CONNECTOR SPECIFIER

Ultrasonic welding "connects" with the auto industry

The ultrasonic metal welding process is widely used in the automotive industry to assemble a variety of connectors used in wire harnesses, wire-to-wire, wire-to-terminal, and wire tipping applications.

BY JANET DEVINE

Ultrasonic metal welding is a solid-state process; no melting of the metal occurs as in resistance welding. There are no consumables such as solder, and no mechanical additions such as crimps or rivets. Ultrasonic welding offers a cost-effective, low-energy, and quick method of joining wire to connectors and wire-to-wire, producing a strong and highly conductive weld. Ultrasonics is also effective for spot welding sheet metal, particularly non-ferrous metals such as aluminum and copper alloys.

Ultrasonic welding occurs by the introduction of oscillating shear forces at the interface between two metals while they are held together under moderate clamping force. The resulting interfacial friction causes disruption of oxides or surface contaminants and subsequent diffusion of metal across the interface produces a structure similar to a diffusion weld but occurring in a shorter time, typically from 0.2 to 1 second.

Ultrasonic equipment

All ultrasonic systems include five components: a power supply that converts line power to the high-frequency and high-voltage power needed by the transducer; a transducer contained in the welding head that transforms high-frequency electrical energy to vibratory energy; a welding head that provides the means, usually pneumatic, to clamp the work pieces; components to transmit the vibratory energy to the welding tooling; and welding tooling consisting of a tip and anvil to deliver the energy and to support the weldment.

> "By far the most common use of ultrasonic welding is wire-to-wire for automotive wire harnesses, in which stranded copper wire is welded in bundles."

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FIGURE 1. The wedge-reed ultrasonic system is particularly useful in welding tinned or heavily oxidized parts

The ultrasonic or acoustic system has two distinct designs: the wedge-reed and the lateral drive-type systems. The wedge-reed produces low-amplitude vibration combined with high vibratory force, which is particularly useful in welding tinned or heavily oxidized parts (see Fig.1). High vibratory amplitude and lower vibratory force characterize the lateral-drive type system. This is useful in welding parts requiring moderate energy levels but these systems may stall at high clamping forces.

Weld tooling for the wedge-reed system consists of an easily oriented and replaced taper-lock tip made of heat-treated tool steel. The lateral drive system usually has a horn with an integral welding tip, making it more costly to replace than the taper-lock insert-style tip. Depending on the application, tools may last up to several hundred thousand welds with some redressing.

Equipment operation

Operation of the welder is relatively simple once the process parameters have been determined, usually at the factory or by a process engineer. The operator is required only to load the parts into a supporting/locating fixture, press the palm buttons or other starting means, and unload the finished part. Equipment is also adaptable to automated or semi-automated production lines, usually requiring only a contact closure to start the welding cycle. Equipment is available with microprocessor controls that can store job parameters, control the weld by time, energy, or distance, and can perform in-process monitoring or indicate faults.

Ultrasonic welding does not require an arc, spark, or molten filler material. No electrical current passes through the weldment, but since the welder is configured in the form of a press with moderately high forces, normal precautions need to be taken for operator safety. Anti-tie-down palm buttons or similar provisions protect the operator's hands.

Connector applications

The most common application for ultrasonic metal welding is in the joining of copper alloys, often in the form of stranded wire, to terminals or to other wires. An electronics company that was having difficulty getting consistent welds across a flat multi-connection terminal with a system that welded one wire at a time switched to an ultrasonic wedge-reed system that gang welds five to seven flat wires at a time to the terminal. The new process involves stripping the flat cable to expose the multiple wires, which are placed on the terminals separated by a plastic separator. The tip is serrated to contact and weld in each of the five or seven locations in a single pulse. The finished connector is used in a steering wheel clock spring (see Fig. 2).

