Improvement of the Surface Properties of Aluminium by the Formation of Intermetallic Phases and Metal Matrix Composites during Laser Surface Alloying

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Aluminium is widely used in industry due to its low cost, light weight and excellent workability, but is lacking in wear resistance and hardness. Laser alloying is used to improve the surface properties, such as hardness, by modifying the composition and microstructure of the surface without affecting the bulk properties of the material [1,2]. The process involves melting the substrate surface and injecting the powder of the alloying material into the melt pool. Process parameters such as laser power, beam spot size, laser scan speed and powder feed rate have to be controlled to achieve the desired surface properties [3].

This research project is a preliminary investigation into laser surface alloying of aluminium AA1200 using a 4.4 kW Rofin Sinar Nd:YAG laser to improve its mechanical and tribological properties. The alloying powders were a mixture of Ni, Ti and SiC in different proportions. The laser scanning speed was varied between 10 and 20 mm/s in order to determine the optimum laser parameters, i.e. parameters for homogeneous surfaces free of cracks and porosity. The laser beam created a melt pool in the aluminium substrate and the alloying powder mixtures were injected into this molten pool. The microstructures of the laser-alloyed layers were examined using different microscopes.

Surfaces reinforced with metal matrix composites and intermetallic phases were achieved. The phases observed in the microstructure depend on the composition of the alloying powder mixture. The reactions of Al with Ni resulted in the in situ formation of 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. Surface hardness increased with increasing Ni content in the alloying powder mixture and a maximum hardness of 13 times that of aluminium was achieved when alloying with 80 wt% Ni + 15 wt% Ti + 5 wt% SiC. The increase in hardness was attributed to the intermetallic phase formed in the alloyed surface, especially the Al_3Ni_2 phase.

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