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Model for Stress and M & Strain Rate in Superplastic Deformation of TiAl

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Abstract: *- The superplastic behavior is modeled to analyze the phenomenon of plasticity through changing strain rate to stress and m as to K & ņ、ε. Through observing the curve of stress &strain rate it is found that the dependent relation as m> >n turn from strain rate& stress. It may be obtained that σ>K. Q will increase somewhat when temperature k increases. Meantime according to different strain rate it has various value Q. The highest one is =1.25E-3 and 1, 25E-4; then 1.5E-1 and 1.25E-2; then 1.25E-4 and 1.65E-5; at last 1.25E-2 and 1.65E-3.*

Keywords: *- model; superplastic deformation; K & ņ、ε; stress; strain rate; m; constant A/dp, creep, activated energy Q, TiAl, function*

1 Introduction

The relationship between n, m and K has not been systematically studied so far, so this paper calculates and compares the relationship among them to explore the mechanism of super plasticity. The increase of m value caused by super plasticity and the decrease of flow stress are the main evidences so far. [1]Alloy has superplastic properties and can produce super plasticity at high temperature and appropriate strain rate. So studying it is a major topic today. We get the curves of strain rate-stress and strain rate- m from the equation, and we know their sizes and trends by comparing them, so we make a systematic study to thoroughly investigate their relations. In the previous paper, under the relation of super plasticity m>K>n, [2, 3], this paper investigated the curves of -σ and -m, so as to compare their intrinsic characteristics. The variation law of their internal characteristics is obtained, so as to get ready for the parameter selection of super plasticity.

Q as an activated energy constant at TiAl creep is important parameter which is needed to calculate in Creep test. Q is changing with strain rate and temperature after it is considered through, because Q is various constant at strain rate and temperature its function is investigated to clarify the attribution. Q is calculated through mean way to decide has error problem since different condition has different value. We should take account into it to define the precision value in this paper to clarify the intrinsic attribution in TiAl creep. On the other hand the A/dp as a constant in activated energy equation has effect with strain rate, stress and temperature. It depends on the strain rate and temperature mainly. So the two parameters have been further studied here to look for their internal rule is the main purpose of this paper [4, 5].

2 Model research

Now the numerical model is built as below turns. For the tensile test course

In terms of equation $\sigma = K\varepsilon^{n}$ --（1）

Take the logarithm it has $LN\sigma = LNK + nLN\varepsilon$ --（2）

In terms of equation too $\sigma = K_1 \dot{\varepsilon}^m$ --（3）

The same as above (2) it has $LN\sigma = LNK_1 + mLN\dot{\varepsilon}$ -（4）

from（1）&（2）it gains below two equations

$$n = \frac{LN(\sigma_1/\sigma_2)}{LN(\varepsilon_1/\varepsilon_2)} \text{-- (5)}$$

$$K = EXP[LN\sigma_2 - \frac{LN(\sigma_1/\sigma_2)LN\varepsilon_2}{LN(\varepsilon_1/\varepsilon_2)}] \text{-- (6)}$$

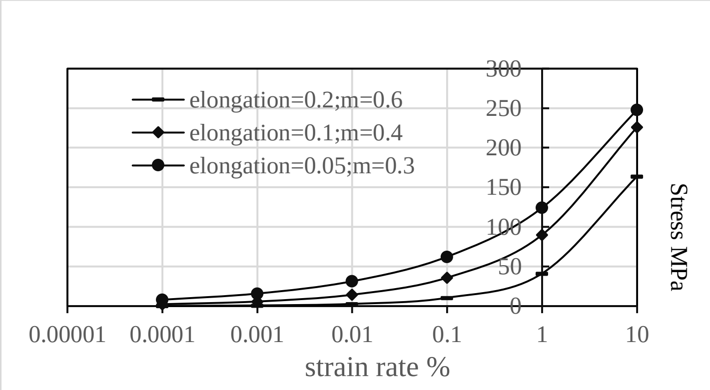
from（3）&（4）we gain below two equations too

$$m = \frac{LN(\sigma_1/\sigma_2)}{LN(\dot{\varepsilon}_1/\dot{\varepsilon}_2)} \text{--（7）}$$

