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The Sources and Affecting Factors of Creep Threshold Stress of Magnesium-Based Composite

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Tensile creep experiments were carried on AZ91D magnesium alloy and aluminum silicate short fiber reinforced AZ91D magnesium matrix composite. The creep threshold stress of AZ91D composite depends on the Al atoms solute atmosphere, the bearing and transferring force of short fiber. Threshold stress decreases with increasing temperature, increases with the increase of short fiber volume fraction and the load transfer coefficient α*, but the extent of increase decreases with the increase of the amount of* β*-*$Mg_{17}Al_{12}$ *precipitation phase. The load transfer coefficient* α *characterizes the bearing and transferring capabilities of short fibers. As a result, the mathematical model of threshold stress in the magnesium matrix composite is obtained.*

Keywords: magnesium matrix composite, creep, threshold stress, AZ91D, load transfer coefficient.

Introduction. Currently, a lot of researches have been conducted on the high temperature creep properties and behaviors of metal matrix composites [1, 2]. Many researchers underlined that there is a threshold stress and the creep is not generated when the applied stress is below that limit value [3, 4].

So far, there is not an available creep theory which can explain all the characters of creep. The core issues of researches are the mechanisms of dislocation over the second phase and the sources of threshold stress. The sources and physical meaning of creep threshold stress and the way of quantitative expression have not been determined. Some researchers believe that the creep threshold stress may come from the interactions between mobile dislocations and precipitated phase in matrix [5, 6]. A one-dimensional micro-mechanical model, which is based on the law for interfacial sliding, has been developed for thermomechanical deformation of continuous fiber reinforced metal matrix composites [7]. Based on the recent studies on (coherent precipitates Al_3Sc + non-coherent dispersion Al_2O_3 reinforcing phase) / aluminum alloy composite strengthening, the synergetic effect of the two ways is discovered. Furthermore, the total threshold stress is the sum of stress and back stress. The former is generated when mobile dislocations field is imposed by coherent precipitates to the mobile dislocation [8]. Dispersion strengthened Al-Mg alloys are same with pure Al-Mg alloy in that creep deformation is related to dislocation climb and dislocation – solute drag. The threshold stresses in the two materials are related to the function of mobile dislocation density, dislocation velocity and solute concentration in the dislocation core [9]. However, the creep studies focus on the dispersion strengthening, particle reinforcement or long fiber reinforced metal matrix composites. There are few studies about the high temperature creep of short fiber reinforced metal matrix composites. For example, the assessment of back stress and load transfer approaches for rationalizing creep of short fiber reinforced aluminum alloys has been demonstrated [5]. Chmelik et al. [2] studied the creep properties and behaviors of an unreinforced AZ91 magnesium alloy and a similar alloy reinforced with short alumina fibers. And his results showed the introduction of short alumina fibers into an AZ91 magnesium alloy improved the creep resistance because of the introduction of a threshold stress that serves to reduce the effective stress acting on the material [10]. Sklenička et al. [1] conducted creep tests on an

AZ91–20 vol.% Al_2O_3 short fiber composite and on an unreinforced AZ91 matrix alloy, and the results showed the creep resistance of the reinforced material considerably improved compared with the matrix alloy, and the creep strengthening arose mainly from the effective load transfer between plastic flow in the matrix and the fibers. However, the sources of threshold stress of metal matrix composites reinforced with short fiber have not been explained. Nowadays, the research and development of magnesium matrix composites play a more and more important role in automotive and aerospace industries. Therefore, it is necessary to conduct a systematic, experimental and theoretical analysis on the creep behavior and mechanism of short fiber reinforced magnesium matrix composite. Here, the constant stress tensile creep tests are conducted on two kinds of metal materials in different conditions of temperatures and stresses. One is aluminum silicate short fiber reinforced AZ91D composite with different fiber volume fraction, the other is AZ91D magnesium alloy. The nature of the threshold stress and the affecting factors of aluminum silicate short fiber reinforced AZ91D composite are investigated intensively. It strives to obtain the reasonable explanation and insights of the source of creep threshold stress in aluminum silicate short fiber reinforced AZ91D composite, which is currently still a controversial issue. The goal of this paper is to guide the practical application of the material and enriching the creep theory of short fiber reinforced magnesium matrix composites through the findings.

