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Correlation Between Microstructure, Thermal Parameters and Mechanical Properties of a Directionally Solidified Al-1%wt Mn Alloy

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Abstract

This works aims to study the mechanical properties of a Al-1%wt Mn alloy directionally solidified under unsteady-state conditions. The as-cast microstructure was analysed by measuring the cellular spacing, and the mechanical properties were obtained through Vickers microhardness and tensile strength tests. The correlation between the mechanical results and the as-cast microstructure was fundamental to imply a relation between the solidification thermal parameters and the rolling process in which this kind of alloy is submitted to afterwards.

Key words:

Al-1%wt Mn, Microstructure,Solidification

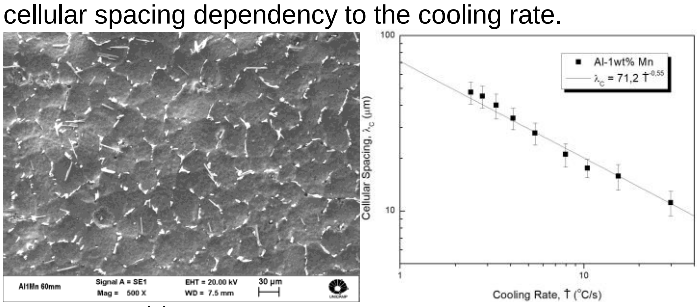
Introduction

The Al-1%wt Mn alloy is basically the composition of the Aluminum 3003 alloy, which is used in radiators, antennas, heat exchangers tubes, cars bodies and more[1].

Normally, this alloy has to be put into mechanical conformation processes like rolling and forging in order to achieve the desired mechanical properties[2]. As these properties are correlated with the microstructure[3], this research focus on solidification thermal parameters that would reduce the number of operations needed to get the desired properties.

Results and Discussion

The as-cast microstructure was characterized by hexagonal Al-rich phase cells, with fiber-like $Al_{12}Mn$ intermetallic compound at the intercellular spacing, as shown in Figure 1a. The power law in Figure 1b shows the cellular spacing dependency to the cooling rate.



(a) (b)

Figure 1. (a) Characteristic transversal SEM microstructure of the directionally solidified alloy (b) cellular spacing as function of the cooling rate.

The Vickers Microhardness test has not shown any tendency of increasing or decreasing values according to cellular spacing, with values about 25 HV. The tensile tests also has shown no variation of ultimate tensile strength according to the change of cellular spacing, and its value was about 70 MPa. Both properties are appear to be constant in due to few intermetallic in the intercellular spacing, as those are responsible for reinforcing the matrix properties. The only property that had a response to variation in cellular spacing was the elongation-to-fracture, which decreased with increasing grain size (Figure 2).

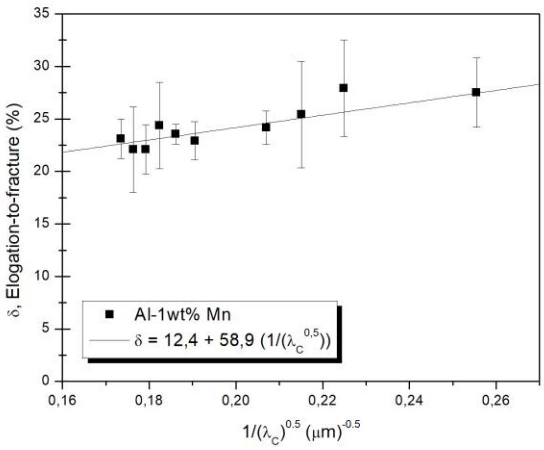


Figure 2. Experimental dependency of elongation-to-fracture on the cellular spacing.

Conclusions

As we could see, the as-cast Al-1%wt Mn alloy has low hardness and ultimate tensile strength compared to the rolled alloy. The cooling rate seemed to have little or none influence in these properties, confirming that it needs further processing to increase its mechanical properties and being able to be used for its purposes. Nevertheless, it could be implied that higher cooling rates produce microstructures favouring the rolling process due to the increase in elongation to fracture, fact which may reduce the number of required steps to achieve the desired cross section reduction.

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