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Model for n and m & K of Superplastic Deformation in Ti_3Al

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Abstract: *- the super plastics of alloys is recently developed method to obtain the optimum plastic property on Ti3Al alloys. On order to research the superplastic distribution with parameters such as n､m&K the modeling established is analysis and calculated the results, and find the parameters is fit to the curve expressing the high plastic well here. m>K>n is the found turn in these three parameters which causes the super-plasticity effectively. This effect may be studied further to demonstrate it to be effective definitely. The stress under =1.25*E-4 decreases more than half of one that is under =1.25*E-2 in these three statuses as reference. It explains that the high plastic behavior is to be anticipated when strain rate becomes low in this paper. the superplastic behavior is modeled to analyze the phenomenon of plasticity through changing strain rate to be 10%, 20% & 30%，strain rate to be 200MPa, 300MPa&400MPa as to n & m in Ti3Al alloys. Through observe the curve of n&K it is found that the dependent relation As.> ε> σ=200MPa> σ=300MPa. Meantime the m (n) and K is increasing function relation.*

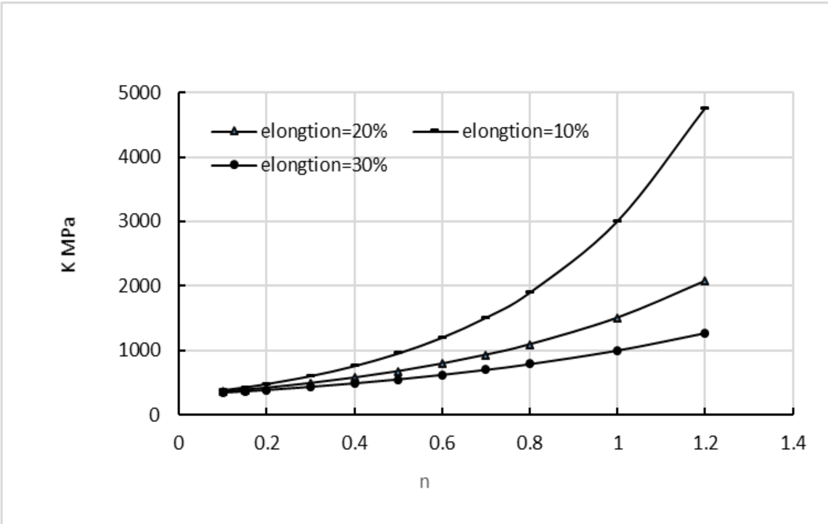
Keywords: *- super plastics; Ti3Al; n､m&K; model；superplastic deformation；n&K；stress；strain rate*

1. Introduction

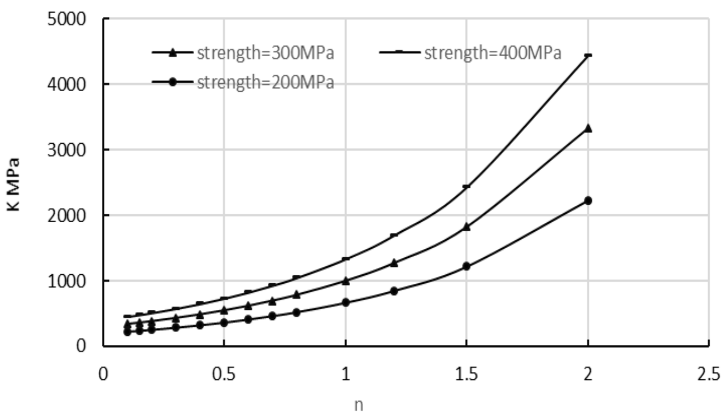
The relationship between n, m and K has not been systematically studied so far, so this paper calculates and compares the relationship among them to explore the mechanism of super plasticity. The increase of m value caused by super plasticity and the decrease of flow stress are the main evidences so far. [1]Ti3Al 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 n-k and m-k 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 n-k and m-k, 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. The super plasticity on Ti3Al has been prevalent recently in many researches. In some papers the conclusions are done as the strain sensitive exponent is one main parameter to cause ductility and super plasticity. The studies research experimental data to explain the effective size to super plasticity. The super plasticity is high plastic behavior in alloys. For instance, many metal has this property which is concluded as three conditions. Firstly the high temperature; second the high strain rate; thirdly the small grain boundaries. [4, 5] Only satisfied these three conditions can a metal wield this superplastic behavior? So this paper will analysis and compute this behavior in terms of different parameters such as n､m and K to find the properties behaviors as well.

