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Laser and Resistance Welding - Minimizing Weld Splash

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Weld Splash Definition
Weld splash is the unwanted creation of small metal particles that are expelled from the welding area during the welding process. These small metal particles can be airborne in the form of "hot sparks" or can solidify as small "balls" or "filaments" that remain loosely attached to the welding area. Figure 1 shows two flat plates being welded together with weld splash occurring in the form of hot sparks (a) and attached filaments (b).

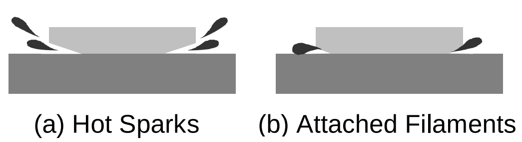

Figure 1 – Sectional view of weld sparks (a) and attached filaments (b).

Using force to hold both parts together during the welding process can result in part deformation and material flow from the welding area. Weld flow comes from the base materials and should not be categorized as weld splash. When compared to the laser welding process, resistance welding typically produces a larger amount of weld flow and parts deformation due to the higher contact force employed in the resistance welding process. Figure 2 shows weld flow for both a round wire-to-flat plate weld (a) and a flat plate-to-flat plate weld (b).

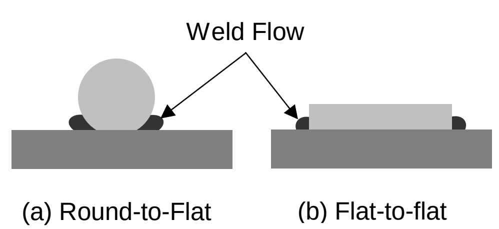

Figure 2 – Sectional view of weld flow round-to-flat (a) and flat-to-flat (b)

Why Care About Weld Splash?
Excessive weld splash can be an indicator of a weld joint filled with voids and cracks, which can propagate with vibration and temperature cycling to create a future weld failure.

Both weld sparks and weld filament particles can cause part contamination and mechanical damage. For electrical and electronic applications, conductive debris is prohibited.

Severe weld sparking in particular can contaminate the face of a laser focusing lens or protection glass, creating surface "hot spots" that can potentially crack these elements. At best, weld sparking reduces the laser energy to the parts. Excessive weld sparking in resistance welding results in reduced electrode life since a portion of the weld sparks comes from the electrode tip.

What Causes Weld Splash?
Material plating, dissimilar thermal conductivities, excessive weld energy, surface effects such as organic contamination and reflection characteristics (laser), parts geometry, and point of heat application can create severe weld splash.

Material Plating
Cadmium (320°C), lead (327°C), solder (183°C), tin (232°C), and zinc (419.5°C) are typically used as plating materials. These low temperature materials flow and vaporize long before the base materials begin to melt and thus represent the major source of weld splash. Entrapped hydrogen gas produced by electroplating can also produce weld splash.

Material Thermal Conductivity and Weld Energy
Weld splash can occur when welding two thermally dissimilar materials such as copper and iron. The copper requires a short duration, fast rise time, high energy weld pulse, whereas the iron needs a longer duration, slower rise time, low energy weld pulse. Thus, a weld heat profile that fits the copper's heating requirement usually creates iron weld splash.

Surface Effects
Organic contamination and disparities in reflection (laser) can cause significant weld splash, particularly if the top part is thermally absorbent and the bottom part more thermally reflective.

Parts Geometry and Point of Heat Application
Weld splash can be easily created by trying to conduct weld heat through parts that do not fit together properly or by welding too near a part's

edge. In both cases, the air/part barrier increases the weld energy density, resulting in weld splash.

Minimizing Weld Splash
Minimizing weld splash involves displacing the plating, optimizing the weld energy profile, and controlling the weld geometry.

Displacing the Plating
If plating must be used, limit the thickness to 12 microns (500 micro-inches) or less. Plating thicker than 12 microns must be displaced or substantially thinned through the use of a pre-heat weld energy profile and sufficient weld or clamping force. An oven bake prior to welding may help free any entrapped hydrogen gas.

Figure 3 shows three different pre-heat weld energy profiles. For thermally conductive materials, use a constant, low energy pre-heat profile (a). For thermally resistive materials, use up slope (b) or dual pulse (c) profiles. Use the Design of Experiment (DoE) process to optimize pulse shape. For a quick review of the DoE process for both laser and resistance welding, please retrieve these microTips from the microJoining Solutions web site at:
http://www.microjoining.com/microTip_Library.htm

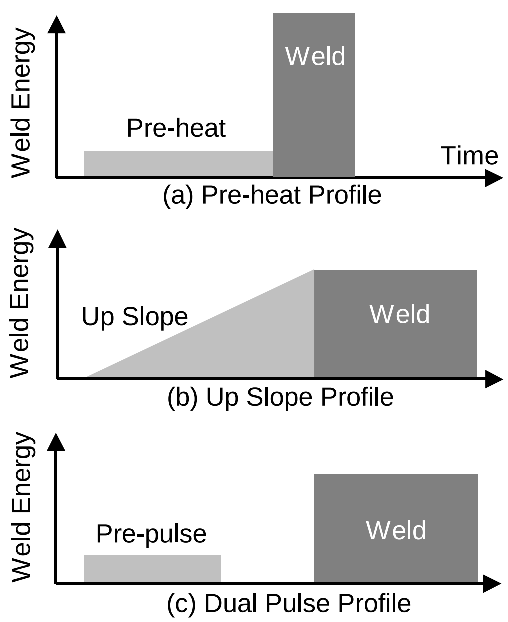

Figure 3 – Pre-heat weld profiles: (a) Pre-heat, (b) up slope, and (c) dual pulse.

Optimizing the Weld Heat Profile
As shown in Figure 3, parts that are thermally similar are the easiest to optimize for pulse shape and weld energy. The more typical welding application involves the joining of thermally dissimilar materials such as nichrome or steel and brass or copper. Tin or solder plating further complicates the welding process.

The final weld energy magnitude and weld energy application rate is a compromise between the thermal needs of the resistive and conductive parts. Use weld strength and the degree of weld splash as the two output response measurements for the DoE.

Figure 4 shows a weld energy profile for a nichrome wire to tin-plated brass terminal weld. Note the low energy pre-heat pulse for displacing the tin-plating followed by the high, but slowly rising weld pulse. The up slope portion of the weld pulse helps to prevent the nichrome from sparking.

Controlling the Weld Geometry
For new projects involving weld joints, prevent or reduce weld splash by controlling the weld geometry. Ensure that the weld joint is sufficiently inside the closest part edge. Depending on the thermal conductivity and thickness of the parts and the energy used to weld the parts, this distance can range from 0.5 to 6 mm (.02 to .24 inches). Higher weld energy requires a greater distance from the closest part edge. Design parts to fit together with an air gap that is less than 10% of the thinnest part. Hard parts

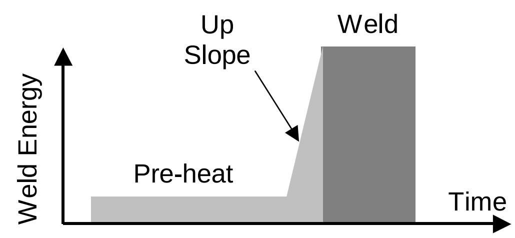

Figure 4 – Nichrome wire to tin-plated brass terminal weld energy profile.

require a high contact force to overcome the spring pressure.

Conclusion
Weld splash can be significantly reduced by displacing the plating, optimizing the weld heat profile, and by controlling the parts geometry.