EFFECT OF DISSOLUTION OF GUINIER-PRESTON ZONES AND B-PHASE ON THE TRANSIENT CREEP CHARACTERISTICS OF Al-14 wt.% Zn

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Abstract:

Transient creep of Al-14 wt.% Zn alloy has been studied under different constant stresses ranging from 88.4 MPa to 106.6 MPa and at different constant temperatures ranging from 423 K to 513 K. From the transient creep described by the equation: $\epsilon_{tr} = B\, t^n$, *the parameters B and n were calculated and found to change with the applied stress from* 5×10^{-5} *to* 3.5×10^{-4} *and from 0.37 to 0.79, respectively. The parameter B was related to the steady state creep rate* $\dot{\epsilon}_{st}$, *through the equation* $B = B_0 (\dot{\epsilon}_{st})^{\gamma}$. *The exponent* γ *was found to be ranging from 0.25 to 0.28.*

The energies activating transient creep at the temperature regions of dissolution of Guinier-Preston zones and B-phase were found to be $(3.5 \pm 0.5) \times 10^{-23}$ *K.J./Atom characterizing dislocation mechanism.*

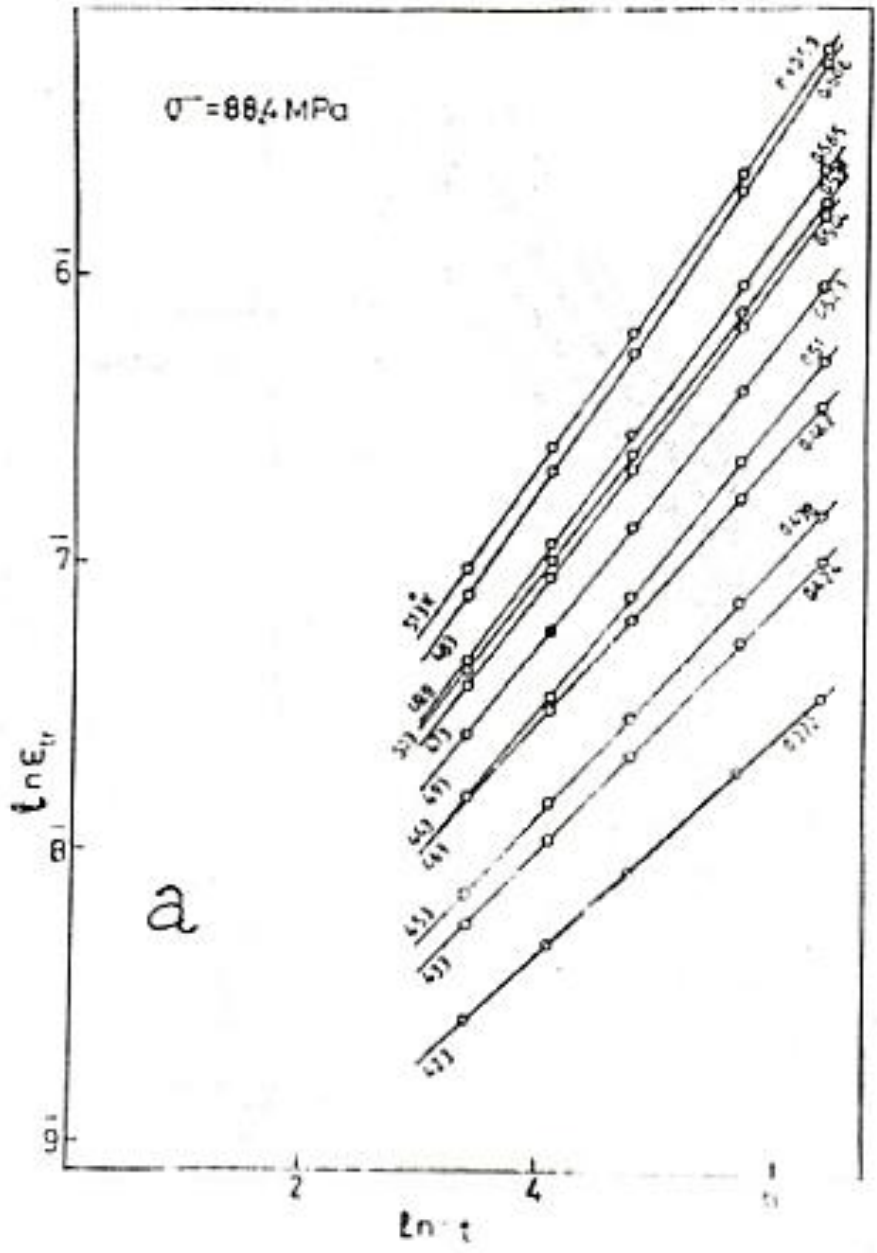
Introductione

Creep is the time dependent deformation of a solid under constant applied stress and constant temperature. The typical creep curve was found to contain three distinct stages, nemaly, the transient, the steady state and the fracture stage.

The transient creep has a decreasing creep rate. This creep was attributed to the exhausion of creep sources. Mott and Naborro [1] attributed the decrease in creep rate to the stress induced duting the motion of dislocation segments that were loosely pinned and detached from their pinning points by mechanical or thermal energy. This type of creep could be tepresented by the equation [2],

$$\epsilon_{tr} = By^n \qquad (1)$$

where B and n are transient creep parameters.


σ = 88.4 MPa
a
ln ε_tr
ln t

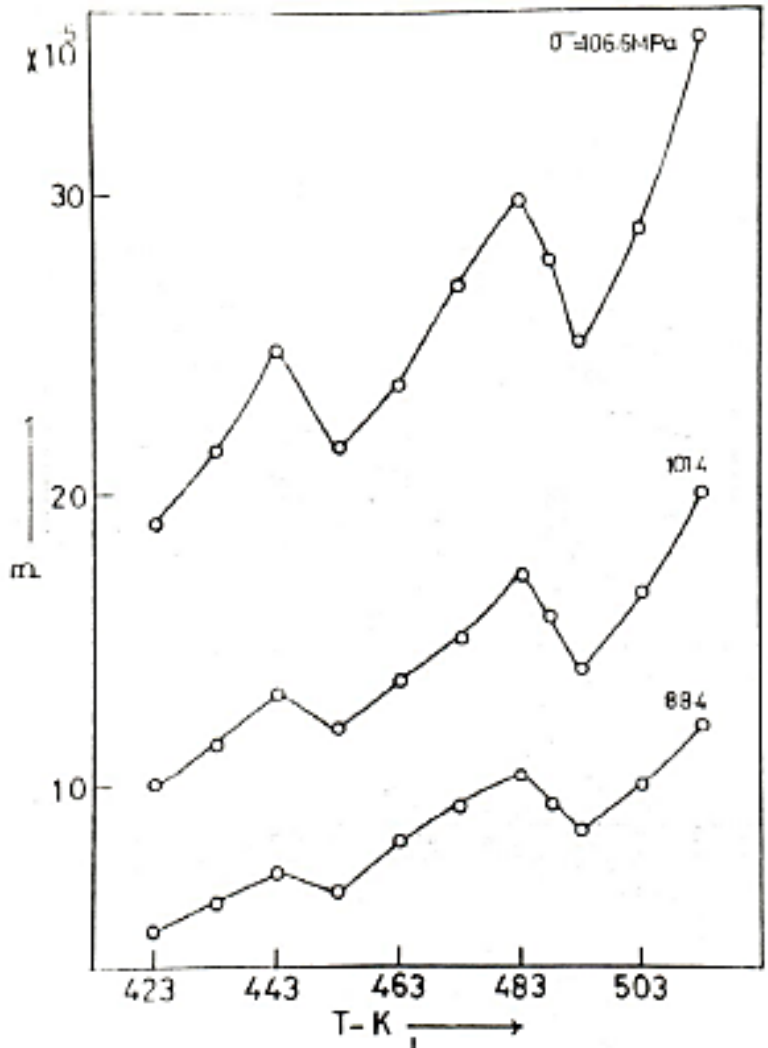
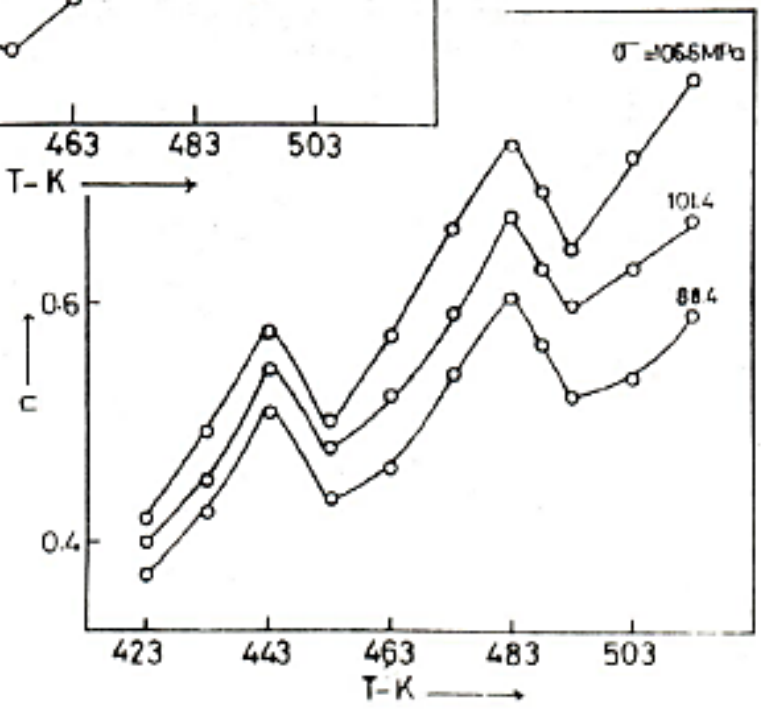


