MICROSTRUCTURE AND MECHANICAL PROPERTIES OF TiAl+ Nd ALLOYS①

Lei Changming, He Yuehui, Chen Shiqi, Qu Xuanhui, Huang Baiyun
Research Institute, of Powder Metallurgy
Central South University of Technology, Changsha 410083

ABSTRACT The effects of Nd addition on the microstructure and room-temperature mechanical properties were studied. The results showed that the bending strength, ductility and hardness of TiAl based alloys were improved by the addition of Nd. The increase of mechanical properties of TiAl alloys with Nd was due to decrease in oxygen content in γ-TiAl matrix and the fine microstructure, but excessive Nd would lead to formation of $TiAl_3$ phase, which results in the brittleness of TiAl alloys.

Key words TiAl based alloy Nd microstructure mechanical properties

1 INTRODUCTION

TiAl alloys are the potential structural materials at elevated temperature for applications in advanced aircrafts because of their attractive properties[1, 2]. The major problems prohibiting their practical applications are room- temperature brittleness and poor formability at hot processing. It is well known that the ductility of TiAl can be obviously improved when a small amount of α_2 phase exists in the single phase γ-TiAl alloy. The researches showed that the solubility of oxygen atoms in the α_2 phase is higher than that in the γ-TiAl phase, so the α_2 phase can reduce the oxygen content in γ-TiAl, thus improving the ductility of the TiAl alloy[3].

Because of their closer affinity for oxygen, rare earth metals can capture oxygen atoms from the γ-TiAl phase to form oxide particles[4]. On the other hand, these dispersing particles will enhance high-temperature strength and wear ability of TiAl alloys. In the present work, the effects of Nd on the microstructure and mechanical properties of a TiAl alloy were investigated.

2 EXPERIMENTAL

The alloys used in this work have the following nominal composition (%), Ti-34Al. Nd content is 0, 0.45, 0.63, 1.16, 1.70, 2.77 respectively. The alloys were prepared by non-consumable electrode arc-melting in an argon atmosphere. Each alloy was melted four times for homogenization. Three-point-bending specimens were spark eroded from the ingots. Dimensions of the specimens were 2 mm × 4 mm × 30 mm. The gauge length was 25 mm and the cross head speed of the testing machine was controlled at 0.2 mm/min. Metallographic observation was conducted on a Neophot-2 type metalloscope and an X-650 type scanning electron microscope. Thin film analysis was conducted on an H-800 type transmission electron microscope.

3 RESULTS

3.1 Microstructures

Fig. 1 shows the microstructures of the TiAl + Nd alloys in as-cast condition. When compared with the binary alloy, the microstructures are fine and even dendritic grains instead of very coarse dendritic grains[5]. The size of dendritic grains and the length of the secondary dendrites decrease with increase in Nd content.

Fig. 2 is the BEI of the alloy with 0.45% Nd. The microstructures mainly consist of

① Supported by the National Advanced Materials Committee of China Received Mar. 29, 1996; accepted May 30, 1996

Fig. 2 BEI of as-cast TiAl+ Nd alloys with 0.48%Nd(a) and 1.16%Nd(b)

dendritic grains and a little amount of second phase existing between dendritic grains, which increases with Nd content (see Fig. 2(b)). The elemental area analyses by means of electronic probe show that the distribution of Nd is higher between adjacent grains than that in the grains.

The X-ray diffraction spectrum for Ti-34Al-0.48Nd alloy is shown in Fig. 3. There appears $TiAl_3$ phase besides Ti_3Al and TiAl phases.

3.2 Room-temperature mechanical properties

Effect of Nd on the room-temperature bending properties is shown in Fig. 4. It can be seen that the deflection and strength increase greatly by 12% and 44% respectively when adding 0.45% Nd. However the deflection and strength of the alloys decrease monotonously with further increase in Nd content. The mechanical properties of all the studied alloys added with Nd element are higher than those of the

g. 3 X-ray diffraction spectrum for Ti-34Al-0.48Nd alloy

binary alloys.

Fig. 5 shows the hardness variation of the alloys vs Nd content. The hardness enhances greatly with a little Nd addition. When Nd exceeds 1.16%, the hardness is almost invariable.

Fig. 5 Hardness of TiAl+ Nd alloys vs Nd content

4 DISCUSSION

The room-temperature mechanical properties of the alloys, especially the ductility, are improved by Nd addition, the main cause is that Nd which has a close affinity for oxygen atoms, can extract oxygen atoms from γ-TiAl matrix, lowering oxygen content in γ-TiAl matrix by forming oxide particles in form of NdO (see Fig. 6), thus increasing the mobility of dislocations in the γ phase matrix.

On the other hand, the NdO particles have very high melting point, they may precipitate from the TiAl liquid in form of very tiny and dispersing particles. These particles play the strong role in refining grains of TiAl alloys, so the ductility is further increased. Though Nd has these favorable roles, the results of Fig. 2 and Fig. 3 show that excessive Nd addition will promote the formation of brittle $TiAl_3$ phase, which is detrimental to the TiAl alloys. So in the TiAl alloys Nd should be controlled under 0.45%.

Fig. 6 TEM image of NdO in TiAl+ 1.16%Nd alloy annealed at 900 ℃ for 24 h

5 CONCLUSIONS

(1) Room-temperature mechanical properties of the Ti-34Al alloy can be improved with addition of Nd.

(2) Nd will reduce the oxygen content by forming NdO particles, which results in increase in ductility.

(3) When it exceeds 0.45%, Nd will promote to form brittle $TiAl_3$ phase, thus reducing the ductility.

REFERENCES

1 Ogden H R. Trans AIME, 1953, 19: 267.
2 Mcandrew J B. Trans AIME, 1956, 206: 1348.
3 Huang S C. In: World Conference in Titaniun, Cannes, 1988, 6: 6.
4 Chen Shiqi, Qu Xuanhui, Lei Changming, Huang Baiyun. Acta Metallurgica Sinca, 1994, 30: A20.
5 Qu Xuanhui, Huang Baiyun, Lu Haibo, Huang Peiyun. Journal of Central-South Institute of Mining and Metallurgy, 1992, 23(6): 706.

(Edited by Peng Chaoqun)