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Analysis on Modelling of Dentrite between the Temperature and Composition

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Abstract

According to composition at solid and liquid interface in solidification the line model of temperature and composition in dentrite has been established. The equation is gained as T=-1000C+2273. Meantime the cool rate and time has been discussed. In the intersection the cool rate of solid and liquid ΔT is gained. According to dentrite therefore the composition can determine temperature. Its error attains inside 5%. The period one of cool rate is from 0.5K/s to 11 K/s in speed of 360mm/hr. The gap is bigger between 720mm/h with drawing speed v than that of 360mm/h. For engineering use the speed is better when the speed is higher like 720mm/h when the cool rate attains from 2K/s to 22K/s with the composition difference increasing with maximum value.

Keywords: Modeling; Dentrite; Analysis; Temperature; Composition; Interface; Gibbs free energy

Introduction

The change of temperature in the solid and liquid in solidification transformation can deduce the related formula. The curve expresses its trend better. From this relation their composition will change when the transformation happens. It is known that the temperature in solidification can solve their relationship. In this study in terms of these equations the deduction and analysis is done and the error analysis to them is done. Here the solid and liquid equation is explored within line and find the simple formula which make us to calculate the cool rate rapidly [1,2]. Therefore in this study the model of temperature and composition has been established to observe the trend and intrinsic relationship between them. Then the error is checked with variance to both of constant. On the other side the relationship with cool rate and energy difference & temperature has been investigated according to varied speed and ΔS respectively for the application. According to the solidified crystalline and phase diagram the application will be known. In addition relationship between cool rate and energy difference & temperature are drawn for further research in this study. To calculate the cool rate is our destination in the end in terms of the composition in TiAl alloys. Therefore the establishment equation between temperature and cooing rate in terms of the equilibrium diagram.

Calculation

The relationship between composition and temperature

Figure 1 shows that the two lines with liquid and solid phase meet in one point. The cool rate ΔT is known. It shows two phases decrease below the liquids phase line. It shows these two line relations in constitutional super cool. We choose the certain value to proceed experiment. Here C is the Al composition, C_l and C_s is the liquid and solid composition of Al (Figure 1).

Let T=aC+b (1)
We have
$Tl=aC_l+b$ (2)
$Ts=aC_s+b$ (3)
According to Ti-Al state equilibrium state we have supposed
C_l=0.44, T_l=1833K and
C_s= 0.46, T_s=1813K
Substitute above constant to (2) and (3), so

a=-1000, b=2273. The formula (1) is

T=-1000C+2273 (4)

This is the equation to calculate temperature in terms of composition (Figure 2).

From Figure 2 we know the distribution of temperature and composition in directional solidification. When composition difference increases temperature decreased somewhat in term of content in dentrite. When composition difference is from 0.4 to 0.6 the temperature changes from 1880K to 1680K.

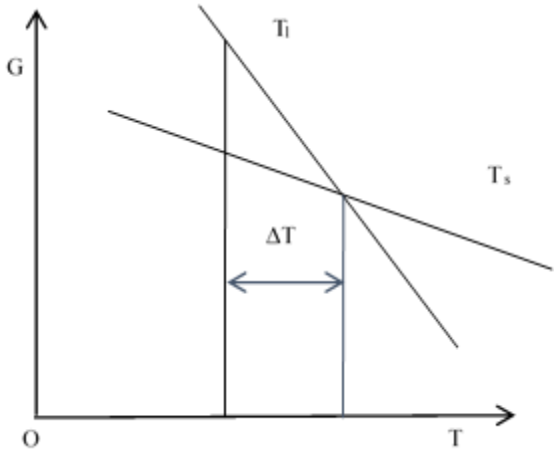


Figure 1: *The relations of dentrite and equilibrium state.*

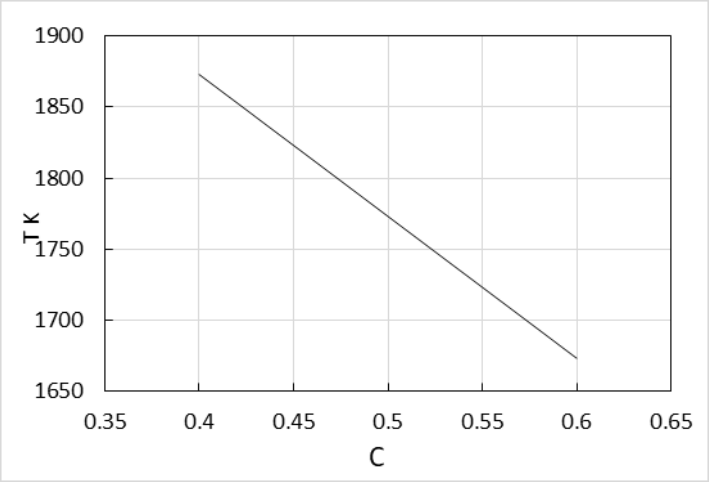
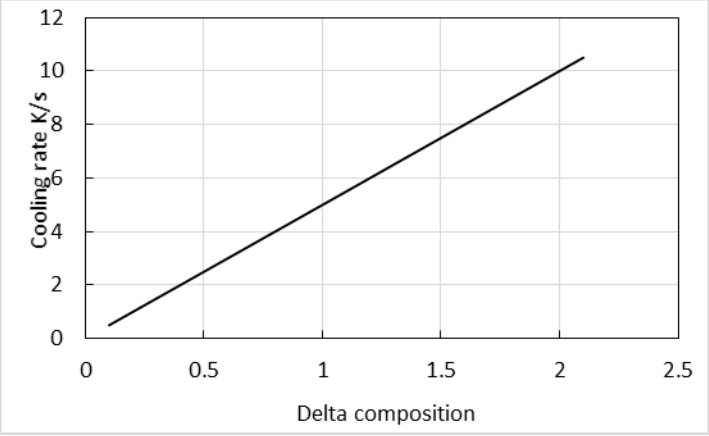
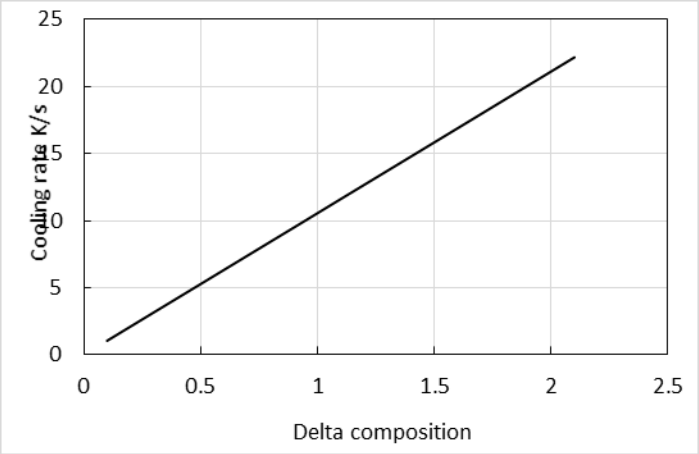


