Microstructural characterization of an eutectic Al-Si-Ni alloy treated by laser surface remelt.

Lucas R. Ramos*, Rafael Kakitani, Noé Cheung.

Abstract

This work aims to analyze the effects of the Laser Surface Remelt Treatment (LSR) on Al-11%Si-5%Ni alloy's microhardness and microstructure. The operational parameters of the laser involved in the treatment were scanning speed (V) and power (P). Fourteen tracks resulting from the combination of these parameters were analyzed by optical and scanning electronic microscopes (OM and SEM, respectively), observing the dimensions of the remelted pool and the change in the microstructure. Vickers microhardness tests were conducted to examine the effects of LSR on the surface and X-ray diffraction (XRD) was performed on treated and non-treated alloy samples to examine the present phases. The increase in P resulted in the increase in the pool dimensions, while the increase in V presented the opposite effect. The LSR was very effective in the refinement of α -Al dendrites and interdendritic eutectic region, with a minimum primary dendritic spacing of 0,86 μm . The Vickers microhardness increased up to 105% for single tracks and 76% for overlapped tracks, comparing to conventional casting.

Key words:

Laser surface remelting, microhardness, aluminium alloy.

Introduction

Among laser treatments, LSR is capable to improve hardness and corrosion resistance of Al alloys¹. This treatment consists in a focus laser beam over the surface, melting a thin layer (order of magnitude of 1 mm). The resolidification presents high cooling rates (10^5 - 10^8 °C/s) resulting in extreme fine microstructures. This refinement is followed by better properties compared to the non treated substrate. The objectives of this work were to perform the LSR in an eutectic Al-11%Si-5%Ni alloy, analyze the effect of the treatment parameters in the pool dimensions (depth D and width L), observe the Vickers microhardness in the remelted area and examine the phases after the treatment, aiming a possible amorphization.

Results and Discussion

The range of the P was 500 to 1000 W and of the V was 750 to 1250 mm/min. The increase in P resulted in the increase in width and deep of the remelted pools. The increase in v resulted in an inverse tendency, as expected. In the image from SEM (Image 1.a) it is observed α -Al, Si and Al_3Ni phases in non treated regions, and a very refined microstructure inside the molten pool (Image 1.b). From XRD analyses, the same phases were identified in the remelted region, suggesting that amorphization did not occur, although the existence of high cooling rates in the LSR.

of microhardness increase with the decrease of λ_1 . Comparing with the conventional casting, the microhardness in the single track increased up to 105%.

Table 1. λ_1 and microhardness of selected tracks.

Track	P [W]	V[mm/min]	λ_1 [μm]	Microhardness [HV]
4	500	1000	1,14 $\pm$ 0,27	155,1 $\pm$ 14,5
7	1000	1000	0,86 $\pm$ 0,16	143,0 $\pm$ 12,1
9	1000	1250	1,25 $\pm$ 0,24	139,6 $\pm$ 13,4
11	1000	1000	1,01 $\pm$ 0,20	125,0 $\pm$ 10,4
13	1000	1250	0,93 $\pm$ 0,19	155,8 $\pm$ 15,9

For the tracks 4 and 13, which presented the highest microhardness increase, the LSR with overlapped tracks was performed. The microhardness reduced if compared to the one from the single tracks, as can be seen in Table 2.

Table 2. Microhardness for overlapped tracks.

Track	Microhardness [HV]
4	133,6 $\pm$ 4,1
13	126,8 $\pm$ 14,7

Conclusions

The LSR is effective in terms of microstructure refinement and microhardness improvement, obtaining λ_1 less than 1,3 μm and a maximum of 155,8 HV. It is also notable the increase of P reflected in the increase of pool dimensions and the increase of V has the opposite effect. There is no evidence of amorphization in the remelted region.

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Image 1. a) Remelted pool and b) microstructure of the pool.

The dendritic spacing (λ_1) and the microhardness of selected single tracks are in Table 1. There is a tendency