Experimental Procedure. The metal materials were prepared by squeeze casting method with aluminum silicate short fiber and AZ91D magnesium matrix alloy (Mg-9%Al-1%Zn-0.3%Mn, the percentage is mass fraction). The AZ91D magnesium matrix composite is proved to possess good bonding interface and mechanical properties, and be able to reinforce composite effectively. The preform of aluminum silicate short fiber is composed of randomly distributed aluminum silicate short fiber (Al_2O_3-SiO_2, the diameter is not more than 5 μm and the length is less than 80 μm). The volume fractions of short fiber in the three metal materials after squeeze casting are 20, 25, and 30%, respectively. For the convenience of expression, such as reinforced AZ91D magnesium matrix composite with 25% aluminum silicate short fiber is written as 25%Al_2O_3-SiO_2(sf)/AZ91D, where sf indicates the short fiber. AZ91D magnesium matrix composites and AZ91D alloy were both tested with the tensile creep experiments to the final creep rupture. The experiments were conducted using the GWT105 lasting test machine at 473, 523, and 573K, with the applied stresses of 30 to 100 MPa. The creep curve was drawn through linear variable displacement transducer (LVDT) data acquisition system.

Results and discussion.

High-Temperature Creep Curve. The curves of strain ε and strain rate $\dot{\varepsilon}$ of AZ91D alloy versus time t at $T = 473$ K, $\sigma = 60$ MPa are depicted in Fig. 1. The curves of strain ε and strain rate $\dot{\varepsilon}$ of 25%Al_2O_3-SiO_2(sf)/AZ91D composite versus time t at $T = 473$ K, $\sigma = 70$ MPa are depicted in Fig. 2. It is clear that these two creep curves performed as typical metal creeps in three stages: after the generation of an initial deformation in an instant at the first phase, strain increases rapidly, while strain rate decreases gradually. The first stage is deceleration creep stage. When the strain rate decreases gradually to a stable value, the second stage of creep begins, which is called steady creep stage. The character of the stage is that the creep strain increases almost linearly with time. The creep time of the steady creep stage accounts for a large proportion of the entire creep time. The third stage is creep damage stage, the strain rate increases significantly until the fracture of the material. Temperature and load are the two main factors affecting the creep process. The steady-state creep time of AZ91D alloy at $T = 473$ K and $\sigma = 60$ MPa is about 12 h, while the steady-state creep time of AZ91D composite at $T = 473$ K and $\sigma = 70$ MPa is about 100 h. The steady-state strain rate of the composite is significantly lower than the alloy of one order of magnitude. It is visible that the creep resistance of the composite is much higher than that of the alloy under the same temperature and similar external stress.

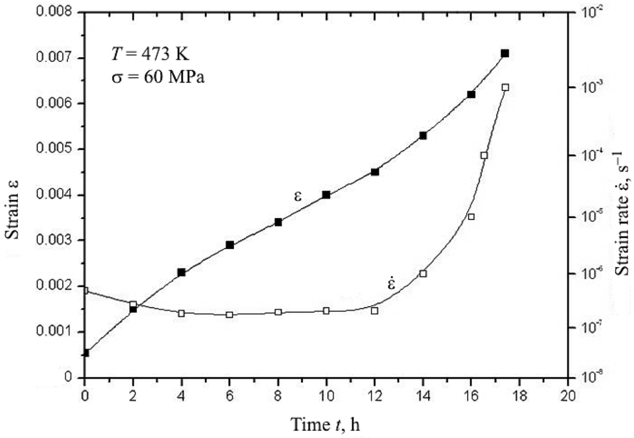


Fig. 1. The creep and strain rate curves of AZ91D magnesium alloy at $T = 473$ K and $\sigma = 60$ MPa.

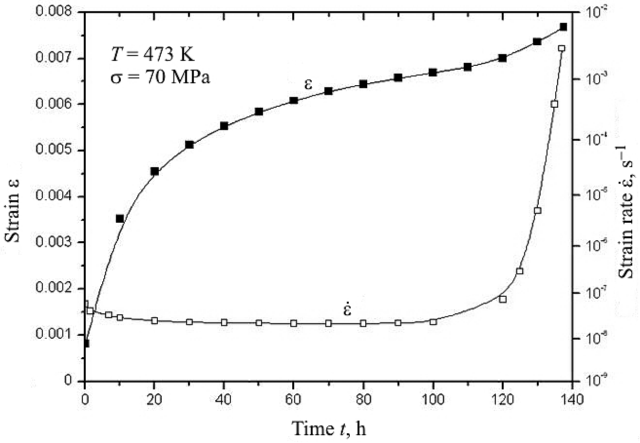


Fig. 2. The creep and strain rate curves of 25%Al_2O_3-SiO_2(sf)/AZ91D composite at $T = 473$ K and $\sigma = 70$ MPa.