A Japanese auto maker with assembly plants in Mexico and Japan is welding as many as 16 stranded wires together to a custom-designed brass terminal for a single point ground. Special tooling performs the ultrasonic welding operation and then the tool set is used to mechanically crimp the brass terminal arms over the insulated section of the wires for strain relief (see Fig. 3).

Another company welds copper brush braid to stranded wire in the assembly process for small motors that can be used for automotive accessories. They also ultrasonically join a pair of braided brush wires to make a carbon brush set used in automotive lumbar seat motors.

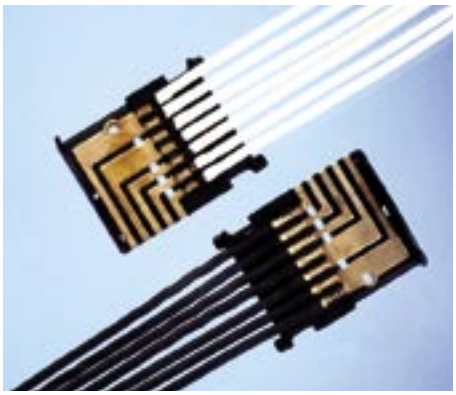

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FIGURE 2. Ultrasonics is a cost-effective, low-energy, and quick way to join wire to connectors and wire to wire. This technology produces a strong and highly conductive weld as in this connector, used in steering wheel clock springs.

The electrical wire-harness assembly between a tractor truck and trailer uses ultrasonic welding to join stranded copper wire in the range of 14 to10 AWG to nickel-plated brass terminal pins. Each wire-to-pin is joined in a separate operation to form the complete wire harness (see Fig. 4).

Another company is evaluating equipment tooled to combine 19-mm^2 stranded wire to 9-mm^2 fuse link wire to make a 28-mm^2 wire bundle for the main terminal for automotive batteries. In another automotive ap-

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FIGURE 3. An overseas automaker uses special tooling to weld 16 stranded wires together to a custom-designed brass terminal for a single point ground.

plication, tinned and bare copper stranded wire ranging from 10 to 2 AWG is being tipped for insertion into special terminals for use in the electrical-power-distribution control cabinets of military vehicles.

By far the most common use is wire-to-wire for automotive wire harnesses, in which stranded copper wire in a variety of gauges is welded in bundles. A bundle may consist, for example, of five 16 AWG and two 18 AWG wires welded together. The result is a strong and highly conductive joint which is then wrapped in electrical tape or encapsulated with heat shrink material to become part of the automotive wire harness. Wire bundles from 1 to 30 mm^2 are successfully welded, tipped, or combined into terminals.

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FIGURE 4. The most common use of ultrasonic welding is for automotive wire harnesses, in which wire bundles of various gauges are welded together and wrapped in electrical tape or heat-shrink material.

Cost concerns

Cost considerations for ultrasonic equipment include the equipment cost, typically ranging from $20,000 to $45,000, depending on power capacity and "bells and whistles." Resistance welders, by comparison, cost between $8,000 and $30,000.

The lowest capital costs are associated with the traditional crimp-and-solder assembly method. However, when the consumables, associated environmental issues, and slower assembly process are factored in, together with a lower quality electrical connection, then this method becomes less attractive. Many manufacturers specify ultrasonic assembly for their wire-harness connections.

A typical ultrasonic welder may use 2,500 to 3,000 W compared with the 10 kVA or more of a resistance welder, so energy costs greatly favor the ultrasonic method. A factory with multiple resistance welders may need a new electric substation to handle the energy requirements, whereas the same number of ultrasonic welders can be powered within the existing capacity of an industrial plant. Also, resistance welding often requires costly water cooling with its additional recycling and purifying costs.

Ultrasonic tooling may be costlier to purchase but will last for several hundred thousand cycles versus the resistance tooling that typically requires daily change in a high production environment. Ultrasonic welding represents the most economical, highest quality assembly choice for many types of electrical connectors when all factors are considered. It is a fast, energy efficient method without additional consumables or extensive operator training. **CS**

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