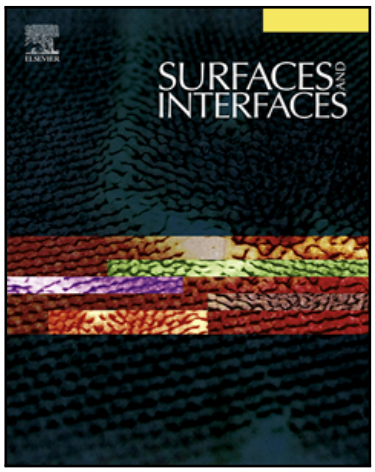

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Study of Wear and Friction of Chemically Deposited Ni-P-W Coating under Dry and Lubricated Condition

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Abstract:

In the present work, ternary Ni-P-W coating is deposited on mild steel substrates from an alkaline hypophosphite based electroless bath. The coatings are characterized in terms of their composition, phase structure and surface morphology using energy dispersive X-ray analysis, X-ray diffraction analysis and scanning electron microscope. It is seen that the coatings exhibit a mixture of X-ray amorphous and nanocrystalline nature in their as-deposited condition due to the co-deposition of tungsten and turns crystalline on heat treatment at 400°C for 1h. A typical nodular surface morphology is observed in scanning electron micrographs. Microhardness and surface roughness of the coatings are also reported. Tribological characterization of the coatings are carried out on a pin-on-disc configuration tribo-tester by varying the test parameters namely the applied normal load, sliding speed and sliding duration with coefficient of friction and wear depth being the responses. The tests are carried out under lubrication as well as in dry condition to strike a comparison between the two environments. Wear depth is seen to increase with an increase in the applied normal load, sliding speed as well as sliding duration under lubricated condition. The variation of COF under lubricated condition is seen to be quite complex due to the synergistic effects of the tribo-testing parameters, lubrication, coating surface morphology and microstructure. A noteworthy improvement in the tribological behavior of Ni-P-W coating is achieved under lubricated sliding condition.

Keywords: Electroless, Ni-P-W, wear, friction, hardness, roughness, lubrication

1. Introduction

Electroless nickel (EN) plating is a process of coating deposition on a substrate without the use of electricity. It is an autocatalytic process, where reduction of metal ions in the solution and the coating deposition is carried out through the oxidation of a chemical compound present in the solution itself i.e. a reducing agent. An electroless bath comprises of an aqueous solution of metal ions, reducing agent, bath stabilizer and complexing agent. The development of this variant of coating technology can be accredited to Brenner & Riddell in the year 1946 [1]. Though electroplating is a more straight-forward process, electroless coatings have received wide acceptance because of their enhanced mechanical and tribological properties [2]. Most importantly the deposition of coating is uniform and intricate parts can be coated very easily. This process is widely used in various industries such as electrical, aerospace, automotive, electronics, etc [3]. EN coatings possess enhanced wear resistance and hardness, and thus mostly find their use in applications requiring lower friction and wear of parts [1 – 5].

In general, EN coatings can be classified as pure nickel, nickel alloy coatings (binary, ternary or polyalloy coating) [5 – 10] and electroless nickel composite coatings [3, 11 – 13]. Hypophosphite reduced Ni-P coating and borohydride reduced Ni-B coating have already gained immense significance because of their enhanced tribological properties such as low surface roughness, high hardness, high resistance to wear and abrasion and good corrosion resistance. They also have reduced friction properties due to their microstructure. Ni-B coating has a cauliflower like structure making it self-lubricating in nature [7, 14 – 16]. The hardness of both Ni-P and Ni-B increases significantly with heat treatment as well as by varying the bath components [17, 18]. But the hardness for both of them degrades significantly with excessive heating [2, 5, 17]. The wear resistance of electroless nickel coatings can be improved by incorporating hard particles such as TiO_2, SiC, Al_2O_3 , diamond, etc., the choice of which depends on the application