
	40	5	4.9880	4.9878	0.037736
	40	10	4.9878	4.9875	0.056604
	40	10	4.9875	4.9872	0.056604
	40	15	4.9872	4.9868	0.075472
	40	15	4.9868	4.9863	0.09434
	40	30	4.9863	4.9856	0.132075
3	50	5	4.8655	4.8652	0.056604
	50	5	4.8652	4.8649	0.056604
	50	10	4.8649	4.8645	0.075472
	50	10	4.8645	4.8640	0.09434
	50	15	4.8640	4.8635	0.09434
	50	15	4.8635	4.8630	0.09434
	50	30	4.8630	4.8621	0.169811

wear rate of WC-Co is very little as compared to bare MSEN-8, which is shown by a flat curve between CVL and time in Figure 1. The CVL for bare MSEN-8 is comparatively high as compared to WC-Co coatings.

The wear volume loss was also calculated from the weight loss and density of the coatings as well as substrate material for all the investigated cases. These data were reported in the form of plots showing the cumulative wear volume loss Vs cumulative time for all the cases. Bar charts were also drawn to show net wear volume loss for all the cases.

Volume = mass/density

Wear Volume Loss = $(\delta w/9.81)/\rho$

Where δw is the weight loss in, g

and ρ is the density of material, g/mm^3

CONCLUSION

- Detonation Sprayed Stellite-6, Cr_3C_2NiCr, and WC-Co coatings have successfully been deposited on MSEN-8 grade of high tensile steel.
- The detonation sprayed Stellite-6, Cr_3C_2NiCr, and WC-Co coated on MSEN-8 specimens showed significantly lower cumulative volume loss as compared to uncoated MSEN-8 substrate.
- Cumulative volume loss for detonation sprayed Stellite-6, Cr_3C_2NiCr, and WC-Co coated as well as uncoated MSEN-8 specimens increases with increase in load.
- The cumulative volume loss for WC-Co coating was observed to be minimum in the present study.

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