aluminations

Shedding light on aluminum welding issues

Inside

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- How AC balance control enhances TIG welding on thin aluminum.
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Issue 1

Introducing three advanced Squarewave capabilities from inverter-based AC/DC TIG.

Issue 1

aluminations

For the last 20 years, anyone TIG welding aluminum or other alloys requiring an AC arc knew that a Squarewave™ output provided the best results. Today, though, the best results might come from an *inverter-based* AC/DC TIG welder that incorporates *advanced* Squarewave technology. To see if an inverter can improve weld quality, increase travel speed or reduce costs in your operation, read on.

Shedding light on aluminum welding issues

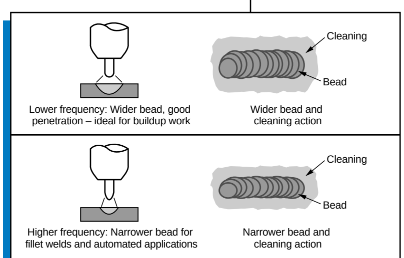
questions & ANSWERS

Q. I've heard that inverters let me adjust the arc to stay in the electrode negative mode for up to 90% of the AC cycle. Can this really improve my travel speed?

A. *Absolutely. You can increase travel speed, get better penetration or both because inverters let you direct about 25% more heat into the weldment in the same amount of time. When welding at 100 amps, an inverter like the Dynasty™ DX essentially gives you 125 amps of welding power.*

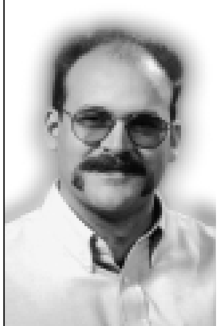
Q. Why do inverters have an "adjustable output frequency" function?

A. *Increasing the output frequency (which conventional machines cannot do) creates a tighter and more focused arc cone, directing the heat into a smaller area. In fact, you can get better penetration and reduce the size of the weld profile. This may let you increase travel speed, use less filler metal and reduce or eliminate pre-heating, pre-weld beveling and post-weld grinding.*



Q. I don't have much room in the shop, and my incoming power is at capacity. Would an inverter be a good solution?

A. *Yes. For example, the Dynasty DX has a footprint of 17 in. x 12.5 in. x 24 in. and weighs only 90 lb. Even better, it draws just 26.3 amps of 230 V three-phase primary power to create a 250 amp Squarewave output. A conventional Squarewave machine, which only accepts single-phase power, draws 92 amps on the primary side.*



Mike Sammons
TIG Product Manager
Miller Electric Mfg. Co.

In 1974, Miller Electric invented and patented the Squarewave AC output and balance control function found on their Syncrowave® series of TIG welders. Squarewave technology made the transition through the zero amperage range faster than a regular sine wave, which improved arc starts and created a more stable arc. With balance control, the operator could change the duration of the AC half cycle, adjusting the electrode negative (EN) from 45 to 68%.

Now Miller introduces the next generation of technology with their new AC TIG inverter, which features three advanced Squarewave capabilities. First, it produces incredibly smooth, stable arcs because the Squarewave is driven through the zero point thousands of times faster than a rectifier-based welder. Miller's Dynasty™ DX is so fast that its built-in high-frequency capabilities are used for arc starting only.

Second, inverter-based welders extend EN balance control. The Dynasty DX lets operators fine-tune duration times from 50 to 90%. Making the EN portion of the cycle last longer:

- Achieves greater penetration.
- Narrows the weld bead.
- May increase travel speeds up to 20%.
- May permit using a smaller diameter tungsten to more precisely direct the heat or make a narrower weld bead.
- Reduces the size of the etched zone for improved cosmetics.

Less EN time produces greater cleaning action to remove heavier oxidation, lessens penetration for work on thin materials and widens the bead profile.

Third, inverter-based welders let operators adjust the welding output frequency, from 20 to 250 Hz in the case of the Dynasty DX. Conventional welders have a fixed output of 60 Hz. Lowering the frequency produces a broader arc cone, which widens the weld bead profile and better removes impurities from the surface of the metal. Increasing frequency above 60 Hz produces a tight, focused arc cone. This drives more heat into the weldment for better penetration, and it narrows the weld bead, which helps when welding in corners, on root passes and fillet welds.

