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Modeling of Parameters with Strain Rate、K、m & n etc. for Superplastic Deformation in Ti-Al Alloys

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Abstract: *The stress is to be lower with lowering strain rate from* $\dot{\varepsilon}$*=1E-1/s to* $\dot{\varepsilon}$*=1E-3/s which expresses that the higher superplastic deformation may be formed. When K=240MPa the lowest one may be formed to compare with the one of 340MPa and 440MPa. The bigger m may result in better plasticity, however when that plasticity indicates beyond the critical strain point with 300% the reverse one will happen as .providing* $\dot{\varepsilon}$*=0.1/s in this paper where the value indicates too large. The deformation is to be lower with enhancing* $n=1/\varepsilon$、$n=1/\sqrt{\varepsilon}$ *and* $n=1/\sqrt[3]{\varepsilon}$*.*

Keywords: *modeling，parameters; strain rate; strain; K、m & n;* Ti_3Al *alloys，superplastic deformation, Ti-Al alloy*

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I. Introduction

The superplastic deformation of Alloys is to lead to a good performance in failure situation. Such as the creep and tensile test, in this situation it can wield its toughness up to utmost. So the simulation is to be proceeded in advance for the sake of evaluating its synthetic ability of superplastic deformation. It will help to save manufacture cost and control the process and parameters like n、K & m in materials. In Ti_3Al and TiAl alloys the plasticity has dominated in many fields as an important components in aeronautics. In some papers the conclusions are done as its function for causing ductility and high strength has provided good one. In China some institutions propose its detail application for future search project in aeronautic turbine blade part like Ti-25at.%Al-(12~26)at.%Nb alloys.

Therefore, the detail narrate will be done for searching this alloys. Through the computation the stress and strain tendency is to be observed for us to discuss further. In this paper the equation between stress and strain, strain rate is to be used for exploring σ and ε, $\dot{\varepsilon}$ performance. Because this three parameters can affect the plasticity in literature, the simulation with formula will clarify certain problem where the destination is existed in. The lower m may increasing plasticity while the same n may increasing it as well where the conclusions has been arrived through this simulation with modeling their relationship in the end. [1~8] Thereby, the super plastic deformation is to become the main destination by this paper at all where the respective parameters have been controlled through simulating the performance course.

II. Calculation & Discussions

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)

Here K is strength coefficient, MPa; K_1 is the same for strain rate, MPa; n is strain hardening exponent; m is strain rate sensitive coefficient; σ is the true flow stress, MPa; ε is the strain; $\dot{\varepsilon}$ is strain rate.

The same as above (2) it has

$$LN\sigma = LNK_1 + mLN\dot{\varepsilon} \text{ -----(4)}$$

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

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

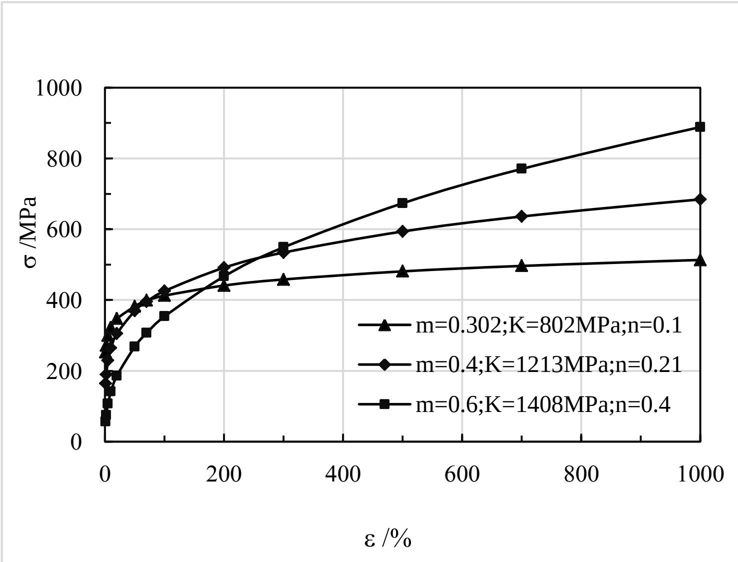
$$K = EXP[LN\sigma_2 - \frac{LN(\sigma_1/\sigma_2)LN\varepsilon_2}{LN(\varepsilon_1/\varepsilon_2)}] \text{----- (6)}$$

