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Resistance Welding – Quality Assurance Issues
“Appearances are Deceiving-1” By David Steinmeier

The Problem
Most manufacturing companies utilizing resistance welding processes to join metal parts use visual criteria to pass or fail welded parts.

Regardless of who does the inspection, the operator or a trained quality assurance inspector, the visual inspection process can not predict weld quality in terms of weld peel or pull strength. Relying on visual inspection virtually guarantees unnecessary product scrap and welded products that will fail in the field.

Why Visual Inspection Doesn’t Work
Visual inspection techniques fail to measure weld quality for the simple reason that the interface between the welded parts is not visible without sectioning or X-raying the parts.

In the case of similar materials, the depth of fusion weld penetration is not visible. For dissimilar materials such as molybdenum and tungsten, the extent of sold state bonding is not visible. For metal parts plated with low melting temperature coatings such as cadmium, lead, silver, or tin, the degree of interface reflow is not visible.

Finally, heat balance problems can cause one part to heavily melt while the other part hardly heats up. This imbalance results in a weak weld that is not visible to the operator or inspector.

Visual Inspection Techniques
Visual inspection techniques primarily fall into three categories: a) weld mark size and shape, b) degree of surface discoloration, and c) degree of “sparking” or expulsion.

Weld Mark Criteria
Most resistance welding leaves a “footprint” or surface mark that is created by the electrode. The amount of heat generated in the part determines the size and shape of the final weld mark. Unfortunately, the weld mark does not indicate the size and depth of the fusion weld or “nugget” at the interface between both parts being welded.

Consider the following weld mark inspection example. A very small wire is resistance welded to a large stainless steel pin at one end of the wire and to a large stainless steel header at the opposite end of the wire. The machine operators use a series of photographs prepared by the manufacturing engineer to identify “good”, “hot”, and “cold” welds. They also use the photographs to initiate electrode changes based on the weld mark appearance.

Weld quality was suspected to be a function of the minor diameter dimension (“Y” in Figure 1) because as the electrode degraded, the shape of the minor diameter changed. To prove or disprove this supposition, new and used electrodes were used to make a series of test welds. Key dimensions defining the weld mark were measured. Each weld was then pulled tested. All of the dimensional data and pull test data were then analyzed to see if a correlation existed between any weld dimension (appearance) and the weld pull strength.

Figure 1 shows the welded wire profile and corresponding dimensions used in the analysis.

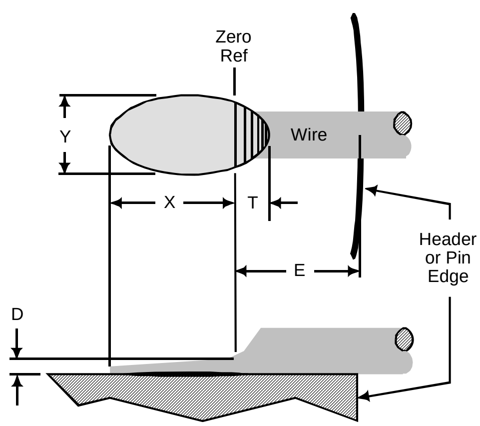

Figure 1 - Welded wire dimensions.

Figures 2 and 3 show a scatter plot of the weld mark’s minor diameter for both the header and pin welds versus pull strength for a *worn out* electrode and a *new* electrode respectively.

Weld Mark Criteria Example

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Note that each set of data points falls primarily in a horizontal plane, indicating a lack of strong correlation with the pull strength.

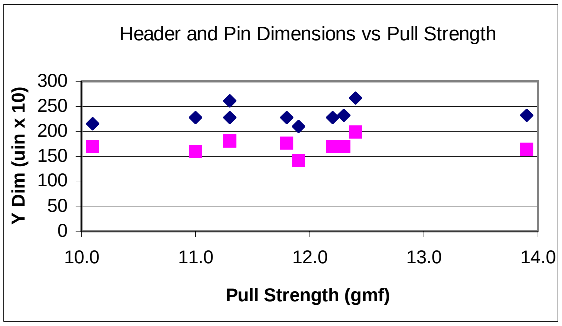

Figure 2 - Body (Diamonds) and Pin (Squares) dimensions versus pull strength – worn electrode.

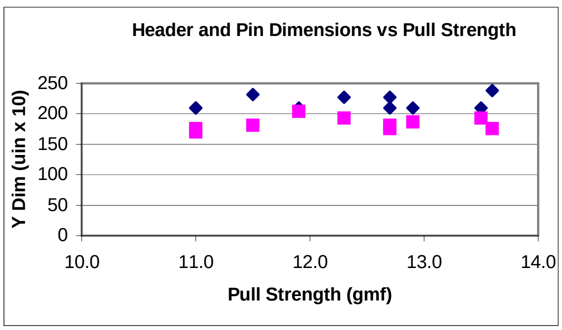

Figure 3 - Body (Diamonds) and Pin (Squares) dimensions versus pull strength – new electrode.

A comprehensive regression analysis also showed no correlation between *any* dimension, new or worn electrode and pull strength. Therefore, visual inspection of each weld represents an economic loss to manufacturing and does not create any quality assurance for the end customer.

Weld Surface Discoloration Criteria
Gauging the degree of weld surface discoloration is also pointless since the spread and intensity of the surface discoloration depend both on the external and internal heat generated by the welding process. Discoloration doesn't represent the weld condition between the parts interface.

Weld "Sparking" Criteria
Many manufacturers use weld "sparking" or material expulsion to judge resistance weld quality. The operators are told that more "sparking" represents a stronger weld. In reality, the sparks come from bits of over-heated electrode tip and parts material. "Sparking" creates voids in the weld area, substantially reducing the weld strength.

Consider the following battery pack welding application. The 90° peel test strength of interconnecting tab weld was about 1 dN. After optimizing the weld energy and weld force, all "sparking" was eliminated. The peel strength rose to an average of 5 dN, and the electrode life improved by a factor of three times or more. "Sparking" is a potential contra-indicator of weld quality.

What's a Manufacturer to Do?
Since weld appearance, discoloration, and sparking are useless measures of resistance weld quality, how can a six-sigma oriented manufacturer ensure reliable resistance welds?

Fortunately, there are three possible solutions:
1. Periodically sample weld quality by using destructive peel or pull testing.
2. Periodically sample weld quality by sectioning welded parts to monitor weld penetration.
3. Monitor peak weld current or voltage for correlation with peel or pull strength.

Figure 4 shows how peak weld current was successfully used to monitor the weld quality of the previously described wire weld example. As the peak weld current exceeds 30 amps, the pull strength decreases rapidly.

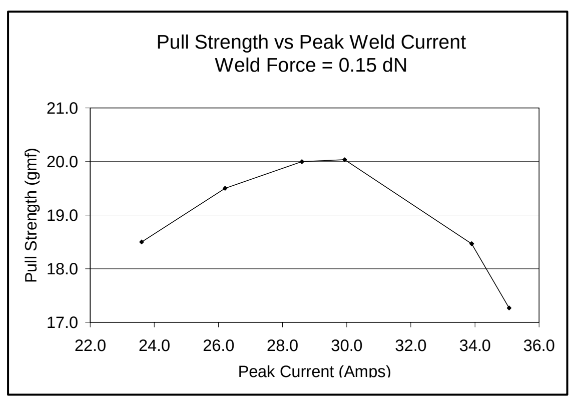

Figure 4 – Peak weld current versus pull strength.

Use destructive testing, sectioning, and weld current or voltage monitoring to ensure weld quality.