Accepted Manuscript

Characterization of the solidification path and microstructure of secondary Al-7Si-3Cu-0.3Mg alloy with Zr, V and Ni additions

Jovid Rakhmonov, Giulio Timelli, Franco Bonollo

PII: S1044-5803(16)30688-X
DOI: doi: 10.1016/j.matchar.2017.03.039
Reference: MTL 8621

To appear in: *Materials Characterization*

Received date: 24 October 2016
Revised date: 7 December 2016
Accepted date: 21 March 2017

Characterization of the Solidification Path and Microstructure of Secondary Al-7Si-3Cu-0.3Mg Alloy with Zr, V and Ni Additions

Jovid Rakhmonov, Giulio Timelli, Franco Bonollo*

[*] *Mr. Jovid Rakhmonov, Ass. Prof. Giulio Timelli, Prof. Franco Bonollo*
University of Padova, Department of Management and Engineering, Stradella S. Nicola, 3 I-36100 Vicenza, Italy.
E-mail: rakhmonov@gest.unipd.it

Abstract
The effect of individual and combined Zr, V and Ni additions on solidification path and microstructural evolution of secondary Al-7Si-3Cu-0.3Mg alloy were investigated using microscopy and thermal analysis techniques. The results show how the Zr addition caused remarkable grain refinement due to the precipitation of primary pro-peritectic Al_3Zr particles that lead to a peritectic reaction to yield α-Al during solidification; however, the peritectic transformation was incomplete due to a limited solid-state diffusion. Moreover, with Zr addition, few numbers of flaky $(AlSi)_3(ZrTi)$ compounds appeared in the microstructure. Vanadium addition showed also grain refinement level similar to that of Zr-added alloy. However, the role of V cannot be explained by the precipitation of primary pro-peritectic particles that would provide potent nucleation sites; instead, vanadium addition substantially increases the degree of constitutional undercooling, thus activating certain particles to more easily nucleate α-Al. Excess vanadium were mainly bound to pro-eutectic and polyhedral-shaped $(AlSi)_2(VMnTi)$ compounds. Combined Zr and V addition exerted better grain refinement level than the individual Zr or V addition; this occurred due to both increased the population of Al_3Zr phase particles as a result of its enrichment with V, and enhanced the degree of constitutional undercooling. Nickel addition exerted no apparent influence on the formation of both α-Al and eutectic Si; however, significant changes occurred in the sequence of post-eutectic reactions: the script-like Al_6Cu_3Ni and flaky-like $Al_9(FeCu)Ni$ phases formed in addition to the Al_2Cu and $Al_5Si_6Cu_2Mg_8$ particles; this led to a substantial reduction in the alloy's freezing range. The findings of this study can benefit and contribute to developing a new Al-Si based foundry alloys intended for high-temperature applications.

Keywords
Aluminium alloys; Transition metals; Microstructure; Solidification; Peritectic reactions; Thermal analysis.

1. Introduction

Aluminium-Silicon based foundry alloys are widely used in the automotive industry, particularly for pistons, cylinder blocks and -heads, due to their low thermal-expansion coefficient, high wear resistance, good corrosion resistance, and improved mechanical performance [1, 2]. A remarkable improvement in the mechanical properties of Al-Si alloys can be achieved by alloying with Cu and Mg via precipitation strengthening mechanism [3]. However, these Cu- and Mg-rich precipitates can only be effective for strength and creep resistance at temperatures below 200ºC [4]. At higher temperatures, dissolution and/or coarsening of Cu- and Mg-rich strengthening particles can occur [5], hence, inducing