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Resistance Welding - Weld Monitoring Basics-1
By David Steinmeier

The “Holy Grail”
The “Holy Grail” of weld monitoring for micro resistance welding is to find one or more real time welding parameters that can positively identify each weld as good or bad in terms of the potential pull or peel strength of the welded parts.

Reality
Unfortunately, the present state of the art of micro resistance weld monitoring does not live up to the “Holy Grail” standard for a variety of reasons. One, the standard deviation of the weld pull (tensile) or peel strength is very large in relation to the range of the weld monitor parameters. Two, the poor sensitivity, frequency response, and signal-to-noise ratio characteristics of most weld monitor sensors mask potential weld quality information.

Both Figure 1 and Figure 2 illustrate the weld monitoring dilemma. For example, Figure 1 shows that given a weld current of .550 KA, the pull strength can range from 19 to 34 lbs.

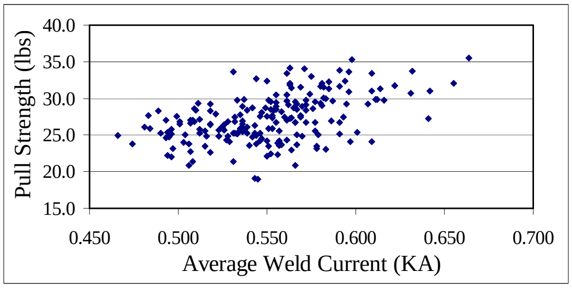

Figure 1 - Pull strength versus weld current.

Figure 2 demonstrates that given a weld displacement, also called “set down”, of .0030 inches, the pull strength can range from 19 to 35 lbs.

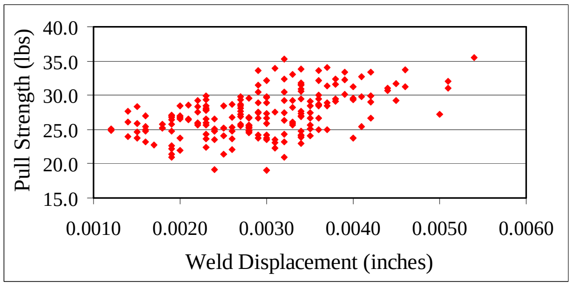

Figure 2 - Pull strength versus weld displacement.

Process Variation Sources
The standard Design of Experiment (DoE) process using constant weld current, voltage, or power, weld time, and constant weld force as the prime input factors is a good predictor of *average* weld strength. However, these highly controlled input factors do not explain the large variations in weld pull strength shown in Figures 1 and 2.

It is suspected that these large variations are caused by variations in the electrical interface conditions between the parts, in the base weld material strength, weld monitor sensor noise, and in the pull strength test method.

Then Why Bother with Weld Monitoring?
The success of weld monitoring depends to a very large degree upon the definition of weld quality. Referring to Figures 1 and 2, a minimum “weld quality” requirement of 35 lbs demands that the weld current never drops below .670 KA or the weld displacement never drops below .0057 inches. However, the yield for this high level of “weld quality” is much less than 1%.

If the minimum “weld quality” requirement is 15 lbs, then a minimum weld current of .470 KA or a minimum .0013 inches of weld displacement will ensure a yield of virtually 100%.

Thus for a minimum weld quality level of 15 lbs, weld monitoring does offer significant economic benefits by ensuring that the welding process does not drift below a minimum acceptable level. However, weld monitoring can not be used to predict the exact weld strength of each weld.

Weld Monitor Parameters
Micro resistance weld monitor parameters include electrical and mechanical measurements.

Electrical Parameters
Weld voltage and current comprise the basic welding electrical parameters. As the number of welds increases, weld voltage typically increases while weld current decreases. Dividing the weld voltage by the weld current produces weld resistance, which increases with the number of welds. Multiplying the weld voltage by the weld current produces weld power, which is a useless weld monitor parameter

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because the weld voltage and current trends tend to cancel each other, keeping the calculated power relatively constant with each weld.

The type of welding power supply automatically narrows the choice of weld monitor parameter. Monitor the weld current when using constant voltage welding. Monitor the weld voltage when using constant current welding. Monitor both weld voltage and weld current when constant power welding or when using a non-feedback power supply.

The weld voltage and weld current measurement technique can make a big difference in the sensitivity and resolution of these parameters. Common measurement techniques include: peak, root-mean-square (RMS), average, and time integration, which is just another averaging technique. Peak measurements work well with linear DC, inverter, and stored energy (CD) power supplies. Average, RMS, and time integration work well with direct energy (AC) power supplies.

Mechanical Parameters

Weld force and weld displacement constitute the prime mechanical welding parameters. Weld nugget size measurement requires x-ray or destructive cross sectioning. Visual weld appearance inspection, while very popular, is totally useless due to the complete lack of correlation of visual appearance and dimensions with predicted weld strength.

Peak weld force represents electrode impact on the parts and thus controls the initial interface resistance between the parts. Depending on the application, peak weld force can be used to predict the average electrode life and average weld strength, but not the exact weld strength of each weld.

Displacement monitoring measures the distance that the parts compress into each other during welding. Displacement monitoring works well with most “soft” materials such a nickel and stainless steel, but is ineffective when used on hard materials such as carbon steel, molybdenum, and tungsten. Displacement monitoring can be used to set a minimum weld strength limit, but like its other electrical and mechanical brethren, displacement monitoring can not predict the exact weld strength of each weld.

Sensor Types

The user must make the proper weld monitor sensor selection to ensure signal sensitivity, accuracy, and resolution. Weld voltage must be measured near the electrodes. Weld current requires a current coil, precision resistor, or Hall Effect Device to convert current to a voltage representing the weld current. The precision resistor offers the best resolution, accuracy, and waveform preservation, but is harder to install compared to the other current sensors.

Weld force can be measured with a load cell or accelerometer. Weld displacement can be measured using capacitance, magnetic, optical, and resistive sensors or by double integrating the weld force over the weld time.

Installation

The improper installation of a weld monitor sensor can negate the measurement capabilities of even the best and most sensitive weld monitor sensors. Weld current can be monitored anywhere in the power supply output circuit since the same current flows through the entire output circuit. However, weld voltage must be monitored as close to the electrode tips as possible, especially when using high resistance electrodes such as molybdenum or tungsten, which drop appreciable voltage and thus decrease the measurement sensitivity. The distance from each electrode tip to the parts should be as short as possible and must remain constant.

Weld force and displacement sensors must be in direct line with electrodes in order to produce the best signal-to-noise ratio. Figure 3 shows the best location for each sensor type.

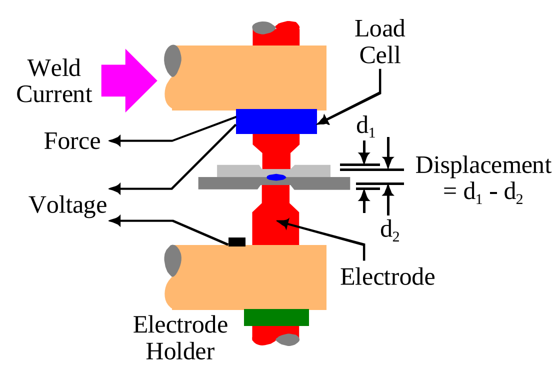

Figure 3 - Weld monitor sensor placement