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Resistance Welding - Battery Pack Connections

By David Steinmeier

Introduction

Portable power applications continue to grow at a rapid pace. Increasing battery life is one way for a manufacturer to differentiate his product from his competition. Portable power battery packs are typically constructed by laser or resistance welding multiple metal "connections", "straps" or "battery tabs" between each individual cell. This microTip will cover parallel gap resistance welding of 0.25 mm (0.010 in) thick battery tabs.

There are several design goals when constructing a portable power battery pack:

- Create the lowest electrical resistance between each cell to minimize energy losses and permit higher peak currents for more torque.
- Create mechanical connections between each cell that can withstand multiple drops, tool vibration, impact, and temperature cycling.
- Use the minimum weld energy to avoid over-heating the cell's internal separator material.
- Keep the construction cost down by employing the lowest cost interconnection materials.

Battery Pack Connection Materials

Presently, nickel alloys or nickel plated steel are used to make battery pack tabs. These materials are electrically and thermally resistive and are relatively easy to parallel gap resistance weld. Using projections in conjunction with a tab slot provides substantial weld current control for tab materials thicker than 0.25 mm (0.010 in).

Parallel gap resistance welding brass or copper tabs is not easy due to the high electrical and thermal conductivity of these materials and the poor metallurgical characteristics of brass.

Technical Materials, Inc. of Lincoln, Rhode Island, recently developed a battery tab material called "NiTrueClad36", which is comprised of a copper core sandwiched between two very thin layers of pure nickel. This new material has a conductivity of 36% compared to Nickel-201 at 18%. This extra conductivity should improve battery pack life and provide for higher peak battery current when needed. NiTrueClad36 can be successfully laser and parallel gap resistance welded and costs less compared to Nickel-201 battery tabs.

Welding Study Goals

microJoining Solutions conducted a parallel gap resistance welding study to compare welding schedules for the new Technical Materials, Inc. NiTrueClad36 with Nickel-201. The study goals looked for differences in:

- Weld current
- Weld time
- Weld force
- Battery tab slot length
- 90° peel strength

Welding Study Materials

The parallel gap welding study used NiTrueClad36 and Ni-201 battery tabs provided by Technical Materials, Inc.

Geometry	mm	inches
Thickness	0.25	0.010
Width	6.35	0.25
Length	32	1.25
Slot width	0.75	0.030
Slot length	5 to 9	0.20 to 0.35
Projection Qty/Tab	2	2
Projection Diameter	1.5	0.06
Projection Height	0.5	0.02
Projection Distance from Tab end	2.3	0.90

The tabs were welded to a nickel plated 1010 steel, battery cap, 0.28 mm (0.011 in) thick by 12 mm (0.47 in) diameter.

Welding Equipment

The following welding equipment was provided by Miyachi Unitek Corporation:

Equipment	Model
Power Supply	HF27
Weld Head	88A/EZ
Weld Cables	2/0 x 30 inches long
Electrodes	ES0850E, 2.3mm dia

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Welding Study Design of Experiment (DoE)
This study employed a Taguchi, L18, DoE model using the input factors in the adjacent table. The weld force was fixed at 50 N (11.2 lbs). The output response employed a 90° peel test.

Input Factor	Level	Input Factor	Level
Material	2	Weld Time	3
Slot Length	3	Weld Current	3

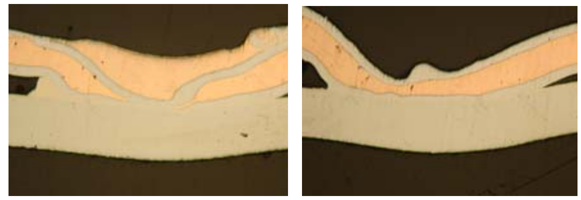
Welding Study Results – Heat Profile
The DoE revealed that <u>different</u> weld schedules are required for the NiTrueClad36 and Ni-201. The NiTrueClad36 behaves more like a conductive weld schedule used to weld copper or copper alloys. The optimum weld force is about 40% less than the weld force used to weld the Ni-201. The following table summarizes the key findings.

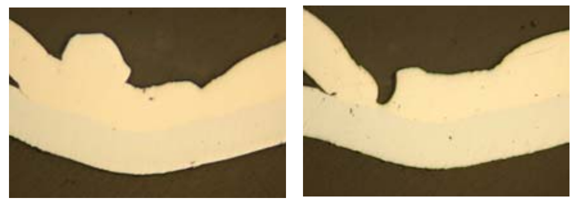
	NiTrueClad36	Ni-201
Weld Type	Electrically Conductive	Electrically Resistive
Bond Type	Diffusion: Ni-Ni	Diffusion: Ni-Ni
Weld Heat Source	• Interface resistance between tabs	• Bulk tab resistance • Interface resistance between tabs
Key Pareto Parameters	• Weld force • Weld current • Tab slot length	• Weld current • Tab slot length

Welding Study Results – Weld Schedules
Based on the DoE results and an additional mini-study to find the optimum weld force for NiTrueClad36, the following weld schedules were used to generate weld samples for the for cross-sections and 90° peel test.

	NiTrueClad36	Ni-201
Weld Force	30 N (6.7 lbs)	50 N (11.2 lbs)
Weld Current	2.30 KA	2.00 KA
Slot Length	7.8 mm 0.31in)	6.4 mm 0.25in)
Weld Time	10.0 ms	12.0 ms
Upslope Time	2.0 ms	4.0 ms

Welding Study Results – Cross-sections
Cross-sections were made through the center of each projection. The right and left welds differ in appearance, which may indicate a polarity effect caused by the weld current direction.


Negative Weld - **NiTrueClad36** - Positive Weld


Negative Weld – **Ni-201** - Positive Weld

Welding Study Results – Peel Strength
There is a 20% difference in peel strength between NiTrueClad36 and Ni-201 welds due to the difference in tensile strength between NiTrueClad36 (365-448 MPa) and Ni-201 (414-517 MPa). This small difference is not significant since surviving drop and vibration tests is strongly dependent on the battery pack housing mechanical design.


NiTrueClad36 = 200 N


Ni-201 = 250 N

Welding Study Conclusions
NiTrueClad36 offers battery pack designers a new opportunity to improve battery life. Successful parallel gap resistance welding of 0.25 mm (0.010 in) thick, ¼ hard, NiTrueClad36 requires using:

- A new weld schedule compared to Ni-201
- Lower weld force
- Higher weld peak weld current
- Projections and a tab slot
- Shorter weld time

Note – Results may be different for welding NiTrueClad36 tabs employing different geometries.

Acknowledgements:
<u>Miyachi Unitek Corporation</u> – Welding Equipment
<u>Technical Materials, Inc</u>. – Battery Tab Materials