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The Study on bonding test of Inconel 617 Heat Exchanger by Measuring Properties

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1. Introduction

Recently, the heat exchangers which are applied to plant require high performance and reliability where is under the high temperature and pressure. In order to meet the those requirements, its materials should be special alloy such as inconel and diffusion bonding technology is being used.

The diffusion bonding is that two materials are put into contact in being heated and pressurized under the vaccum condition. Basic materials are not melted and bonded through the diffusion of atoms. It is different from welding in a view point of not melting and additional bonding insertion materials are not used which is different from the method in brazing. This bonding method is favor for ultra high temperature and pressure condition, and the bonding part becomes almost same structure and property with high heat resistance and strength when it is compared with brazing method. But the process time is long and the cost is high. The quantitative analysis in bonding surface has not been suggested yet. [1,2]

In this paper, the bonding performance for diffusion bonded heat exchanger is examined and analyzed where its material is inconel 617. thermal and mechanical properties such as thermal diffusivity and tensile strength are measured and compared for different bonding conditions.

2. Methods

Inconel 617 is adopted for heat exchanger material which is known as heat and oxidation resistance material. Figure 1 shows inconel plate and diffusion bonding facility. The size of the plate is 100 x 200 mm in retangular shape and the thickness is 1.6 mm. The plates piled up are diffusion-bonded with being pressurized and heated under the proper condition.

The specimens are made for the purpose of measuring thermal and mechanical properties after diffusion bonding as shown in fig. 2. Thermal diffusivity is measured using Laser Flash Analysis(model:Netzsch LFA 447) as shown in fig. 3.

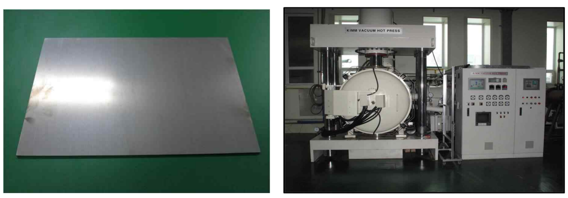


Fig. 1 Inconel plate and diffusion bonding equipment

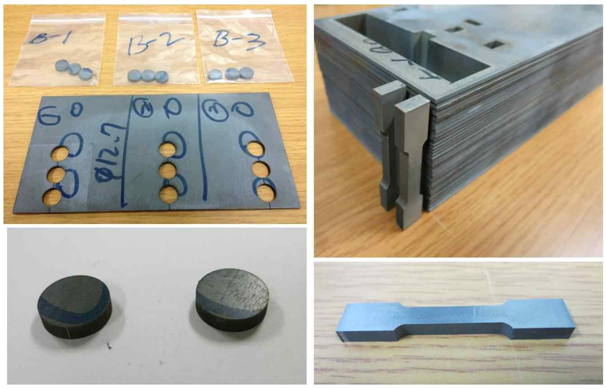


Fig. 2 Specimen of tensile strength and LFA.

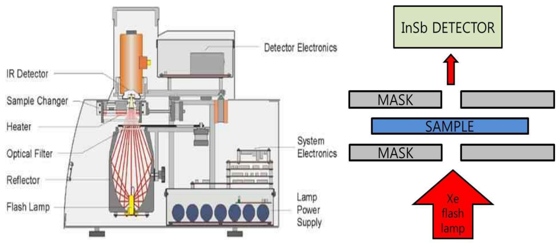


Fig. 3 Schematic of Laser Flash Analysis.

3. Result

Figure 4 shows the results of thermal diffusivity with diffusion bonding temperature. Two overlaped plates are bonded for 3 hours where the temperature conditions are 800, 900, 1000, 1100℃ under the 40 ton press pressure. LFA measuring temperature ranges are 25, 100, 200, 300℃ and each specimen has been measured three times. As measuring temperature increases, the thermal diffusivity increases.