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

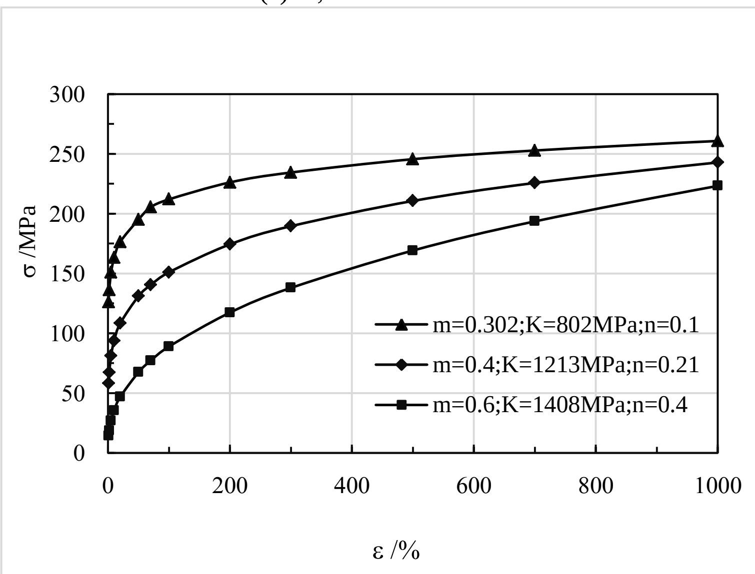
$$K_1 = EXP[LN\sigma_2 - \frac{LN(\sigma_1/\sigma_2)LN\dot{\varepsilon}_2}{LN(\dot{\varepsilon}_1/\dot{\varepsilon}_2)}] \text{----- (8)}$$

Those(5-8) equations are the parameters resolution in tensile test. From(3) & (4) those two equations is to be gained for below results as well.

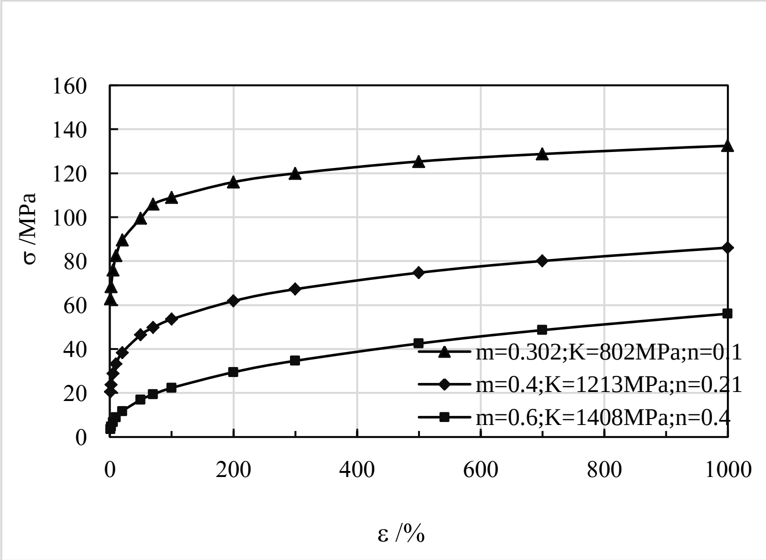
The m to be 0.302~0.6, K to be 802MPa~1408MPa & 240MPa~440MPa and n to be 0.09~0.21 is to be chosen for simulating the deformation of Ti-Al alloys in this paper. The conclusion with each stress and strain may be narrated as below in details and discussed respectively.