So we carry experimental data of based Ti3Al alloys to simulate the stress and strain curve to find their ductility and super plasticity. To find the function these three parameters respectively we proceed chart to file up according to three conditions. We find the K and n are also two factors to affect the ductility. The results are fitting to well with the results m in literatures. To look for the size of them it has been done that method of comparing with others as for one parameter. We find definitely some difference at x-y coordinate ie stress and strain, so that the value size of them is judged in this paper.

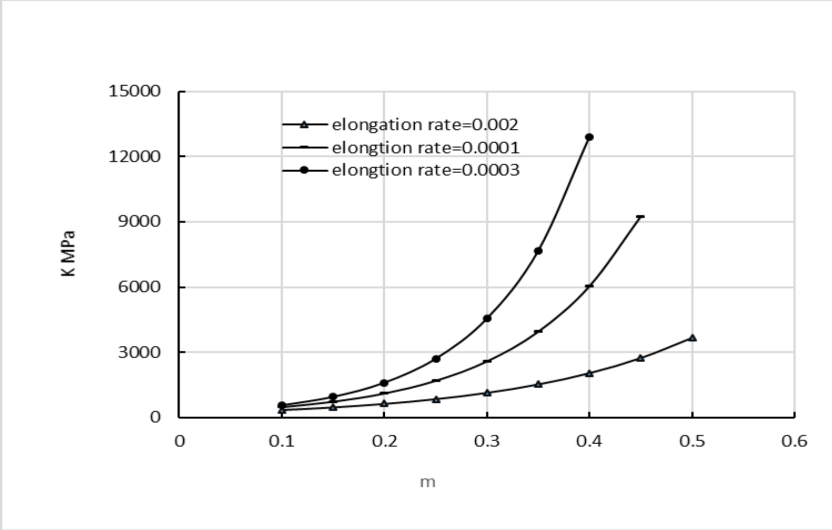
In some papers it had been said that the super plasticity was obtained in terms of Single crystalline. In some directions the superplastic behavior was observed. So that the directional super plasticity will be discussed in the future. This is a new method to look for ductility even super plastics in terms of dislocation or twins. At the lowest energetic plane are there an easy way to split and slip as for dislocation and twins according to material engineering [2].



