Simultaneous Optimization of Laser Energy and Coating Thickness in Surface Alloying of Al with Fe

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Abstract. In two-step deposition technique of laser surface alloying process, the alloying elements are introduced onto the surface of the bulk material. In such process, two main parameters determine the quality of the alloying which are the thickness of the coating and the laser energy supplied onto the specimen. In this work, laser surface alloying of aluminium (Al) with iron (Fe) is carried out by optimizing both parameters. This is accomplished by assessing the improvement in the hardness after laser treatment. In general, the thicker coating desires higher laser energy to cause surface melting and sequentially diffusion of Fe into molten Al to occur. This is indicated by the linear relationship between the thicknesses for the peak hardness value with the laser energy whereby the optimum energy shifted to higher energy for thicker coating. The increase in laser energy increases the chance for Fe particle to migrate via diffusion into the bulk Al substrate. However at 140µm the optimized energy reaches a peak value at 455mJ which is the maximum energy to be supplied in this process before the coating is lost due to excessive ablation. For thicker coatings, the action of the laser does not penetrate enough onto the substrate to cause sufficient melting of the Al surface for alloy formation. The maximum hardness obtained was 40.8 HV at the optimum condition for 140µm thickness treated with 455 mJ. The formation of alloyed compound is further confirmed by x-ray diffraction technique whereby compounds such as AlFe, $Al_{13}Fe_4$, and $AlFe_6Si$ are present in the treated specimens.