Fig.(2) The dependence of creep parameter (β) on the working temperature at different applied stresses for Al-14 wt.% Zn alloy.



Fig(3) The dependence of the exponent (n) on the working temperature at different applied stress for Al-14 wt.% Zn alloy

Peak values of B and n were detected at the temperature 443 K of dissolution of G.P. zones and 483 K of the transformation of B-phase to the α-phase refering to the enhancement of the transient creep strain. This observation was attributed to the formation of Frank-Read sources during the rearrangement of dislocations in the dislocation network at the dissolution and transformation temperatures.

In order to correlate between transient and steady state creep, the linear relation between $\ln B = \ln (\epsilon_{tr})_{t=1}$ (as deduced from transient creep and $\ln (\dot{\epsilon}_{st})$ for different constant stresses, through the transformation regions was plotted (see Fig. 4). The relation $B = B_0 (\dot{\epsilon}_{st})^{\gamma}$ was found to be valid wth the exponent which was found to be ranging from 0.25 to 0.28.

The dependence of the steady state strain rate ($\dot{\epsilon}_{st}$) seemed to be induced by the transformation which enhanced the transient and steady state stage.

The dissolution of G.P. zones and the transformation of B-phase to the α-phase created internal stresses. Beside, creep deformation during structure transformation is based on the difference in mechanical properties of parent and product phases [7]. The change of specific volume of the sample during phase transformation activated Frank-Read sources which created glide and cross-slipping dislocations at the phase and grain boundaries.

The activation energy of transient creep was calculated from the slopes of the straight lines relating $\ln (\epsilon_{tr})_{t=1}$ and $(\frac{1}{T})$, (see Fig. 5), ranging from 3.4×10^{-23} K.J./Atom to 6.4×10^{-23} K.J./Atom refering that the controlling mechanism of transient creep during transformation of Al-14 wt.% Zn is the dislocation mechanism [8].

References:

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