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NASA TECH BRIEF

Lewis Research Center

Joining Precipitation-Hardened Nickel-Base Alloys by Friction Welding

The problem:

The use of precipitation-hardened nickel-base alloys in welded structures has been limited because of cracking that occurs around the welded joints during or after fusion welding. Cracks result from the thermal expansion and contraction that occur during fusion welding, and also from the precipitation of the gamma prime crystalline phase which gives the nickel alloys their precipitation hardening properties. This cracking problem has rendered the higher content, gamma prime-strengthened nickel-base alloys virtually unweldable by even the most advanced fusion welding techniques.

The solution:

A solid-state deformation welding process; friction welding.

How it's done:

In a recent study, 1.25-cm (½-inch) diameter bar stock of a representative precipitation hardening nickel-base alloy (Udimet 700) was successfully butt welded using a stored energy (inertia) friction welding machine. This method of utilizing the discharge of energy from a flywheel to rotate one part to be welded, which is subsequently forced against the other (stationary) part, results in the dissipation of all the energy of the rotating part into the weld interface as the flywheel slows down, thus producing a solid-state weld of excellent quality. The welding process cleans and heats the weld interface and also forces out surface material containing impurities, leaving only fresh, but unmelted, metal to form the solid-state weld. After post-heating in a furnace, the weld line was not detectable in the recrystallized structure.

A series of such welds was tested and found to be equal in strength to the parent metal in tensile and stress rupture tests at 760°C and 980°C.

Notes:

1. The utilization of friction welding developed in this study is believed to be applicable to other precipitation-hardened nickel-base alloys (such as IN-100 and other gamma prime-strengthened materials) which heretofore have been virtually unweldable.
2. Friction welding requires rotation of one of the parts to be welded, but where applicable, it is an ideal process for high-volume production jobs.
3. 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 TM-X-2411 (N72-11431), An Exploratory Study of Friction Welds in Udimet 700 and TD-Nickel Bar
4. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10288

Patent status:

No patent action is contemplated by NASA.

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