Figure 2: *The relationship between temperature ad composition in dentrite.*



(a) *360mm/hr.*



(b) *720mm/hr.*

Figure 3: *The relation between cool rate and Δ composition under different speed in directional solidification.*

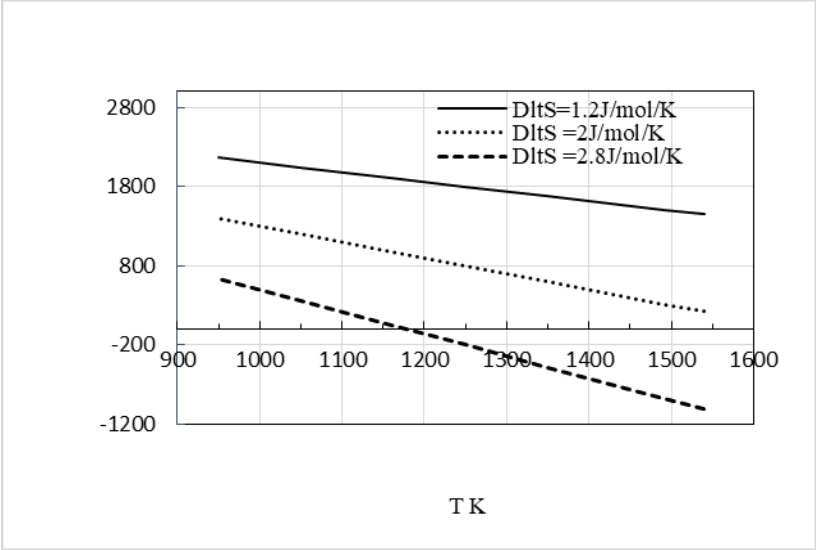


Figure 4: *The relations of liquidus and solidus solidified state.*

Calculation of cool rate (Figure 3)

As Figure 3 when composition deference increases cool rates rate increases properly. Drawing speed increases so that cool rate increases a certain. The period one of cool rate is from 0.5K/s to 11 K/s in speed of 360mm/hr. The gap is bigger between 720mm/h with drawing speed v than that of 360mm/h. For engineering use the speed is better when the speed is higher like 720mm/h when the cool rate attains from 2K/s to 22K/s with the composition difference increasing with maximum value. This is the result of concentration of liquid and solid in terms of composition. G is Gibbs free energy [3].

DT=T1-T2=-1000(C1-C2) =-150K (5)

t=L/v=20*3600/360=200s

So C= (T1-T2)/t (6)

Here C and DT is cool rate and temperature difference respectively (Figure 4).

From Figure 4 DG decreases with temperature increasing. It decreases with enthalpy DH increasing from 1,2 to 2.8 J/mol/K. Its decreasing means cool rate increases along the dendrite. When speed increases it decreases like 720mm/h. Here DS is entropy.

DG=DH-TDS (7)

In Ti-Al DH and DS are to be

DH=3.3KJ/mol, DS=1.2 J/mol/K at 1492℃.

Conclusions

- According to composition at solid and liquid interface in solidification the line model of temperature and composition in dentrite has been established. The equation is gained as T=-1000C+2273。Meantime the cool rate and time has been discussed. In the intersection the cool rate of solid and

liquid ΔT is gained. Composition difference has been deduced and analyzed according to dentrite therefore the composition can determine temperature. When composition difference is from 0.4 to 0.6 the temperature changes from 1880K to 1680K.

- The period one of cool rate is from 0.5K/s to 11 K/s in speed of 360mm/hr. The gap is bigger between 720mm/h with drawing speed v than that of 360mm/h. For engineering use the speed is better when the speed is higher like 720mm/h when the cool rate attains from 2K/s to 22K/s with the composition difference increasing with maximum value.

Foundation

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