March 1973

B73-10005

NASA TECH BRIEF

Lewis Research Center

IMPROVED DIFFUSION WELDING AND ROLL WELDING OF TITANIUM ALLOYS

The Problem:

Reduce the time conventionally required for diffusion welding, and the deformation conventionally required for roll welding titanium alloys. Typically, one to three hours at 1227 K (1750°F) under 1.38 MN/m^2 (200 psi) pressure in a vacuum hot press chamber is required for diffusion welding titanium alloys. With pumpdown time also considered, diffusion welding is a time consuming operation in an expensive piece of equipment. Roll welding of titanium alloy structures typically requires 60 percent deformation at 1227 K (1750°F). This high degree of deformation necessitates spacer blocks to prevent collapse of the thinner sections of the structures. Often the spacer materials are unintentionally welded to the part and must be removed by machining or chemical leaching. Also, the parts being welded are severely deformed.

The Solution:

Apply the auto-vacuum cleaning technique to the titanium parts prior to diffusion welding or roll welding. The auto-vacuum cleaning technique (previously described in NASA Tech Brief 71-10455) provides oxide-free welding surfaces. Diffusion welding can be accomplished in as little as five minutes of hot pressing. Roll welding can be accomplished with only ten percent deformation.

How It's Done:

For diffusion welding, the surfaces to be welded are ground flat, cleaned with acetone, butted together, and the joints are seam welded on all sides to form a seal. The assembly is then heated in an inert gas atmosphere for two hours at a temperature of 1255 K (1800°F). During this heat treatment, the oxides on the welding surfaces and the gases trapped between the welding surfaces are dissolved into the parent materials, and a vacuum is created. The welded seal prevents surface oxides from reforming. The assembly can then be diffusion welded in any atmosphere that will not severely oxidize the titanium. Using the auto-vacuum cleaning technique, 13 mm (0.5 inch) diameter bars of Ti-6Al-4V were diffusion welded in five minutes under pressure of 1.38 MN/m^2 (200 psi) at 1227 K (1750°F). Comparatively, conventional diffusion welding in a vacuum hot press required two hours at the same pressure and temperature. Welds made using the auto-vacuum cleaning technique had strength and ductility equal to the parent metal and were metallurgically indistinguishable from the parent metal.

For roll welding, the surfaces to be welded are ground flat, pickled, washed, and cleaned with acetone. The surfaces are clamped together, sealed by welding on all sides, and canned in 0.4 mm (0.015 inch) thick stainless steel to prevent oxidation during rolling. The canned sheet assemblies are then auto-vacuum cleaned by heating in air for two hours at 1255 K (1800°F). Alternately, auto-vacuum cleaning can be accomplished during heat-up to the rolling temperature, heat soak, rolling and cool-down. Heating the sealed assemblies at a temperature high enough to cause decomposition and dissolution of the oxides on the welding surfaces and the gases trapped between the welding surfaces eliminates the high degree of deformation conventionally required to break up oxide films and allow their dissolution. Using this technique, 1.6 mm (0.06 inch) thick Ti-6Al-4V sheets were roll welded with only 10 percent deformation. Complete grain growth was achieved across the weld interface showing that high quality solid-state welding was obtained.

Notes:

1. This welding technique should be applicable to any titanium alloy and any other materials capable of dissolving their own surface oxides. Any shape that can be diffusion welded or roll welded will benefit from this technique.
2. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA TN-D-6958 (N72-31552), Hot Press and Roll Welding of Titanium - 6% Aluminum - 4% Vanadium Bar and Sheet with Auto-Vacuum Cleaning

(continued overleaf)

Reference: NASA TN-D-6409 (N71-30524), Practical Method for Diffusion Welding of Steel Plate in Air

3. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10005

Patent Status:

NASA has decided not to apply for a patent.

Source: Kenneth H. Holko
Lewis Research Center
(LEW-11852)