The 55th International October Conference on Mining and Metallurgy
15 - 17 October 2024, Kladovo, Serbia
https://ioc.irmbor.co.rs

DOI: 10.5937/IOC24237Z Original Scientific Paper-Material Science

COOLING CURVE ANALYSIS IN THE Al-Cu-Mg-Ti ALLOY

Biljana Zlatičanin[1a], Branislav Radonjić[1b]

[1]Faculty of Metallurgy and Technology, Cetinjski put bb, 81000 Podgorica, Montenegro
[1a] biljana@ucg.ac.me, https://orcid.org/0000-0002-9659-3191

Abstract

Cooling curves are obtained by calculation with the available JMatPro's model. The JMatPro's model have been developed for calculation of various thermo-physical and physical properties for various types of the multi-component-alloys during solidification. Comparison of the calculated and experimental results has shown that the experimental data support the results of calculations quite well.

***Keywords**: JMatPro's model, Al-Cu-Mg-Ti alloys*

1. INTRODUCTION

The academic and technological importance of the Al-Cu-Mg-Ti alloys is well known. The Al-Cu-Mg-Ti alloys have been widely used in the aerospace, automobile, and airplane applications. Casting of the Al-alloys is one of the most important features of the Al technology and increasing use of the process modelling software to design and optimize the castings makes it important that the thermo-physical and physical properties of the Al alloys are well characterized, as they are critical input for almost all types of process modeling. In recent years, various thermodynamics – based computer models have been developed enabling the phase diagrams to be predicted for the multicomponent alloys. A complete set of materials properties can be calculated using the JMatPro's property models [1,2,3].

2. EXPERIMENTAL

The studied material was the Al-Cu-Mg-Ti alloy with the chemical composition shown in Table 1.

Table 1. *Chemical composition of the studied alloy (in mass%)*

Type of sample	%Fe	%Si	% Ti	%Cu	%Zn	%Mg	%V	%Cr	%Mn
Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti	0.19	0.10	0.082	15.08	0.081	5.386	0.006	0.005	0.014

The Al-Cu-Mg-Ti alloy has been experimentally tested by the DSC analysis and the temperatures of phase transitions for studied alloy were determined.

3. RESULTS AND DISCUSSION

Aluminium is the primary constituent in this alloy and, in the cast alloy, the basic structure consists of aluminium solid solution, with a variety of constituents at the grain boundaries. Figures 1-7 presents the calculation using the JMatPro. For Al-alloys, in particular, it was seen that the JMatPro's gives the good predictions for features such as fraction solid transformed as a function of temperature as well as the equilibrium phases, which can appear. This is of considerable importance in modelling the casting processes.

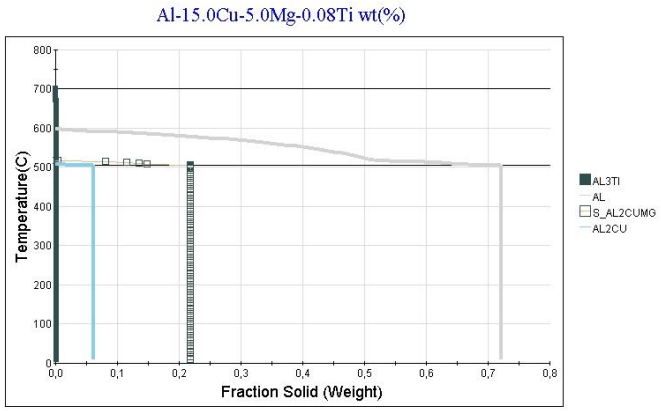

Figure 1. *Fraction solid vs. temperature curve calculated for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

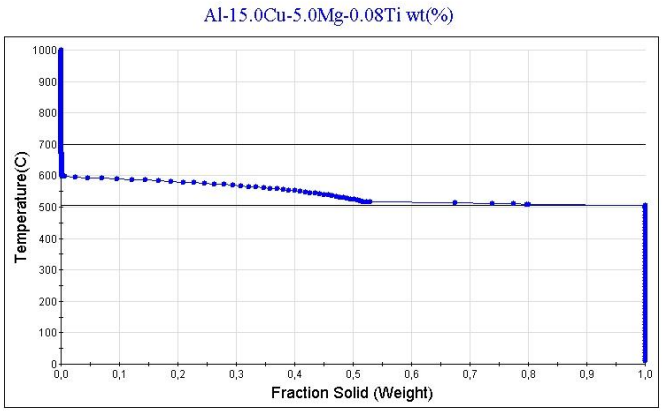

Figure 2. *Fraction α solid vs. temperature curve calculated for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