Indexes of Creep Threshold Stress and True Stress. If there is creep threshold stress σ_{th} in a metal material at fixed temperature, the strain rate equation of the metal material can be expressed with Eq. (1), which is given in [11]. Formula (1) can be rewritten as formula (2):

$$\dot{\varepsilon} = A(\sigma - \sigma_{th})^n, \tag{1}$$

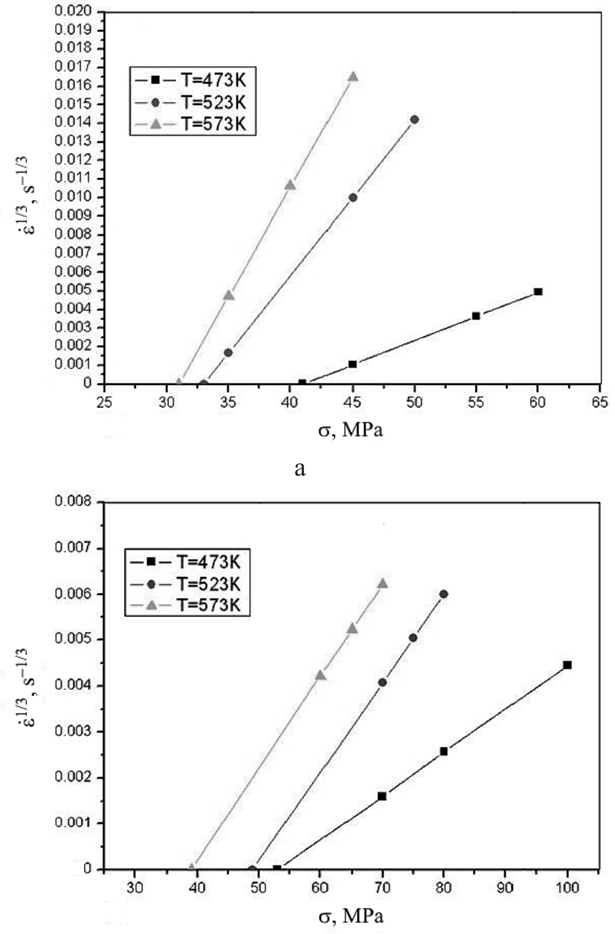
$$\dot{\varepsilon}^{1/n} = A_1(\sigma - \sigma_{th}), \tag{2}$$

where A and A_1 are constants, which are related with material and temperature, n is the creep exponent, σ is the applied stress, σ_{th} is the threshold stress, and $\sigma - \sigma_{th}$ is called as effective stress of the metal material. Because of the aluminum silicate short fiber reinforced AZ91D magnesium matrix composite with different fiber volume fractions and AZ91D magnesium alloy, n is valued as 3, 5, and 8 to make $\dot{\varepsilon}^{1/n} - \sigma$ diagram. In the diagrams with good linear relationships, where the corresponding values of n are indexes of true stress, the true threshold stress can be obtained at different temperatures. The linear relationship between the composite and matrix alloy becomes the best when $n = 3$ in Figs. 3 and 4. Then, the creep threshold stress σ_{th} can be obtained in Table 1.

Table 1

Creep Threshold Stress Values of Materials

Material	T, K	Threshold stress σ_{th}, MPa
AZ91D	473	41
	523	33
	573	31
	473	50
20%Al_2O_3-SiO_2(sf)/AZ91D	523	46
	573	37
	473	53
25%Al_2O_3-SiO_2(sf)/AZ91D	523	49
	573	39
	473	57
30%Al_2O_3-SiO_2(sf)/AZ91D	523	53
	573	42



a

b

Fig. 3. The $\dot{\varepsilon}^{1/3} - \sigma$ plots of AZ91D alloy (a) and 25%Al_2O_3-SiO_2(sf)/AZ91D composite (b).