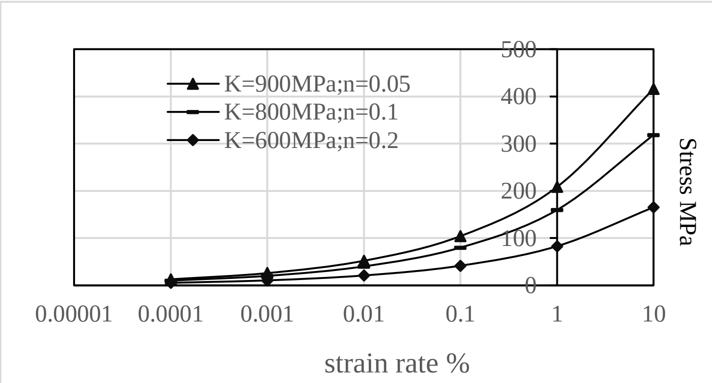
$$K_1 = EXP[LN\sigma_2 - \frac{LN(\sigma_1/\sigma_2)LN\dot{\varepsilon}_2}{LN(\dot{\varepsilon}_1/\dot{\varepsilon}_2)}] \text{-- (8)}$$

These (5-8) equations are the parameters resolution in tensile test.

Discussion& conclusions



(a) ε&m



(b) K&n

Figure 1 relationship between stress and strain rate.

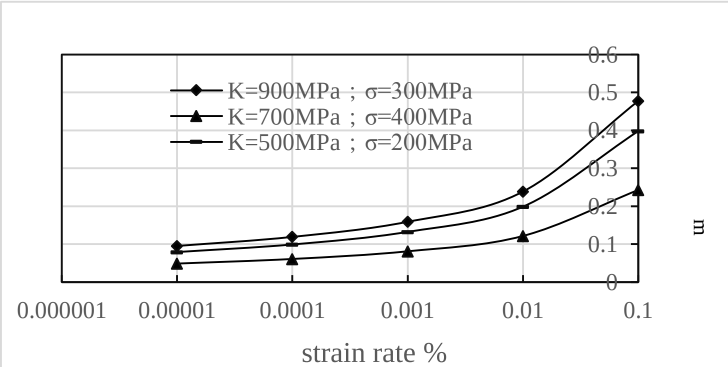


Figure 2 relationship between m and strain rate.

Figure 1 (a) shows that stress will increase with the increasing strain rate, meantime it leads to stress decreased with increasing elongation and m. It matches the m> $\dot{\varepsilon}$ >n

Turn well. [2]Figure 1(b) shows the stress increases with the decreasing K and n [2] while it leads to stress decreased with K=600MPa and n=0.2 which proved K>n too. Figure 2shows that m will increase with the increasing strain rate. [1] When K=500MPa and σ=300MPa the low m will be. Meantime the maximum m is acquired in K=900MPa and σ=300MPa which is to benefit to super plasticity and the minimum m is in K=700MPa and σ=400MPa. It proves that the role to super plasticity can be σ> K. in general through two groups it may be obtained that σ>K and meantime proves K>n too.

Due to Zener-Holloman formula it has below

$$\dot{\varepsilon} = \frac{A}{dp} EXP(-\frac{Q}{RT})\sigma^{n}$$ [1,2] (9)

It has

$$\dot{\varepsilon}_1 / \dot{\varepsilon}_2 = \frac{A_1 P_2}{P_1 A_2} e^{\frac{Q}{RT2} - \frac{Q}{RT1}} \quad (10)$$

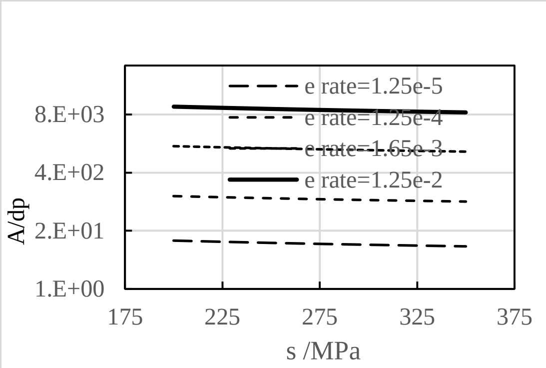
Take natural logarithm it has

$$LN\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_2} = LN\frac{A_1 P_2}{A_2 P_1} + Q/R(\frac{1}{T_2} - \frac{1}{T_1}) \quad (11)$$

