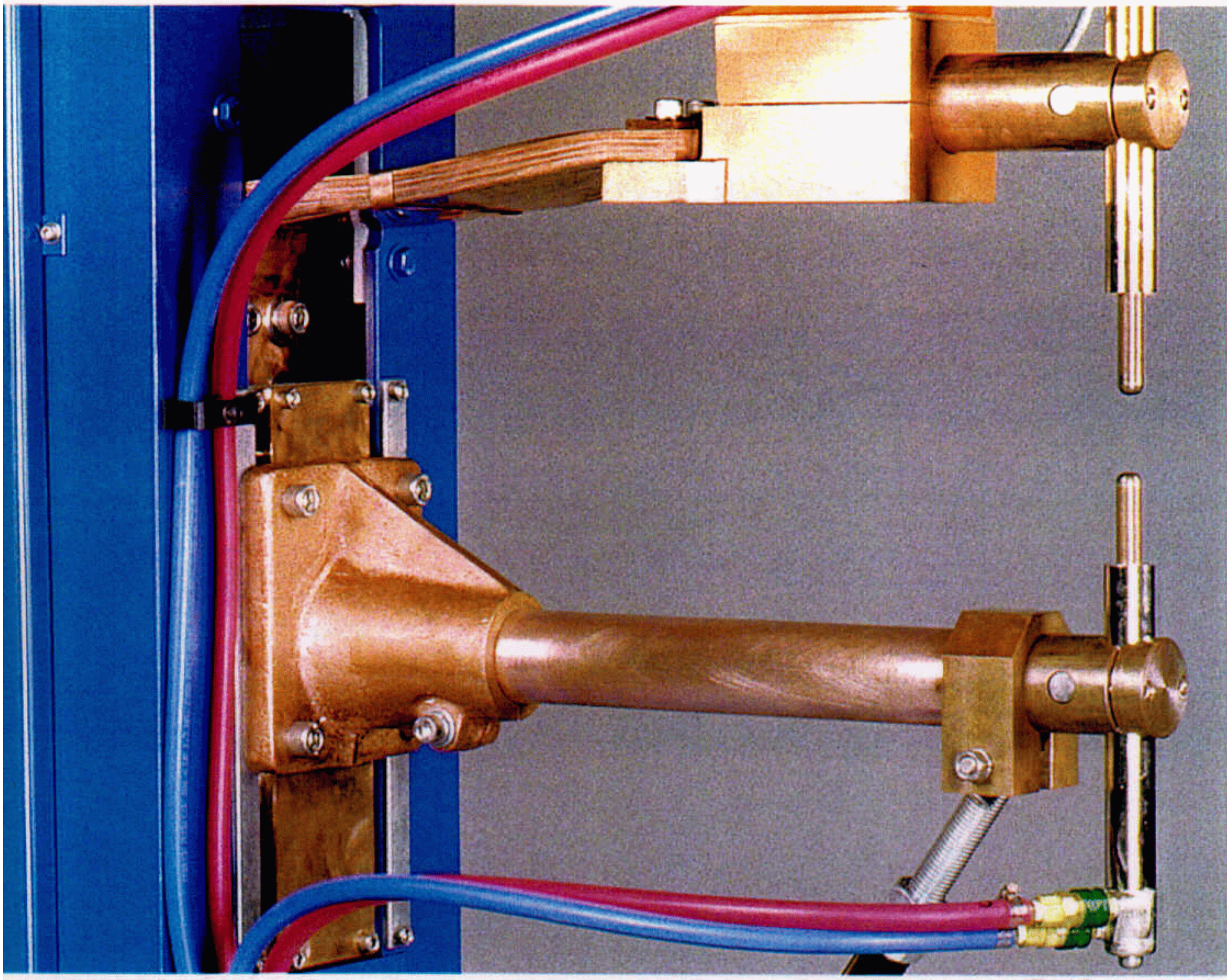

Using multiple-impulse (*pulsation*) resistance welding for coated materials

A benefit for ferrous metals

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By Robert Cuff

The basics of resistance welding are quite simple. It applies heat energy and pressure to produce a weld. The proper association and application of these basics are the real concern in resistance welding.