Note that when AC TIG welding with an inverter, the operator should treat the tungsten as if the weld were being made in the DC mode: select a 2%-type tungsten (thorium, cerium, etc.) and grind the electrode to a point. Electricity likes to come off a point, which further improves controlling the weld puddle. For example, a skilled welder can make a 1/8 in. fillet weld on 1/8 in. aluminum plate with a pointed electrode.

For more information on the Dynasty DX, AC TIG welding, or a free copy of our White Paper, *"New controls for AC TIG welders,"* call 1-800-4-A-MILLER (1-800-426-4553, ext. 602).

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Issue 2

How AC balance control enhances TIG welding on thin aluminum.

Issue 2

aluminations

TIG welding thin aluminum? Don't ball your tungsten — sharpen it. To advance everyone's knowledge, this aluminations answers questions on welding thin material, describes the operation and benefits of AC balance control and discusses selecting a TIG welder based on amperage requirements.

Shedding light on aluminum welding issues

questions & ANSWERS

Q. How do I pick a TIG welder for thin gauge aluminum?

Mike Sammons
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A. First, recall that you need about 1 amp of heat for every .001 in. of metal (e.g., you need a welder that goes down to 15 amps AC for work on .015 in. aluminum). Next, consider a machine with a reputation for a stable arc and good starts at low amperages, such as one of Miller Electric's Syncrowave® units. Lastly, note that many fabricators use high-end TIG welders for fine detail work because of their low amperage capabilities.

Q. I keep making holes in thin material. What can I do?

A. *Try a set-up that gives you finer control over amperage adjustments. If your foot pedal and front panel amperage control have a leader/follower relationship, limit output on the machine (e.g., if you need 20 amps, set the machine at 40). Now the entire range of foot pedal motion only controls a fraction of the welder's output. In other words, 1 in. of travel might change the heat by 5 amps, not 50.*

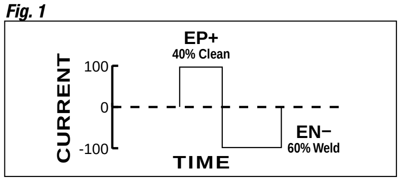
Q. Should I ball a pure tungsten electrode for welding thin material?

A. *No. Instead use a 3/32 in. tungsten with 2% cerium (2% thorium is second choice), grind it to a point and put a small land on the end. Compared to a balled tungsten, a pointed electrode provides greater arc control and lets you direct the amperage precisely at the joint, minimizing distortion.*

Using AC to TIG weld aluminum evolved from the need to remove the oxide layer that forms on its surface. The electrode positive (EP) portion of the AC cycle, in which electricity flows from the work to the tungsten, "blasts" off surface oxides. The electrode negative (EN) portion of the cycle does the actual welding, directing heat from the tungsten into the metal.

When Miller engineers invented the Squarewave AC output, they also discovered that an *unbalanced* AC wave form works best for many applications. That's why lighter-duty machines, like the Syncrowave® 180 SD, feature a fixed balance control set for more penetration (60% EN) than cleaning (40% EP), as shown in Fig. 1.

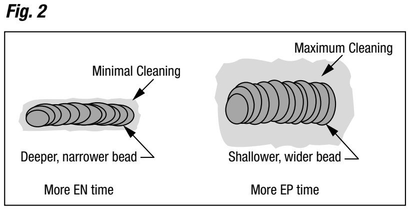
Fig. 1



Miller also invented *adjustable balance control.* This feature permits tailoring the EN/EP ratio to match an application. For example, Miller's Syncrowave® 250 and Syncrowave® 350 LX let you adjust EN values from 45 to 68% (32 to 45% EP).

Greater amounts of EN create a deeper, narrower weld bead and better joint penetration. This helps when welding thick material, or it may permit faster travel speeds. Conversely, greater EP values remove more oxide and create a shallower, wider bead (see Fig. 2).On materials that have a heavy oxide layer or cast aluminum, increasing the cleaning action minimizes the chance of foreign particles becoming included, promoting a better weld.

Fig. 2



No hard rules exist for setting balance control. The typical error involves over-balancing the cycle. Too much EP creates a large ball on the end of the tungsten. Consequently, the arc loses stability and you can't control arc direction or the weld puddle; arc starts also degrade. Too little EP results in a scummy weld puddle. Add more cleaning action if the puddle looks like it has black pepper flakes floating on top.

