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Attaching Thermocouples by Peening or Crimping

These techniques are simple, effective, and minimally invasive.

John F. Kennedy Space Center, Florida

Two simple, effective techniques for attaching thermocouples to metal substrates have been devised for high-temperature applications in which attachment by such conventional means as welding, screws, epoxy, or tape would not be effective. The techniques have been used successfully to attach 0.005-in. (0.127-mm)-diameter type-S thermocouples to substrates of niobium alloy C-103 and stainless steel 416 for measuring temperatures up to 2,600 °F (1,427 °C). The techniques are equally applicable to other thermocouple and substrate materials.

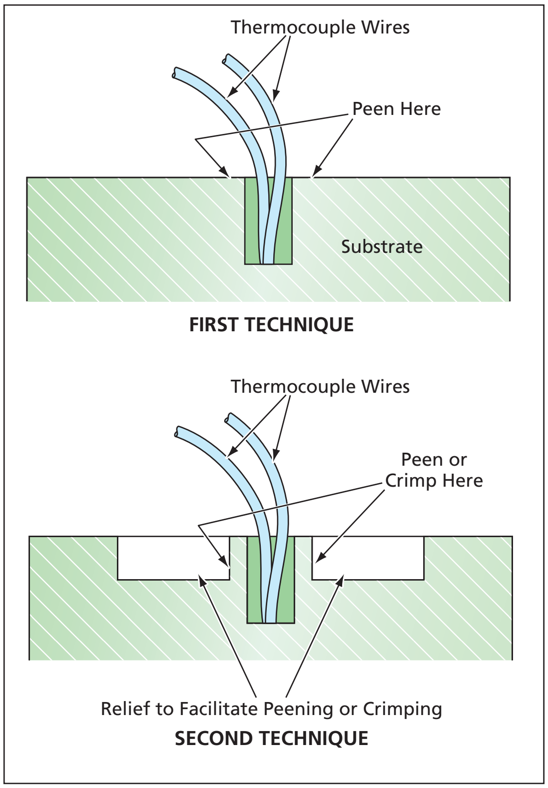
In the first technique, illustrated in the upper part of the figure, a hole slightly wider than twice the diameter of one thermocouple wire is drilled in the substrate. The thermocouple is placed in the hole, then the edge of the hole is peened in one or more places by use of a punch (see figure). The deformed material at the edge secures the thermocouple in the hole.

In the second technique a hole is drilled as in the first technique, then an annular relief area is machined around the hole, resulting in structure reminiscent of a volcano in a crater. The thermocouple is placed in the hole as in the first technique, then the "volcano" material is either peened by use of a punch or crimped by use of sidecutters to secure the thermocouple in place. This second technique is preferable for very thin thermocouples [wire diameter ≤0.005 in. (≤0.127 mm)] because standard peening poses a greater risk of clipping one or both of the thermocouple wires.

These techniques offer the following advantages over prior thermocouple-attachment techniques:

- Because these techniques involve drilling of very small holes, they are minimally invasive — an important advantage in that, to a first approximation, the thermal properties of surrounding areas are not appreciably affected.
- These techniques do not involve introduction of any material, other than the substrate and thermocouple materials, that could cause contamination, could decompose, or oxidize at high measurement temperatures.
- The simplicity of these techniques makes it possible to attach thermocouples quickly.
- These techniques can be used to attach thermocouples at locations where access is somewhat restricted by the surrounding objects.

This work was done by Kevin Murtland, Robert Cox, and Christopher Immer of ASRC Aerospace Corp. for **Kennedy Space Center**. *For further information, contact the Kennedy Innovative Partnerships Office at (321) 867-1463. KSC-12775*



A **Thermocouple is Placed in a Hole** wide enough to accommodate the wires with a little clearance. Then the thermocouple is secured in the hole by peening or crimping substrate material near the hole.

Heat Treatment of Friction-Stir-Welded 7050 Aluminum Plates

Strength, ductility, and resistance to stress corrosion cracking are increased.

Lyndon B. Johnson Space Center, Houston, Texas

A method of heat treatment has been developed to reverse some of the deleterious effects of friction stir welding of plates of aluminum alloy 7050. This alloy is considered unweldable by arc and high-energy-density beam fusion welding processes. The alloy can be friction stir welded, but as-welded workpieces exhibit low ductility, low tensile and yield strengths, and low resistance to stress corrosion cracking. Heat treatment according to the present method increases tensile and yield strengths, and minimizes or eliminates stress corrosion cracking. It also increases ductility.

This method of heat treatment is a superior alternative to a specification-required heat treatment that caused the formation of large columnar grains, which are undesired. Workpieces subjected to the prior heat treatment exhibited elongations <2 percent, and standard three-point bend specimens shattered.

The development of the present heat-treatment method was guided partly by the principles that (1) by minimizing grain sizes and relieving deformation stresses, one can minimize or eliminate stress corrosion cracking and (2) the key to maximizing strength and eliminating residual stresses is to perform post-weld solution heating for as long a time as possible while incurring little or no development of large columnar grains in friction stir weld nuggets. It is necessary to perform some of the solution heat treatment (to soften the alloy and improve machine welding parameters) before welding.

The following is an example of thickness-dependent pre- and post-weld heat treatments according to the present method: For plates 0.270 in. (≈6.86 mm) thick milled from plates 4.5 in. (114.3 mm) thick, perform pre-weld solution heating at 890 °F (477 °C) for 1 hour, then cool in air. After friction stir welding, perform solution heating for 10 minutes, quench, hold at room temperature for 96 hours, then age at 250 °F (121 °C) for 5 hours followed by 325 °F (163 °C) for 27 hours.

This work was done by George E. Petter of **Johnson Space Center** *and John D. Figert, Daniel J. Rybicki, and Timothy Burns of Lockheed Martin Corp.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23472.