Brazing of Inconel 600 by active filler metal

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Inconel 600 alloy was brazed at three different brazing temperatures 830, 865 and 900°C for 30 minutes. An active filler metal, Ag–Cu–Ti, was utilised to study its effects on bonding strength by the diffusion of some elements with Inconel 600 during brazing. The experiment was carried out in a high vacuum chamber at 1 × 10−4 Pa. Scanning electron microscope—energy dispersive spectroscopy and electron probe microanalysis was conducted for element identification and a shear test served to evaluate the bonding strength. The results show that good bonding was achieved and two continuous reaction layers were formed in the brazed area. The reaction layers were crossing in the middle in most areas at 865°C compared to 820 and 900°C. It was revealed that a stronger Ti–Ni interaction than Ti–Cu influenced the formation behaviour of reaction layers and the highest shear strength identified was at 865°C.

Keywords: Brazing, Inconel 600, Active filler metal, Ag–Cu–Ti, Reaction layer, Shear strength

Introduction

Inconel 600 alloy is one of the more widely used superalloys at high temperatures and harsh environments. Owing to the attractive properties of Inconel 600, such as corrosion resistance and strength retention at elevated temperatures, this material has been widely chosen in marine, aeronautical and aerospace engineering.1,2 Thus, for repairing and joining these materials, proper joining techniques should be considered to prolong the lifetime of Inconel 600 during service.

Brazing is more practically suited to be considered than welding to avoid the melting of base metal that can change the mechanical and metallurgical properties. Other techniques of joining Inconel 600 alloy have been reported, such as diffusion brazing, which involves a combination of transient liquid phase joining and diffusion bonding techniques.3–6 Nevertheless, it is worth mentioning that vacuum brazing offers an economical and simple brazing technique compared to diffusion bonding that is considerably more expensive since it requires surface preparation before joining and has geometrical limitations.7 It is also well documented that in the diffusion bonding method, nickel-based filler metal is commonly selected as the filler metal3–6 and it requires high brazing temperatures normally above 1000°C.8,9 This would increase fabrication cost as high-temperature furnaces required for brazing.

The selection of brazing filler metal influences bonding strength since the brazing temperatures are set according to the liqudus temperatures. By using silver-based filler metal, the brazing temperature may be maintained below 1000°C and commonly in the range of 800–900°C.10 Silver-based filler metal also provides ductile joining capable of withstanding considerable vibration and shock.11 The consideration was additionally made so as to avoid grain growth in Inconel 600 alloy starting at 1000°C and above, normally for Ni-based superalloy.12 Yet, there are limited reports on brazing using active filler metal containing titanium in the joining of Inconel 600 alloy.13 Thus, in this research, the authors aim to study the effects of brazing temperature on the shear strength of Inconel 600 by applying active 1–75 wt-% filler alloy. The analysis focuses on investigating the effects of some elements and/or phases formed as a result of the reaction between Inconel 600 and active brazing filler metal, and the relation to bonding performance.

Experimental details

In this research, Inconel 600 alloy was melted and manufactured by Huntington Alloy, USA. The composition of the as-received Inconel 600 alloy (in wt-%) is presented in Table 1.

The Inconel 600 alloy (plate of 4 mm thickness) was prepared for brazing and shear strength test. The material was cut into dimensions of 4 × 25 × 25 mm3 for the base and 4 × 8 × 8 mm3 for the top of the prepared specimen in sandwich configuration. Then, the Inconel 600 alloy was directly brazed with CuSi ABA active filler metal which was cut into 0.05 × 10 × 10 mm3 pieces. The filler metal was manufactured and supplied by Wego Metals, USA, in the form of foil with a thickness of 50 μm. The chemical composition (in wt-%) was 63Ag–35.25Cu–1.75Ti and the solidus and liquidus temperatures were 780 and 815°C, respectively. The specimens were stacked in sandwich configuration and clamped...