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Resistance Welding Stranded Copper Wire

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Introduction

The key to successfully resistance welding stranded copper wire to a variety of different terminals is to prevent the stranded copper wire from spreading out during the welding process.

This microTip describes wire and terminal material requirements for creating a solid-state or diffusion bond and the wire captivation methods used to prevent the wire from spreading out during welding.

Stranded Copper Wire Requirements

- Wire Diameter - 8-AWG (3.26-mm) to 38-AWG (0.10-mm)
- Wire Plating – None to 6-microns of tin.

Terminal Requirements

- Alloys – Brass, bronze, copper, invar, kovar, nickel, and 304L stainless steel.
- Plating – None to 6-microns or less of gold, nickel, or tin.
- Thickness – 25-microns to 1-mm.

Wire Captivation Methods

There are four methods for captivating the wire strands during resistance welding: a) Electrical Solidification, b) Electrode Tip Shape, c) Pig Tail Insulation, and d) Fixture Design. Each method has its own set of advantages and disadvantages and covers a range of wire diameters best suited to the captivation method.

Electrical Solidification

This captivation method solidifies the stranded copper wire into a solid copper block. This method works by passing a high electrical current through a top tungsten electrode, the wire, and a bottom tungsten electrode. The high electrical resistance of both tungsten electrodes generates heat, which flows into the stranded copper wire. Additional heat is generated by the stranded copper wire resistance. Force on the top electrode helps to compress and solidify the stranded wire.

Large Wire Solidification - 8 to 20-AWG (3.26 to 0.64-mm)

The stranded wire is placed on top of the bottom electrode. The two ceramic clamping blocks then contact each side of the bottom electrode, preventing the wire from escaping. Finally, the top electrode descends to start and complete the solidification process. See the illustration in Fig-1.

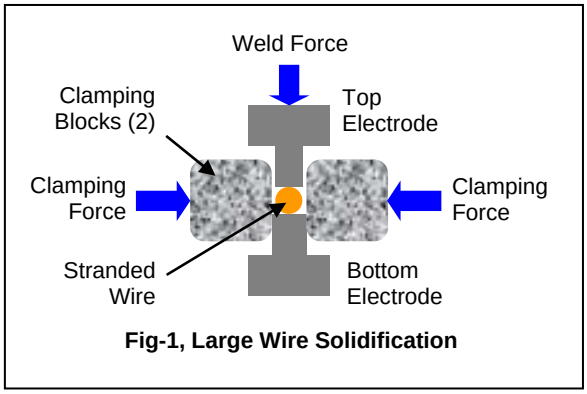

Fig-1, Large Wire Solidification

Small Wire Solidification - 20 to 28-AWG (0.64 to 0.26-mm)

The stranded wire is placed into a groove in the bottom electrode. The grooved sides prevent the wire from escaping. The top electrode descends to start and complete the solidification process. The narrow tungsten top electrode can easily overheat and fracture. Thus, small wire solidification using this technique is limited to wire diameters larger than 28-AWG (0.26-mm).

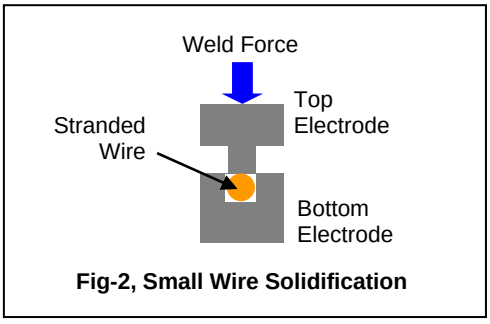

Fig-2, Small Wire Solidification

The final solidified wire mass can then be resistance welded to a terminal using a rectangular or round, flat tip electrode. The flat tip is easy to clean, which is a major advantage of this method. Two welding systems are required, one to solidify the wire and a second system to weld the solidified wire to the terminal. The two welding systems represent a minor disadvantage.

