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Numerical and experimental analysis of laser surface remelting of Al–1.5wt%Fe alloy samples

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Abstract

In this work, numerical simulations of temperature fields during laser surface remelting process were performed by using a finite element technique. In order to accomplish this work, the finite elements technique and the ANSYS software program were used. Theoretical predictions furnished by previous models from the literature and results of experiments of laser surface remelting of Al–1.5wt%Fe samples, carried out in the present investigation, were used for validation of numerical simulations performed with the proposed model. The work also encompassed the analysis of microstructural parameters by scanning electron microscopy and microhardness variations throughout the resulting treated and unmolten zones.

Laser surface melting allows selective heating and melting of the surface, which modifies the surface properties of the material due to rapid melting followed by rapid solidification. The intimate contact between the melt and the solid substrate causes very fast heat extraction during solidification resulting in very high cooling rates of the order of 10^5-10^8 K/s. The high cooling rates at which this surface layer is subjected results in the formation of different microstructures from the bulk metal, leading to improved properties such as better resistance to wear and corrosion. The microstructures of materials via rapid solidification tend to show advantages of refined microstructure, reduced microsegregation, extensive solid solubility and formation of metastable phases. Since the mechanical properties of a material depend largely on its microstructure, controlled growth of such microstructures is essential to develop new materials with desired properties [1].

Because of the reduced size of the laser treated zone, physical measurements of important parameters such as the temperature and velocity fields in the remelted pools are not easy to do. Therefore, mathematical modeling of the laser surface remelting process has been used for enhancing both the qualitative and quantitative understanding of the process mechanics that cannot be obtained otherwise [2]. The purpose of this study is to numerically simulate the laser surface remelting process by applying the finite element method thorugh the ANSYS software program. The work also deals with the analysis of microstructural parameters, using SEM to characterize the laser treated Al-1.5wt%Fe samples. Finally, the experimental results and simulations were compared. Figure 1 shows a cross-sectional view of the laser molten region perpendicular to the scanning direction for a laser power of 600 W and scanning speed of 80 mm.s $^{-1}$. Figure 1 reveals the contrast between the refined microstructure of the resolidified region and the coarse dendritic structure of the unmelted substrate.

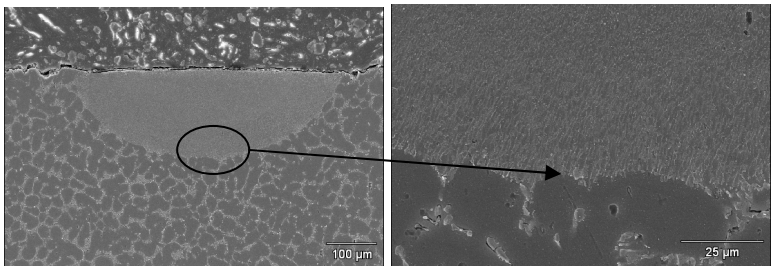

Figure 1: Scanning electron micrograph showing contrast between microstructures of molten and unmelted regions

References

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