

[Article ID] 1003- 6326(2001) 06- 0920- 03

Aging characteristic and mechanical properties of TiC/ 2618 composite^①

LONG Chun-guang(龙春光), ZHANG Hou-an(张厚安), PANG You-xia(庞佑霞), LIU Hou-cai(刘厚才)
(Department of Mechanical Engineering and Automation, Xiangtan Polytechnic University,
Xiangtan 411201, P. R. China)

[Abstract] TiC/ 2618 composite was prepared by XD method. The constituent and microstructure of the composite have been investigated by X-ray diffraction and TEM technique. The aging characteristics and mechanical properties at high and room temperatures were studied. The results show that: 1) it is possible to prepare multiple alloy matrix TiC/ 2618 composite by XD method; 2) the TiC particles in TiC/ 2618 composite have the characteristics of fine size, clean appearance and a good bond with the matrix; 3) the aging law of the TiC/ 2618 composite has been changed by the addition of TiC particles. Two peak value phenomenon has been observed when it was aged at 190 °C; 4) TiC/ 2618 composite has better mechanical properties than those of the matrix both at room and high temperatures.

[Key words] aging characteristics; mechanical properties; TiC/ 2618 composite

[CLC number] TG 113. 25

[Document code] A

1 INTRODUCTION

XD method is also called the *in situ* synthesized method originated from America in the 1980's^[1,2], by which a metal matrix composite can be reinforced by self-grown ceramic particles. It has the characteristics as fine and dispersion reinforcement in the composite good boundary compatibility with the matrix, with no reaction occurring in the boundary between the particle and the matrix, and the composite prepared by this method having good properties^[3]. So the method has been widely used in preparing metal matrix composites reinforced by ceramic particles. However, in the earlier reports, the matrix was restricted only on pure metals or binary alloys.

2618 alloy (LD7) is a multiple alloy in the Al-Cu-Mg-Fe-Ni series. The alloy, with the best heat-resistance in traditional wrought aluminum alloys^[4], is widely used in out-space engines and other parties serves at high temperatures. According to Ref. [5], of all the particle reinforcements used to strengthen aluminum or its alloy, TiC has the best strengthening effect. In order to enhance the heat-resistance of the 2618 alloy and to enlarge its application field at high temperatures, XD method has been successfully used to prepare 2618 composite by the addition of TiC particles in this paper.

2 EXPERIMENTAL

2.1 Preparation of materials

The preparing process of the TiC/ 2618 composite is: Al, Ti and C powders $\rightarrow$ compounding $\rightarrow$ pressing into blocks $\rightarrow$ Al/TiC preform $\rightarrow$ being melt with

2618 alloy $\rightarrow$ stirring $\rightarrow$ casting into mold. The reversal casting method was used in the process from the TiC/ Al preform to the TiC/ 2618 composite^[6]. TiC/ Al preform was firstly melted, then the 2618 matrix alloy was added.

2.2 Constituent and microstructure

The SIMENS 500 X-ray diffraction meter was used to analyze the constituent of the TiC/ Al preform and the TiC/ 2618 composite. H-800 transmission electron microscopy was used to observe the microstructures of TiC particles and the interfaces between the matrix and TiC particles.

2.3 Aging

After being hot-rolled and cold-rolled, the samples were heated in the salt-bath at 525~ 535 °C for 15 min, then were quenched in hot water. After that, the samples were aged at 190 °C, 250 °C, 350 °C respectively.

2.4 Tensile test

Tensile experiments were done to the samples which had been aged at 190 °C by the Instron 8032 universal material tester at room temperature, 100 °C, 150 °C, 200 °C, 250 °C, 300 °C and 350 °C respectively, and each specimen was held for 10 min. The extension rate was 1 mm/ min.

3 RESULTS AND DISCUSSION

3.1 Constituent and microstructure

Fig. 1 shows the X-ray diffraction pattern of TiC (30%)/ Al preform by XD method. It can be seen

① **[Foundation item]** Project (99C154) supported by the Education Bureau of Hunan Province

[Received date] 2001- 05- 21; **[Accepted date]** 2001- 07- 13

that there exist only Al and TiC peaks, indicating that TiC particles are self-grown in the perform.

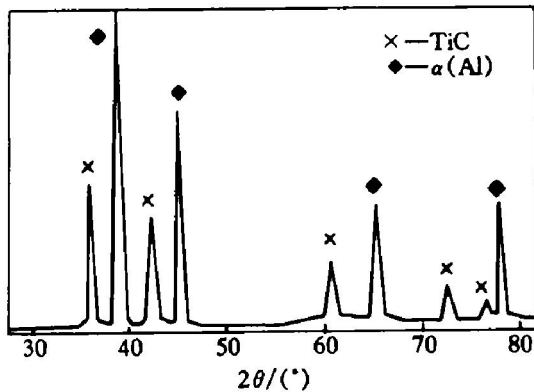


Fig. 1 XRD of TiC (30%) / Al alloy

Fig. 2 shows the X-ray diffraction pattern of TiC (6%) / 2618 composite by the reverse casting method. It can be seen that TiC particles could exist steadily at high temperatures in the melting and casting course, which indicating that the multiple 2618 alloy reinforced by TiC particles could be prepared by XD method.

