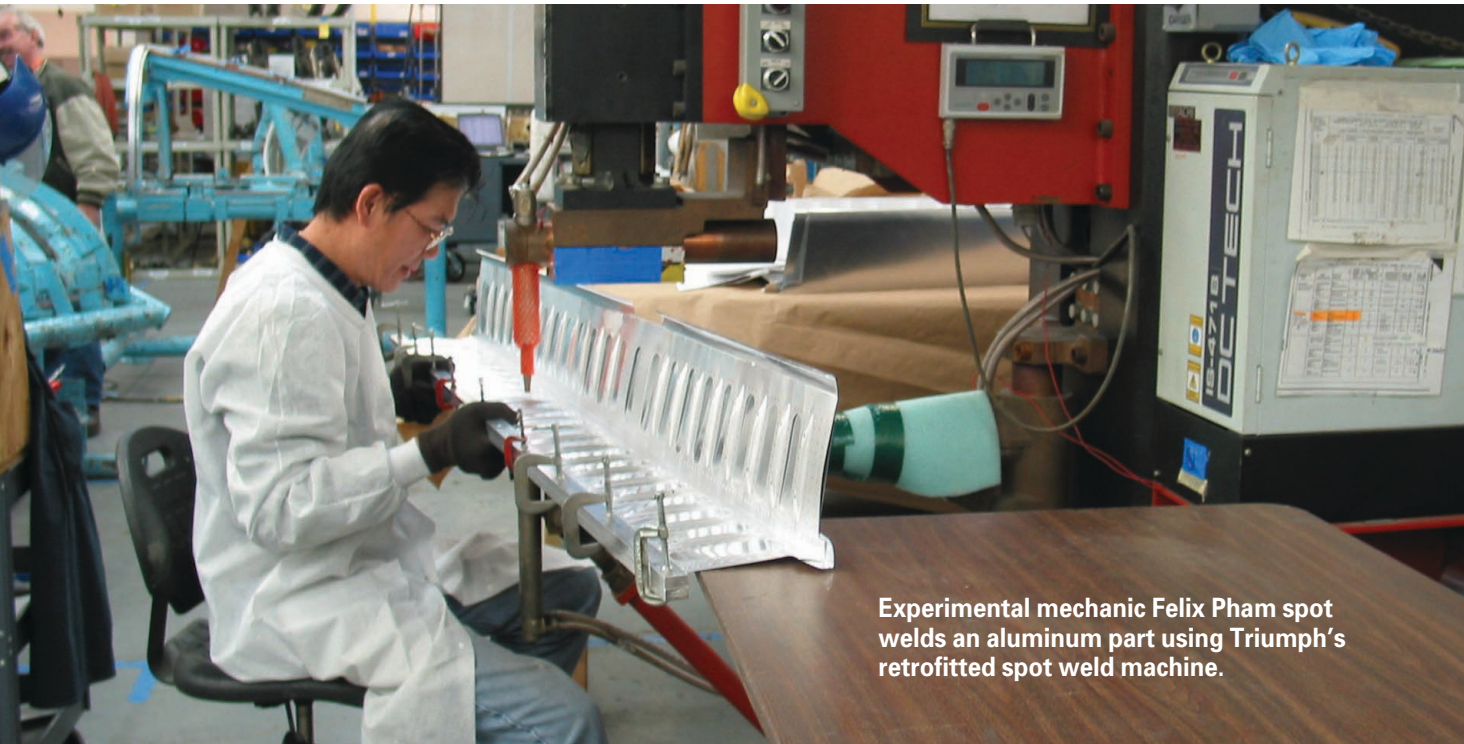


## resistance welding

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Experimental mechanic Felix Pham spot welds an aluminum part using Triumph's retrofitted spot weld machine.

# Retrofits boost welding precision and control

Aerospace shops get precise and consistent welds by switching to high-frequency inverter-based resistance welding power supplies.

Resistance welding aluminum to tight military specifications can be a challenge for aerospace manufacturers. Extremely precise process control is essential for consistent results, but aluminum's inherent properties (high conductivity, fast oxidation) make this difficult to do. One way companies are dealing with the problem is by retrofitting existing equipment with new inverters. That's what Six Sigma supplier Triumph Components, San Diego, did — with great results.

"Inverter-based resistance welding power supplies boosted productivity, improved weld quality, and rapidly evolved into a competitive advantage," affirms

company president, Mark Gobin.

The firm works on a range of tight-tolerance, high-temperature aluminum alloys that are bulge, hydraulic, and drop-hammer formed. It joins components into complex assemblies such as primary exhaust systems, pneumatic ducting, bleed air ducting, and plugs and nozzles. It also deals with aircraft structural components, rocket engine components, and turbine engine weldments.

When the company began evaluating new technology options, it started by sifting through vendor claims that inverter power supplies could rectify incoming three-phase power into a uni-polar, adjustable duration weld current pulse with an adjustable rise time. Triumph's shop

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Triumph Components, retrofitted its existing equipment for use on a range of tight-tolerance, high-temperature aluminum alloy applications.

pros knew that if these claims were true, the result would be good repeatability. Triumph could also benefit from reduced power consumption, smaller welding transformers, and the ability to send a “check pulse” to test electrode position.

The firm’s production staff measured the company’s incoming line voltage and found power from about 480 to over 508 V. As the voltage changed throughout the day, weld sizes became inconsistent and shop workers had to conduct periodic

resistance weld pull tests.

