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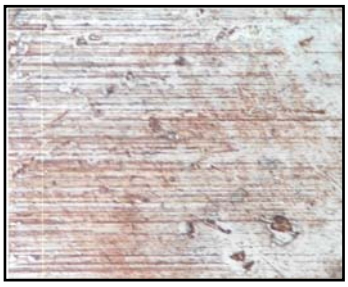
Resistance Welding – Electrode Seasoning-2
By David Steinmeier

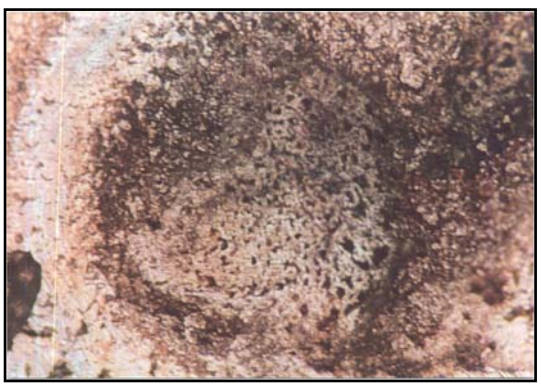
What is Electrode "Seasoning"?
Electrode "Seasoning" is the alteration of a clean electrode tip surface over time by mechanical deformation, oxidation, and part plating and base material build-up. This alteration changes the weld heat balance between both weld parts and can affect the weld strength. Newly cleaned electrode tips can produce "hot" or "cold" welds, depending on the welding power supply feedback mode. "Hot" welds exhibit significant electrode sticking and uncontrolled weld splash. "Cold" welds have weak weld strength values. Electrode seasoning typically occurs over a period of 10 to 100 welds before stabilizing.

This photo shows a clean Glidcop copper alloy electrode tip surface after sanding the tip with #600 silicon-carbide sandpaper.



This photo shows same electrode tip surface after making 30 welds on two 0.12 mm thick Nickel Alloy 200 parts.

The last photo shows both nickel build-up and copper pitting on the electrode tip face after 100 welds.

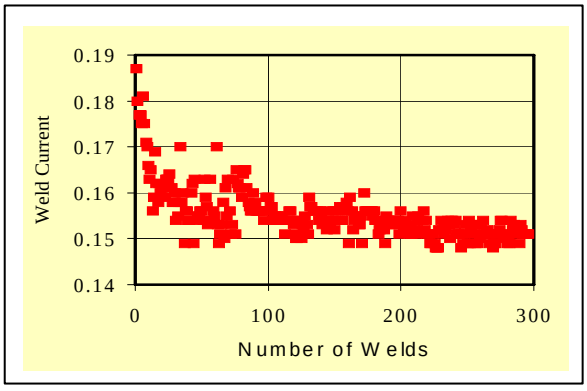


Hot or Cold Weld?
The welding power supply feedback mode determines if a clean electrode tip surface will cause a "hot" or a "cold" weld.

Constant voltage, power, or no feedback resistance welding power supplies produce an initial "hot" weld due to the high peak weld current that flows as a result of the low electrical interface resistance between the clean electrode tip surface and part surface.

Constant current feedback produces an initial "cold" weld due to the low peak voltage drop between the clean electrode tip surface and part surface.

Electrode Seasoning Physics
Repeated heating of the electrode tip by the weld current causes the electrode tip to rapidly undergo plastic deformation, oxidation, and to alloy with the part plating and part material. With each new weld, this process of electrode tip transformation slows down until the electrode becomes relatively stable or "seasoned". The graph below represents a series of constant voltage welds. The graph does not tell us if the seasoning affects the weld strength. However the high initial peak current may cause part damage and severe electrode tip sticking. Note the quick drop in weld current within the first 25 to 30 welds before a steady trend downward begins. The seasoning effect is normally complete by 100 welds.



After many welds, the electrode tip surface eventually becomes so heavily pitted, oxidized, and covered with part plating and part material that the heat generated in the weld is adversely affected, resulting in degraded weld strength.