Amperage Requirements

When choosing a TIG welder, consider how much amperage you need for a given thickness. To weld aluminum less than 3/16 in., a 15 to 180 amp machine like the Syncrowave 180 SD works well. For thicker metal, or if you want adjustable balance control, the Syncrowave 250 with its 5 to 310 amp range makes sense. Consider the Syncrowave 350 LX and its 3 to 400 amp output for work on heavy sections, or when you need a full-featured machine with pulsing control, Lift-Arc™ and a sequencer option.

Thickness (in.)	Amps required
1/16	60 - 90
1/8	125 - 160
3/16	190 - 240
1/4	260 - 340
3/8	330 - 400

For more specifications on Miller's Syncrowave family or information on TIG welding, call 1-800-4-A-MILLER (800-426-4553, ext. 604).

WD&F 6/99 472-552

Issue 3

New push-pull feeder technology improves MIG welding.

Issue 3

aluminations

Burnback. Wire stubbing. Porosity. Erratic feeding. These common problems plague fabricators that MIG weld aluminum. Often, they result from an inadequate or improperly adjusted wire feeder system. If you want to gain more control over MIG aluminum productivity, this aluminations provides troubleshooting tips and introduces new push-pull feeder technology.

Shedding light on aluminum welding issues

questions & ANSWERS

Q. I have gas flow from the gun, but not a clean weld. How can I solve this?

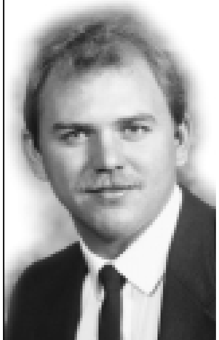
A. *Porosity and black welds indicate poor gas coverage or contamination. To ensure good coverage, check for: proper gas flow (CFH), leaks in the system (loose fittings, cuts in the gas hose, worn O-rings) and excessive spatter in the nozzle. Make sure the contact tip is recessed about 1/8" in the nozzle. To ensure 100% coverage and prevent contamination, Miller designed a unique gas delivery system for its XR-Edge™ gooseneck gun. It even sends gas through the contact tip with the wire. This enhances the cleaning action and reduces porosity and post-weld clean-up.*

Q. What causes aluminum wire to burn back to the contact tip?

A. *90% of "burnbacks" result from poor arc starts caused by incorrect run-in speed, not tuning the wire feeder to the power source and poor electrical continuity between the wire and contact tip. [Note that the patent pending XR-Edge gun design helps eliminate poor electrical pick-up.]*

Q. How can I prevent birdnesting?

A. *Soft aluminum wire is prone to buckling, so using a larger diameter may help. Better yet, invest in a push-pull feeder. In such systems, a torque motor at the wire spool steadily feeds the wire while a drive motor located in the gun precisely controls wire speed at the arc. This maintains constant tension, so the wire feeds consistently, even when the cable is looped, and at distances up to 50 ft. The XR-Edge torque motor features a high and a low torque setting, letting you adjust performance, respectively, for larger or smaller diameter wires.*



David Almy
Welding Engineer
Miller Electric Mfg. Co.

The inherent properties of aluminum make it prone to poor MIG arc starts. For example, aluminum wire requires a lot of current to initiate the arc, yet the wire melts very quickly once the arc starts. It requires a fast wire feed speed, but any oxide on the weldment delays arc initiation because it melts at a much higher temperature. Thus, the solution to arc starting problems often involves fine-tuning the speed at which the wire approaches the weldment.

Assuming you have a "push-pull" style wire feeder, start by finding the run-in speed control. This sets the wire feed speed from the time you pull the gun trigger until arc initiation (after sensing an arc, the machine switches to welding speed). Because run-in speed is generally slower than welding speed, the arc has more time to establish itself. If you experience wire stubbing, use a slower run-in speed.

Always adjust run-in speed first. For additional fine-tuning, Miller incorporated a unique feature in its XR-Edge™ push-pull feeder that adjusts how long the wire drive motors take to ramp up to full speed. This "motor ramp control" can help tune the wire feeder to better match a welding power source's arc starting characteristics. To prevent long, flaring arc starts or wire burning back to the contact tip, increase ramp control. For example, ramp control is factory-set at maximum speed to match Miller's fast-responding Invision™ 354MP inverter. Slower ramp speeds have benefited users who pair the XR-Edge with magnetic amplifier-type CV welders or CC machines for running larger wires.

