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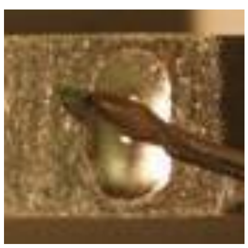
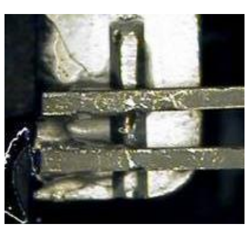
Resistance Welding – Updated Projection Design for Small and Miniature Scale Resistance Welding By David Steinmeier

What Are Projections?
Projections are small indentations stamped or machined into one of the parts that will be resistance welded. While many projection shapes exist for large scale resistance welding, three basic projection shapes can adequately accommodate most small and miniature scale resistance welding applications. The three primary projection shapes are shown below.

Button Projection

The button projection is simply a spherical indentation stamped into one part. The wire crimp terminal shown has a single button projection. If the welded assembly is subjected to rotational stresses, then utilize two button projections to prevent the weld from breaking.

Elongated Spherical Button

The elongated spherical button is a button that is "stretched" or elongated in one direction. This projection is very useful for welding component leads to a lead frame. The elongated spherical button helps to increase localized weld heat in thermally conductive materials including copper alloys such as beryllium-copper and brass. The elongated shape allows for a wide tolerance in the component lead position for automated applications.

Elongated Flat Button

The elongated flat button is a variation of the spherically elongated button except the top has wider, flat surface. This projection is also very useful for welding component leads to a lead frame. The flat surface is excellent for creating a weld heat balance between thermally resistive materials such as Inconel and a copper-clad, iron core component lead. Like its elongated spherical cousin, the elongated flat button allows for a wide tolerance in the component lead position for automated applications.

Why Use Projections?
Differences in part thickness, geometry, and material create unequal thermal loads. These inequalities produce blowouts, expulsion, weak welds and inconsistent weld quality. Projections help create a uniform weld heat balance between parts with different thermal loads.

How Do Projections Work?
Projections work in two ways. One, the projection creates a high electrical resistance between both parts. Two, the projection confines the weld current to a small starting area. This combination of high interface resistance and confined weld current produces localized, repeatable weld heat using less weld current compared to a no-projection weld.

Projection Welding Advantages
- *Improved Weld Heat Balance* –Weld materials substantially different in thermal conductivity and size.
- *Single Weld Current Path* – Improve welding consistency by creating a single weld current path.
- *Less Weld Current Required* – Improve electrode life by reducing weld current.

Projection Economic Advantages
- *Higher Production Yields* – Experience consistent welding and weld quality.
- *Improved Electrode Life* – Save on electrode replacement costs because the electrode tips run cooler thus extend electrode life.
- *Simpler Electrode Tips* – Save on electrode manufacturing and maintenance costs. Projection welding electrodes are flat, cheaper, and easier to maintain in an automated production environment compared to electrodes with complex tip geometry.

Common Projection Design Problems
Most projection implementation problems can be traced to improper projection geometry. Projection geometry mistakes include projections that are too small, too large, too many, too closely spaced, improperly shaped and do not have sufficient cross-sectional strength, which causes the projection to collapse too early in the welding cycle. The next section provides projection design guidelines.

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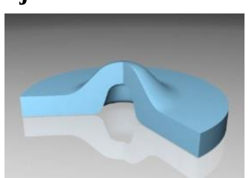
Projection Design – General Guidelines

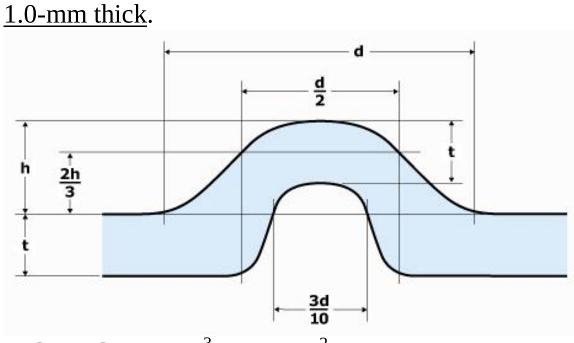
The following list should provide an excellent starting point for small and miniature scale welding projection design.

- Put the projection in the thicker or stamped part.
- Use the elongated button shape when welding component leads onto a lead frame. A component lead will roll off a button projection.
- Use the button and the elongated flat button projections for welding thermally resistive materials such as Inconel, nickel, stainless steel, or nickel-plated steels.
- Use the button and the elongated spherical button shape for welding thermally conductive copper alloys and beryllium-copper alloys.
- When simultaneously welding more than one projection, limit your design to two button projections to ensure self-leveling and near-equal weld current division.
- Use two button projections or one of the single elongated buttons to prevent rotational forces from breaking the weld.

Design Geometry – Button Projection



Button projection geometry for large scale welding (>0.5 mm) is well known[1]. Small and miniature scale welding geometry must be extrapolated using the reference data in conjunction with personal experience using the various metals commonly employed in small and miniature scale welding. All projection designs must be proven through testing. The following formulas are for materials less than 1.0-mm thick.



Inches: $d = 948.5t^3 – 120.32t^2 + 6.3721t – 0.0124$

Inches: $h = -9.955t^2 + 1.3187t - .0022$

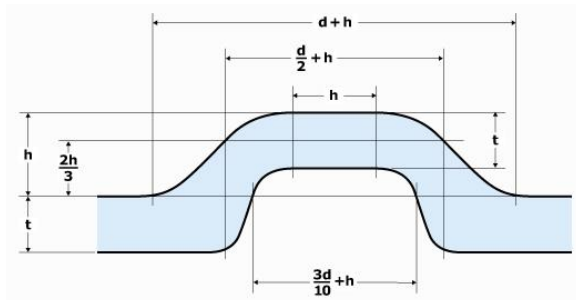
mm: $d = 1.4702t^3 – 4.7371t^2 + 6.3721t -0.316$

mm: $h = -0.3919t^2 +1.3187t – 0.0571$

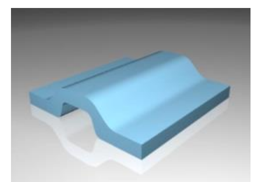
Where: t = material thickness, d = projection diameter, h = projection height

Tolerance for d and h = ±5% of value

Design Geometry – Elongated Flat Button



Projection Testing



The Resistance Welding Manufacturing Alliance (RWMA) Manual[1] has five excellent testing rules, four of which are applicable to small and miniature scale welding. Rule-3 is not applicable. The rules are paraphrased below.

Rule-1

The projection must be sufficiently rigid to avoid collapse when applying weld force without weld current.

Rule-2

The projection should provide the proper heat balance between the two parts. A projection that immediately collapses at the beginning of the weld period is not providing the proper heat balance.

Rule-4

Projections should not be sheared, cut, or deformed during the forming process.

Rule-5

Projections should not distort or seriously change the base material dimensions during the formation of the projection or during the actual welding process.

Acknowledgments:

1. The projection photos were provided by Miyachi Unitek, Monrovia, California, USA.
2. Computer models were provided by Steinmeier Design, Hawthorne, California, USA.

References:

1. For a detailed description covering large scale resistance welding projection design, refer to the RWMA, Resistance Welding Manual, 4th Edition, Chapter X.