



The Dendrite Modelling of Cooling Rate and Secondary Arm Space and Solidificational Speed in TiAl

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Abstract

The parameters simulation of solidificational speed and cooling rate and secondary & composition has been established for the sake of searching their intrinsic relationship. It is observed that the cooling rate will with increasing speed of solidification. The detail is that Cr changes from 0 to 23K/s when the solidification changes from 0 to 1800mm/hr. 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 dendrite secondary arm space will increase from 33mm to 0.1mm when the solidificational speed increases from 5 to 1800mm/hr. The dendrite secondary arm space will increase from 698 μ m to 0 μ m when the solidificational speed increases from 0 to 1800mm/hr. The arm space is big which is bigger than 100 μ m in low solidificational speed like 30mm/hr. The cost will be high in less than 30mm/hr so in order to acquire low cost the bigger one than 30mm/hr will be chosen in manufacture. The temperature will decrease from 1584K to 4K with the increasing solidificational speed from 0 to 1800mm/hr in terms of calculation.

Keywords: Modeling; TiAl; Dendrite; The secondary arm space; Analysis; Temperature; Cooling rate; Composition; Solidificational speed

Introduction

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. Meanwhile the solidificational speed is main parameter to search for its property in this study because it affects directly to the cooling rate and secondary arm space etc. 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 cooling rate in terms of the equilibrium diagram [1-3]. 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 [3-8]. Therefore in this study the model of temperature and composition has been established to

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observe the trend and intrinsic relationship between them. Then the error is checked with variance to both of constant.

Discussion and Simulation

From the secondary arm space in dendrite 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 (Figure 1,2).

As seen in Figure 1 the Cr increases with increasing speed of solidification. The detail is that Cr changes from 0 to 23K/s when the solidification changes from 0 to 1800mm/hr. They are proportional to each other. As seen in Figure 2 the temperature will decrease from 1584K to 4K with the increasing solidificational speed from 0 to 1800mm/hr (Figure 3).

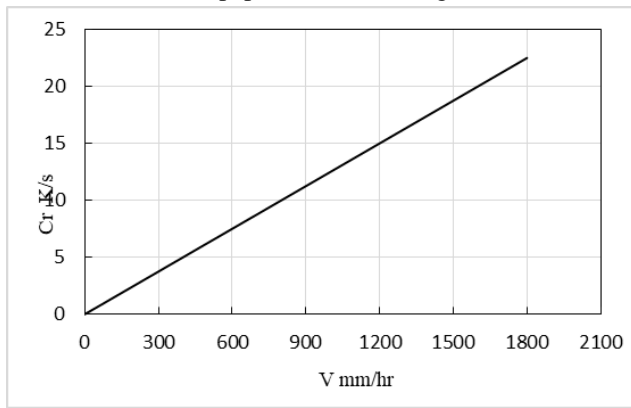
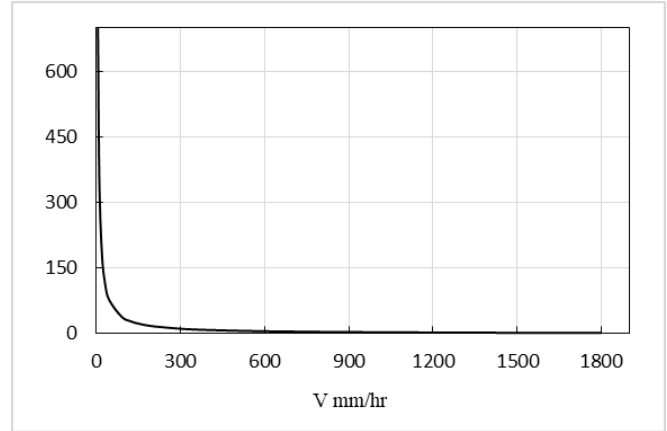
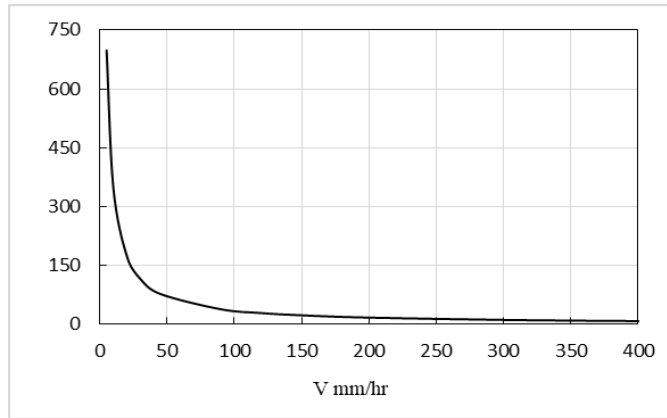


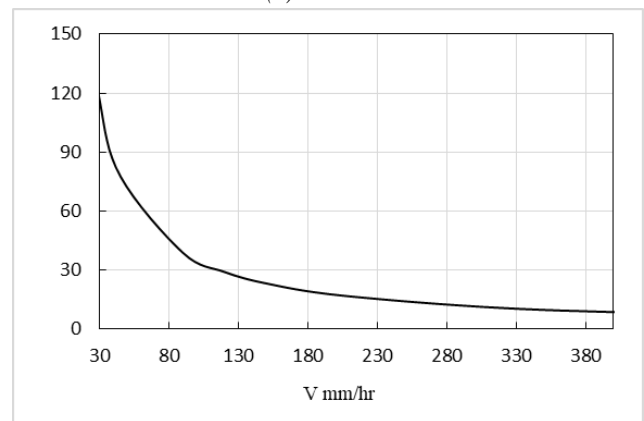
Figure 1: The graph between the cooling rate and solidificational speed in TiAl.