The thermal diffusivity differences between the two plates in bonding condition-900, 1000, 1100℃ and single plate exist within 3%, which is thought to be good bonding performance. On the other hand, the bonding failed plates which is conducted in 800℃ bonding temperature has very low thermal diffusivity as shown in fig.4.

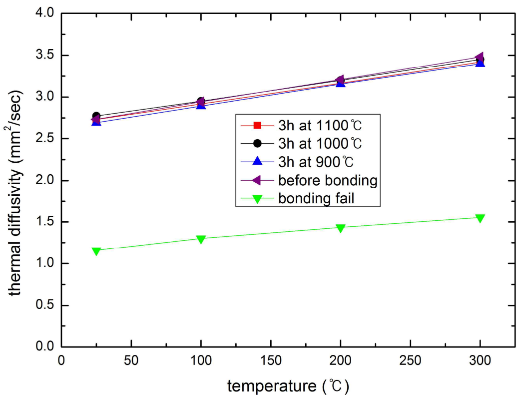


Fig. 4 Thermal diffusivity of Inconel plates made by diffusion bonding

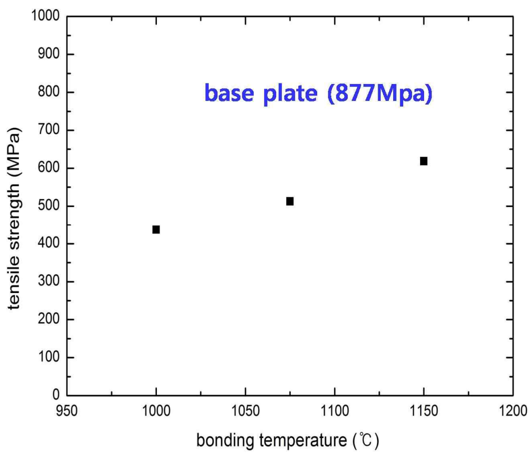
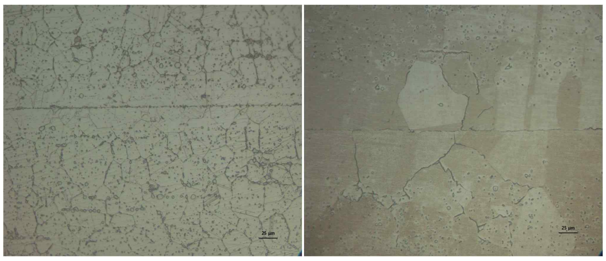


Fig. 5 Measurement result showing tensile strength of bonding temperature.

Figure 5 shows tensile strength with diffusion bonding temperature. The inconel plates piled up to 60mm are diffusion-bonded in different temperature 1000, 1075, 1150℃ with 60 ton press pressure for 5 hours. It is found that as diffusion bonding temperature increases, the tensile strength increases. Although the results have lower value when compared with orginal property, it is considerable value over 600 MPa at 1150℃. Figure 6 is micrographs showing grain growth across the joint interface with two different bonding time, 5 and 10 hours at 1150℃. As bonding time increases, the size of grain boundary increases due to the diffusion process of the material.



(a) (b)

Fig. 6 Surface organization of optical microscope by bonding time : (a) 5 hours, (b) 10 hours

3. Conclusions

In this study, the bonding performance for heat exchanter using inconel 617 is analyzed by measuring thermal and mechanical properties such as thermal diffusivity and tensile strength. The following results are obtained.

1. From measuring thermal diffusivity, it is found that the difference between the diffusion bonded plates and bond failed plates is within 3%.
2. The tensile strength in diffusion bonding is about 25% lower than that of original plate at 1150℃, but it is over 600 MPa.
3. As bonding temperature increases, the size of grain boundary decreases

From these results, the possiblity for inconel 617 heat exchanger under the high temperature and pressure through diffusion bonding process could be obtained and it is thought to be applied for many industrial equipments.

Acknowledgements

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