SURFACE CARBURIZATION OF TiAl BASED ALLOY①

Huang, Baiyun He, Yuehui Qu, Xuanhui Kong, Gaoning
Powder Metallurgy Research Institute,
Central South University of Technology, Changsha 410083

ABSTRACT

The effects of carburization on the mechanical properties and oxidation-resistance of TiAl based alloy have been investigated. It has been found that not only can the room temperature strength and ductility of TiAl based alloy be enhanced by carburizing treatment, but also its oxidation-resistance can be improved. The X-ray diffraction analysis shows that after carburized at 900 C for 2 h, a carburized layer has formed on the surface of sample and it consists of $Al_2Ti_4C_2$ and Al_2C_3.

Key words: TiAl based alloy carburization oxidation resistance mechanical properties

1 INTRODUCTION

Titanium aluminide is under wide investigation as a candidate material for the advanced aerospace airframe because of its low density and relatively good mechanical properties at high temperatures[1,2]. The major obstacles to be overcome for its engineering use are the low tensile ductility at ambient temperature and poor formability by hot working[3-5]. Hashimoto *et al*[6] showed that the mechanical properties of TiAl based alloys at room temperature also depended on the surface state of the specimens. This study will discuss the effect of surface carburization on properties of TiAl alloy.

2 EXPERIMENTAL

The alloy used in this work was prepared from Ti of 99.7% and Al of 99.9% purity (mass%) with non-consumable electrode arc melting technique in an argon atmosphere. The nominal composition of the studied alloy was Ti-34 wt.-% Al. Three-point bending specimens were spark eroded from the ingots. The specimen size was 2 mm × 4 mm × 30 mm. The span length was 25 mm and the cross head speed of the testing machine was 0.2 mm/min. The surface of specimens was treated by solid carburizing. The metallographic samples were prepared in a standard fashion and etched with the kroll's solution. The microstructures and fracture morphologies were analysed by means of a scanning electron microscope. The phase constitution was detected by X-ray diffraction. The weight gains of oxidation experiments were measured in a thermal analysis instrument.

3 RESULTS

3.1 *Mechanical Properties*

The room temperature bending test results of TiAl based alloy specimens with different kinds of surface states were shown in Table 1. It could be seen that the mechanical properties of TiAl based alloy specimens at the room temperature increased largely after they were carburized. Compared with the as-cast specimens, the room temperature bending strength of specimens carburized at 900 C for 2 h increased by 26.0%, deflection by 75% and bending ductility by 75%. It also was found that the mechanical properties at the room temperature of specimens carburized at 900 C for 4 h didn't

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Table 1 Mechanical properties of TiAl based alloy specimens

No.	alloy state	σ /MPa	D /mm	δ /mm
1	cast	801	0.41	0.20
2	Cast+carburized at 920 C for 2h	1008	0.72	0.35
3	cast+carburized at 900 C for 4h	863	0.52	0.26

Notes: σ —bending strength; D — deflection; δ —bending ductility

exhibit better values. The SEM micrograph, as shown in Fig. 1(a), showed that the carburized layer of surface of the specimen carburized at 900 C for 2h was homogenous and dense, with metallurgical connect with the matrix. It was a single layer. When the carburizing time lasted 4h at 900 C, the carburizing layer became thicker and exhibited as multilayer structure, and there was a distinct defective layer between surface carburizing layer and matrix (Fig. 1(b)). X-ray diffraction analysis results of TiAl based alloy samples showed that there were $Al_2Ti_4C_2$ and Al_4C_3 phases in the sample carburized at 900 C for 2h, and an additional Ti_3AlC phase formed in the sample carburized at 900 C for 4h, as shown in Fig. 2.

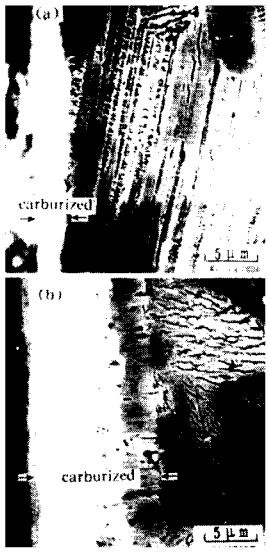

Fig. 1 SEM micrographs of TiAl based alloy samples carburized at 900 C for 2h (a) and 4h (b)

3.2 *Oxidation Resistance*

The oxidation tests were made at 900 C for 2 h in a still air surrounding. Fig. 3 showed the curves of the sample carburized at 900 C for 2h and that at cast state. The unit weight gain of the as-cast sample after oxidation was 1.4 times as much as the carburized sample. The slope of the oxidation curve for the as-cast sample at stable stage was 1.6 times of that for caburized one.

4 DISCUSSION

A carburized layer has formed on the sample surface of TiAl based alloy after carburization. The carburized layer was homogenous and connected tightly with the matrix. The carburized layer can prevent the generation of cracks on the sample

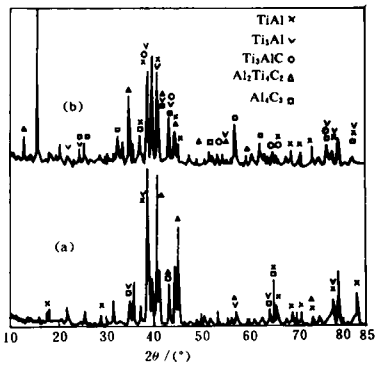

Fig. 2 X-ray diffraction spectra for samples carburized at 900 C for 2h (a) and 4h (b)

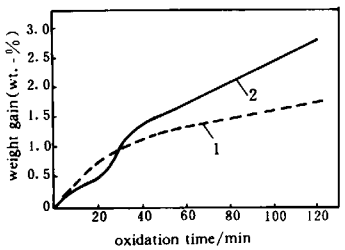

Fig. 3 Oxidation gain curves for carburized sample at 900 ℃ for 2 h and as-cast specimen
1 caburized; 2 as-cast

Fig. 4 SEM fractograph of sample carburized at 900 ℃ for 2 h

surface and also the propagation of the secondary cracks in the body can be stopped in front of the carburized layer, as shown in Fig. 4, which shows that the carburized layer has enough strength and toughness. Moreover, the carburized layer changed the stress state of the matrix and overcame the environment effect of the TiAl matrix. Therefore, the mechanical properties can be improved after carbuirzation.

However, when the carburizing time increased to 4 h, the carburizing layer became thicker and porous, and it did not connect with the matrix very well, which deteriorates the mechanical properties. The dense carburized layer could prohibit the oxygen from diffusing into the sample, therefore it improved the oxidation-resistance of TiAl based alloy.

5 CONCLUSIONS

(1) A carburized layer has formed on the surface of TiAl based alloy after it is carburized.

(2) The homogenous and dense carburized layer can prohibit the formation of cracks on the surface and their propagation, which improves the room temperature mechanical properties of TiAl based alloy.

(3) The carburized layer metallurgically connected with the matrix well can prohibit oxygen atoms from contacting with the matrix, thus improving the oxidation-resistance of TiAl based alloy.

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