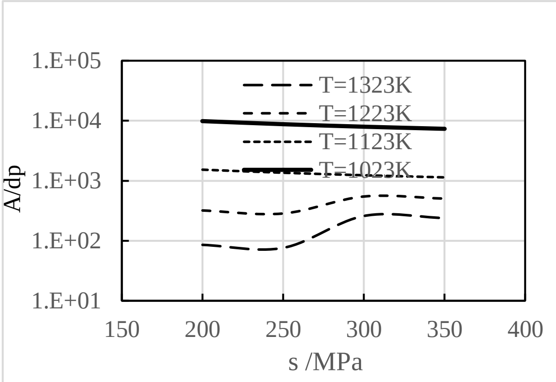
So $$Q = \frac{RT_1 T_2}{T_1 - T_2} LN\frac{\dot{\varepsilon}_1}{\dot{\varepsilon}_2} \quad (12)$$

As shown in Figure 1(a,b) it is found that A/dp is increasing when strain rate decreases. Meantime A/dp will increase when temperature decrease as well. So this constant is mainly controlled by strain rate and temperature. On one hand it slightly decreases with strain size and decreases at strain rate of 1.25E-4. At 1323K and 1223K it will have increasing trend, which is odd phenomenon. For instance it is chosen that A/dp of 500MPa is correspondent with $\dot{\varepsilon}$ of 1.65E-3 and temperature of 1223K. As shown in Figure 1（c）Q will increase somewhat when temperature k increases. Meantime according to different strain rate it has various value Q. The highest one is $\dot{\varepsilon}$=1.25E-3 and 1, 25E-4; then 1.5E-1 and 1.25E-2; then 1.25E-4 and 1.65E-5; at last 1.25E-2 and 1.65E-3. So it has been chosen a certain strain rate to experiment and calculate to analyze the different value Q. Though the activated Q is not so different it is chosen that the fit one is necessary. To apply to the Figure 3(c) is a way to determine the detail parameters. For instance

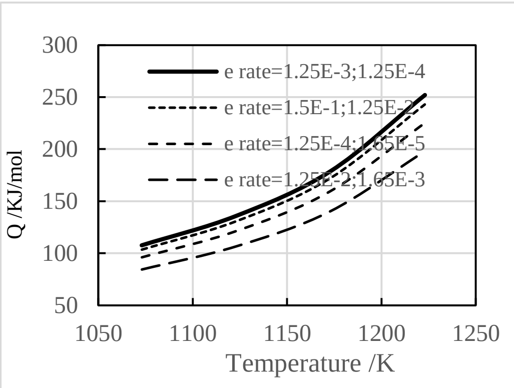
Q=200KJ/mol it has been chosen 1200K temperature and strain rate 1.25E-3 and 1.25E-4 is one, for instance to 208KJ/mol the one is 1200K and 1.25E-3 and 1,25E-4 strain rate etc as figure.



(a) ε rate



(b) T; strai rate 1.25E-4



(c) ε rate

Figure 3 the relationship of A/dp and Q & parameters in TiAl.

Conclusions

1. It matches the m> k >n turn well from strain rate& stress.
2. Through two groups it may be obtained that σ>K and meantime proves K>n too.
3. A/dp is increasing when strain rate decreases. Meantime A/dp will increase when temperature decrease as well. So this constant is mainly controlled by strain rate and temperature. On one hand it slightly decreases with strain size and decreases at strain rate of 1.25E-4.
4. Q will increase somewhat when temperature k increases. Meantime according to different strain rate it has various value Q. The highest one is =1.25E-3 and 1, 25E-4; then 1.5E-1 and 1.25E-2; then 1.25E-4 and 1.65E-5; at last 1.25E-2 and 1.65E-3.

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