Temperature working fluid. This high efficiency is due primarily to the use of compact heat exchangers, which enhance heat transfer between the high- and low-temperature working fluid.

Joining High-Temperature Alloys

For the compact heat exchangers, availability of materials determines the maximum operating temperatures, thus cycle efficiency. Currently, formable Ni-alloys such as Alloy 230, 625, 637, 794H, and 282 are the only option for heat exchangers operating above 700°C at high pressure differentials (>20 MPa). These alloys provide necessary creep strength and high-temperature oxidation resistance as well as a high ductility to form thin sheet. Joining methods such as diffusion bonding and transient-liquid-phase (TLP) bonding are the most robust approaches for joining thin layers of sCO₂ compact heat exchangers with tight dimensional tolerances. Goal of this work is to demonstrate the bondability of Alloy 230 using TLP bonding technique.

High-Temperature Oxidation Test

The 230 monolithic coupons (H230-Sheet) showed mass gains which were less than that of the TLP bonded coupons (H230-TLP). The mass for both bonded and monolithic Alloy 230 increases fast during the first 500 h of exposure and slower during the rest of the exposure. Cross-section examination of the exposed TLP bonded coupons using back-scattered electron (BSE) imaging revealed a thin oxide scale on all of the coupons (Fig. 7). The scale was approximately 1-2 µm thick. A thicker scale was observed above carbide particles near the sample surface. No significant thickness variation was observed between the scale on the bond and the scale on the sheet.

SUMMARY AND ON-GOING WORK

• Although TLP bonded Alloy 230 showed yield strength comparable to the bulk Alloy 230 alloy, plastic strain localization in the bond region (ISZ) caused low tensile and creep elongation. This is shown to be a major challenge with the TLP bonding of Alloy 230.

• Ventilation system to improve the tensile elongation of joined Alloy 230. Diffusion bonding with and without Ni interlayer is being investigated in collaboration with West Virginia University.

• High-temperature oxidation behavior of TLP-bonded Alloy 230 was not significantly different from that of Alloy 230 sheet.

• Currently, NETL is working on improving the tensile elongation of joined Alloy 230. Diffusion bonding with and without Ni interlayer is being investigated in collaboration with Oregon State University. In addition, NETL is investigating diffusion bonding of another high-temperature Ni superalloy, IN 740H, in collaboration with Vacuum Process Engineering, Inc.

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