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Seasoning Variables
The seasoning effect depends strongly on a) the interaction between part and electrode materials b) weld current density, and c) weld force.

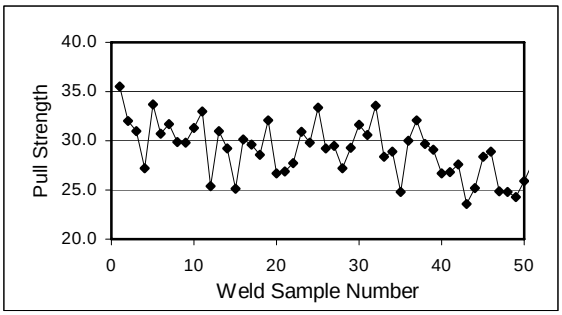
Material Interactions
Low temperature plating like tin and tin-lead solder form a diffusion bond to copper and copper-tungsten electrode tips. The high melting temperature of tungsten (3410°C) and molybdenum (2617°C) electrode tips slows down the build-up of silver, tin, and tin/lead on the tip surface. In all cases, plating build-up causes electrode tip sticking, shifts the heat balance between both weld parts, and can adversely affect the weld strength. The thicker the plating, the faster the plating build-up on the electrode tips.

Part materials like brass, silver, and nickel can also alloy with the electrode tips. Many of the part and electrode material combinations form brittle intermetallic compounds that cause portions of the tip to break off prematurely.

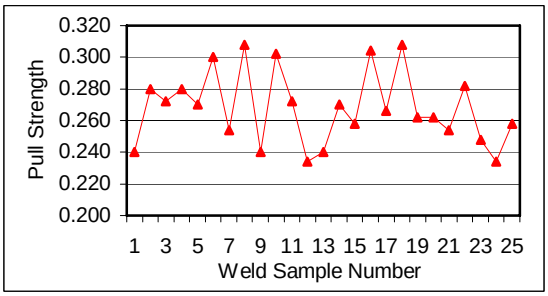
Weld Current Density
If the weld current density is too high in relation to the electrode tip area, then the average tip temperature rises, causing rapid tip deformation, build-up of part plating and material, severe electrode sticking, and short electrode tip life. Use a short electrode tip length, a tip surface area that is larger than the weld current contact area, and water or air cooling to reduce the wear-out effect and increase electrode tip life.

Weld Force
The weld force should be optimized for the welding application. A weld force that is too low causes electrode tip overheating, part material expulsion, and electrode sticking. Excessive weld force produces mechanical damage to the electrode tip surface and can change the weld current density when using a constant current resistance welding power supply.

Does Seasoning Affect Weld Strength?
To find out if seasoning affects the weld strength for your application, gather weld data such as weld current, displacement, voltage, and weld strength over a minimum of 50 welds. The first welding application graph shows that electrode seasoning does affect the pull strength. "Pre-season" the electrode tips before making production parts.



The second welding application shows that electrode seasoning does NOT affect the weld strength and therefore electrode pre-seasoning is not necessary.



"Pre-Season" Electrodes
If seasoning affects weld strength, then "pre-season" clean electrode tips to create a more stable electrode-to-part interface condition. Welding delicate parts such as solar cells without pre-seasoning the electrode tips is very likely to result in solar cell damage. Season electrode tips on scrap parts before beginning a production run or use a "seasoning weld schedule" that adjusts the weld energy to accommodate the seasoning effect.

Design of Experiment (DoE) Precautions
Conducting a DoE without first pre-seasoning the electrode tips can produce DoE results that are unreliable. It may be impossible to attribute the variations in weld strength to deliberate changes in the DoE input factors or to the effect of electrode tip seasoning during the DoE. Use midpoint values for all input factors and then make at least 50 welds before starting the DoE.

Electrode Design Issues
To learn more about electrode design, download the microTip on "Electrode Design for Small and Miniature Scale Resistance Welding" at:
http://www.microjoining.com/microTip_Library.htm