(a) 0~1800mm/hr



(b) 0~400mm/hr



(c)30~400mm/hr

Figure 3: The graph between the dendrite secondary arm space and solidificational speed within different speeds in TiAl.

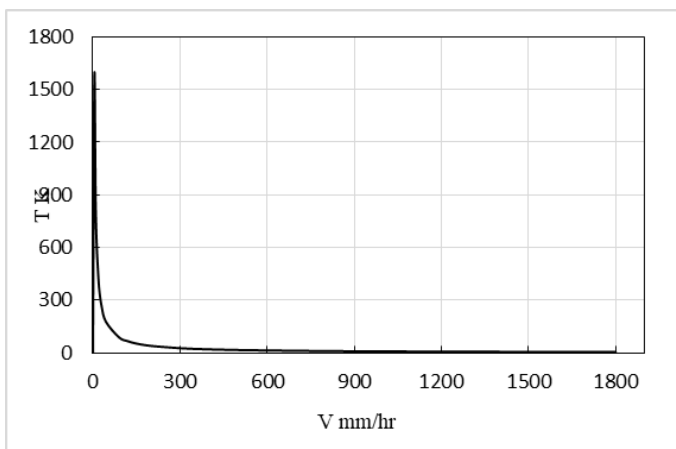


Figure 2: The graph between the temperature and solidificational speed in TiAl.

As seen in Figure 3(a,b,c) the dendrite secondary arm space will increase from $698\mu\text{m}$ to $0\mu\text{m}$ when the solidificational speed increases from 0 to 1800mm/hr . The arm space is big which is bigger than $100\mu\text{m}$ in low solidificational speed like 30mm/hr . The cost will be high in less than 30mm/hr so in order to acquire low cost the bigger one than 30mm/hr will be chosen in manufacture. In Figure 3(b) is the one part of Figure 3(a) the detail graph is seen there the 30mm/hr is the critical value with $100\mu\text{m}$ of solidification arm space. The curve will change stable one which means that low arm space happens later. In Figure 3(c) the secondary arm space is from $110\mu\text{m}$ to $10\mu\text{m}$ within increasing speed from 30mm/hr to 400mm/hr . It fits to the principle well. If the destination is 180mm/hr the secondary arm space occupies $22\mu\text{m}$ in TiAl alloys. The predict value is very precise to compare with literature in this study. On the other hand below 30mm/hr the cell will be formed only more than this value the dendrite is formed. So for the sake of decreasing the cost the dendritic one is been needed in materials direction. The higher speed will produce more production in one time with low cost in fighter jet of aerospace (Figure 4).

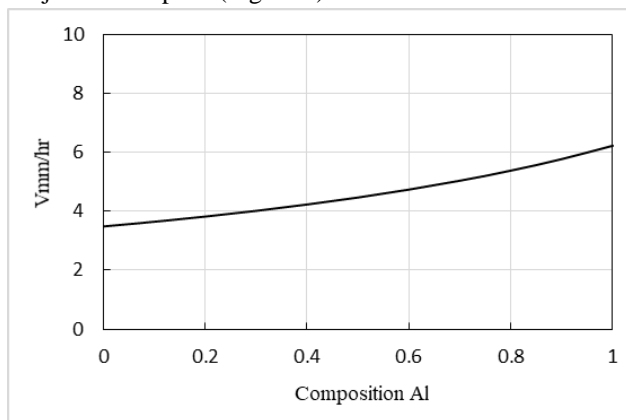


Figure 4: The graph between the solidificational speed and composition Al in TiAl.

As seen in Figure 4 when composition increase from 0 to 1 the solidificational speed will increase too from 3.4mm/hr to 6.3mm/hr . It is a low value so it means that composition affection is weak to solidificational speed which can be neglected somewhat.

The modelling equation is as below

$$Cr=45V \text{ --- (1)}$$

$$T=2.2/V \text{ --- (2)}$$

$$L=0.009/V \text{ --- (3)}$$

$$V=2.2/(-1000Com+2273) \text{ --- (4)}$$

Here Cr is the cooling rate K/s; V is solidificational speed m/s; L is dendrite secondary arm space mm; Com is composition of Al.

Conclusions

When composition increase from 0 to 1 the solidificational speed will increase too from 3.4mm/hr to 6.3mm/hr . It is a low value so

it means that composition affection is weak to solidificational speed which can be neglected somewhat. The secondary arm space is from $110\mu\text{m}$ to $10\mu\text{m}$ within increasing speed from 30mm/hr to 400mm/hr . It fits to the principle well.

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