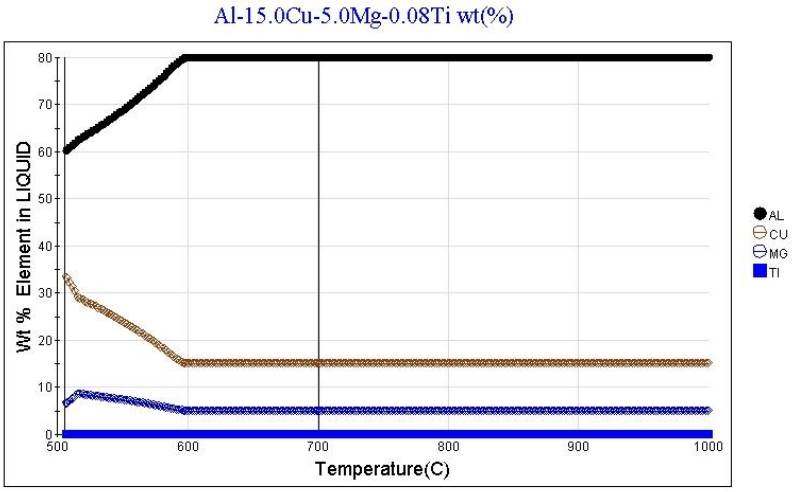

Figure 3. *Composition profiles of Cu and Mg in liquid for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

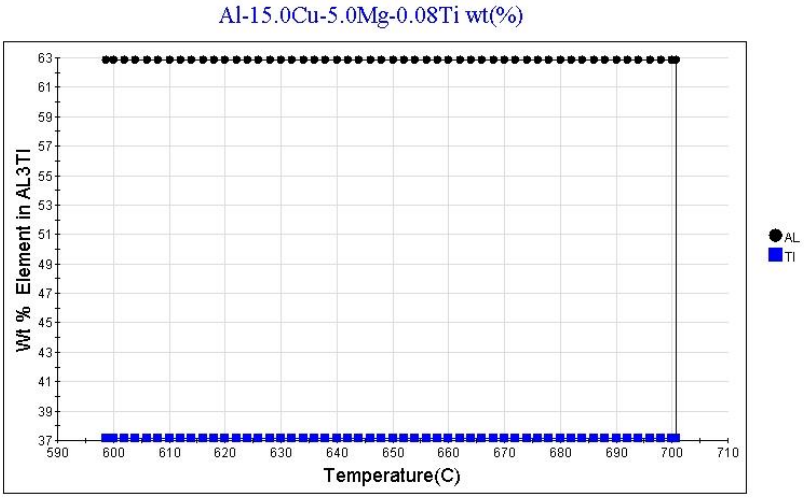

Figure 4. *Composition profiles of elements in Al_3Ti for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

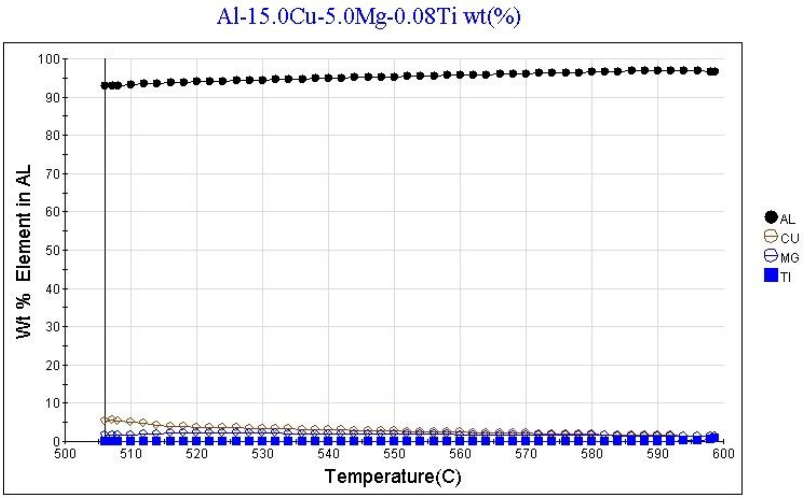

Figure 5. *Composition profiles of Cu and Mg in the primary Al for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

