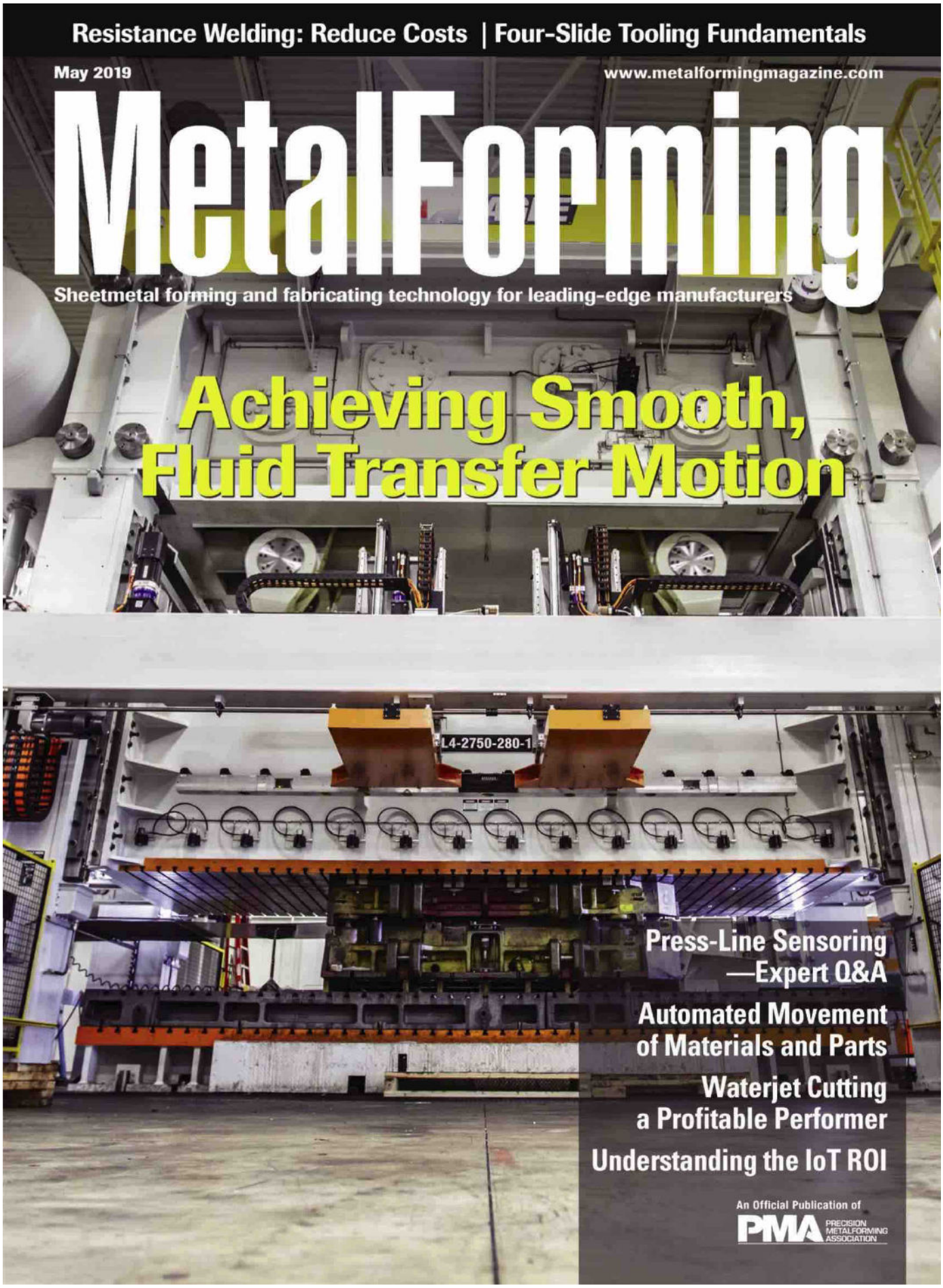
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The Greening of Resistance Welding

BY TOM SNOW

What if you were only allowed to run your resistance welding (RW) machine during the middle of the night?