(a) m; K & n/$\dot{\varepsilon}$=1E-1/s



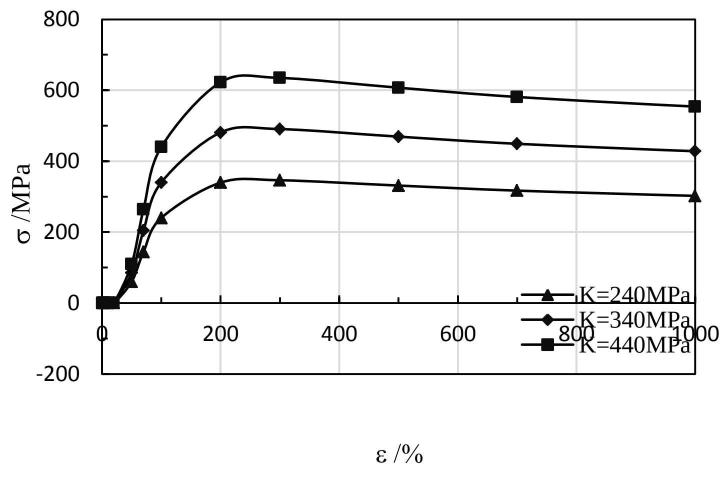
(b) m; K & n/$\dot{\varepsilon}$=1E-2/s



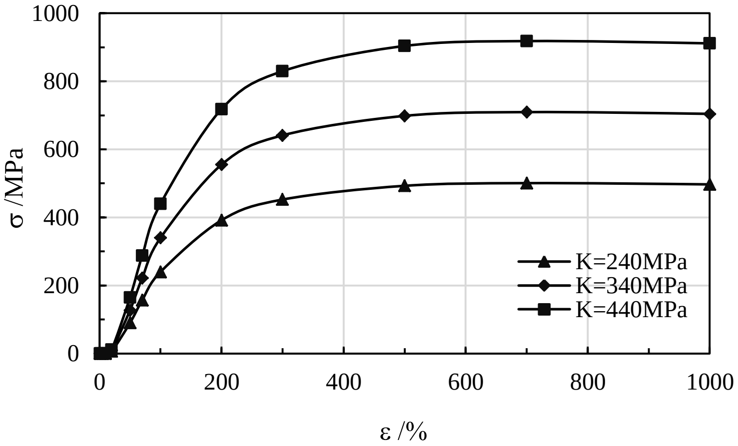
(c) m; K & n/$\dot{\varepsilon}$=1E-3/s

Figure 1 The relationship between σ (MPa) and ε with m、n、K in the Ti-Al alloys.

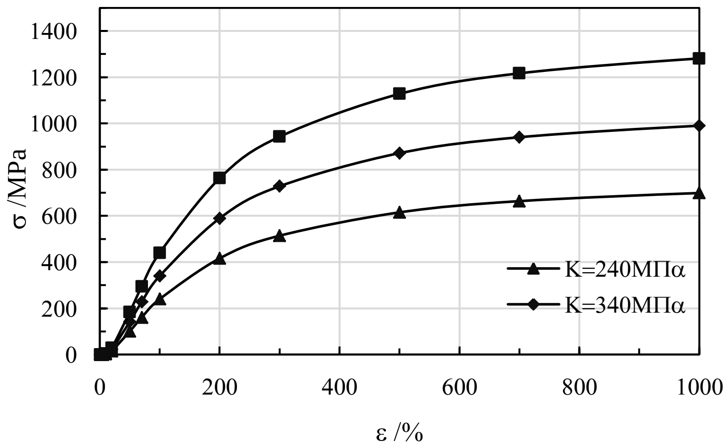
From Figure 1(a~c) the curve for different m、n and K may be exhibited with regard to stress and strain in the Ti-Al alloys. With decreasing $\dot{\varepsilon}$=1E-1/s to $\dot{\varepsilon}$=1E-3/s the stress may indicate smaller one which explains the better deformation will be formed. Therefore, the low stress rate is to form the low strain that results in high strain and fits to literature [2~4] well. With increasing m=0.302 to m=0.6 it may express the better plasticity where it explains that m is to indicate the same tendency with strain rate. It has provided the main role of those parameters may become m and strain rate, meanwhile, the n and K is to provide the second role in Ti-Al etc. Alloys. As shown in Figure 1(a) the stress may reverse with strain rate because it attains 0.1/s beyond strain value 3/s where the strain rate indicates too big value.



(a) n=1/ε



(b) n=$1/\sqrt{\varepsilon}$



(d) n=$1/\sqrt[3]{\varepsilon}$

Figure 2 The relationship between σ (MPa) and ε with n、K in the Ti-Al alloys.

For the sake of controlling those K and n~ε the respective stress curve has been shown as following ones according to the calculation results. In Figure 2(a~c) the stress is to be higher with enhancing n=1/ε、n=$1/\sqrt{\varepsilon}$ and n=$1/\sqrt[3]{\varepsilon}$, meanwhile it is to be the same tendency with lowering K as above correspondingly. The stress may become low with enhancing n and lowering K respectively. In details when n=$1/\sqrt[3]{\varepsilon}$ and K=440MPa the highest stress may be provided. When K=240MPa and n=1/ε the lowest one may be formed with about 350MPa where it means the highest plasticity may be acquired with it.

As literature [9] the bigger m may result in bigger plasticity, however when that plasticity beyond the critical strain point with 300% the reverse one will happen to $\dot{\varepsilon}$=1E-1/s as shown in Figure 1(a) in this paper. The reason for that may be considered is to account for little one of them. In Figure 2(a~c) it is to be supposed that parameter n=1/ε、n=$1/\sqrt{\varepsilon}$ and n=$1/\sqrt[3]{\varepsilon}$ in this paper for deducing super plasticity. Here n may be enabled the various parameter in each curve point of corresponding condition.

III. Conclusions

The stress is to be lower with lowering strain rate from $\dot{\varepsilon}$=1E-1/s to $\dot{\varepsilon}$=1E-3/s which expresses that the higher deformation may be formed. When K=240MPa the lowest one may be formed to compare with the one of 340MPa and 440MPa.

The bigger m may result in better plasticity, however when that plasticity indicates beyond the critical strain point with 300% the reverse one will happen as .providing $\dot{\varepsilon}$=0.1/s in this paper where the value indicates too large.

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