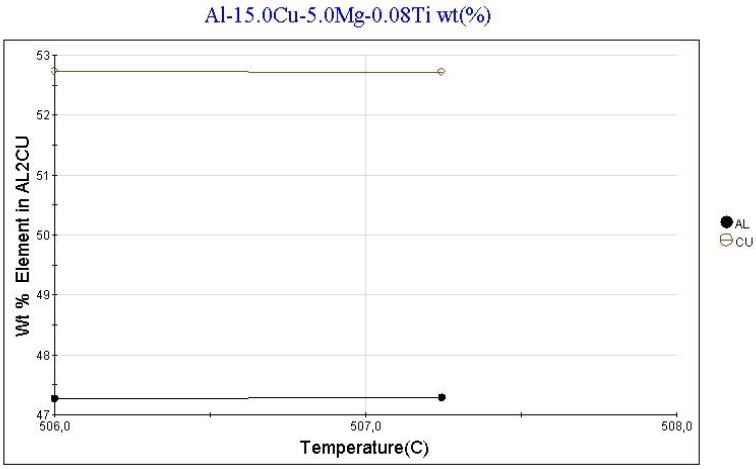

Figure 6. *Composition profiles of Cu and Al in $CuAl_2$ for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

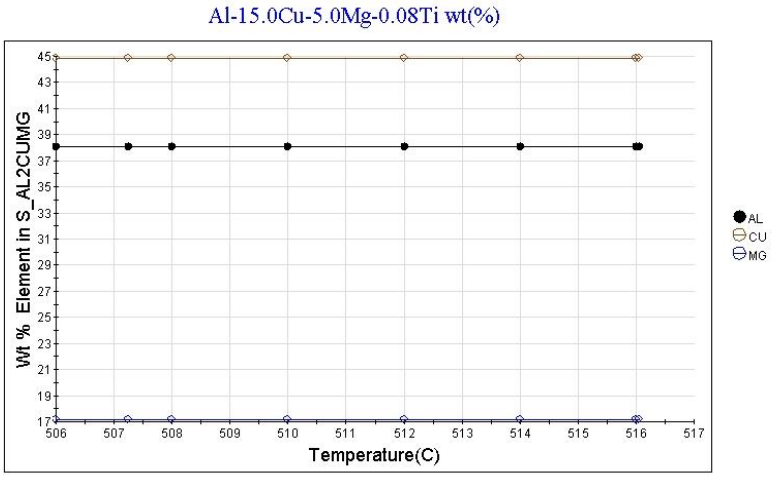

Figure 7. *Composition profiles of Cu, Mg and Al in $CuMgAl_2$ for the Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti alloy*

The presented phase transition temperatures were obtained from the extrapolated onsets of the corresponding DSC peaks, whereas the temperatures of phase transitions were evaluated from the peak maximum. The obtained transition temperatures were compared with the calculated ones, using the JMatPro. Model calculates the composition profiles of Cu and Mg in the primary phase and liquid and takes into account a diffusion in the solid phase due to the compositional gradients. Table 2 shows the agreement between the calculated and experimentally determined critical temperature by the DSC. The calculated temperature of the ternary eutectic reaction is 515.9ºC for the alloy Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti while the experimentally determined temperature is 524.5ºC.

Table 2. *Comparison between the experimentally determined phase transition temperatures (DSC results) and calculated using the JMatPro for the investigated alloy (temperatures all in ºC)*

Type of sample		Liqui-dus	Al_3Ti	α h.s. start	$CuAl_2$	α h.s.+ $CuAl_2$+ $CuMgAl_2$	Solidifi-cation end
Al-Cu15wt.%-Mg5wt.%-0.08wt.% Ti	experimentally observed (DSC)	-	-	582.0	-	524.5	-
	Calculated	694.4	694.2	597.0	507.0	515.9	507.0

4. CONCLUSION

This paper has shown how the software programme JMatPro has been able to calculate the material properties for the multi-component alloys. The cast Al-Cu-Mg-Ti alloy contain the soluble phases: Al_2Cu and Al_2CuMg which appear in various amounts

and at various locations in the microstructure. The results of DSC were used for detection the phase transition temperatures for the investigated alloy. In general, the overall close agreement between the calculated and experimentally determined temperatures was obtained. Emphasis has been placed both on validation the database against experiment and practical use of calculations. This means that the properties can now be calculated for many alloys where no experimental information exists.

REFERENCES

[1] B. Zlatičanin, FEB - Fresenius Environmental Bulletin Germany, 32 (2023) 1061-1071.
[2] O. Fornaro, H. Palacio, Journal of Materials Science, 44 (2009) 4342-4347.
[3] S. Chen, C. Huang, Acta Mater., 44 (1996) 1955-1965.