TRIBOLOGICAL BEHAVIOR OF Al-B_4C METAL MATRIX NANOCOMPOSITES

Thesis submitted

By

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Doctor of Philosophy

(Engineering)

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Abstract

The present thesis deals with the tribological behavior of Al-B_4C metal matrix nanocomposite and establishes the composite matrix as a potential tribo material. Aluminum has several favourable factors like low-cost availability, low density, better strength, corrosion resistance, near-infinite recyclability, and casting ease. Aluminium alloys for wear applications are generally based on Al-Si alloy system. Accordingly AlSi12 alloy is used as a base matrix. Boron carbide (B_4C) nanoparticle is selected as reinforcement material as it has better interfacial bonding with aluminium. Besides, it has superior properties like low density (2.52 g/cc), high melting point (2450°C), high elastic modulus (460 GPa), thermal & chemical stability, extremely high hardness (30 GPa), good wear and impact resistance, low thermal expansion coefficient (5 x 10^{-6}/ °C), low thermal conductivity (40 W/mk) etc. Al-B_4C nanocomposites are fabricated using a combination of mechanical stirring and ultrasonic vibration assisted stir casting methods. Initially the fabricated specimens are tested for density and porosity to ensure defect free castings. Microhardness values of the composites are determined and compared with the base matrix. Afterwards the cast specimens are characterized using optical microscopy, scanning electron microscopy, and energy dispersive spectroscopy analysis. Wear and friction properties of the nanocomposites are investigated by considering several parameters like reinforcement content, applied loads, speeds, sliding distances, and the elevated operating temperatures. Tribochemical interactions occur in the sliding surfaces which are studied using worn surface micrographs and elemental analysis. Nanoindentation and elastic modulus of the fabricated composites are determined by nanoindentaion tests. Scratch behavior is studied using a single point scratch test. Finally corrosion behavior of the composites is studied in 3.5% NaCl solution. Corroded surfaces and the degradation mechanisms are examined using FESEM images and EDX spectra.

Microstructural characterization of Al-B_4C composites revealed that the particles are homogeneously distributed in the composite structure with good interfacial bonding. Micro hardness of the alloy is enhanced with increasing B_4C content. Presence of hot hard ceramic particles significantly improved the tribological properties of Al alloy tested

under different parametric conditions. Increased strength of alloy, delay in thermal softening and lubricative transfer layers formed in the sliding interface were found crucial for this enhanced performance. Significant increase in nanohardness and scratch resistance is observed with the increasing content of ceramic particles. Corrosion resistance of alloy is improved for the small incorporation (0.5 wt %) of B_4C particles. However further increase in the reinforcement content degraded the corrosion behavior. It is expected that the results presented in the thesis will be of significant interest, both from the academic and industrial viewpoint.

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