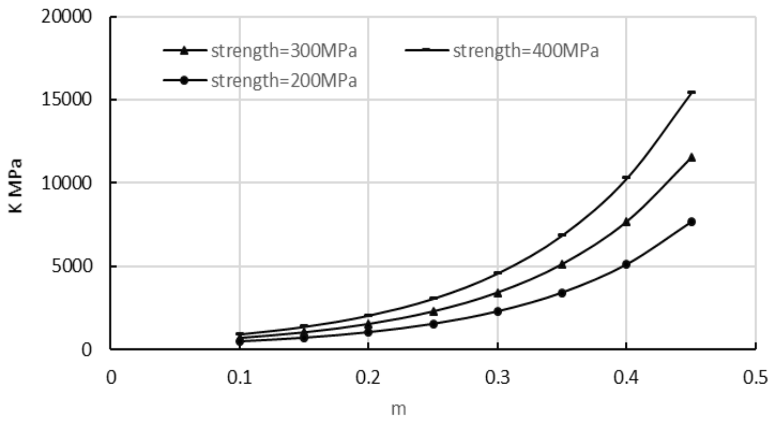
(a) n/σ=300MPa



(b) n/ε=0.3



(c) m/σ=200MPa



(d) m/$\dot{\varepsilon}$ =0.0003

Figure 1 the relation between n&m and K

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

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

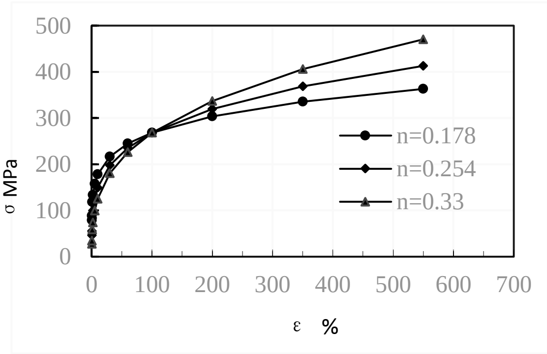
$$K = EXP[LN\sigma_2 - \frac{LN(\sigma_1/\sigma_2)LN\varepsilon_2}{LN(\varepsilon_1/\varepsilon_2)}] \text{ -- (6)}$$

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

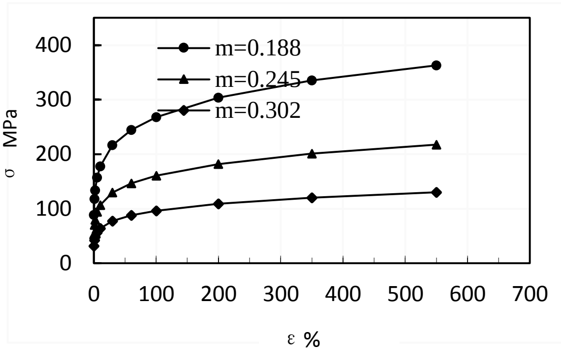
$$m = \frac{LN(\sigma_1/\sigma_2)}{LN(\dot{\varepsilon}_1/\dot{\varepsilon}_2)} \text{ -- (7)}$$

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

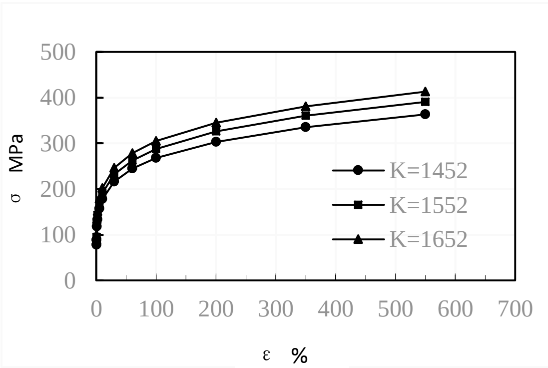
These (5-8) equations are the parameters resolution in tensile test.



（a） n



(b) m



(c) K

Figure 2 the curve of strain and stress on different parameters under $\dot{\varepsilon}$ =1.25*E-4 in Ti_3Al.

