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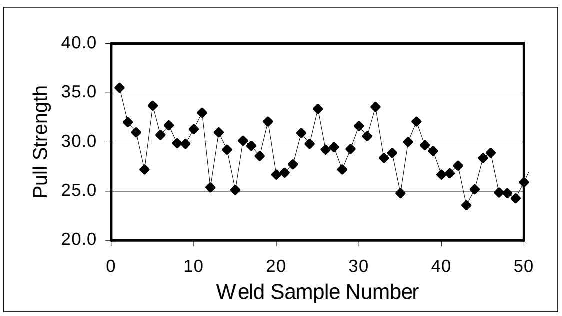
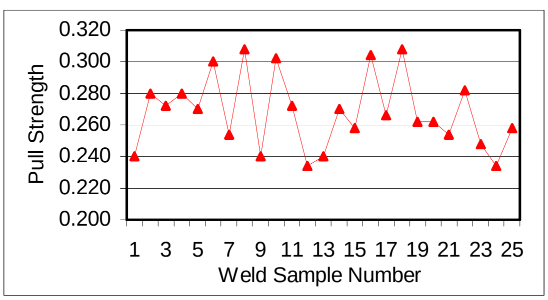
Resistance Welding - Electrode Seasoning-1
By David Steinmeier

What is "Seasoning"?
"Seasoning" is the alteration of new electrode tip surfaces by metallurgical and mechanical forces. Seasoning occurs at the beginning of the electrode life cycle. New electrodes initially produce hotter welds with more material expulsion until the electrode tip surfaces are fully seasoned. Depending on the electrode tip material, part materials, and generated weld heat, electrode seasoning can occur in as few as 5 welds and up to as many as 100 welds or more.

Why Seasoning Electrodes Can Be Important
Installing electrodes with freshly ground tip surfaces on a production line without first seasoning the electrodes off-line, can severely affect the weld quality of delicate parts such as semiconductor materials and solar cells as shown below.



Other parts may be sufficiently thermally robust so that the electrode seasoning process has no effect on the welded parts. See graph below.

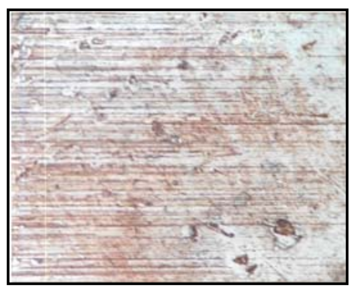


Pre-seasoning the electrodes helps to create a more stable electrode-to-part interface condition, slowing the typical drop off in weld strength with each new weld.

The Design of Experiment (DoE) process can also produce unreliable results if the electrodes are not pre-seasoned before each DoE. Without pre-seasoning the electrodes, it is difficult to determine if the variations in weld strength are caused by the lack of pre-seasoning or by the actual DoE process.

Finally, each resistance welding application responds differently to the seasoning effect. The only positive way to test each weld application for its sensitivity to this effect is to gather weld data such as weld current, displacement, voltage, and weld strength over the electrode life cycle.

What Happens During Electrode Seasoning?
Seasoning affects the new electrode surface in two important ways. One, the flat electrode surface undergoes a deformation process. Two, the part material begins to build up on the electrode tip surface.



The adjacent figure shows a new Glidcop copper alloy electrode tip before welding two 0.12 mm thick Nickel Alloy 200 parts together. The electrode tip was sanded using #600 silicon-carbide sandpaper.

This photo shows same electrode after 30 welds.

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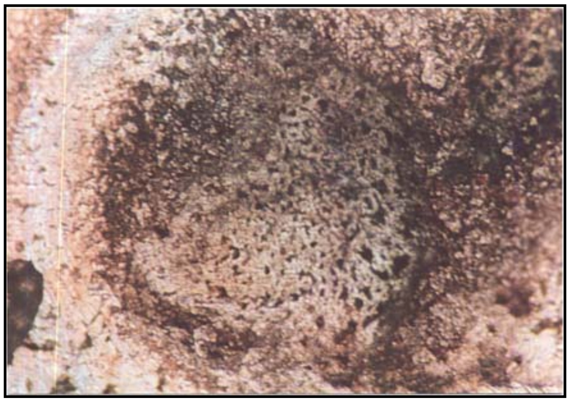
The photo below shows both nickel build up and copper pitting on the electrode face after 100 welds.



Seasoning Variables
The rate at which new electrode tips season depends strongly on: a) weld current density, b) part and electrode alloys, and c) weld force.

Weld Current Density
The initial weld current density for a newly ground or sanded electrode tip is higher than a seasoned electrode tip for two reasons: One, a new electrode tip is free of heavy surface oxides and part material. Two, the electrode tip to part interface consists of many tiny contact points. As the weld current passes through each of these electrically resistive contacts, they begin to deform and then melt due to the intense heat generated at each contact point. Repeated heating of the electrode tip by the weld current causes the electrode tip to undergo plastic deformation, thus increasing the electrode tip to part contact area which in turn decreases the weld current density and weld heat.

Part and Electrode Alloys
Depending on the part and electrode materials and the electrode to part interface temperature, the electrode tip face can alloy or react to the parts material in several different ways. Part material can stick to the electrode tip (solid state bond) or actually alloy (fusion bond) with the electrode tip material. Many of the part and electrode alloy combinations form brittle intermetallic compounds that result in portions of the electrode tip breaking off during the life of the electrode.

Electrode Alloy Selection
Electrode alloy selection is a delicate balance between minimizing the unwanted electrode tip to part bonding and maximizing the required mechanical strength to withstand repeated impacts.

Copper Alloy Electrodes
Electrically conductive copper alloy electrodes are used to weld electrically resistive materials such as iron, nickel, and titanium. The low electrical interface resistance between the copper alloy electrode tip and the part suppresses the interface temperature and thus minimizes the rate of part material transfer to the electrode tip surface. Thus pre-seasoning copper alloy electrodes before beginning a production run may not make any difference from a weld quality viewpoint.

However, as soon as a low temperature plating like tin or tin/lead solder is applied to the iron or nickel part, the tin will quickly form a brittle alloy with the copper electrode surface. Subsequently, the interface temperature gradually increases causing electrode sticking. When the alloying process completely covers the contacting electrode tip surface, weld quality degradation slows down considerably but still continues since mechanical wear creates newly exposed copper surfaces. Thus, pre-seasoning the electrodes can help to create process stability.

Tungsten and Molybdenum Electrodes
Electrically resistive electrode tips are used to weld electrically conductive materials such as brass and copper. The high melting points of tungsten (3410°C) and molybdenum (2617°C) reduce silver, tin, and tin/lead build up on their surfaces. Tungsten is superior to molybdenum both in its higher melting temperature and its hardness, a feature that is important to maximizing electrode life.

In many automated applications, tungsten electrodes are used to weld electrically resistive materials like nichrome and steel. Depending on the weld energy required to join these parts, the tungsten can form a solid state bond with iron, nickel, platinum, and titanium because the interface temperature between the electrode tip surface and the part can cause the part to undergo plastic deformation or even melting. Thus, even tungsten is not immune to the seasoning effect of these higher melting point alloys.