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Ni-W-P Alloy Coating as an Alternate to Electroplated Hard Cr Coating

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Abstract : Electroplated hard chromium is widely known in coatings and surface finishing, automobile and aerospace industries because of its excellent hardness, wear resistance and corrosion properties. However, its precursor, Cr+6 is highly carcinogenic in nature and a consensus has been adopted internationally to eradicate this coating technology with an alternative one. The search for alternate coatings to electroplated hard chrome is continuing worldwide. Various alloys and nanocomposites like Co-W alloys, Ni-Graphene, Ni-diamond nanocomposites etc. have already shown promising results in this regard. Basically, in this study, electroless Ni-P alloys with excellent corrosion resistance was taken as the base matrix and incorporation of tungsten as third alloying element was considered to improve the hardness and wear resistance of the resultant alloy coating. The present work is focused on the preparation of Ni–W–P coatings by electrodeposition with different content of phosphorous and its effect on the electrochemical, mechanical and tribological performances. The results were also compared with Ni-W alloys. Composition analysis by EDS showed deposition of Ni-32.85 wt% W-3.84 wt% P (designated as Ni-W-LP) and Ni-18.55 wt% W-8.73 wt% P (designated as Ni-W-HP) alloy coatings from electrolytes containing of 0.006 and 0.01M sodium hypophosphite respectively. Inhibition of tungsten deposition in the presence of phosphorous was noted. SEM investigation showed cauliflower like growth along with few microcracks. The as-deposited Ni-W-P alloy coating was amorphous in nature as confirmed by XRD investigation and step-wise crystallization was noticed upon annealing at higher temperatures. For all the coatings, the nanohardness was found to increase after heat-treatment and typical nanonahardness values obtained for 400°C annealed samples were 18.65±0.20 GPa, 20.03±0.25 GPa, and 19.17±0.25 for alloy coatings Ni-W, Ni-W-LP and Ni-W-HP respectively. Therefore, the nanohardness data show very promising results. Wear and coefficient of friction data were recorded by applying a different normal load in reciprocating motion using a ball on plate geometry. Post experiment, the wear mechanism was established by detail investigation of wear-scar morphology. Potentiodynamic measurements showed coating with a high content of phosphorous was most corrosion resistant in 3.5wt% NaCl solution.

Keywords : corrosion, electrodeposition, nanohardness, Ni-W-P alloy coating
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