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Effect of brazing temperature on tensile strength and microstructure for a stainless steel plate-fin structure

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ABSTRACT

This paper presented a vacuum brazing technology for 304 stainless steel plate-fin structures with BNi2 filler metal. The effect of brazing temperature on tensile strength and microstructure has been investigated. The tensile strength is increased along with the increasing of brazing temperature. The microstructure is very complex and some Boride compounds are generated in the brazed joint. Full solid solution can be generated in the middle zone of joint when the brazing temperature is increased to 1100 °C. The brittle phases always exist in the fillet no matter how the brazing temperature changes, but the microstructure in fillet becomes more uniform and the tensile strength is increased with the brazing temperature increasing. In total, the brittle Boride compounds are decreased with the brazing temperature increase. Brazing with a filler metal thickness 105 μm and 25 min holding time, 1100 °C is the best suitable brazing temperature and a tensile strength of 82.1 MPa has been achieved for 304 stainless steel plate-fin structure.

1. Introduction

High Temperature Gas Cooled Reactors (HTGR) with a closed cycle gas turbine have become potentially interesting for future power generation [1]. The heat exchanger plays a key role in HTGR because 95% heat exchanging efficiency in power converting system is required to assure the efficiency [2]. Hence the stainless steel plate-fin heat exchanger (PFHE) is one of the most promising compact technologies to be used in the future HTGR. The heat exchangers in HTGR operate under very harsh conditions, such as high temperatures, high pressures, and high pressure difference between the circuits, which raise high demands for stainless steel PFHE, such as fabrication technology, creep and fatigue performance.

In manufacture of PFHE, NORDON Company has mastered the brazing technology and the technological risk is low for temperatures up to about 500 °C [2]. Kawashima et al. [1] fabricated a large-size stainless steel plate-fin core with a dimension of 1000 mm, and the bonding ratio in this core reached almost 100%. But the key fabrication technology for stainless steel PFHE is still kept secret. Recently, we [3] did brazing experiments to a 304 stainless steel plate-fin structure, and a new cooling method was proposed to increase the strength greatly. Moreover, we performed a simulation of vacuum brazing to 304 stainless steel plate-fin structure and the residual stress field has been achieved [4]. In addition, the effects of geometrical conditions [5] and material mismatching [6] on residual stress have been fully researched. In the creep strength, Tu [7] and Zhou [8] performed viscoelastic analysis of plate-fin structures and the time-dependent deformation and stresses were analyzed by assuming the fins as elastic springs. Masatoshi Tsuda et al. [9] investigated the elastic-visco-plastic behavior of an ultra-fine plate-fin structure by homogenized method. We did a finite element analysis of the effect of residual stress and filler metal thickness on creep for 304 stainless steel plate-fin structure [10,11]. In the fatigue field, Carter et al. [12] carried out failure analysis to an aluminum PFHE and found that fatigue was the failure mode, but the fatigue life prediction method for the whole plate-fin structure has not been established up to now.

Brazing temperature has great effect on the microstructure and strength [13,14]. Kim and Weil [15] discussed the effect of brazing temperature on the microstructure and mechanical properties of aluminum air brazed joints. He found that the bend strengths of the joints generally increase with brazing temperature increasing. Zhang et al. [16] researched the effect of brazing temperature on mechanical properties of TiC cermet/Ag–Cu–Zn/steel joints. It was found that the maximum shear strength was achieved by brazing at 850 °C and the fracture site was also varied with the brazing temperature changing. Stainless steel plate-fin structure is fabricated by vacuum brazing. It consists of stacked corrugated sheets (fins) separated by flat plates, forming passages that are

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