STUDIES ON MECHANICAL AND TRIBOLOGICAL BEHAVIOUR OF PARTICULATE ALUMINIUM METAL MATRIX COMPOSITES

A THESIS

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SOMASUNDARA VINOTH K

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ANNA UNIVERSITY

CHENNAI - 600 025

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ABSTRACT

Particulate aluminium matrix composites are increasingly used in various automobiles and aerospace applications since they exhibit isotropic and improved physical and mechanical properties. In addition, they can be processed through by conventional methods. Aluminium-silicon alloys and aluminium-based metal-matrix composites are used in the manufacture of various automotive engine components such as cylinder blocks, pistons and piston ring inserts. Wear resistance of Al-Si alloys improved with increasing Si content up to a near-eutectic composition. Extensive research has been done in the development of Al-Si/SiC composites with near eutectic Al-Si alloys (A356, A359, Al-Si10, and Al-Si12) as matrix. However, only few tribological studies have been reported on Al-Si10Mg alloy composites (Al-Si10Mg/Al_20_3 and Al-Si10Mg/Al_20_3/MoS_{2p} and A360/17SiC and Al/17SiC/17B_4C). In addition, aluminium metal matrix composites reinforced with a solid lubricant (graphite, molybdenum disulfide, etc.), hard ceramic particles (silicon carbide, alumina, boron carbide, etc.), and short fibres show reduction in friction and wear compared to the matrix.

In the present study, an attempt has been made to fabricate Al-Si10Mg/SiC_p, Al-Si10Mg/MoS_{2p} composites and Al-Si10Mg/SiC_p/MoS_{2p} hybrid metal matrix composites reinforced with Silicon Carbide (SiC_p) and Molybdenum disulphide (MoS_{2p} using stir casting technique. SiC_p particulates help to impart higher specific stiffness, strength, and hardness, while MoS_{2p} particles impart improved self-lubrication property.

Density as well as mechanical properties such as tensile strength, hardness of Al-Si10Mg/SiC_p, Al-Si10Mg/MoS_{2p} composites and Al-Si10Mg/SiC_p/MoS_{2p} hybrid metal matrix composites were determined and compare with those of matrix alloy. Morphology of worn surface of the composites as well as the fracture surface from tensile test were investigated using a Scanning Electron Microscope.

Response Surface Method (RSM), a statistical tool that uses quantitative data from appropriate experimental design to determine and simultaneously solve multivariate equations was employed to analyse the experimental results. Genetic Algorithm [GA], a direct, parallel, and stochastic method for global search and optimisation, which mimics the evolution of humans, was also used in the analysis. An integrated RSM GA approach was adopted to combine the benefits of both RSM and Genetic algorithm in the present studies.

Dry sliding wear tests were conducted using a pin-on-disc apparatus. Wear studies were conducted using sliding speed , applied load and weight percentage of dispersoid as the chosen experimental parameters**.** Mathematical models were developed based on RSM using experimental results as per Box Behnken design for Al-Si10Mg/SiC_p, Al-Si10Mg/MoS_{2p} composites as well as Al-Si10Mg/SiC_p/MoS_{2p} hybrid metal matrix composites. Consistency of the developed model was verified using supplementary random wear tests. Determination of optimum dry sliding wear conditions for the composites was done using GA approach. Scanning Electron Microscope investigations were used to confirm the results of RSM-

GA models. The ability of this RSM formulated using Box Behnken to predict the extended experimental results from Full factorial experiments was confirmed

High stress abrasive wear behaviour of composites was examined using pin-on-disc apparatus. The disc was covered with a commercial grade SiC emery sheet, bonded to the rotating disc. In order to allow exposure of fresh abrasive material, the specimen was moved against the parallel surface of the rotational steel disc. Abrasive Wear Rate was measured for various conditions by altering the wear parameters such as load, abrasive grit size, sliding speed, volume fraction of SiC_p and volume fraction of MoS_{2p}. A mathematical model was developed using RSM method for Al-Si10Mg/SiC_p/MoS_{2p} hybrid metal matrix composites.. Optimisation of high stress abrasive wear conditions for the composites was carried out by GA approach. Results of RSM-GA models were validated experimentally and by confirmed Scanning Electron Microscope investigations.