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The Modelling between the Parameters of Cooling Rate, Secondary Arm Space and Composition in Solidification of TiAl

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Abstract

The parameters simulation of cooling rate and secondary & composition has been established for the sake of searching their intrintic relationship. It is observed that the cooling rate will decrease from 105K/s to 2K/s when the secondary arm space changes from 4µm to 170µm in dentrite of TiAl. It explains that the bigger secondary arm space will be if the cooling rate is smaller. It fits to the principle well. For the making TiAl intermetallic compounds the fit cooling rate and secondary arm space will be determined in advance to proceed the experiment which is necessary for us to regulate. The line is drawn between cooling rate with 0~100K/s and composition with 0~ 0.1 in TiAl alloy respectively. It is better value since it fits to the object very well. The maximum arrives 100K/s that is big value for solidification with high speed. The bigger the composition the lower secondary arm space is. The former changes from 0 to 1 with the later changing from 10.5µm to 5.8µm.

Keywords: Modeling; TiAl; Dentrite; The secondary arm space; Analysis; Temperature; Cooling rate; Composition; Difference

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 secondary dendrite arm space 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 cooling rate rapidly [1-3]. 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. TiAl as a promise materials has been searched and developed for many years. However the cooling rate with compositions is not much yet, so in this study the equation is established through temperature and composition according to the phase diagram. It is modelled with cooling rate and composition difference too in directional solidification test. The detail value is combined through phase equilibrium line and it is compared with thermal dynamics. The research scope is from 0 to pure Al here. On the other side the relationship with cooling rate and energy difference & temperature has been investigated according to varied speed respectively for the application. According to the solidified crystalline and phase diagram the application will be known. In addition relationship between cooling rate and energy difference & temperature are drawn for further research in this study. To calculate the cooling 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 [3-8]

Discussion

Simulation

In Figure 1 the cooling rate will decrease from 105K/s to 2K/s when the secondary arm space changes from 4μm to 170μm in dentrite of TiAl. It explains that the bigger secondary arm space will be if the cooling rate is smaller. It fits to the principle well too. In general the secondary arm space has been 20μm~40μm in dendrite therefore the corresponding cooling rate attains 20K/s~10K/s according to the curve in Figure 1. So from the secondary arm space in dentrite the cooling rate will be checked out and it can be convenient for us to use in practice and experiment. On the contrary from the cooling rate the secondary arm space the cooling rate is also seen in this study. It is said again the bigger secondary arm space creates lower cooling rate and the higher cooling rate creates the lower arm space. It is seen evidently in this study. For the decreasing making cost the high cooling rate is effective to compare with low one so the secondary arm space will be low too. This is the valuable data computed and shown in this study. For the making TiAl intermetallic compounds the fit cooling rate and secondary arm space will be determined in advance to proceed the experiment which is necessary for us to regulate. For the cost down the high solidified speed is needed on the other side the single crystal is not neglected for the science experiment and high quality. This is the final destination in this paper to look for (Figures 1-3).

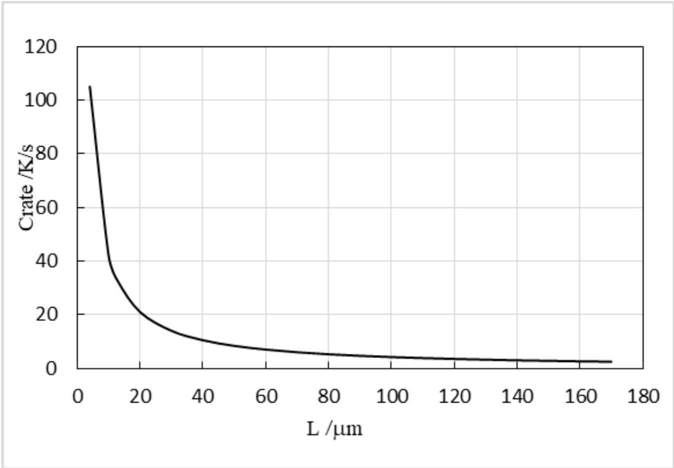

Figure 1: *The relationship between cooling rate and secondary arm space in dentrite.*