That happened to one manufacturer in a small Iowa community several years ago when it installed a large 300-kVA single-phase AC press-type RW machine in what once was a retail building that lacked adequate incoming power. Daytime operation of the machine was quickly banned by the local power company due to complaints received from locals who experienced flickering lights and TVs when the machine ran.

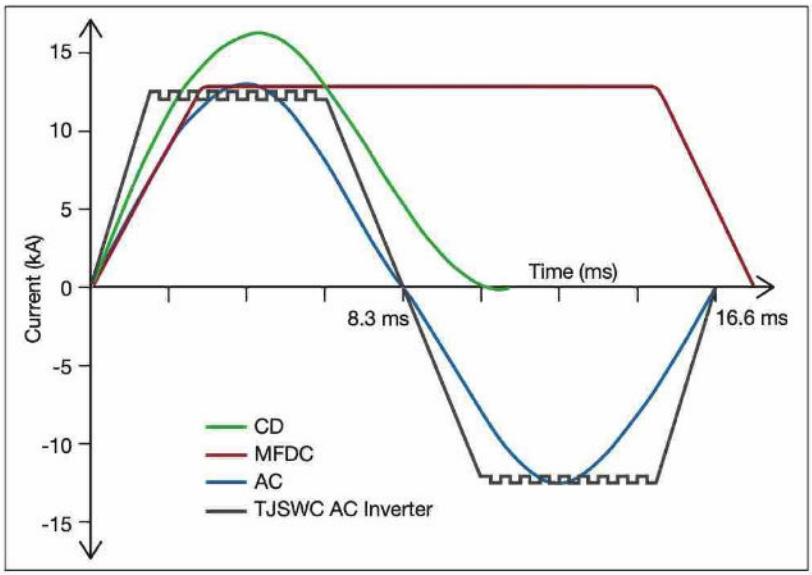
Single-Phase vs. Three-Phase

Although engineers at companies new to the RW process often assume that all machines are wired for three-phase operation, most of the machines in use, outside of the aerospace industry, have been single-phase for decades.

Single-phase RW machines, connected to only two of the three legs of an incoming three-phase service, can cause problems because they require a large and instantaneous primary amperage draw to operate properly. In addition, the power factor or efficiency rating of single-phase machines is around 25 percent, considered poor in comparison to a three-phase machine.

If connected to a 440V incoming power supply, a 300-kVA single-phase machine requires a 600A primary service to operate at full capacity and the power draw for that machine would double to 1200A if connected to 220V. In addition, expensive heavy-gauge primary wire sizes and disconnect switches are required.

For years, electrical engineers have attempted to balance a plant's electrical load by connecting their single-phase RW machines to different pairs of the three-phase service. In addition, to avoid high demand charges from the power company, large-kVA single-phase machines are sometimes connected to one another through a load scanner that acts like an electronic traffic cop. However, since this device allows only one machine to fire at a time, production rates could be impacted.



This comparison of the different methods of controlling and regulating the energy shows how the more advanced methods, MFDC and TJSWC AC inverter, deliver more efficient energy by reducing the off time between welding pulses.

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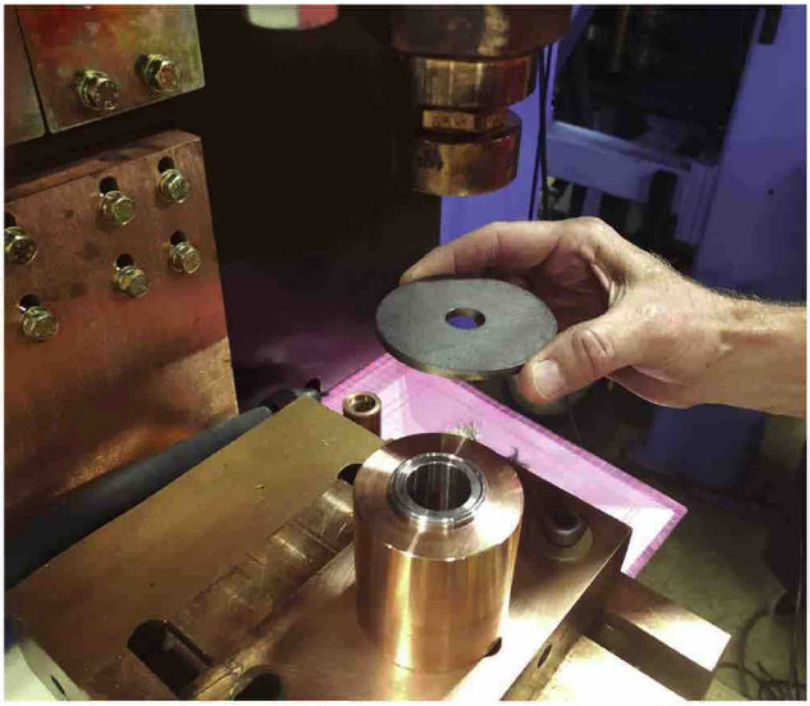