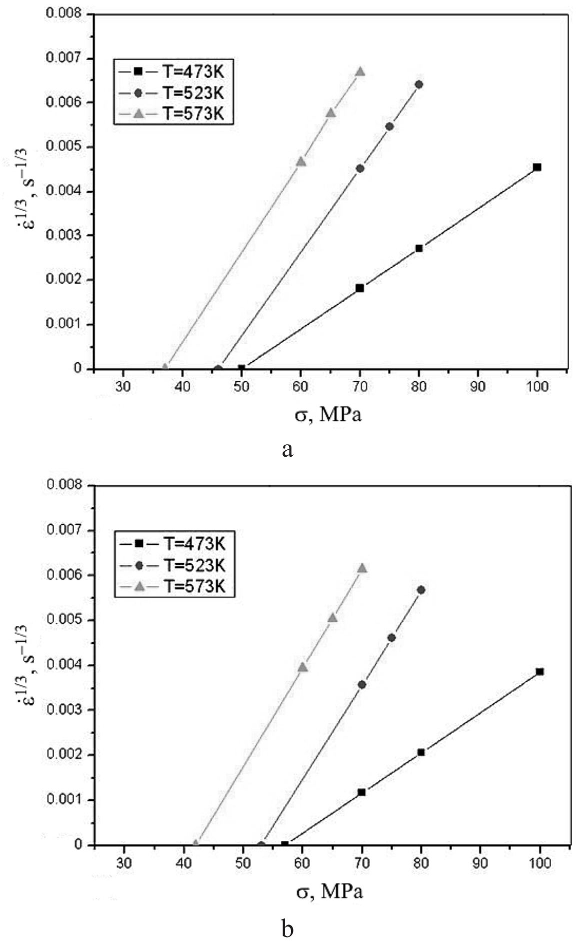


Fig. 4. The $\dot{\varepsilon}^{1/3}-\sigma$ plots of 20%Al_2O_3-SiO_2(sf)/AZ91D (a) and 30%Al_2O_3-SiO_2(sf)/AZ91D (b) composites.

The Sources of the Creep Threshold Stress. Non-equilibrium solidification, the segregations of Mg solid solution Al-poor (magnesium dendritic crystals) and Al-rich (solidification of remaining liquid) regions are caused in the casting-state structure of AZ91 alloy. Al-rich area is composed of white intermediate phase β-$Mg_{17}Al_{12}$ or black β-$Mg_{17}Al_{12}$+α-Mg eutectic phase. The phase of AZ91D in cast state is mainly composed of α-Mg and β-$Mg_{17}Al_{12}$ [12]. When the creep is generated at high temperature, the solute Al in supersaturated α-Mg solid solution will firstly segregate in the grain boundary to form the Al atoms air mass. Then, the non-continuous precipitation of lamellar or rod-like β-$Mg_{17}Al_{12}$ phase will occur in the form of particle. The coarsening softening of β-$Mg_{17}Al_{12}$ will decline creep resistance of AZ91D alloy. At the moment, only α-Mg matrix will continue to prevent the creep. α-Mg matrix is solid solution, so the Al atoms solute atmosphere, which is formed by the segregation of solute Al in the α-Mg solid solution in the grain boundary, will follow dislocation motion through diffusion. Because the diffusion rate is slower than slip rate of dislocation slow motion of dislocation, the Al atom solute atmosphere will drag the movement of dislocation. The drag attraction of mobile dislocation generates the threshold stress. The threshold stress of AZ91D magnesium alloy is 41 MPa at $T = 473$ K. It is visible that solute Al atoms atmosphere generates great pinning on mobile dislocation, which is the source of threshold stress of AZ91D alloy.

Most of the nanoparticles in the surface of aluminum silicate short fiber reinforced AZ91D composite are MgO particles, while a small amount of the particles are $MgAl_2O_4$ particles [12]. It is obvious that there is a layer of nanoparticles on the fiber surface of the composite under high temperature creep. Most of the nanoparticles are uniform MgO particles with a layer thickness of about 0.2 μm [12]. The reinforcement of the composite is achieved, i.e., the bearing and mass loading capabilities of short fiber are enhanced. The threshold stresses of AZ91D alloy are 41 and 31 MPa, at $T = 473$ and 573 K, respectively. While at the same temperature, the threshold stresses of 25%Al_2O_3-SiO_2/AZ91D composite are 53 and 39 MPa, respectively. It can be seen that the threshold stresses of 25%Al_2O_3-SiO_2/AZ91D composite are larger than matrix with 12 and 8 MPa, at $T = 473$ and 573 K, i.e., the threshold stresses increase by 29.3 and 25.8% compared with the matrix. The increased value can only be derived from the effect of aluminum silicate short fiber reinforcement.

Besides the α-Mg and β-$Mg_{17}Al_{12}$ phases which can be observed in the matrix, there are $AlPO_4$, MgO, and $Al_2O_3 \cdot SiO_2$ phases in AZ91D composite [12]. α-Mg and $Al_2O_3 \cdot SiO_2$ are two major phases in AZ91D composite, and the mobile dislocation movement is mainly affected by these two phases. Other phases can be considered to take effects through $Al_2O_3 \cdot SiO_2$. It can be considered that, mobile dislocation motion is only affected by these two factors after an influence coefficient is introduced to describe the effects of other phases. Creep is generated when mobile dislocations get rid of the two effects and start to move. And now the sum of the two forces is threshold stress. During the process of high temperature creep, solute atmosphere will attract the mobile dislocation, which is a part of the source of the threshold stress of AZ91D composite. The solute atmosphere is formed by the segregation of Al atoms in grain boundary in the supersaturated α-Mg solid solution. Because the elastic modulus of AZ91D matrix is smaller than the one of aluminum silicate short fiber, the strain of matrix is larger than that of short fiber under external loads, and dislocations in matrix will undoubtedly be dragged by short fiber. The drag force on mobile dislocation, which is generated from the inconsistency of the strains of matrix and short fiber, is the bearing and transferring force of short fiber, i.e., another part of the source of the threshold stress in AZ91D composite.

