

C. Transient Liquid Phase Bonding of 304L Stainless Steel to 5083 Aluminum using a Gallium Interlayer

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The joining of 304L stainless steel to 5083 aluminum is currently used in certain offshore pipeline connectors. A stainless steel stub end with nickel, titanium, and aluminum cladding is explosively bonded to an aluminum stub end, and then the part is heavily machined, which is an extremely costly process. The goal of the present research is to bond 304L stainless steel to 5083 aluminum using transient liquid phase bonding with a gallium interlayer, which would be beneficial because of the simplicity of the manufacturing process and the low cost relative to explosive bonding.

Transient liquid phase bonding with a gallium interlayer was the first approach, which was chosen because prior research has demonstrated that aluminum could be bonded to aluminum at 500 °C, and stainless steel could be bonded to stainless steel at 1000 °C, both with a gallium interlayer. The current research successfully confirmed that aluminum could be bonded successfully at 500 °C, but stainless steel could only be bonded at temperatures above 750 °C, still well above the melting temperature of aluminum. The addition of high pressure applied by a hot press did not improve bonding at temperatures below the melting point of aluminum.

Ongoing research involves bonding aluminum to coated steel, such as Ni, Zn, or Sn, using both transient liquid phase bonding and brazing. The aluminum should more easily bond to the coating than to the stainless steel itself, but may be limited by the adhesion strength of the coating to the stainless steel. Electrolytic plating, hot dipping, and thermal spraying are being explored as coating methods. Brazing is also being used on non-coated steel to establish a reference and to compare to the bonding of the coated steel. The possibility of success for brazing should be high since various aluminum and steel grades have been bonded using the brazing process. Literature suggests there are also possibilities for diffusion bonding and brazing using aluminum as the interlayer and brazing material.

Other bonding methods such as friction stir welding are being pursued as well. Friction stir welding has been successfully used to join Al 5083 and a mild steel, and should have some success joining Al 5083 and 304L stainless steel. The advantage of friction stir welding is that deleterious chemical interactions between aluminum and steel, such as intermetallics, can be minimized. Also, the large melting point difference that creates such a problem in fusion joining is avoided due to the mechanical mixing and non melting of the base materials.