Shown here, an example of typical part geometry and tooling for a part being welded using capacitor-discharge welding. Notice the ring projection.

AC Inverter

In single-phase RW applications, where primary current requirements present an excessive load on incoming power lines, AC inverter wave-synthesis technology offers a practical way to retrofit an existing machine while still retaining its robust original single-phase transformer. AC inverter technology reduces primary-current demand by distributing the load over all three phases.

In addition, the three-phase AC inverter control system decreases the weld current and time required to produce the same weld strength as the original machine operating on single-phase AC.

Two benefits of converting to AC inverter technology come from Bob Cohen, CEO of WeldComputer, a Troy, NY-based manufacturer of RW controls. He reports that a newly installed resistance flash/butt welding machine in Southern California was putting 1500A spikes on the power grid when it fired. Since the local power company reported that the machine produced voltage flicker experienced by customers connected to the 12kV power system, it demanded that the manufacturer stop operating the machine.

The power company suggested that the manufacturer install a new power feed at a cost of $250,000. Instead, Cohen received permission to install an AC inverter control on the existing machine. With no other changes to the system, the current draw on the power line dropped to 107A and the power grid flicker fell to within allowable limits.

Similarly, a manufacturer of wire-mesh welding machines in South Africa reports that installing an AC inverter control on an existing multigun RW machine resulted in a 45-percent improvement in electrical efficiency, while still producing quality welds.

MFDC Dominates

Though thousands of single-phase RW machines will continue to have their place, over the past 25 years automotive manufacturers have led the way in converting to inverter-type medium-frequency direct-current (MFDC) machines, designed to be connected to all three legs of the incoming electrical service.

In some cases, especially when dealing with an expensive single-phase special design AC production machine welding a specific part, it may make sense to convert the machine to MFDC by retrofitting new components in place of the original AC transformer and control.

However, there are trade-offs because MFDC power supplies don't withstand abuse as well as single-phase resistance-welding transformers, and the water-cooled secondary rectifiers require about three times more water cooling (heat removal) than a comparable single-phase machine.

MFDC machines also have other water-cooled components and to remain green, a water-cooled MFDC machine (and most other RW machines) should be connected to a refrigeration-type water recirculator/chiller with adequate flow.

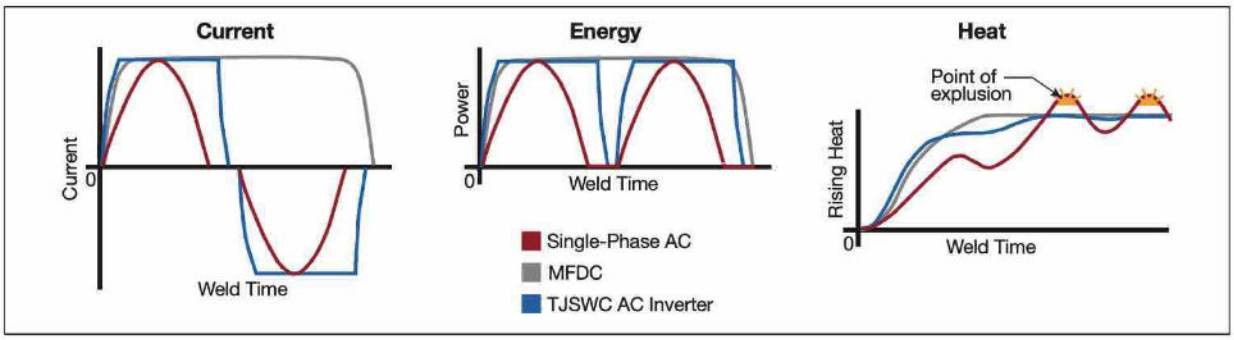
Although MFDC transformers and controls are more expensive than AC, Don DeCorte, vice president, RoMan Manufacturing, a Wyoming, MI-based manufacturer of AC and MFDC resistance-welding power supplies, reports that MFDC technology dominates the global market.

