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Influence of cooling rate on microstructure of an eutectic Al-Ni alloy: Experimental and computational analysis

Thomas J. Obara*, Rafael Kakitani, Noé Cheung.

Abstract

The microstructure of an eutectic Al-6,3wt.%Ni alloy solidified under transient conditions were analysed in as-cast condition and after a laser surface remelting process. Considering that the laser treatment reaches a small portion of sample surface and provide higher cooling rates ($\dot{T}$) than conventional cast processes, $\dot{T}$ had to be calculated with the aid of a computational program. Therefore, microstructure of both as-cast and treated samples were compared. The microstructure of the remelted zone showed cell-like structures, which achieved very refined scale (< 10 µm).

Key words:

Al-Ni alloy, Microstructure, Laser surface remelting.

Introduction

Aluminum alloys with the addition of nickel are widely used in aerospace industry, due to its high corrosion and wear resistances, especially under high temperatures[1]. It is known that the microstructure of Al alloys feature various intermetallic compounds in an α-Al matrix[2], which directly determines the mechanical properties performance. Also, the morphology of microstructure can be altered via solidification parameters[3]. In surface treatments such as laser surface remelting can achieve cooling rates in the order of 10^4 ºC/s, resulting in a great microstructure refinement and interesting mechanical properties. Hence, the aim of this work is to compare the microstructure of both treated and as-cast eutectic Al-6.3 wt.%Ni alloys.

Results and Discussion

With the use of a scanning electron microscope, cellular spacings and eutectic colony spacings were measured on remelted pool and not remelted zone, respectively. As can be seen in Image 1, the microstructure in the area that received remelting treatment grew into very refined cell-like arrangements. A numerical heat transfer model based on the Finite Difference Method has been developed in order to simulate not only the remelting but also the solidification phenomena. The numerical simulations have provided the simulated cooling rates necessary for the correlation with the cellular spacing. Image 1 shows an schematic grid of the numerical model.

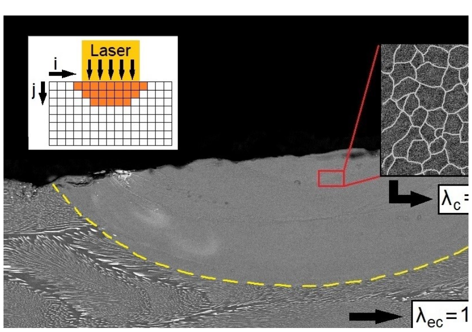

Image 1. Representative numerical grid and microstructure of the melt pool and Al-6,3% wt.Ni substract.

The correlation between cellular spacings and eutectic colonies with cooling rates revealed that λ_c of the laser remelted samples did not follow the power function law as λ_{ec} of the as-cast ones, shown in Image 2.

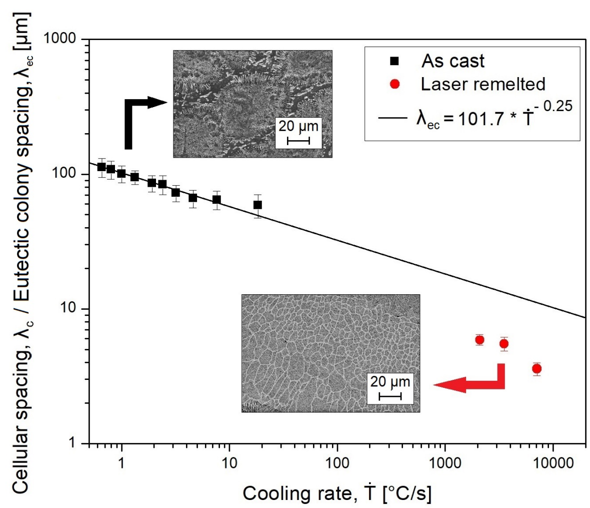

Image 2. Cellular spacing (λ_c) / Eutectic colony spacing (λ_{ec}) vs. Cooling rate ($\dot{T}$).

Conclusions

Laser surface treatment provides an elevated microstructure refinement, promoting a great reduction in cellular spacing along the entire length and depth of the remelting pool. Also, it was observed that growth at the remelted region did not follow the same behavior of the as-cast alloy.

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