The Impacts of Load Transfer Factor and Material Impacting Factor. When creep is generated in AZ91D alloy and mobile dislocations leave from the solute atmosphere, a kind of stress will form. Friedel [13] called the threshold stress that exists in alloy as breakaway stress σ_b, and the stresses at creep in the alloy can be expressed by means of the following expressions:

$$\sigma_b = \frac{W_m^2 c}{5b^3 kT}, \tag{3}$$

$$W_m = -\frac{1}{2\pi}\left(\frac{1+\mu}{1-\mu}\right) G\,|\Delta V_a|, \tag{4}$$

where W_m is the binding energy of dislocations and solute, c is the solute concentration (Al atom concentration, $c = 0.08$), b is the Burgers vector of dislocation, $b = 3.2 \cdot 10^{-10}$ m, G is the shear modulus of Mg, $G = 1.92 \cdot 10^4 - 8.6T$, k is the Boltzmann constant, $k = 1.3806505 \cdot 10^{-23}$ J/K, T is the absolute temperature, ΔV_a is the volume difference caused by the difference of Mg and Al atomic radius, $\Delta V_a = 8.2 \cdot 10^{-30}$ m^3, and μ is Poisson's ratio of Mg, $\mu = 0.34$. However, Eq. (3) overestimates the value of stress σ_b, and Eq. (3) cannot estimate the variations of the elastic interaction energies of dislocations and solute atmosphere. The variations of the energies are caused by the variations of solute atoms concentrations, while the variations of the concentrations are caused by variations of the distances between line dislocations and solute atoms. Therefore, the value of σ_b calculated by Eq. (3) increases more than 2-fold. Hence, both the concentration of Al atom and the coefficient c in Eq. (3) will be reduced. If the concentration of aluminum atom changes from 0.08 to 0.06 and multiplying Eq. (3) changes by a factor of 1/2, it can be obtained that $\sigma_b = 42$ MPa, at $T = 473$ K. The result is close to the experimental stress of AZ91D alloy, $\sigma_b = 41$ MPa. Therefore, Eq. (3) can be rewritten as Eq. (5) to obtain the empirical formula of threshold stress of AZ91D alloy (breakaway stress):

$$\sigma_b = \frac{1}{2}\frac{W_m^2 c_1}{5b^3 kT}, \tag{5}$$

where c_1 is the reduced solute concentration (Al atom concentration, $c_1 = 0.06$).

With Eq. (5), the creep threshold stresses of AZ91D alloy at $T = 523$ and 573 K are obtained as 35 and 32 MPa. The results are very similar to the experimental results of $\sigma_{th} = 33$ MPa ($T = 523$ K) and $\sigma_{th} = 31$ MPa ($T = 573$ K), which confirms that formula (5) possesses considerable accuracy.

The other part of the threshold stress in AZ91D metal materials is the loading and transferring force of short fibers, which is affected by many internal factors such as the orientation, aspect ratio and the distribution of short fibers, the MgO particles on surfaces and the interface of short fibers and matrix. Thus, the calculation of force is quite complicated. In order to estimate the force, one can simply calculate it by multiplying the load transfer capacity with a material influence coefficient H. H comprehensively reflects the internal factors which affect the force. And H can be obtained through the experimental data.

When AZ91D composite creeps under certain temperature T and certain stress σ, the load transfer capacity of aluminum silicate short fiber reinforcement is equal to the product of the load transfer factor α and the external stress σ, which is $\alpha\sigma$. The loading and transferring forces of short fibers are equal to the product of load transfer capacity and material influence coefficients H. Thus, the mathematical model of threshold stress of AZ91D metal materials can be expressed with Eq. (6):

$$\sigma_{th} = \frac{1}{2}\frac{W_m^2 c_1}{5b^3 kT} + H\alpha\sigma. \tag{6}$$

Because of the varying lengths, fibers are randomly distributed in approximate two-dimensional form. Strict dealing with load transfer is a highly complex issue in mechanics. As a simplified experimental method, a load transfer factor α has been involved, which varies from 0 to 1. $\alpha = 0$ indicates no load transfer, while $\alpha = 1$ indicates that load fully transfers to short fiber. Thus, load transfer coefficient α characterizes the bearing and transferring load capacity of short fiber. The empirical formula of composite strain rate can be expressed as Eq. (7) [11]:

$$\frac{\dot{\varepsilon}_c}{\dot{\varepsilon}_b} = (1-\alpha)^n, \tag{7}$$

where $\dot{\varepsilon}_c$ is the strain rate of composite and $\dot{\varepsilon}_b$ is the strain rate of matrix.