Smooth Groove, Smoother Performance

The soft nature of aluminum wire leads to feeding problems. For example, when the wire slips through the drive rolls, burnbacks and arc stumbling often result. Don't over-tension the drive rolls or use knurled drive rolls as a "solution." This inevitably deforms and defaces the wire, producing shavings. These wire particles then build up in the drive roll grooves, cable liner and contact tip. Ironically, this also causes burnbacks and arc stubbing.

Instead, look for a wire feeder system with 1) the new-style smooth groove drive rolls and 2) all gear driven drive rolls (no idler roll). Both the gun and the feeder rolls on Miller's new XR-Edge have these features, and this particular system offers excellent feeding performance without deforming and defacing the welding wire.

XR-Edge gun with all gear driven drive rolls.

For more information on wire feeder systems and welding power sources that give you the flexibility and control to optimize MIG welding aluminum, call 1-800-4-A-MILLER (1-800-426-4553, ext. 603) or visit our website at www.MillerWelds.com.

Issue 4

Why you should consider pulsed MIG for your aluminum welding jobs.

Issue 4

aluminations

Is spray transfer too hot? Short circuit too cold? Then consider pulsed MIG for aluminum. It can combat warpage, burn through, lack of puddle control, lack of fusion, spatter and poor appearance. This aluminations explains the pulsed process and introduces a simple, affordable machine with built-in pulsing controls.

Shedding light on aluminum welding issues

questions & ANSWERS

Q: Can pulsed MIG boost productivity?

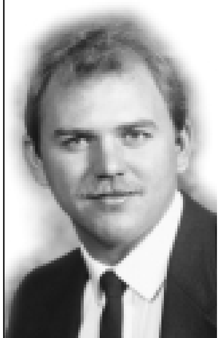
A. *For certain applications, absolutely. Compared to short circuit or spray transfer, pulsed MIG often permits using a larger diameter wire and/or faster wire feed speeds without adding excess heat. This increases travel speed and/or deposition rates. For example, one fabricator welding lap joints on thin gauge aluminum increased travel speed from 105 to 144 in./min. after switching to pulsed MIG.*

Q: Does pulsed MIG create cleaner looking welds than spray transfer?

A. *Yes, in aluminum with high magnesium content, such as the 5000 series. The higher current and arc temperatures of spray transfer vaporize the magnesium, causing a gray film to form on the weld surface, especially at the toes. Pulsed MIG, with its lower average current, reduces the amount of vaporization. As a secondary benefit, it also reduces fume generation.*

Q: Why switch to pulsed MIG for aluminum?

A. *Many shops switch for greater control and to obtain a highly uniform bead. With pulsed MIG, the weld puddle cools between pulses and freezes faster. This provides operators with better directional control over the weld bead. Also, the puddle is less likely to sag or look excessively convex when welding out-of-position. In fact, bead appearance can approach that of TIG (see photo). Shops TIG welding aluminum thicker than 1/8 in. might consider pulsed MIG as a way to increase output while satisfying appearance and quality control demands. Also, pulse welding avoids lack of fusion which can occur with the colder short circuiting transfer.*



David Almy
Welding Engineer
Miller Electric Mfg. Co.

In pulsed MIG welding, technically a modified spray transfer process, the machine switches between a high peak current and a low background current (see Fig. 1). The peak current pinches off a spray transfer droplet and propels it toward the weldment. The background current maintains the arc, but is too low for metal transfer to occur.

Pulsing can lower heat input to levels associated with short circuit transfer, yet it provides benefits associated with spray transfer. For example, pulsed welding a 1/8 in. thick section of aluminum with a 3/64 in. diameter wire requires an average of 140 amps. In this program, a 90 amp background current eliminates worries about burn through or warping, while a 350 amp pulse of peak current provides good penetration and wet out. As with spray transfer, pulsing produces little to no spatter or porosity; like short circuit transfer, it works well in thinner gauge and out-of-position applications.

As a financial incentive, consider that non-pulsed welding 1/8 in. aluminum typically calls for .035 in. wire, which lists for $5.16/lb. Now compare this to the 3/64 in. wire in the pulsed example above; it lists for $4.85/lb. Standardizing on larger diameter wire, and using that single wire for a wide variety of thicknesses, is a common benefit of the pulsed process.

