Transforming the inferior metal alloy by electroless Ni-P/SiC deposit

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1. Introduction

Surface modification by metal deposition onto inferior material is of paramount importance for many engineering applications. A type of metal coating by electroless technique is versatile owing to its promising material properties and characteristics. Heat treatment of electroless nickel coating is important owing to the properties enhancement such as increase in microhardness, tribology and phase transformation [1].

1.1 What is the purpose?

For automotive and aerospace industries light weight aluminium alloy are the back bone for any grand design and structure. But these alloys are vulnerable to wear, erosion, corrosion. Electroless nickel coated reinforced with hard particles can transform the surface behaviour of the substrate. With optimal heat treatment the coating properties can further be enhanced.

1.2 Research state

The present work aims to develop and understand the composite coating Ni-P/SiC by electroless technique. The characteristics such as phase structure, morphology and properties like microhardness, friction and wear are investigated systematically.

Aluminium alloy LMD (Al-80%Si-5.5%Cu) alloy was used as substrate. It underwent pretreatment as shown in Table 1. Each step was followed by tap water washing and deionized water rinsing. The composite coating process parameters are shown in Table 2. The hard particles were introduced and stirred for 30 min prior to the plating process started. Upward and downward of the pH adjustment was done using 50 % NH4OH and 10 % H2SO4, respectively.

Heat treatment was done in furnace and for vacuum all the samples were sealed in glass before placing in the furnace. XRD analysis on coated samples was carried out at room temperature using PANalytical X-ray diffractometer applying CuKα radiation. The step size of scans was 0.2°. Energy dispersive X-ray (EDX) map by Aico- versar 2.0 software was used for chemical composition analysis. Microhardness by microindenter using load of 100 g. Tribology behavior was tested using wear tester with load of 30 N rotating in circular track of 8 mm diameter at a rotational speed of 200 rpm with the ball diameter of 7 mm. And also in-air (200°C) monitoring using 2 N load with ball diameter of 6 mm and track diameter of 15 mm was performed using different pin-on-disc wear tester.

2. Results and discussion

The coating uniformity and the distribution of the reinforcing particles are shown in Fig. 1. The particles are evenly distributed in the coating which also follows the contour of the substrate [5].

2.1 Phase structure

The black peak for the as-deposited state (AA) of the coating shows the amorphous structure for all the samples. The heat treated state in both amorphous (A-HT) and vacuum (V-HT) conditions show well defined sharp peaks mainly from the crystalline Ni and NiP, and SiC peak for composite coatings. Oxide peaks are not observed for the two types of heat treated samples.

3. Microstructure

Significant increase in microhardness post coating as compared to the base Al substrate (Fig. 3) is observed. Upon heat treatment the microhardness further increases. Reference grey cast iron was taken as it is the conventional material for cylinder liner in engine system.

4. Wear characteristics of the base aluminium and the coatings in terms of wear rate is tabulated in Table 3. Wear rate is lower after the coating. Wear resistance is improved on heat treatment as compared to as-deposited state.

5. Conclusion remarks

- Deposition of composite Ni-P/SiC onto aluminium alloy shows uniform coating and even distribution of reinforcing particles. SIC content increase on increasing Ni-Si concentration in the plating solution.
- XRD profile shows crystalline peaks from NiP and SiC peaks for composite samples in heat treated conditions and amorphous phase in as-deposited state.
- Microhardness increase after coating as compared to uncoated aluminium. Heat treatment further enhances the microhardness.
- Instability of the friction during the early stage of sliding is noticeable for atmospheric environment and vacuum samples of nickelated coating. No abrupt changes in the friction are found for vacuum heat treated samples.
- High temperatures of worn engine environment shows lower friction for coated samples as compared to grey cast iron.
- Wear resistance in better for coated samples in terms of lower wear rate. Heat treated samples exhibit better wear resistance as compared to as-deposited state.

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References