With the strain rate values of matrix and 25%Al_2O_3-SiO_2(sf)/AZ91D composite within the experimental range, the diagram of load transfer factor corresponding to temperature

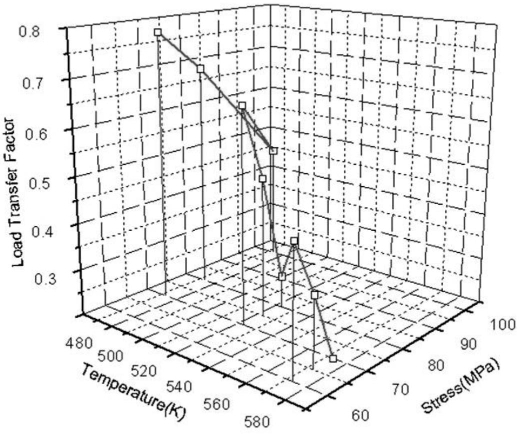


Fig. 5. The $\alpha - T - \sigma$ plot for 25%Al_2O_3-SiO_2(sf)/AZ91D composite.

and stress can be plotted by applying Eq. (7) in Fig. 5. It is obvious that load transfer factor α is more sensitive to temperature than stress. Fitting the space points with quadratic surface equation, the empirical formula of the load transfer factor α of Al_2O_3-SiO_2(sf)/AZ91D composite, which varies with temperature and stress, can be obtained as Eq. (8):

$$\alpha = 1.16\cdot 10^{-5}T^2 + 3\cdot 10^{-4}\sigma^2 - 2\cdot 10^{-4}T\sigma - 2\cdot 10^{-3}T + 4.06\cdot 10^{-2}\sigma + 1.441. \tag{8}$$

Of course, as for the Al_2O_3-SiO_2(sf)/AZ91D composites with different volume fractions, the load transfer factors are also affected by the volume fractions. The diagrams of fiber volume fraction versus the load transfer factor of Al_2O_3-SiO_2(sf)/AZ91D composite are plotted at same temperature and different loads in Fig. 6. At the same temperature and low external loads, the impact of fiber volume fraction on load transfer factor is not obvious. However, the effect becomes more obvious with the increase of external load. Similarly, at same loads and lower temperatures in Fig. 7, the impact of fiber volume fraction on load transfer factor is not obvious, while the effect becomes more obvious as the temperature increases. The main reason is that the influences of temperature and load on load transfer factor are greater than the influence of volume fraction. Temperature and load affect the rate of increase of load transfer, which increases with the increase of volume fraction.

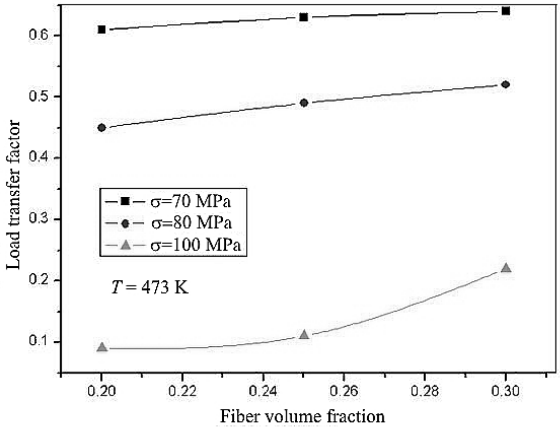


Fig. 6. Load transfer factor dependence of fiber volume fraction for Al_2O_3-SiO_2(sf)/AZ91D composite at the same temperature and different loads.

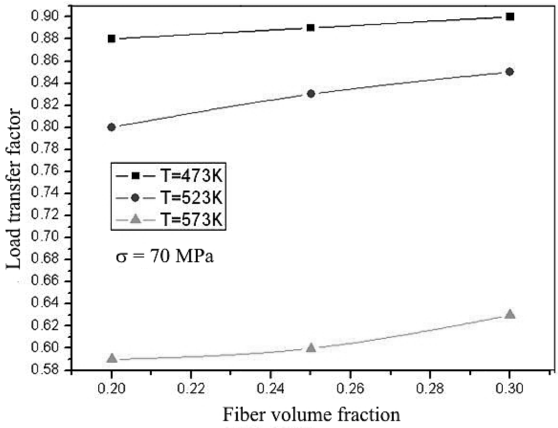


Fig. 7. Load transfer factor dependence of fiber volume fraction for Al_2O_3-SiO_2(sf)/AZ91D composite at the same load and different temperatures.