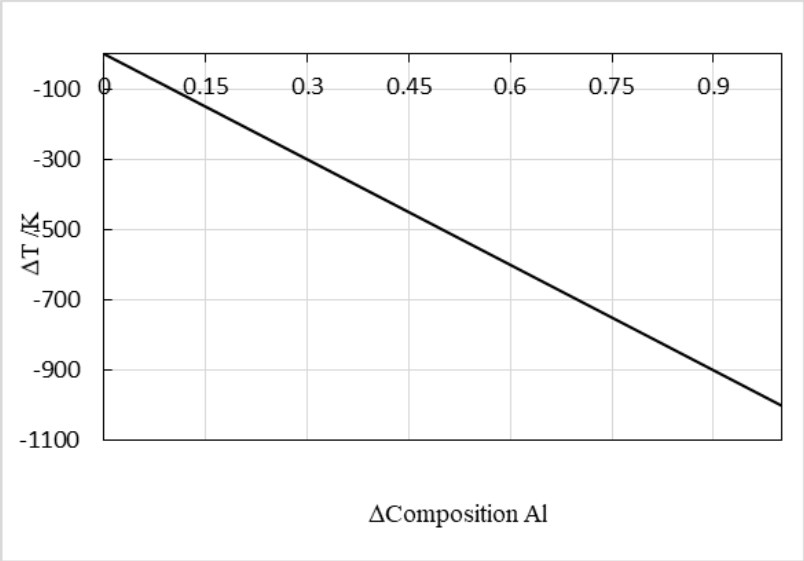

Figure 2: *The relationship between temperature difference and composition difference in dentrite.*

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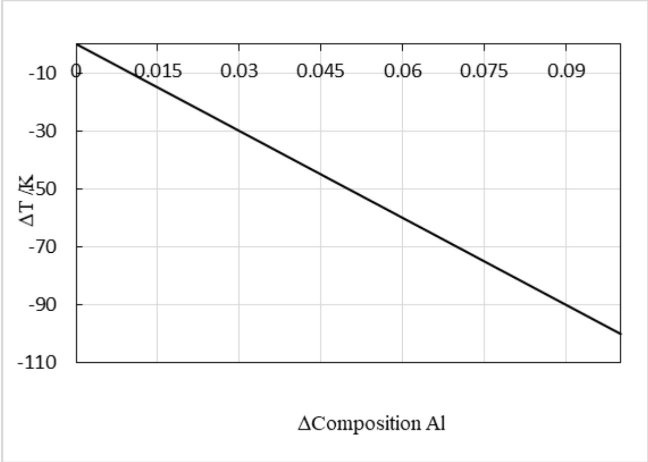

Figure 3: *The relationship between temperature difference and composition difference with 0.1 in dentrite.*

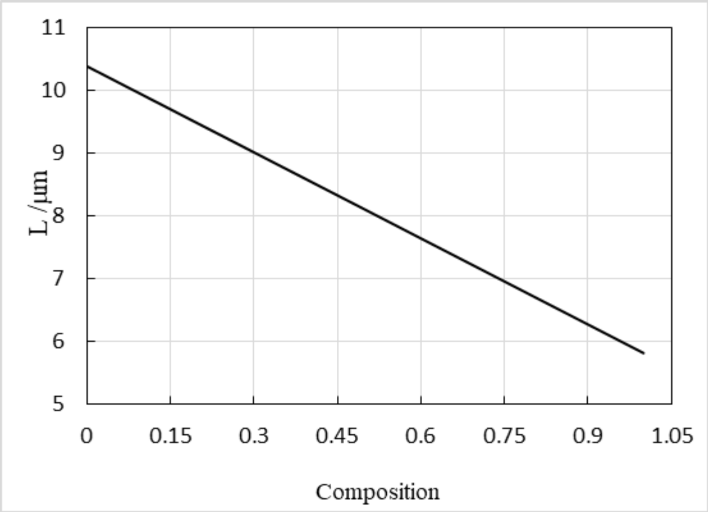

Figure 4: *The linear relationship in secondary arm space and composition in Dendritic Ti-Al.*