Simply stated, heat energy is added to a system to raise the temperature to reach the plastic, or near molten, state of the materials to be welded. The changes of state of material due to these applications of heat energy can be explained by using water as an analogy to metal.

Metal is usually in the solid state. The solid state of water is ice. As heat energy is added to ice, the ice melts and becomes liquid water. As heat energy is added to the water it becomes a gas, or steam. The same changes occur with a piece of metal.

When welding zinc-coated (galvanized) steel, both the amount of heat energy and the temperatures needed to reach these changes of state are much greater for steel than for zinc. Zinc melts at approximately 790 degrees Fahrenheit (F); steel at approximately 2,800 degrees F. Zinc boils (becomes a gas) at approximately 1,660 degrees F; steel at approximately 5,000 degrees F (see **Figure 1**).

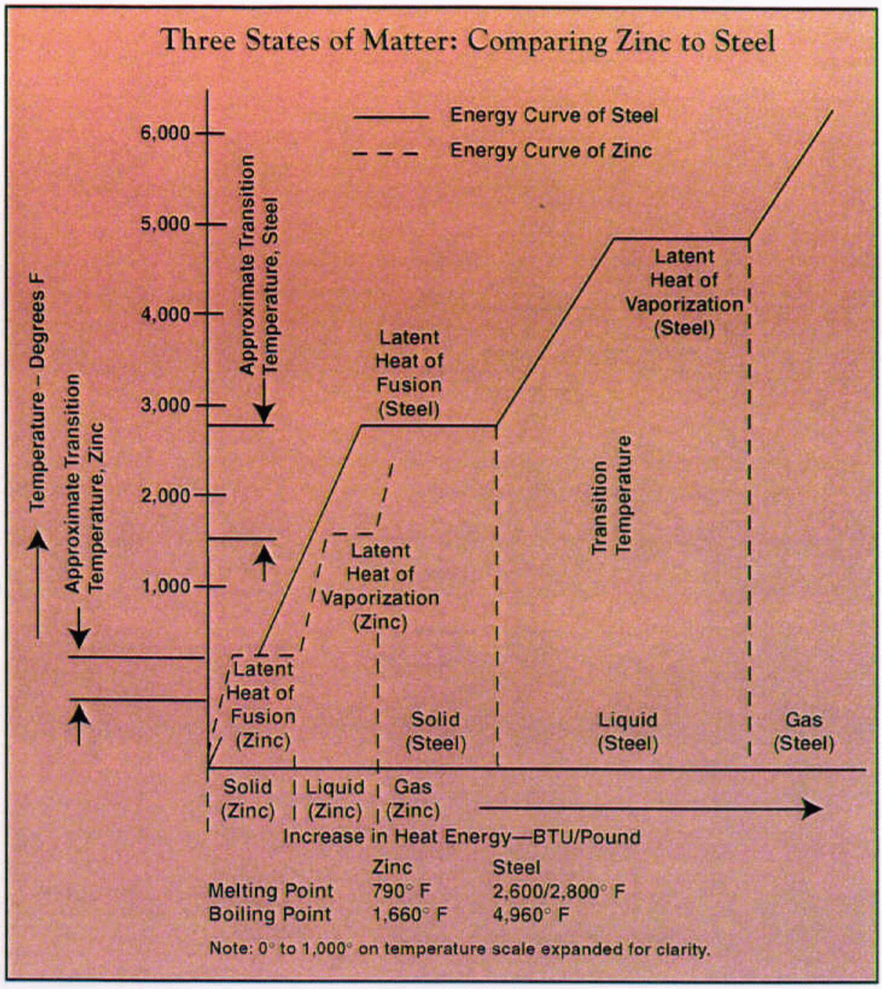


Figure 1

Zinc will boil (evaporate) before the melting point of steel is reached. The plastic range (transition point) of steel begins at about 1,700 degrees F.

Multiple-Impulse Welding Galvanized Steel

Pulsation welding techniques have been used successfully for welding zinc-coated steels. The multiple-impulse (pulsation) sequence, with percent current adjustment, is probably the second most widely used control sequence for resistance spot welding applications.