Electrode Tip Shape

Grooving an electrode tip with a ½-diameter or V-Groove shape reduces the tendency of the stranded wire to spread out during the welding process. See Fig-3. IMPORTANT - Shaped electrodes will NOT prevent all wire strands from separating from the main wire bundle.

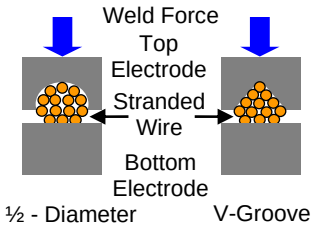

Fig-3, Electrode Tip Shapes

Welding stranded wire to a terminal using the electrode tip captivation method requires only one step, an advantage for this method. Disadvantages to using shaped electrodes include: a) not all wire strands are captivated and welded, b) tip is difficult to clean and maintain, c) changes in the tip geometry change the weld heating density, which affects the weld quality, d) electrode life is generally much shorter compared to flat tip electrodes, and e) the top electrode may short out against the bottom electrode, effectively terminating the welding process.

Pig Tail Insulation

Welding stranded wire to a terminal using the Pig Tail Insulation captivation method requires two steps, which can be a minor disadvantage for this method. See Fig-4.

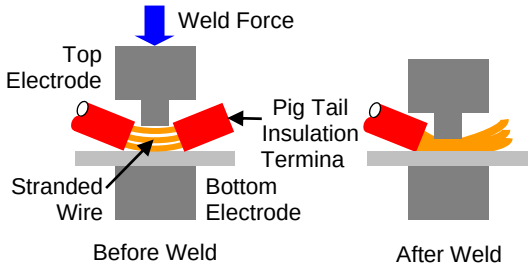

Fig-4, Pig Tail Insulation

First, separate but do not remove the wire insulation. This "Pig Tail" reduces the wiring spreading during welding. Leave sufficient space for the top electrode to contact the exposed wire strands. Second, complete the weld by contacting the stranded wire with a flat rectangular top electrode. Removing the Pig Tail after welding is optional. The flat tip is easy to clean, which is a major advantage of this method. Use a tip with a rectangular cross-section instead of a tip with a round cross-section. The rectangular tip shape ensures that no wire strands escape and also produces more even weld heat compared to a round flat tip electrode.

Fixture Design

A fixture with guideposts or retaining pins can both hold the stranded wire over the terminal and reduce the strands from spreading during welding. The fixture design can accommodate one or more terminals. See Fig-5.

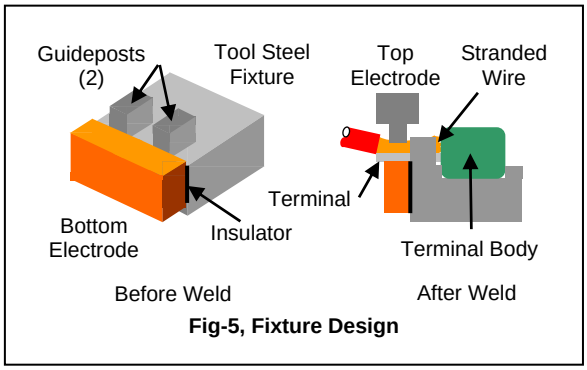

Fig-5, Fixture Design

Place the terminal body on the Tool Steel Fixture. The terminal leads should cover and touch the bottom electrode surface with minimum contact force.

Fabricate the bottom electrode from molybdenum, copper-tungsten, or tungsten to produce the proper heat generation and heat balance. Next, place each stranded wire over each terminal. The guideposts will captivate the open end of each stranded wire. Complete the weld by contacting the stranded wire with a flat rectangular top electrode. Important – the top electrode tip should NOT touch the guideposts. Weld current shunting from the stranded wire to the tool steel will be minimal due to the insulation layer between the bottom electrode and the tool steel. This captivation method offers the advantage of being able to easily clean both electrode tips. Placing each stranded wire correctly requires time, a primary disadvantage for this method.

Summary

Each stranded wire captivation method offers advantages and disadvantages. The wire diameter size, number of strands, and the operating space to accommodate the top and bottom electrodes will dictate the wire captivation method.