There are three composition difference in Ti-Al, including ΔTi3Al, ΔTiAl and ΔTiAl3 which can be found in Figure 2. They are -200K/s, -500K/s and -750K/s in solidification when the composition difference is 0.25Al, 0.5Al and 0.75Al respectively. As seen in Figure 3 which is a part of Figure 2 from 0 to 0.1 with ΔCom the line is drawn between cooling rate with 0~100K/s and composition with 0~ 0.1 in TiAl alloy respectively. It is better value since it fits to the object very well. The maximum arrives 100K/s that is big value for solidification with high speed. That is our final destination to make higher speed sample to launch. How to use this chart is the task here. In the case of 0.44 Al and 0.46Al the difference is 0.02 therefore ΔCom equals 0.02 correspondingly the 20K is the temperature difference in Figure 2~ Figure 3 in special the latter is easier to check the value. If ΔCom is 0.04 ie.0.44Al and 0.48Al the 40K is the ΔT. So as the composition difference becomes bigger the temperature difference changes bigger too. That is due to the deeper gap to be formed. It makes the bigger super cooling to happen which results in smaller dentrite secondary arm space to be formed. It fits to the low cost and launch producing. This satisfies our destination to form rapid solidification to be harder and small crystals not only research and study but also cost down problem. If they are observed carefully the ΔT and Crate has been near the same within 0~100K value in Figure 1 and Figure 3. Under 20K and 0.02Al the cooling rate is slow and ΔT is big still. It explains that the cooling rate i.e. Solidification is difficult to control so controlling composition difference ie. Constitutional supercoiling will be necessary.

Due to their relationship equation the following transformating equation has been computed.

Since $\mathrm{T} = -1000C_{om} + 2273$ -- (1)

And it has $C_{rate} = \dot{\mathrm{T}} = -1000\dot{C}_{om}$ -- (2)

So $\Delta C_{rate} = -1000\Delta C_{om}$ -- (3)

It has $L = 44/(-1000C_{om} + 2273)$ --- (4)

These (3) and (4) are the composition and cooling rate and secondary arm space relation equations. Here Com is composition rate; T is temperature K; Crate is cooling rate K/s; ΔCom is temperature difference; ΔCrate is the cooling rate K; L is secondary arm space in dentrite mm (Figure 4).

As seen from Figure 4 the bigger the composition the lower secondary arm space is. The former changes from 0 to 1 with the later changing from 10.5μm to 5.8μm. They are non-proportional relationship. When the composition is 0.25, 0.5 and 1 the secondary arm space will be 9.2μm, 8 μm and 5.8μm respectively in non-constitutional supercoiling. The composition turn is from low to high like Ti3Al, TiAl and TiAl3 with above values correspondingly which says the larger and easier and more rapid supercoiling will be. Nevertheless the cooling rate is still low in the whole with highest value of 10μm~5.8μm. Therefore there is still other factor like ΔT.

Conclusions

The parameters simulation of cooling rate and secondary & composition has been established for the sake of searching their intrinsic relationship. It is observed that the cooling rate will decrease from 105K/s to 2K/s when the secondary arm space changes from 4μm to 170μm in dentrite of TiAl. It explains that the bigger secondary arm space will be if the cooling rate is smaller. It fits to the principle well. For the making TiAl intermetallic compounds the fit cooling rate and secondary arm space will be determined in advance to proceed the experiment which is necessary for us to regulate. The line is drawn between cooling rate with 0~100K/s and composition with 0~ 0.1 in TiAl alloy respectively. It is better value since it fits to the object very well. The maximum arrives 100K/s that is big value for solidification with high speed. When the composition is 0.25, 0.5 and 1 the secondary arm space will be 9.2μm, 8 μm and 5.8μm respectively in non-constitutional supercoiling. The composition turn is from low to high like Ti3Al, TiAl and TiAl3 with above values correspondingly. The composition trun is from low to high like Ti3Al, TiAl and TiAl3 with above values correspondingly which says the larger and easier and more rapid supercoiling will be. Nevertheless the cooling rate is still low in the whole with highest value of 10μm~5.8μm. Therefore there is still other factor like ΔT.

Foundation

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