Solidification Paths of Al-Cu-Sn Alloys: Comparison of Thermodynamic Analyses and Solidification Experiments Using in Situ X-Radiography

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Abstract:

The Al-Cu-Sn alloys represent a new candidate material for the self-lubricating bearings manufacturing in the automotive industry. The addition of Sn to the Al-Cu binary alloy modified the solidification path of the ternary alloys and thus its microstructure. In this study, the solidification paths of Al-10 wt.% Cu-X wt.% Sn (with X = 0; 5; 10 and 20) alloys were investigated using three complementary approaches, namely: Thermo-Calc calculations, DSC (Differential Scanning Calorimetry) thermal analysis, and directional solidification experiments with in situ and real-time X-radiography were conducted to gain insight into the liquid phase separation dynamic. The qualitative results for the three methods demonstrated a high degree of correlation. For a low Sn addition (X = 5 wt.%), solidification path starts with α-Al dendrite formation, followed by θ-Al_2Cu precipitation, and ends with an eutectic reaction. The two alloys with higher Sn compositions (X = 10 wt.% and X = 20 wt.%) exhibit comparable dynamics at the outset of their solidification paths with low Sn composition alloy. However, the formation of the primary α-Al phase is followed by liquid phase separation (nucleation and growth of Sn droplets in the melt) and a monotectic reaction before the final eutectic reaction.

Keywords:

Al-Cu-Sn alloys, Thermo-Calc, solidification microstructures, liquid phase separation, monotectic, DSC, in situ radiography.