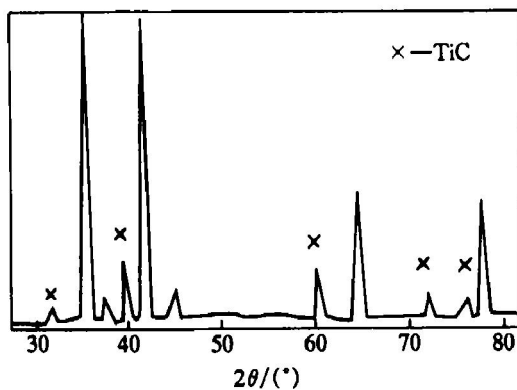


Fig. 2 XRD of TiC (6%) / 2618 composite

The TEM micrographs of TiC/ 2618 composite is shown in Fig. 3. It can be seen that the TiC particles is fine with average size of 0.65 μm, the interface between the particles and the matrix is clean (very few

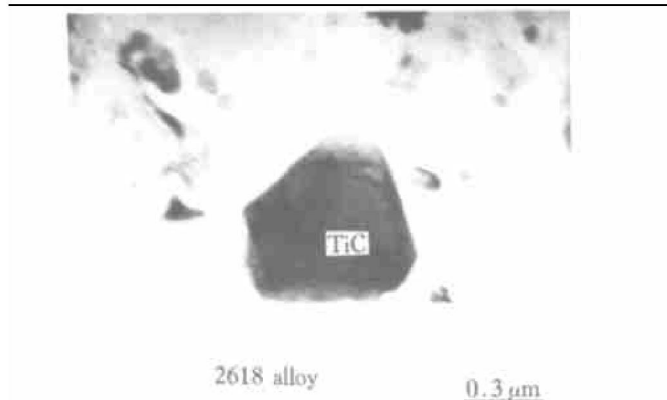


Fig. 3 TEM micrograph of TiC/ 2618 composite

interfacial phases can be seen in the boundary)^[7], it means that the particle has a good compatibility with the matrix, or a high boundary bonding strength. This will be very helpful for enhancing the mechanical properties of material.

3.2 Aging curves

The aging curves of 2618 alloy and TiC/ 2618 composite at 190 °C, 250 °C and 350 °C are shown in Fig. 4, respectively. Two-peak value phenomenon can be seen in the aging curves of TiC/ 2618 composite at 190 °C. However, it does not occur in the curves of 2618 alloy. This indicates that the aging law of the 2618 alloy is changed by the addition of TiC particles. The reason is that aging is a heat treatment strengthening method controlled by diffusion^[8], which is closely related with the content of solute and its diffusion velocity. When 2618 alloy is aged at 190 °C, there is no cluster (G. P. [1]) but the intermediate phase θ' (G. P. [2]) precipitates directly, because the content of the secondary solute in 2618 alloy is relatively low^[9,10]. But for TiC/ 2618 composite, the addition of TiC particles raises the relative content of solute and decreases the diffusion rate, this may be helpful for promoting the formation of the cluster (or G. P. [1]), So the first peak value appears as shown in Fig. 4(a). As for why the two-peak value phenomenon cannot be seen at high temperatures, it is mainly because that the diffusion ve-

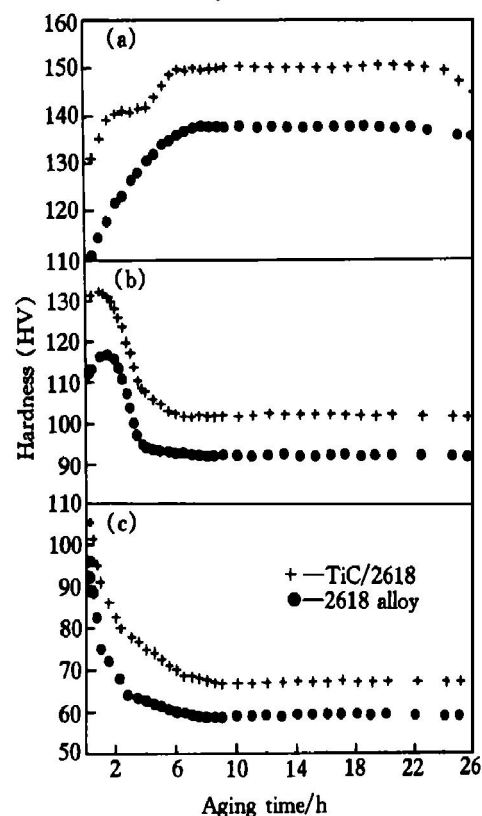


Fig. 4 Aging curves of 2618 and TiC/ 2618 at different temperatures
(a) —At 190 °C; (b) —At 250 °C; (c) —At 350 °C

locity of the solute atoms increases at higher temperature, and it can diffuse relatively sufficiently in a short time, so there is no transient phase precipitates in the aging course.