"Today, MFDC has replaced about 85 percent of AC transformers purchased for most general process use in resistance welding around the world," says DeCorte. "As power constraints become more common, especially in heavily industrialized or fringe areas where the power grid is challenged, MFDC technology helps plants expand and add additional machines without severely overloading plant or local power grids.

MFDC Benefits

The benefits of MFDC are more than a reduced primary amperage draw and a balanced three-phase load.

When used with spot-welding robots,



The waveform shows how two of the more efficient forms of energy delivery, medium-frequency DC and the AC inverter, compare with the conventional single-phase AC process.

MFDC power supplies have a distinct advantage over AC technology because the power supplies are dramatically smaller and lighter. This allows spot-welding guns to be designed with integral power supplies instead of remotely mounted transformers.

Previously, heavy AC transformers supplied welding current to robotic-welding guns with long and inefficient water-cooled cables. Another benefit of lighter MFDC spot-welding guns is that robots can now be smaller and faster.

Further, installation of MFDC welding machines enable a plant's copper wiring and feed breakers to be smaller and less expensive. "An important savings with MFDC over AC is in the reduced cost of plant wiring," says Mike Morrow, electrical engineer at T. J. Snow Co. "As an example, an AC RW machine requiring 400A primary service would only need 250A service, if converted to MFDC.

"The same heat energy would still be put into the weld." adds Morrow. "However, the peak currents would be lower with MFDC, resulting in lower demand charges from the power company. In addition, MFDC presents a balanced load to the line, which greatly improves the machine's power factor."

Another benefit: MFDC technology, which typically operates at 1000 Hz, produces more controllable and often superior welding quality than 60 Hz technology. This allows some new MFDC controls to have feedback circuits that monitor and adjust each weld on the fly.

Jeff Morgan, a T.J. Snow welding engineer, adds that "because the output of the welding power supply is DC, inductive loss in the throat of an MFDC machine is virtually eliminated, thus requiring less energy. This is especially evident when welding ferrous materials with pedestal machines and with robotic guns with large throat areas.

"In theory, since the waveform seen at the weld is very much like a square wave," he continues, "the energy and heat signature delivered to the part is virtually continuous during the weld, rather than cyclic, as seen with AC machines. This is particularly evident in projection welding, where we can produce excellent results using the equivalent of one cycle of AC weld time (16 msec.). In the past, this type of weld would have typically required six to seven cycles of AC output."

Capacitor Discharge Coming on Strong

Capacitor-discharge (CD) technology represents the ultimate greening of the resistance-welding process. The machines operate on stored energy and recharging the built-in capacitors can be slowed and low amperage demanded from the power lines.

The popularity of capacitor-discharge technology continues to rise, though the machines cost more than other types, and are physically larger than comparable AC and MFDC machines.

"Since CD is a stored-energy resistance-welding process, it uses the lowest of all instantaneous primary amperage draws, with the energy output not dependent on the stability of the primary voltage," says Morgan. "In addition, a CD RW machine does not affect surrounding welders."

If time permits, a large-output capacitor-discharge machine can be recharged slowly, with only 60A primary service. However, since more welds/min. are often needed to reach desired production rates, recent advances in electronics allow faster recharging of CD resistance welders.

Although CD machines operating at higher speeds require a larger primary service, the savings in the cost of primary wiring and power supplied to the machine can be greater than a comparable MFDC unit.

The technology is especially suitable for projection welding fasteners (nuts and studs) to high-strength steel. Moreover, since secondary welding currents as high as one million amps have been obtained, other ideal welding applications for CD technology include products with large ring projections, such as threaded water-heater connections and automatic-transmission clutch baskets, where CD technology has replaced laser welding in some cases.

Other advantages: Due to the short duration of capacitor-discharge welding current flow, the heat-effected zone is small and the part can be handled immediately after completing the weld; and the short weld time increases the life of copper electrodes. **MF**