ABRASIVE WEAR STUDIES ON COBALT ELECTRODEPOSITED SURFACES WITH TiO_2 DISPERSIONS

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ABSTRACT

Cobalt depositions are generally preferred for high temperature applications. When a second phase of fine tough particles are incorporated in the coating matrix, Tribological properties are found to have improved much. The performance of such composite depositions have rarely been assessed towards different mating conditions. Cobalt depositions with engulfed TiO_2 particles were studied for their performance towards abrasive wear and are reported. Effect of heat treatment of these depositions on the surface mechanical properties were studied. Surface microhardness and wear loss due to rubbing abrasion were estimated on coated panels before and after heat treatment in the range of 100-700°C. The composite containing 12.5% by volume of TiO_2 and heat treated at 600-700°C were found to exhibit high abrasion resistance. This is attributed to the formation of glass like layers on the surface.

INTRODUCTION

The endearing characteristics of composite coatings include high wear resistance and improved surface mechanical properties. Automobile parts and machine tools which wear out at high temperature under stress may be provided with a hard cobalt coating[1]. The surface mechanical properties of such coatings have to be considerably improved to offer resistance to wear at elevated temperatures[2]. Cobalt coatings are employed in such engineering applications to combat tough mating conditions at high temperatures. Electrodeposition is a low cost versatile method used for such surface build up and if fine tough particles are embedded (co-deposited) in the coating matrix the performance could be much improved. TiO_2 particles were co-deposited in Cobalt coatings to observe the surface behaviour towards abrasive wear. The coatings were subjected to post heat treatment and were tested for Micro hardness(HV) and abrasive wear resistance using a precision built test instrument "Taber Abraser (model 174)" as reported by Kalyanaraman etal[3]. A sulphate bath was employed for depositing Co and the coated specimens were subjected to heat treatment for 1hr from 100°C to 700°C to observe the surface changes and were then tested for surface microhardness (HV) and abrasive wear resistance.

EXPERIMENTAL

The dispersive coatings were deposited from suspensions composed of electrolytes containing metal sulphates, boric acid and additives with 50-200g / L of fine tough TiO2 particles. The coating thickness was kept at 30µm. Optimum deposition conditions, such as current density, temperature, concentration, pH, etc., for uniform good coatings were achieved by performing many trials. Abrasive wear tests conducted using the Taber Abraser revealed abrasion resistance at all angles relative to the grain or weave of the material. The wear rate was established by a relative term typical of the testing

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instrument, called the "Taber wear index", which is the loss in milligrammes per thousand cycles of rotation for a test performed under a specific set of experimental conditions. To understand the surface morphology of the coatings, SEM studies were carried out using a JEOLJSM 35 scanning electron microscope. Before the SEM micrographs were taken, the samples were heat treated at 200 °C for 20min in air. The topography of rough and smooth Co coated surfaces was also studied using a topographic profilometer.

RESULTS AND DISCUSSION

The inclusion of TiO_2 achieved was 12.5 vol % in Cobalt depositions , which were then heat treated at various temperatures from 100 °C to 700 °C for 1 hour. Figure 1 shows the variation in microhardness with temperature before and after abrasion for Co-TiO_2 surfaces.

Figure 1

With increase in temperature; an increase in surface micro hardness was observed . The valueswere found to be less for the abraded surfaces. Figure 2 shows the variation in Taber wear index with temperature for Co-TiO_2 surfaces. It could be seen that the surface could be abraded well below 300 °C because the resistance offered was less. Above this temperature, the wear rate was reduced to a great extent.

Figure 2

From the variation in Taber wear index with temperature for Co-TiO_2 surfaces, it was observed that the rise in the hardness value with temperature is more when compared with the nickel deposit reported by the same author[4]. Also no anomalous behaviour after 300 °C was observed for cobalt deposited surfaces.

A typical SEM micrograph of unabraded Co-TiO2 coating after heat treatment at 200 °C .

It can be seen from the micrographs that the coating was uniform with dispersed TiO_2 particles. Below 300 °C, the surface could be abraded well because the resistance offered was less, even with higher surface microhardness, compared with nickel based depositions. Ni based composite depositions offered higher wear resistance at lower temperatures compared to Co composites[5]. Above 300°C, the wear rate was reduced sharply. Also, after heating at 350°C, a glass-like layer was formed on the Co-TiO_2 surface. From 500°C to 650°C, the surface was found to be shiny after abrasion resembling a glass surface, which was easily observed with the naked eye. This glassy layer could be as a result of oxide formation. This oxide build –up on the surface offers higher hardness and abrasive wear resistance offering low wear loss at elevated temperatures. The surface build-up after heat treatment around 350°C offers shift resistance and withstands higher stress

A typical SEM micrograph of Co-TiO_2 coated abraded surface.

In the SEM micrograph of the Co coated abraded surface shown, peaks and valleys were found to be present. This is as a result of the uniform abrasive wear tracks found on the Co coated surface. The surface becomes smooth and hard which does not favour further wear. This is reflected by the low wear index values. These studies indicate that Co-TiO2 surfaces stand as a good choice in high temperature applications.

CONCLUSION

Coating of Co–TiO_2 was performed successfully on mild steel panels. The effects of heat treatment on these deposits were studied. The surface topography and morphology of the coatings were also studied. Heat treatment has a very great influence on the surface properties of Co-TiO_2 deposits. Initially, for Ni coatings the wear rate was lower compared with Co deposits. The Co coatings with 12.5 vol % dispersion of TiO_2 in the matrix heated up to 200°C resulted in some wear due to abrasion and after 350°C the wear index was found to decrease sharply indicating very low wear loss. This is attributed to the glass-like oxide layer of the cobalt coating. Therefore, cobalt coatings with suitable dispersion stand as a good choice in high temperature applications. It is worth evaluating these coated surfaces in different types of wear to understand the wear mechanism of the glass-like layer. Efforts are under way to estimate the thickness of the glass-like layer by spectroscopic methods. Further studies on the depth profile of the glassy layer and evaluation of this surface against different mating surfaces are in progress

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