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ScienceDirect
Acta Metall. Sin. (Engl. Lett.) Vol.20 No.4 pp307-312 Aug. 2007

ACTA
METALLURGICA SINICA
(ENGLISH LETTERS)
www.ams.org.cn

SUPERPLASTICITY AND DIFFUSION BONDING OF IN718 SUPERALLOY

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Manuscript received 8 June 2007

The superplasticity and diffusion bonding of IN718 superalloy were studied in this article. The strain rate sensitivity index m was obtained at different temperatures and various initial strain rates using the tensile speed mutation method; m reached its maximum value 0.53 at an initial strain rate of $1\times10^{-4}s^{-1}$ at 1253K. The diffusion bonding parameters, including the bonding temperature T, pressure p, and time t, affected the mechanism of joints. When the bonded specimen with 25μm thick nickel foil interlayer was tensile at room temperature, the shear fracture of the joints with nickel foil interlayer took place at the IN718 part. Microstructure study was carried out with the bonded samples. The microstructure shows an excellent bonding at the interfaces. The optimum parameters for the diffusion bonding are: T=1273–1323K, p=20–30MPa, t=45–60min.
KEY WORDS *superplasticity; diffusion bonding; nickel foil; IN718 alloy*

1. Introduction

IN718 is a nickel-base superalloy, and possesses an advantageous combination of properties. It is the most widely used superalloy and accounts for 35% of the total superalloy production. IN718 superalloy was mainly used to manufacture complex welding sheet components in the 1960s, and it was used to produce parts of turbine, which had service life of more than ten thousand hours[1-4]. Now, IN718 alloy is practically used in high effective turbines, such as turbine disk, axle, blade, guide blade, shell, *etc.* to satisfy the increasing demands for higher temperature environment[5-7].

To fulfill the requirements of product applications, the superplasticity and diffusion bonding of IN718 have been investigated in detail.

2. Microstructure Features of IN718 Superalloy

2.1 Material

IN718 superalloy used in the tensile experiment was 1mm thick sheet. The analyzed composition (wt%) of the alloy is given as folloows: C 0.067, S 0.005, P 0.008, Cr 19.26, Ni 53.67, Ti 1.13, Cu 0.072,

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Mg <0.01, Mn 0.03, Si 0.08, Mo 3.26, Nb 5.38, Al 0.55, Co 0.05, B 0.008. The specimen used to evaluate the strain rate sensitivity m was heat treated in 1193K for 30min[2].

2.2 Microstructural features

The first detailed characterization of superplasticity was presented by Hayden *et al.*[3] for alloys in the Ni-Fe-Cr system. In the superplastic condition, superalloys are characterized by a fine grained (generally 10μm or less), two-phase microstructure. The microstructure of the IN718 alloy is shown in Fig.1. For this alloy, the second phase is essential in ordered face centered cubic γ′. The presence of a second phase is essential so that the microstructure remains stable throughout hot deformation[8-11].

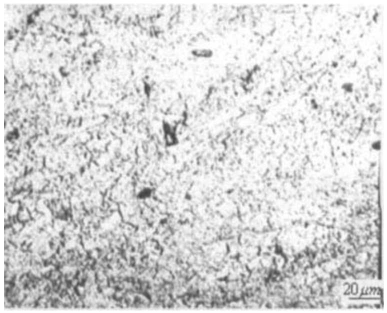

Fig.1 Microstructure of Inconel718 superalloy.

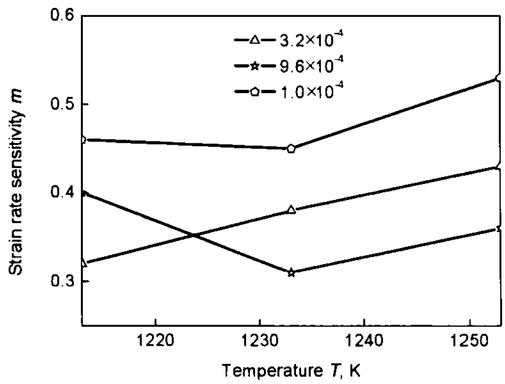

Fig.2 The relationship between the strain rate sensitivity *m* and temperature.

2.3 Superplasticity of Inconel718 superalloy

Early references have appeared relating to the observation of superplasticity in nickel-base alloys at a wide temperature range of 1213 to 1293K and a strain rate range of 10^{-4} to $10^{-3}s^{-1}$ [5].

Fig.2 shows the relation of the strain rate sensitivity *m* and the test temperature at various initial strain rates. The value of *m* increases with the decrease of the strain rate and the rise of temperature and reaches its maximum value at an initial strain rate of $1\times10^{-4}s^{-1}$ at 1253K.

3. Diffusion Bonding of Inconel718 Superalloy

In case of diffusion bonding of Inconel718 alloy, 25μm thick nickel foil interlayer is adopted. The effects of the diffusion bonding parameters, such as temperature *T*, pressure *p*, and time *t*, were investigated.

3.1 Effect of the diffusion bonding temperature T on the shear strength of joint

The temperature of diffusion bonding greatly affects the plastic deformation, creeping resistance, and the diffusion behavior of the joint. The diffusion bonding temperature is increased properly because of the high thermal resistance of Ni based superalloy. Based on the suitable combination of the parameters of pressure, temperature, and time, the diffusion bonding temperature must be in the range of 1273–1323K. Fig.3a shows the relationship between the shear strength of the joints and the temperature in this temperature range. It can be seen that the strength of the joints increases with the increasing bonding temperature.

3.2 Effect of the diffusion bonding pressure p on the tensile strength of the joint

The diffusion bonding pressure is important to control the properties of the joint. The main function