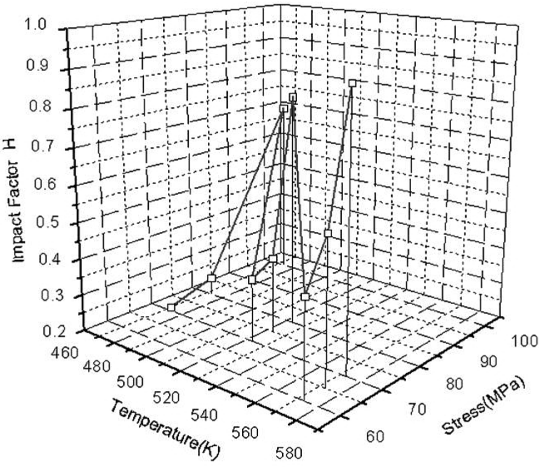


Fig. 8. The $H-\sigma-T$ plot for 25%Al_2O_3-SiO_2(sf)/AZ91D composite.

With the creep threshold stresses of 25%Al_2O_3-SiO_2(sf)/AZ91D composite, which are obtained in the test range, by formula (6) and (8), the diagrams of material impact factor versus temperature and stress can be drawn in Fig. 8. Parameter H is more sensitive and dependent on temperature than stress. Fitting the space points with quadratic surface equation will obtain the empirical formula of material impact factor of 25%Al_2O_3-SiO_2(sf)/AZ91D composite versus temperature and stress, which is expressed as Eq. (9):

$$H = 1.25\cdot 10^{-4} T^2 + 6\cdot 10^{-3}\sigma^2 - 3\cdot 10^{-3} T\sigma - 3.5\cdot 10^{-2} T + 2.06\cdot 10^{-1}\sigma + 2.712. \tag{9}$$

The threshold stresses of 25%Al_2O_3-SiO_2(sf)/AZ91D composite can be determined by formulas (6), (8), and (9). The theoretical values can be calculated with the formulas. The experimental values of threshold stresses are also listed in Table 2. The theoretical values of the threshold stresses are similar to the experimental values, indicating that utilization of formula (6) as the empirical formula of threshold stress of composite is highly accurate.

Influence of Volume Fraction of Short Fiber on Creep Threshold Stress. At same temperature, the threshold stress increases with the increase of aluminum silicate short fiber volume fraction, while the increase is substantially small (Table 1). The diagrams of fiber

Table 2

Comparison of Theoretical and Experimental Values of Threshold Stress of 25%Al_2O_3-SiO_2(sf)/AZ91D Composite

T, K	Theoretical values of σ_{th}, MPa	Experimental values of σ_{th}, MPa
473	54.26	53
523	51.55	49
573	41.65	39

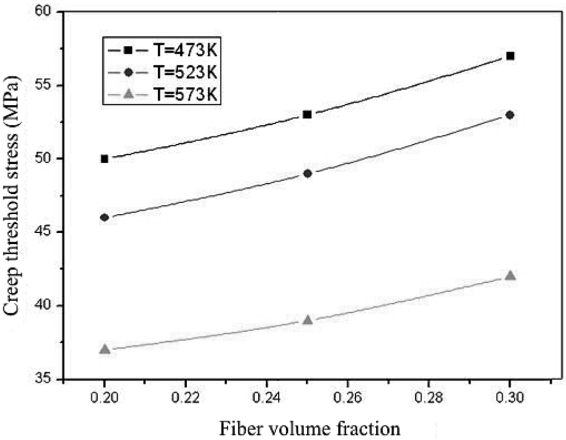


Fig. 9. Creep threshold stress of Al_2O_3-SiO_2(sf)/AZ91D composite versus fiber volume fraction.

volume fraction versus threshold stress of Al_2O_3-SiO_2(sf)/AZ91D composite at different temperatures are depicted here (Fig. 9). The increase rates of threshold stress versus fiber volume fraction are basically the same at different temperatures. Based on the above analysis, it may be attributed that the sources and affecting factors of threshold stresses of Al_2O_3-SiO_2(sf)/AZ91D metal materials with different fiber volume fractions are the same. With the increase in the number of aluminum silicate short fiber, the total drag forces increase. The drag forces are generated from inconsistency of strains of matrix and short fiber on the mobile dislocation. The increase of bearing and transferring capacities of short fiber increases the creep threshold stresses of metal materials. However, with the increase of the amount of fiber and the density of dislocation, the precipitates easily precipitate at the dislocations. Therefore, with the increase of fiber volume fraction, the amount of precipitation of β-$Mg_{17}Al_{12}$ precipitates increase. The precipitates are easy to coarsen and soften, so that the threshold stress of the composite is not greatly improved with increased fiber volume fraction.