The pulsation sequence is similar to the spot sequence, with the exception of the ability to interrupt the weld current with a cooling period for a specific number of weld (heat) impulses. The

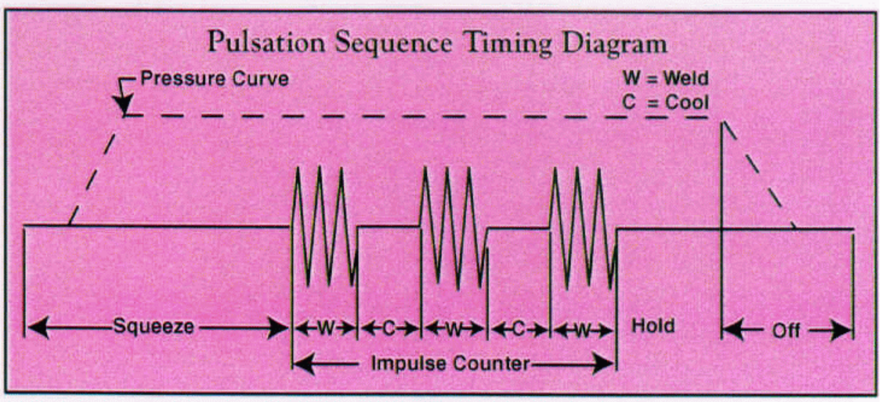


Figure 2

The number of weld impulses can be predetermined and set by front-panel selection on the control.

interrupted weld sequence times are defined as **weld** (when the weld current is on) and **cool**. Older controls may use the terms **heat** and cool, rather than weld and cool.

The weld and cool times and the number of **weld impulses** can be predetermined and set by front-panel selection on the control (see **Figure 2**).

The major consideration when welding galvanized steel is that the melting points of the two metals, zinc and steel, are so dramatically different. Remember, the boiling point of zinc is less than the melting point of steel.

To weld steel to steel through the zinc coating, the temperature of the zinc will be raised well above its boiling point; at this temperature, the zinc is literally evaporated. Witness the white powder that can form when welding galvanized steel, which is oxidized, vaporized zinc that forms zinc oxide.

Severe expulsion of both zinc and steel may also result as the zinc is evaporated. The pressure system of the welder cannot usually follow up to close the secondary fast enough to overcome the gap between the workpieces made by the evaporation of the zinc (see **Figure 3**).

Comparing Welding Conditions with and without Pulsation

Another consideration inherent in resistance welding galvanized steel with copper electrodes is the formation of brass on the surface of the electrodes. **Figures 4** and **5** illustrate the process of welding galvanized steel with and without pulsation.

Resistance welding is a means of joining metals with heat and pressure. Brass is manufactured by amalgamating zinc and copper with heat under pressure. Therefore, it would appear that the resistance welder is also a brass-making machine when welding galvanized steel. Unfortunately, brass has a higher resistance to the flow of electric current than the copper of the electrode.

The net result is that the high resistance of the brass at the face of the electrode begins to create additional heat at an excessive rate. The increased heat at the face begins to overheat and anneal the copper electrode. The softer copper begins to collapse ("mushroom") at a greater rate. The mushroomed electrode has a larger diameter. Increasing the current will help maintain the correct current density to make the weld, but will create more heat at an even greater rate. The greater heat will create more mushrooming, which will require a higher current to make the weld, which will create more heat, which will continue this cycle of increasing electrode deterioration.

This sequence of events sounds self-defeating, but there are solutions. With pulsation welding, the first weld impulse can be selected to provide sufficient heat energy to melt through the zinc, without creating an oxide and an open secondary. After a short cool interval, the next weld impulse will usually be sufficient to make a proper weld, steel to steel.

Two weld impulses are usually adequate for welding up to 16-gauge steel; 14-gauge steel may require three heat impulses. The result is a better weld and longer electrode life. Metal expulsion may be reduced to near zero with pulsation welding.

