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Resistance Welding – Trouble Shooting Guide

When Trouble Happens

Typically, the production technician or machine operator goes to the process engineer and tells her, "Today, the welding process is not meeting spec" or, "The power supply is blowing up the parts". The process engineer responds by telling the operator, "Adjust the power supply". The operator adjusts the weld energy and things seem to work again…for a short while before the welding process goes out of limit and the operator is forced to readjust the power supply once again.

Power Supply Technology – Not the Problem

Today's closed loop, high-speed, feedback controlled power supplies produce consistent constant current, voltage, or power weld energy. The control variance is typically less than 2% of setting, down to a minimum absolute amount, depending on the power supply range. Therefore, the power supply is rarely the source of unexplained resistance welding problems.

What are the Real Problems?

To find the source of the real problems, look at what is happening between the electrodes. Invariably, disregarding one or more of the following "welding rules" is responsible for creating unexplained welding problems:

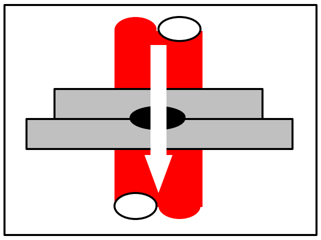
- *Weld current path* - There is more than one weld current path flowing through the parts.
- *Weld current density* – The weld current density is not constant.
- *Heat balance* – The weld heat balance changes over time.

Further investigation always reveals that these problems were either built into the initial welding process development or occurred in production because the effect of time on the welding process was not tested or validated.

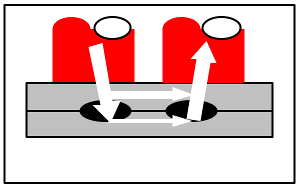
Control the Weld Current Path

The weld current will always follow the path of minimum electrical resistance. The *electrode configuration*, *part geometry*, and *weld fixture design* can ensure welding success by limiting the weld current to a single path.

Electrode Configuration



The opposed electrode configuration shown in the adjacent figure offers the best control over the weld current path. Unless the parts are non co-planar, the weld current passes through the parts in a single path.

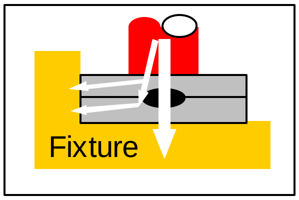


For some applications, electrode access is limited to one part as in this figure. Parallel gap electrodes provide the weld current path into the parts. The bulk electrical resistance, the parts interface resistance, and the electrode gap control how the weld current divides between the top and bottom parts.

Part Geometry

Designing the parts to be resistance welding compliant can prevent many welding problems. Block multiple weld current paths by using physical barriers such as a slot. Equalize thermal loading between a high and low thermal load parts by creating a "thermal island" in the high thermal part to limit heat dissipation.

Fixture Design



Many welding fixture designs inadvertently create multiple weld current paths. Fixture sidewalls that electrically connect the top part with the bottom part can easily shunt the weld current away from the weld in a completely unreliable manner as shown in the adjacent figure.

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Control the Weld Current Density

Passing the weld current through a specific area generates a certain amount of weld heat. Decreasing this area while keeping the weld current constant results in more weld heat. Increasing the area reduces weld heat.

The first major assumption that our process engineer makes is that the electrode contact area is the same as the parts contact area. This assumption is not true. The weld current density is different under each electrode tip and between the parts, leading to a shifting heat balance weld-to-weld and as the electrodes wear over time.

The second major assumption made by our process engineer is that each electrode tip makes 100% contact with its respective part. Due to the micro-scale lack of co-planarity of the electrode tips and parts, and the deflection created by the weld head, the weld current density will be different weld-to-weld and as the electrodes wear over time.

The third major assumption made by our process engineer is that each electrode tip will maintain its shape over time. Regardless of the electrode alloy used, weld heat and pressure will cause the electrode tip to groove when placed against wire, micro-crack, and "mushroom" in size. An electrode tip that increases in size decreases the weld current density and thus the weld heat. Using electrode tips shaped to match their parts helps to slow down this deformation process, but may be hard to maintain in production. There are two methods to deal with decreasing weld current density over time.

One, when using constant current, periodically increase the weld current over time to match the increase in electrode tip contact area. This compensation scheme works until the electrode tips become so heavily plated, oxidized, or cracked that the overall heat balance is affected, which in turn decreases the weld quality.

Two, use constant weld voltage control, which automatically ensures constant weld current density. However, using constant voltage control has a down side. As electrode tips begins to deform and increase in area, plating or oxide from the parts transfer to the electrode tips, increasing the interface resistance between the electrode tips and parts. This increased interface resistance reduces the weld current density, thus reducing weld quality.

Control the Heat Balance

Weld heat balance is the result of the interaction between the weld current path, weld current density, and parts materials properties. The heat balance changes weld-to-weld and over time.

Material properties such as plating quality and thickness radically affect the heat balance. For example, as tin plating builds up on electrode surfaces, the heat balance shifts from the parts interface to the electrode-to-part interfaces. Increased electrode tip heat causes electrode tip sticking, cracking, and mushrooming.

Conclusion - How to Succeed

The key to developing a six-sigma resistance welding schedule is to include time as part of the development process. Most process engineers do not accommodate the shifting effect of time. Here are some key points to ensure success:

- Work with the parts designer and automation designer before making a single part or weld to create a single weld current path.
- Recognize that the weld current density and the heat balance shift with each weld.
- Create a weld quality metric that meets the needs of how your product will be used by your customer. Requiring the maximum pull or peel strength is not necessarily the answer, and can produce unnecessary scrap.
- Run your Design of Experiment (DoE) process in a random fashion to help mitigate the effects of changing weld current density and heat balance.
- Do confirmation testing to find the electrode life limit that will maintain weld quality as the weld current density and heat balance shift.
- DO NOT operate beyond your *proven* electrode life data.
- Measure weld quality at the beginning and end of electrode life.
- Validate your welding process using an independent metric such as temperature and vibration cycling and drop testing.