Temperature Influence on Creep Threshold Stress. According to the previously obtained experimental data, the plot of threshold stress versus temperature is depicted in Fig. 10. The threshold stresses of AZ91D alloy and AZ91D composite both decrease with increasing temperature. The rates of threshold stresses decreasing with increasing temperature for metal materials with different fiber volume fractions are basically the same. The tangent lines of the three curves parallel at the same temperature, indicating that the sources and affecting factors of threshold stress are the same. However, the rate of threshold stress decreasing with increasing temperature for composite is significantly lower than that of alloy, indicating that the creep resistance of composite is significantly higher than that of alloy. The curve of the composite is upward convex, while the curve of the matrix alloy is downward convex, which indicates that the sources and affecting factors of

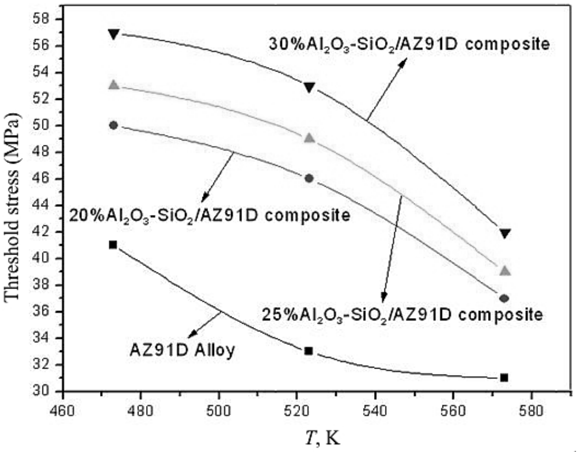


Fig. 10. Creep threshold stresses of AZ91D alloy and Al_2O_3-SiO_2(sf)/AZ91D composite versus temperature.

threshold stresses of the composite and alloy are different. The empirical formulas of threshold stresses of AZ91D alloy, 20%Al_2O_3-SiO_2(sf)/AZ91D, 25%Al_2O_3-SiO_2(sf)/AZ91D, and 30%Al_2O_3-SiO_2(sf)/AZ91D metal materials varying with temperature changes, can be obtained by curve fitting, respectively, such as formulas (10), (11), (12), and (13):

$$\sigma_{th} = 1.2\cdot 10^{-3} T^2 - 1.3552T + 413.5348, \tag{10}$$

$$\sigma_{th} = -1\cdot 10^{-3} T^2 + 0.916T - 159.539, \tag{11}$$

$$\sigma_{th} = -1.2\cdot 10^{-3} T^2 + 1.1152T - 206.0148, \tag{12}$$

$$\sigma_{th} = -1.4\cdot 10^{-3} T^2 + 1.3144T - 251.4906. \tag{13}$$

The mathematical models of threshold stresses varying with temperature fit with experimental data. Compared with the previously derived mathematical models of the empirical formulas (6), (8), and (9), the calculation is simple and convenient. In engineering applications, the models can be employed to simply estimate the threshold stresses of metal materials at different temperatures. Therefore, the high temperature creep properties of material can be predicted.

Conclusions

1. The improvement of creep resistance of composite can be attributed to the effective load bearing and transferring capabilities, and the load transfer coefficient α characterizes the bearing and transferring capabilities of short fibers, and α is more sensitive to temperature than stress and α increases with the increased volume fraction of short fibers.

2. A portion of the creep threshold stress of Al_2O_3-SiO_2(sf)/AZ91D composite is a kind of drag force, which is generated by the Al atoms atmosphere on mobile dislocation. The atoms atmosphere is formed by the segregation of Al in α-Mg solid solution in grain boundary. Another portion of the stress is another kind of drag force, which is generated by the inconsistent strains of matrix and short fiber on the dislocation, i.e., bearing and transferring force of short fiber.

3. Temperature and the volume fraction of short fiber are two main factors which affect the threshold stress. Threshold stress decreases with increasing temperature, increases with increasing volume fraction of short fibers, which are affected by the material impact factor H and load transfer coefficient α.

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