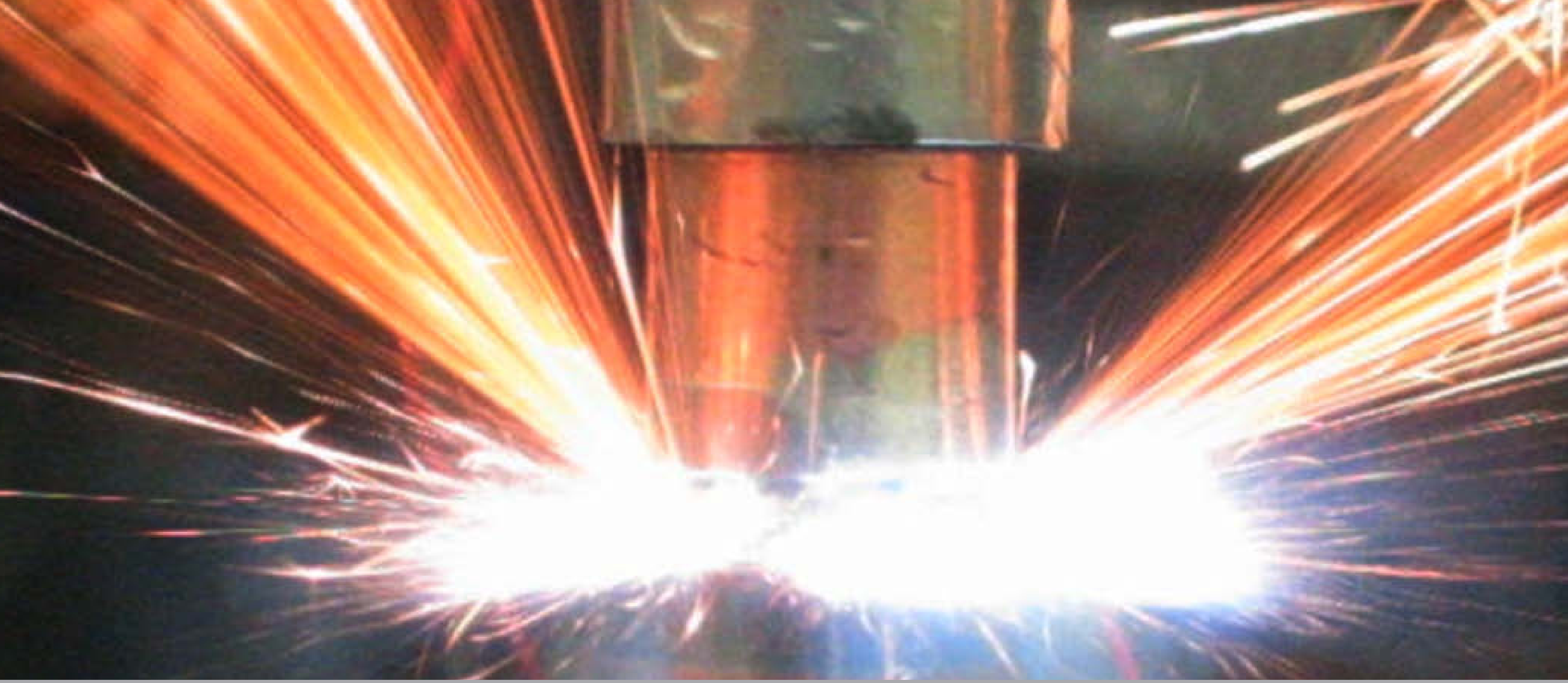

PROJECTION WELDING OF FASTENERS TO HOT-STAMPED BORON STEEL

How capacitive discharge welding helps improve consistency in part quality

By Allen M. Agin and Bob Kollins

Many studies and articles have addressed the subject of spot welding boron aluminum silicon (AlSi) coated and uncoated hot-stamped material, but few have addressed projection welding of fasteners to these materials.

The processes used to transform boron steels for hot stamping can create many obstacles to the welding of fasteners. The extreme change in hardness after the quenching process can strengthen base material by as much as 250 percent. In addition, an AlSi coating is tough to break through with traditional methods. If the material is uncoated, the heating process typically causes oxidation (scaling) and surface decarburization.

Hard Material Versus Soft Projections

Hot-stamped boron steels are lightweight and can offer tensile strengths of 1,500 MPa, making them desirable for use by automobile manufacturers striving for better gas mileage while maintaining 5-star crash test ratings. These materials typically are used to produce A, B, and C pillars; roof reinforcements; moon roofs; and drive shaft tunnels.

The weld nuts and studs used in projection welding, a common joining process for the manufacture of automobile components, are considerably softer than the 1,500-MPa hot-stamped boron steel parts. This causes the projections in the fastener to collapse before a good weld can be made, resulting in vaporized projections and extended weld times as the operator tries to forge the materials.

Unsurprisingly, this type of weld process usually causes weak, inconsistent torque and pushout values.

Extended Weld Times Are the Enemy

Typical weld times with alternating current (AC) or medium-frequency direct current (MFDC) processes are 6 to 10 cycles (100 to 160 milliseconds). These longer weld times make it almost impossible to use the high contact resistance present in the hot-stamped boron steels.

Without being able to capture the heat on the rising edge of the current profile, the projection welding process becomes more of a forging process, which in turn can cause deformation of the nut and damage the threads. The differences in the heating of the projections compared to the base metal cause inconsistent pushout and torque testing.

