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Wear Characteristics of Porous Alumina Based Nanocomposite Coating on 6061 Aluminium Alloy

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Aluminium alloys show higher mechanical properties than pure aluminium owing to the presence of alloying elements. Nanoporous alumina grown on the aluminium substrate by two-step anodization process can be used as a template to synthesize nanocomposites. The pores of the nanoporous alumina layer when filled with a second phase material like copper or nickel results in a ceramic-metal nanocomposite coating. The effect of deposition of the second phase material on the tribological characteristics of porous alumina layer is studied by indentation and reciprocating wear tests of the nanocomposite coating.

Keywords: anodization, nanoporous alumina, wear, tribology

1. Introduction

Anodization of aluminium and its alloys is a widely practiced industrial process to grow passive alumina layers that provide enhanced resistance against corrosion and abrasion. By controlling the electrochemical conditions during anodization, a highly ordered nano porous alumina layer with hexagonal structure can be obtained on pure aluminium. Anodized oxide coatings grown out of the base aluminium substrate have excellent interfacial strength and provide good wear resistance [1]. But their porosity and brittleness reduce the hardness and induces cracking. Depositing a secondary phase material like copper or nickel in the pores of the alumina layer enhances its tribological properties [2,3]. The deposition of a second phase material in oxide matrix results in metal-ceramic nanocomposite. Studying the tribological characteristics under indenting and reciprocating loads on both the porous alumina layer and alumina-based composite helps us to understand the influence of the secondary phase on the properties of the oxide layer.

2. Experimental details

Aluminium alloy 6061 is anodized in oxalic acid electrolytic solution to form porous oxide layer on the base metal. By optimizing the anodizing parameters, a two-step anodization of aluminium results in the formation of uniformly ordered nano porous alumina layer on the surface of the metal substrate as shown in figure (1a). The pores are cylindrical with pore diameter about 100 nm. The samples with porous oxide layer are subjected to electrodeposition to fill the pores with copper. Under optimized conditions, nanopillars of copper are formed in the pores with pulsed electrodeposition as shown in figure (1b). The metallic nanopillars and the oxide matrix together form ceramic-metal nanocomposite layer.

The specimen with porous alumina and copper filled nanocomposite coatings are subjected indentation loads. The indentation hardness is measured, and the indent formed on the oxide layer in both the cases are viewed under a scanning electron microscope to observe the mode of deformation. Reciprocating wear tests are conducted to study the wear characteristics of the layers.

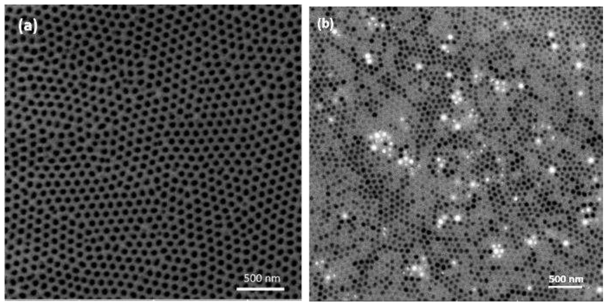

Figure 1: SEM micrographs of (a)nanoporous alumina layer and (b)copper-filled alumina nanocomposite layer.

3. Discussion

The presence of intermetallic elements in aluminium alloys result in non-homogenous nucleation and non-uniform formation of pores in the oxide layer. The porous alumina layer undergoes cracking under loads because of its brittleness. The second phase material in the nanocomposite reduces the fracture of the ceramic layer. The nanocomposite layer shows increased number of life cycles during reciprocating wear test compared to the porous alumina layer.

4. References

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