The sum of the times of the weld impulses may be about 50 percent greater than a single spot weld sequence for the same material. The cool time should be

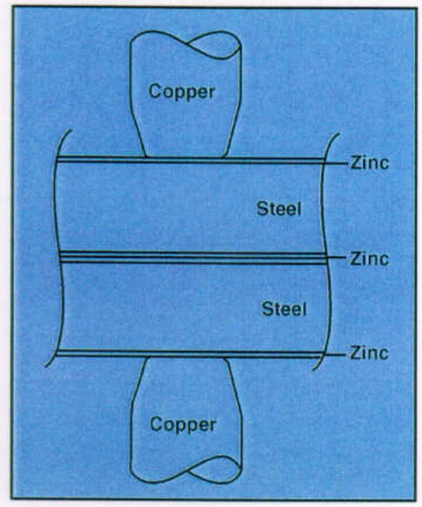
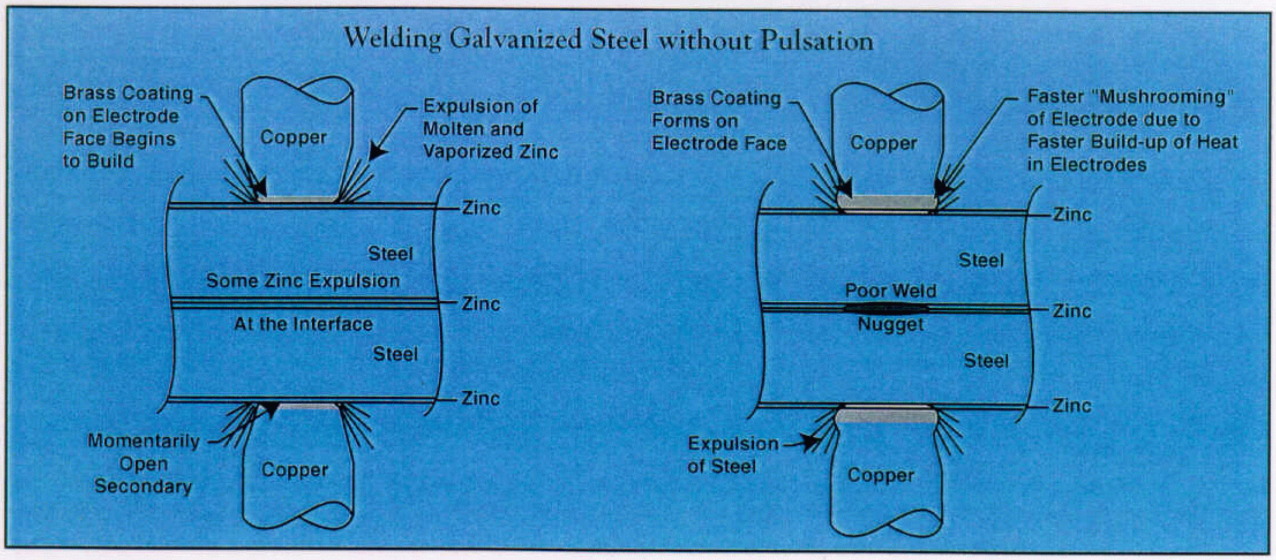


Figure 3
This drawing illustrates electrodes in contact with galvanized steel workpieces before the current flow. Note the gap between the workpieces made by the evaporation of the zinc.



