Traditional equipment drives new technology

Exploring the potential for deformation resistance welding

A tube with a flange and a tube with a fold can be joined with DRW.

By V. (Anthony) Ananthanarayanan and Deepak Sharma

Typically, product designers haven't used tubular structures extensively because thin-walled tubes are difficult and expensive to weld. The lack of economical welding methods specified for tubular structures has led to the use of more sheet metal structures.

Lean, large-volume tube welding technology for tubular structures would enable product designers to capture the benefits of these structures—important to today's manufacturing. One such technology currently being tested is deformation resistance welding (DRW).

DRW was developed and designed to remove tube welding constraints and help make widespread use of tubular structures viable. Conventional resistance welding equipment is used for the process, but generally with higher weld currents. Welding currents up to 300 kiloamperes (kA) can be used to weld 6-inch-diameter, thin-walled tubing.

The use of midfrequency DC resistance welding technology—in which the transformer packs operate at frequencies of 1,000 to 1,200 hertz (Hz)—helps enable the use of existing welding buses. Midfrequency DC technology draws power from all three phases of the bus and uses transformer combination packs that help improve the secondary-weld-current-to-primary-bus-current ratio.

Before DRW, tubes are formed to introduce folds and flanges at their ends (**see introductory photo**). DRW compresses the fold against the tube in a resistance welding machine and passes current through them. The electrodes are designed to permit relative motion between the parts welded while they are hot, at temperatures close to the melting temperatures of the parts welded. The process creates joints through the deformation and displacement of material at the weld interface.

With this process, a joint can be made entirely through solid-state bonding. Higher temperatures engineered at the end of the weld can augment it by creating a melted and solidified weld nugget. This method is designed to create leaktight joints with uniform circumferential joint strength regardless of whether the joint is made in the solid state or consists of a weld nugget.

Tube-to-Sheet Welds

For thin-wall tube (1 to 2 mm thick) welding to sheet metal with the tube oriented perpendicularly to the plane of the sheet, a fold is created in the tube using a forming operation. A hole with a diameter nearly equal to the tube OD is drilled in the sheet metal to make the sheet weldable to the tube.

Upon initial assembly in a resistance welding machine, the tube doesn't enter the hole in the sheet. When the weld pressure is applied, the tube enters the hole, and the fold butts against the sheet metal. The electrode holds the tube, gripping it tightly and pushing it on the fold during welding. The electrode on the sheet metal has an ID nearly one to two times that of the tube OD.

Low-current pulses heat and soften the fold and the contacting areas in the sheet metal initially. One or more high-current pulses slide the weld interfaces along each other and complete the weld. The weld joint occurs between the fold and the sheet metal at the areas of contact. Additional weld pulses create a melted and solidified nugget if necessary. The electrodes can be designed to stop when a predetermined burn-down of the parts welded is accomplished to maintain a desired welded part length.

The hot deformation of parts welded along the weld interface helps make the welding process stable. The stability of a resistance weld typically is measured by calculating the weld window with the following formula:

$$\text{Weld Window} = \frac{\text{HCL} - \text{LCL}}{\text{NWC}} \times 100$$

Where:
HCL = high current limit
LCL = low current limit
NWC = nominal weld current

For the validity of this definition of the weld window, it is necessary that at any weld current value between the HCL and the LCL, the weld quality is good. Higher values of the weld window result in a more stable process.

The weld window seldom is more than 15 percent in conventional resistance welding, but weld windows larger than 30 percent were encountered with DRW. With other variables held constant, sheet thicknesses were varied by more than 50 percent without having to change weld parameters, which yielded good welds. Typically, a 50 percent change in thickness with conventional resistance welding results in the need to increase the total weld heat input by a factor of more than 2.5. Such unnecessary heat increases with DRW

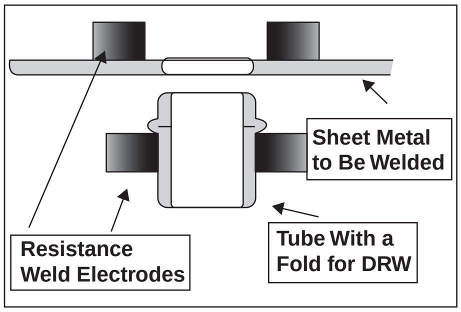

FIGURE 1
This schematic shows a tube with a fold being DRW to sheet metal and the electrode setup.

shows that it can produce good welds with a wide range of heat inputs, making it tolerant to process input variations.

Tube-to-Tube, Tube-to-Solid, and Plate Welds

In a tube-to-tube DR weld, one of the tubes is formed with a fold, and the other is formed with a flange. The electrode setup is similar to that shown in **Figure 1**. The tube with a flange behaves similarly to the sheet with a hole (see Figure 1).

A solid that has a drilled hole diameter nearly equal to the tube diameter can be DRW to a tube with a fold. The tube enters the hole in the solid when it experiences the weld force. Weld current then is passed through the fold into the solid, creating a leaktight weld.

The electrode on the solid surrounds and grips it so the weld can be made with single-sided access. ■

V. (Anthony) Ananthanarayanan, Ph.D., is technical fellow—welding at Delphi Energy & Chassis Systems, 2000 Forrer Blvd., Mail Stop 3-09, P.O. Box 1042, Kettering, OH 45420, 937-455-9277, v.ananthanarayana@delphi.com, www.delphi.com. Deepak Sharma is licensing executive at Delphi Technologies Inc., 5725 Delphi Drive, Troy, MI 48098-2815, 248-813-8064, deepak.sharma@delphi.com, www.delphi.com.

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