ABSTRACT

This thesis describes the novel laser surface alloying of aluminium AA1200 with various combinations of Ni, Ti and SiC powders, using a 4.4kW Rofin Sinar Nd:YAG laser in order to improve its mechanical and tribological properties. The laser alloying parameters were optimized on the breakdown systems of the complex Al-Ni-Ti-SiC system. Various analytical techniques were used to study the microstructures produced. Wear testing was conducted under sliding and abrasion conditions while the fracture mechanisms were investigated using impact tests. Aluminium surfaces reinforced with metal matrix composites and intermetallic phases were achieved. The phases present depended on the composition of the alloying powder mixture. Al reacted with Ni to form Al_3Ni and Al_3Ni_2 intermetallic phases while Ti reacted with Al to form an Al_3Ti intermetallic phase. Some of the SiC particles dissociated and reacted with either Al or Ti to form Al_4C_3, Al_4SiC_4, TiC or Ti_3SiC_2 phases. Si reacted with Ti to form a Ti_5Si_3 phase. An increase in surface hardness was achieved, up to a maximum of 13 times that of aluminium when alloying with 80wt%Ni + 15wt%Ti + 5wt%SiC. The increase in hardness was attributed to the intermetallic phases especially the Al_3Ni_2 phase. Alloying led to a 4-38% improvement in the wear resistance of the pure aluminium under sliding wear conditions and a 19-82% improvement under three body abrasion wear conditions. The predominant wear mechanisms for both wear types were groove formation by ploughing and cutting action of the abrasive particles, smearing, material pile-up, extensive cracking of the intermetallic phases and fracturing of the embedded SiC particles in the MMCs. Alloying led to a 31-50% decrease in the impact resistance of the pure aluminium. Brittle fracture of the SiC particles and transgranular cracking of the intermetallic phases were observed for the laser alloyed surfaces while ductile fracture was observed for the bulk aluminium.