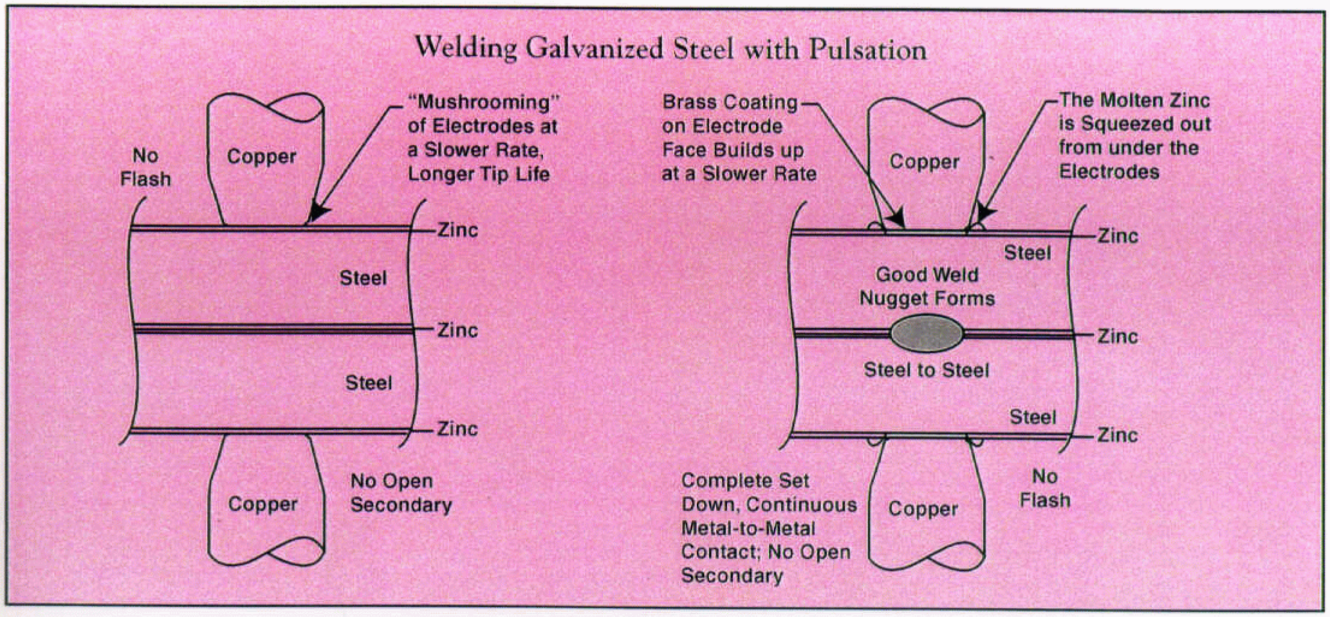


Figure 5

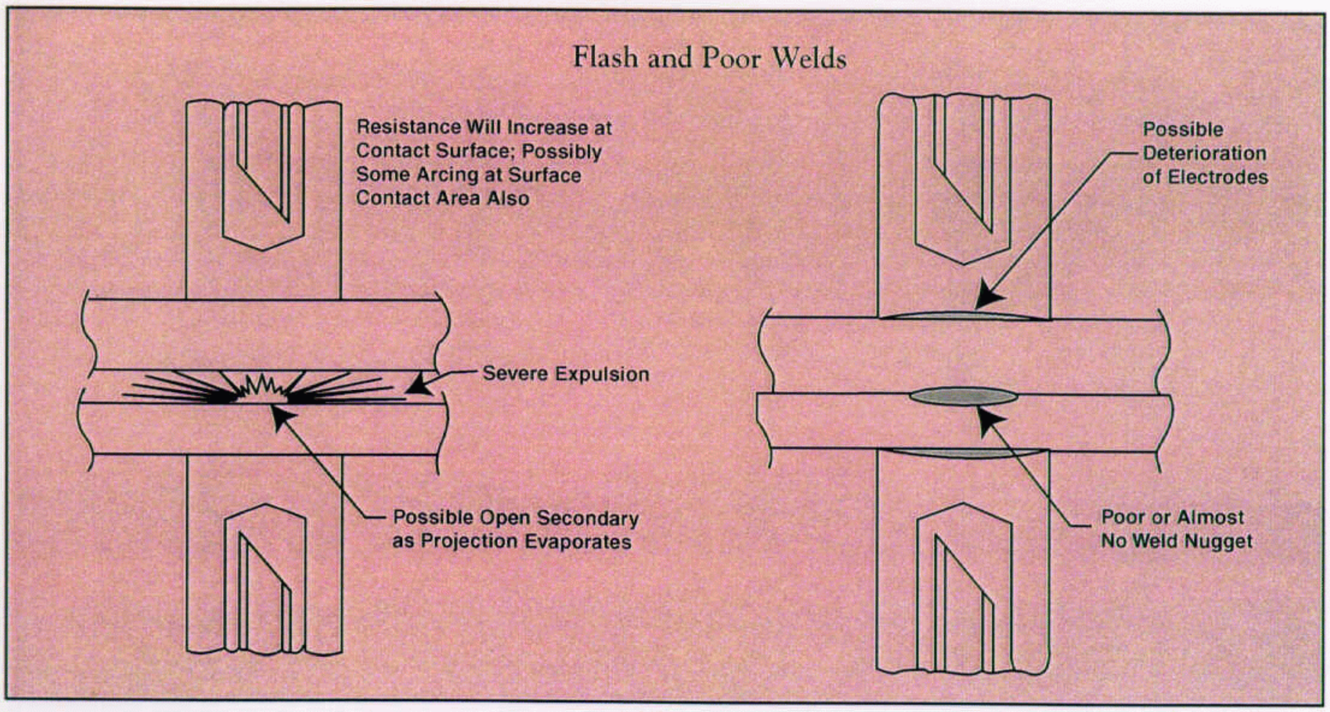


Figure 6

By using pulsation techniques, the total heat energy of the weld will be applied over a longer time, allowing the pressure system of the machine to provide the mechanical follow-up needed to set down the projection properly to make a good weld.

about ½ to ⅓ of the weld time.

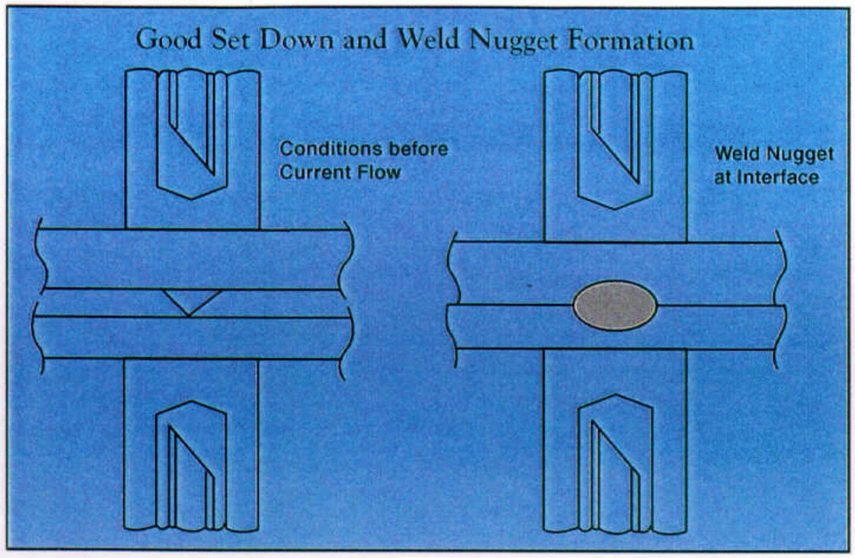
Four methods exist for welding galvanized steels. Although **pulsation welding** will create a longer weld sequence per weld, it provides for a much longer electrode life, usually greatly offsetting the longer weld sequence time. Total production is actually increased, sometimes up to 100 percent, over a simple spot sequence, because maintenance on electrodes is greatly reduced.

Second, **dispersion-strengthened copper electrode caps** can further extend electrode life.

Third, **weld current steppers** are also used to help extend electrode life by advancing the weld current in predetermined increments at predetermined times. They are empirically matched to increase the current to the change in current density required to overcome the mushrooming of the electrodes.

Fourth, **upslope control** can also be used successfully for welding galvanized steel. The upslope function allows starting the weld current at a low enough level to allow the electrodes to melt through the zinc, then subsequently increasing the current to a value sufficient to make the steel-to-steel weld.

Some fabricators combine two, three, or all four methods when welding galvanized steels.