Comparing Fig. 4(a) with 4(b) and 4(c), we can see that when TiC/2618 composite was aged at 190 °C for 8~20 h, it can not only be sufficiently strengthened, but also be guaranteed not being softened for overaging.

3.3 Mechanical properties

Fig. 5 shows the extension curves of 2618 alloy and TiC/2618 composite at different temperatures. It can be seen that:

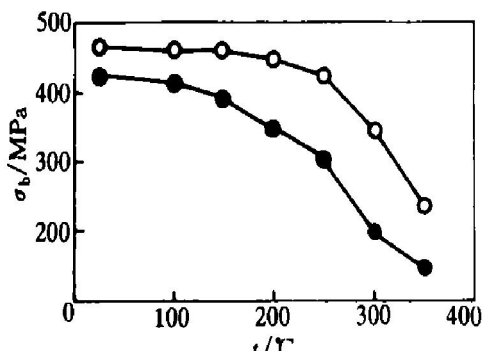


Fig. 5 Extension curves of 2618 and TiC/2618
1—TiC/2618; 2—2618 alloy

1) Below 150 °C, the two lines go relatively flat, indicating that the strength of the two materials varies little with the increase of the temperatures. This is because that, on one hand, the dislocation multiplication caused by deformation in the extension course may lead work-hardening. On the other hand, Al alloy, with high energy of stocking fault, may easily realize dynamic recovery through the climb and cross slip of the dislocation, which makes the material softening^[11]. The synthetical effect of the two factors nearly arrives dynamical equilibrium.

2) Between 150 °C and 250 °C, the extension curve of the 2618 alloy becomes much steeper than that of TiC/2618 composite, and the temperature at which the 2618 alloy begins to soften apparently is lower than that of the TiC/2618 composite. This means that the softening rate of the former is greater than the latter at the range of 150~250 °C. Therefore, the heat resistance of the TiC/2618 composite is better than that of 2618 alloy. This is because of: 1) according to the Orowan mechanism^[12], the interaction between the fine dispersed TiC particles and the dislocation can hinder the movement of the dislocation effectively, so the dislocation will move mainly in the way of rounding the TiC particles; 2) the TiC particles can not only hinder the dislocation to arrange again to constitute subboundary in the heating course, but also influence the formation and migration of the big angle boundary, so the recovery and recrystalliza-

tion of 2618 alloy will be effectively hindered^[13].

3) The two line becomes steep and almost parallel after 280 °C, this is because the deformation mechanism has been changed into the creep mechanism controlled by diffusion. Under this mechanism, the strengthening effect of the secondary phase on the matrix becomes weaker. However, the properties of TiC/2618 composite is still better than those of 2618 alloy. In all, the properties of TiC/2618 composite are better than those of 2618 alloy both at room and high temperatures.

[REFERENCES]

- [1] TAO Chur-hu. The XD synthetic study of TiAl and TiC/TiAl alloy [J]. Materials Engineering, (in Chinese), 1995, 15(12): 21-24.
- [2] MA Zor-yi. Microstructure and properties of Al matrix composite reinforced by in-situ grow ceramic particles [J]. Acta Metall Sinica, (in Chinese), 1995, 30(1): 27-29.
- [3] ZHANG Er-lin. The synthetic study of TiC/Al alloy [J]. The Chinese Journal of Nonferrous Metals, (in Chinese), 1996, 6(5): 223-227.
- [4] ZHU Tian-xiu. Exploitation of CR-18 Al alloy of heat resistance [J]. Aluminium Fabrication, (in Chinese), 1994, 17(5): 48-51.
- [5] Roy M, Venkatramam B, Bhanuprasad V V. Study on Al matrix composite reinforced by the ceramic particles [J]. Metall Trans, 1992(23A): 2833-2840.
- [6] LONG Chur-guang. Technical process study of TiC/2618 composite by XD method [J]. Journal of XIANG-TAN Mining Institute, (in Chinese), 1998, 13(4): 70-73.
- [7] LONG Chur-guang. Microstructure study of TiC/2618 composite by XD method [J]. Functional Material, (in Chinese), 2000, 13(4): 669-671.
- [8] ZHOU Fong-yun. Engineering Material and its Practice [M]. Wuhan. Huazhong University of Science and Technology Press, 1999. 119.
- [9] WANG Zhur-tang, TIAN Rong-zhang. Aluminium Alloy and its Process Manual [M]. 2nd Ed. Changsha: Central South University of Technology Press, 2000. 92-93.
- [10] SHEN Hong, ZHOU Jiar-nan. Mechanical Engineering Manual [M]. 2nd Ed. Beijing: Mechanical Industry Press, 1996. 2-6.
- [11] LI Chao. Physical Metallurgy [M]. Harbin: Harbin Institute of Technology Press, 1988. 342.
- [12] SHEN Hong. Mechanical Engineering Manual [M]. 2nd Ed. Beijing: Mechanical Industry Press, 1996. 2-72.
- [13] LONG Chur-guang. Study of recrystallization process of TiC/2618 composite prepared by XD method [J]. The Chinese Journal of Nonferrous Metals, (in Chinese), 1999, 9(4): 740-743.

(Edited by LONG Hua-zhong)