2. Discussion & conclusions

As shown in Figure 1 (a, b) shows the relationship between n and K when =300MPa and ε=0.3. The K value increases with the increase of with the increase of elongation, K decreases, and stress σ decreases, indicating that elongation plays a role in increasing plasticity. From Figure 1 (b, c) it shows the relationship between m and K1 when σ=200MPa and $\dot{\varepsilon}$ =0.0003. With the increase of n, K1 value increases. Strength, on the other hand, has the opposite effect. To sum up, the smaller the strength will be, the better the plasticity is; the larger the elongation and rate is, the better the plasticity shall be, that is, the better the super plasticity shall be. These are the two conclusions drawn in this paper, indicating that n and K are affected by the sum of σ، ε& $\dot{\varepsilon}$. By observing the above four groups of curves, it can be found that σ=300MPa<ε at n, σ=200MPa< $\dot{\varepsilon}$ at m, respectively $\dot{\varepsilon}$.> ε> σ=200MPa> σ=300MPa was determined by their effect on the reduction of flow stress. In terms of above equations the curves will be obtained here as shown under $\dot{\varepsilon}$ =1.25*E-4 in Figure1. The value ie stress decreases more than half of one that is under 1.25*E-2 in these three statuses as reference. [2~3] It expresses that the low m causes big plasticity to be observed by graphs totally in this paper. It has been the results according to different parameters such as n,m and K. From Figure 2(a~c) the curves of different n have been drawn, the low n and K will cause high stress that's saying low strain. The low m cause low stress ie high strain.in general, high n & K and low m cause high stress. These correspond with the above three conditions well. From Figure 2（b）it is observed that the lowest stress with sensitivity m is proved too. [2, 3] It explains m is the most sensitive factor in these three conditions. The baldest one is n it has high stress and low strain so that the low effect to plastic. The middle one is K it has been the secondary factor to plastic. So turn is listed as below m>K>n from the first to third factor. They have been investigated and find that the difference between these different values in the same parameter is to bigger with increasing strain to 550 % which is super plastically field. It is slow increasing stress is formed within high strain. That explains the similar super plastics phenomenon to take place. So if we choose the fit value the super plasticity will be formed too, which is concluded in this paper. There are controlling the detail value to simulate the super plasticity. It will be done further research to study mechanism forming superplastic behavior in the future. From Figure 2（a）in the point of 100% strain there are turning phenomenon ie. The usual role is formed beyond 100% that is the high strain field. This expresses the good coincidence with the other reports. Below this point the opposite role is done and what it will role true to need to further study. We analyze n is the factor to opposite role because it is bad effect one so that it may do opposite role to stress and strain curve by now. According to three superplastic conditions the m is the regulative factor in reports. Besides these the K and n have also a certain role in super plastic behavior which is conclusion from this paper.

The m>K>n is the found new turn in three parameters this paper as above. The effective factor is m sensitive which mainly regulates the stress size to attain the good ductility because the high stress results low strain as statistic other references. The high m sensitive exponent results in low stress and high strain including to big plasticity even super plasticity. The m below 0.2 will be available one shown in Figure 2(a), the 0.178 causes low stress mostly while 0.33 results high mainly, and the 0.254 is the middle section to ductility. So that 0.15 down is excellent parameter to cause super plasticity. So the condition for comparing is adopted to search more is the future direction for us to proceed. Although m is main factor to regulate the super plasticity the K and n also need to be done to investigate their role in plastic behavior. As there known the n will play opposite role to plastic even super-plasticity phenomenon this function is studied more to demonstrate the opposite cause. When the strain is limited within 100% strain the n decreases strain so that n will be decreased to wield its strain. It is conquered to get more effective method to wield its role ie opposite function to regulate. Secondly K is used to role a certain effect to gain the plastic is a new approach method found in here. Related studies need to be proceeded to find their respective function to improve the ductility disqualification problem.

3. Conclusions

1. K value increases with the increase of n. With the increase of elongation, K decreases, σ decreases, indicating that elongation plays a role in increasing plasticity.
2. For super plasticity, as to n it has been the σ=300MPa<ε, as to m been the σ=200MPa<$\dot{\varepsilon}$. m>K>n is the found new turn in three parameters found in this research. M is a main factor to affect the ductility which default is a current main problem. The stress under $\dot{\varepsilon}$ =1.25*E-4 decreases more than half of one that is under $\dot{\varepsilon}$ =1.25*E-2 in these three statuses as reference. It explains that the high plastic behavior is to be anticipated when strain rate becomes low to 1.25*E-4 in this paper.
3. N will play opposite role to plastic when strain is below 100%. This function is studied further to demonstrate the opposite cause.
4. K is used to role a certain effect to gain the plastic is a new approach method secondly. If its function is satisfactory the well conclusion will be gained as expected.

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