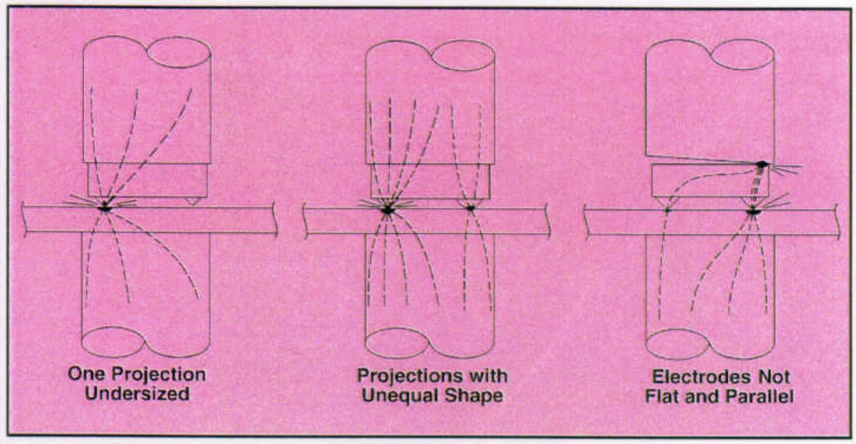


Figure 8

With multiple projections, it is often difficult to maintain tooling that will provide absolutely equally shaped projections. Although the differences in height or size of the projection may be small, the potential for unequal, parallel current paths through the projections is significant.

Projection Welding

Pulsation welding techniques can be applied to projection welding, particularly to help set down large or multiple projections. When welding large or multiple projections, the current requirements may be quite high.

Unfortunately, the pressure system of the welder might not be able to follow up and properly set down the larger projection at the rate the current through the projection is melting the material (see **Figure 6**). The result is often a poor weld with a large amount of metal expulsion (flashing).

By using pulsation techniques, the total heat energy of the weld will be applied over a longer time, allowing the pressure system of the machine to provide the mechanical follow-up necessary to set down the projection properly to make a good weld (see **Figure 7**). Upslope control can also be used with projection welding.

With multiple projections, it is often difficult to maintain tooling that will provide absolutely equally shaped projections. Although the differences in height or size of the projection may be small, the potential for unequal, parallel current paths through the projections (Kirchoff's Law of Distributed Networks) is significant (see **Figure 8**).

If the current paths are not reasonably equal, the resulting total weld may not meet specifications and may cause extensive expulsion at one or more of the projections. This effect can shorten electrode life and cause a personnel hazard as well.

Again, pulsation welding techniques may help to assure a more equal and uniform set down of the projections to create properly formed weld nuggets at each projection.

Welding with an Undersized Transformer

A third use of pulsation welding can be to increase the effective capacity of a welding transformer. A pulsation sequence, weld and cool, provides a cooling period in the welding machine transformer that can essentially reduce the effective thermal duty cycle of the transformer.

In this manner, the capability of a machine designed to meet the production requirements of welding 16-gauge material could possibly be extended to weld 14-gauge or heavier material without damage to the welding transformer. Production rates, of course, will be lower.

Although this may not be the most efficient long-term use of a machine, the technique may be used when short production runs are necessary in job shop applications, when the investment in a larger, properly sized machine cannot be justified.

A pulsation sequence can be programmed into most microprocessor-based controls and can add greatly to the overall efficiency and production capacity of the welding machine.

Conclusion

Multiple impulse (pulsation) welding techniques can be used successfully to overcome, or simplify, the welding of many ferrous-based products, as described previously.

Because of the high conductivity of nonferrous metals, multiple impulse welding cannot be used effectively for joining aluminum or copper-based products, for example. Also, it is not recommended to use constant current functions with multiple impulse welding. ■

Robert Cuff is Chairman of Entron Controls, 465 E. Randy Rd., Carol Stream, IL 60188, phone 630-682-9600, fax 630-682-3374. Entron Controls is a manufacturer of a complete line of microprocessor-based resistance welding controls. The company is a member of the Resistance Welder Manufacturers' Association (RWMA), 1900 Arch St., Philadelphia, PA 19103-1498, phone 215-564-3484, fax 215-963-9785, Web site www.rwma.org.

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1344 Woodman Drive
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888-654-WELD (9353)
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