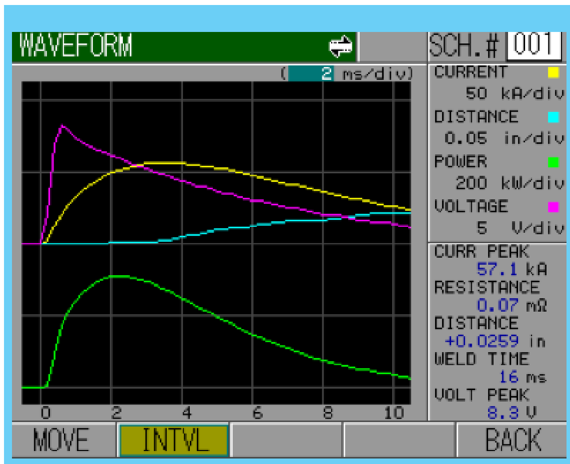

Figure 1
Capacitor discharge welding controls can deliver a peak current in 3 ms, allowing for better use of the high contact resistance of hot-stamped boron steel.

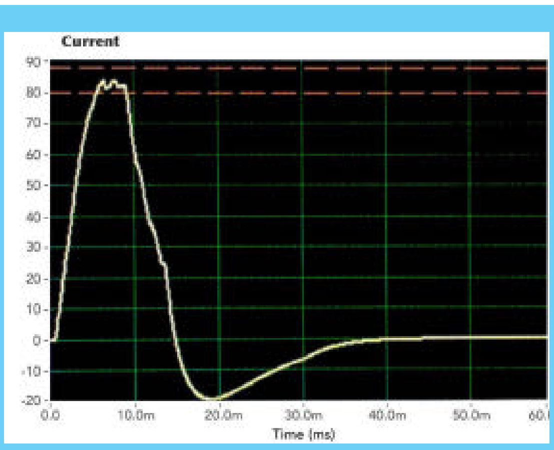

Figure 2
A 4,000-amp MFDC weld control can reach 83 kiloamps in 6 ms. However, its constant-current, closed-loop feedback process works best when the weldment resistance is consistent.

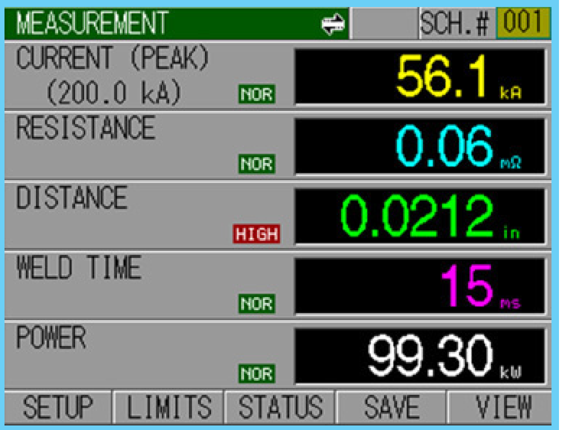

Figure 3
Common baseline parameters are set on a CD welding machine.

Capacitor discharge (CD) welding controls can deliver a peak current in 3 ms (see **Figure 1**). This fast rise to current allows for better use of the high contact resistance of the hot-stamped boron steel, resulting in total weld times typically less than 10 ms.

Shorter weld times in turn allow for much higher currents and higher weld force without damaging the nut or threads. This process can produce higher-than-normal pushout and torque values at a level consistent with automotive requirements.

Fast Follow-up and Machine Rigidity

While CD welding systems can use the high contact resistance inherent in boron steel parts, the challenge remains of keeping the electrodes in contact with the parts during the collapse of the projections.

The solution is to size the weld cylinders, weld ram, and fast follow-up mechanism for each application. Using sizing, the welding machine manufacturer can ensure a correctly configured fast follow-up package that meets the needs of the application.

In addition, the frame of the welding machine must be able to accommodate the added stresses caused by the high forces and increased rates of acceleration in CD welding with little or no deflection.

Closed-loop Versus Open-loop Feedback

Figure 2 shows a 4,000-amp MFDC weld control reaching 83 kiloamps in 6 ms. While this is an extremely fast rise to current for an MFDC welding machine, it uses a constant-current, closed-loop feedback process. While this process typically is preferred, these systems work best when the weldment resistance is consistent. Hot-stamped boron steels with an AlSi coating or an uncoated shot-peened surface have a hard time presenting a consistent surface resistance, so heat generation can be inconsistent.

In comparison, the CD weld process is open-loop, producing a rapid pulse of current that creates instantaneous heating at the weld interface. This is similar to constant-voltage feedback—small changes in current based on resistance changes while maintaining appropriate heat generation.

Process Monitoring

A comprehensive weld monitor is essential for CD welding. After establishing baseline process parameters (see **Figure 3**), the welder can set high and low windows to ensure the process stays within required limits. Welders can measure the electrical characteristics of the weld and the amount of mechanical movement (set-down) of the projection.

Consistent Results

CD welding is not a new technology; fabricators and Tier 1 and 2 suppliers have been applying it to projection welding of fasteners to hot-stamped boron components for several years. High current, high weld force, short weld times, and fast follow-up mechanisms and rigid frames on the welding machines themselves all play into the process.

Customer installations and laboratory testing have shown CD welding to exceed manufacturers' required pushout and torque requirements with no damage to the fastener threads. Consistent results have nearly eliminated postweld inspections at the stamping and assembly plants using this technology. ***FAB***

Allen M. Agin is Midwest regional sales manager, Weld Systems Integrators Inc., 216-475-5629, allen@wsiweld.com, http://wsiweld.com. Bob Kollins is senior applications engineer, Technical Sales & Solutions LLC, 614-793-9612, bob@tsssales.com, www.tsssales.com.