Older resistance welders with “open loop” technology couldn’t cope with the voltage changes, so the shop ended up making small schedule changes throughout the day to maintain weld quality. These changes hurt shop performance but seemed to be unavoidable.

The team doubted any inverter power supply could provide consistent output with such a range of external voltage. But welding equipment supplier Janda Co., Corona, Calif., showed Triumph it was possible. Janda was willing to retrofit Triumph’s existing resistance weld machines or supply a new system using a 1,000-amp inverter made by Unitek Miyachi, Monrovia, Calif.

### The kickoff

The initial installation was a new Janda spot weld machine equipped with a diaphragm head, Roman transformer, and a Unitek Miyachi Model ISA-1000AR inverter power supply.

After Janda delivered the machine and integrated its subsystems, Unitek Miyachi’s representative provided

on-site operator training. He also explained how the unit could be programmed to operate in different output modes. Inverter welding systems use power-switching technologies to provide constant weld current, voltage, and power profiles precisely controlled via closed-loop current and voltage-feedback mechanisms. Each mode benefits different welding applications.

Operators now weld using either cycles ( $1/60$  sec) or milliseconds ( $1/1,000$  sec) to control inverter output. Because standard 60-Hz AC cycles occur in 16.67-msec intervals, an AC welding system must use relatively large weld-time-setting increments. That, in turn, results in large temperature increments. In contrast, inverter systems smoothly deliver direct current with no cycling and continuously heat weldments in increments as small as 1 msec.

This level of precision control lets inverter welders use shorter weld times and control how current is introduced into parts — in essence, shaping the current waveform. Compared to an AC weld control, lower weld current and less force provides the appropriate molten state of the weldments for optimal weld nugget formation.

The feedback loop in new-generation inverters such as the ISA-1000AR is updated at more than 2,000 times each second. The closed loop feedback allows for continuous adjustment of the current, voltage, and power to compensate for changes in resistance that occur in the secondary circuit because of electrode wear, tooling degradation, or part oxidation.

### Built-in monitoring

Another process control benefit is the inverter’s built-in monitor that provides actual measurements of rms values for current, voltage, and power for each weld. Triumph set upper and lower limits to accurately monitor the process and alert operators when these limits are exceeded.

For instance, if operators set the power supply for constant power mode and an upper voltage limit,



Triumph’s inverter uses closed-loop, real-time feedback to compensate for nonuniform workpiece resistance, worn electrodes, and line-voltage fluctuations.



**A Miyachi inverter mounted onto a Janda spot weld machine delivers direct current with no cycling and can continuously heat weldments in increments as small as 1 msec.**

parts with a high oxide surface condition would trigger a voltage spike. This, in turn, would exceed the upper limit set in the machine monitor and alert operators of the problem.

### **A second helping**

The immediate improvements provided by Janda's machine and Unitek Miyachi's inverter convinced Triumph to retrofit an older spot weld resistance weld machine with a 1000AR inverter. The company wanted to see if the machine's heavier frame and more rigid structure enhanced the welder's capabilities.

The company also had the pressure and forge valves upgraded to operate on DC current. This was because AC valves only receive a signal every half cycle while DC valves can receive a

signal at any time. In addition, Triumph added a second dump valve to increase forge speed.

The firm compared standard three-phase DC resistance weld machines with retrofitted machines and observed the following:

- The weld current supplied by the standard three-phase DC resistance weld machines varied more than  $\pm 1.0$  kA when making repeated welds using the same schedule parameters.
- The retrofitted spot-weld machine consistently discharged within  $\pm 0.2$  kA.
- The rebuilt, older model spot-weld machine produced a current discharge with less than 0.1 kA over 90% of the time and varied no more than  $\pm 0.05$  kA for the remaining welds.

Triumph got these good results

even though they had voltage changes throughout the day. In most circumstances, such changes cause additional variations in the output of standard three-phase DC and AC resistance-weld equipment. This wasn't the case at Triumph, however.

### **Test run**

At the time of the upgrade, the company was quoting a welding job that required resistance welding of 0.016-in.-thick clad aluminum. From past experience, Triumph's staff knew it was critical to control the cleaning process, to pass a consistent current between the resistance weld electrodes, and to apply a quick and accurate forge to the material. They are important because resistance welding Group 1 (aluminum and magnesium)

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The firm used this Miyachi MM-360 handheld weld tester to monitor and verify weld data.

materials can be more difficult than welding Group 2 and 3 (steels and titanium).

An additional concern with aluminum is its rapid oxidation rate, which impacts resistance levels. For instance, a batch of parts cleaned 20 min ago will have significantly different oxidation levels than a batch cleaned 2 hr ago. In welding these batches, shops would get uncontrolled weld variations even if they used the same weld schedule and setup parameters.

To compensate for this problem, Unitek Miyachi's inverter precisely controls the total weld energy using closed-loop power mode. Triumph now gets consistent weld results throughout the production day, regardless of variations in surface oxidation on the parts. It has also found that closed-loop real-time feedback automatically compensates for nonuniform workpiece resistance, worn electrodes, and line-voltage fluctuations. The results are extremely consistent weld current delivered to every weld and a process that's less vulnerable to outside variables. Triumph can also tackle some aluminum alloys and precision aluminum components that it couldn't successfully join with other methods. ◀

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