Unretouched photo of pulsed MIG weld bead

Equipment for Pulsing

Unfortunately, many aluminum fabricators hesitate to adopt pulsed MIG. Concerns about equipment complexity, operator comfort and purchase price typically hold them back. Miller's new Invision™ 354 MP and Invision 456 MP, however, overcome such concerns.

These power sources feature built-in programs for 4000 and 5000 series aluminum wire. To begin welding, select the program that matches your wire size and type. After that, they set up like a conventional MIG system: pick a wire feed speed and turn the trim control to find the correct arc length. You never have to modify pulsing parameters to maintain good welding conditions for different wire speeds or trim settings. Using this system, operators feel very comfortable switching to pulsed MIG because it's "familiar."

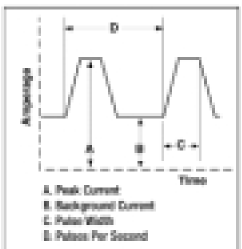


Fig. 1 Pulsed MIG wave form

The Invision 354 and 456 MP provide optimized performance with Miller's standard wire feed systems for MIG welding aluminum, such as the XR™ feeder and XR-Edge™ with gooseneck gun. You do not need a programmable feeder or pulsing pendant. For more information and a free technical article on Pulsed MIG, call 1-800-4-A-MILLER (1-800-426-4553) or visit our website at www.MillerWelds.com

WD&F 4/00 472-706

Issue 5

How altering balance control and output frequency can affect your bottom line.

Issue 5

aluminations

When you control the shape of an AC TIG weld bead, you control profitability. The perfect bead takes less time to weld and looks great without grinding or polishing. This aluminations explains how balance control and output frequency affect penetration depth, bead width, etched zones — and your bottom line.

Shedding light on aluminum welding issues

questions & ANSWERS

Q: How can I weld thinner materials or small parts without burning through?

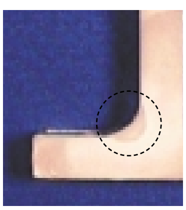
A. *Using an inverter, select a pointed tungsten and weld with an output frequency of 80 to 120 Hz. This narrows the arc cone so you can direct the arc right where you want it. You can establish the weld puddle faster and precisely place the filler wire. This helps prevent the burn-through and/or warping that you might experience with a conventional TIG welder and a balled tungsten.*

Q: How can I tell if I'm over-welding?

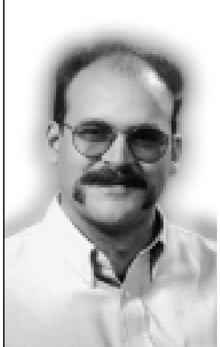
A. *Excessive bead width can be one indication. For example, a fillet weld has a triangular shape. Assuming good penetration, the longest "leg" should be no longer than the thinnest plate. When joining 1/8 in. to 1/4 in. plate, you only need a 1/8 in. bead. Any wider and you lose travel speed and waste filler wire and gas; the bead may also require post-weld grinding.*

Q: Experience tells me that I need to over-weld for good penetration. How can I ensure penetration with a narrow bead?

A. *If you've only used a conventional AC TIG machine, the need to over-weld is understandable. You have very limited control over bead shape. For precisely tailoring bead width and penetration ratios, use a TIG inverter like the Dynasty™ 300 DX. It permits increasing output frequency and extending balance control which, respectively, narrows the bead and directs more heat into the weldment for deeper penetration.*



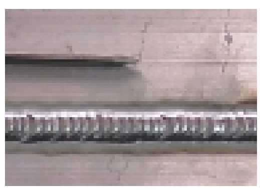
A 200 Hz output created this narrow, yet deep, weld bead.



Mike Sammons
TIG Product Manager
Miller Electric Mfg. Co.

An AC/DC TIG inverter fine tunes the weld bead profile by controlling arc cone shape and arc force. Think of an inverter like adding a nozzle to a fire hose; it lets you change the shape and force of the "water" (welding current) from a wide fan to a more focused stream. But instead of turning a nozzle, you adjust balance control and output frequency.

Balance control adjusts the ratio of electrode positive (EP) to electrode negative (EN). During EN, the welding current travels from the tungsten to the work. Increasing EN duration better defines arc cone and directs more heat into the work. This creates deeper penetration, a smaller bead and pulls the etched zone closer to the weld bead. Compared to conventional machines, inverters let you add about 25% more heat into the work in the same amount of time. This increases penetration per amp of welding power.



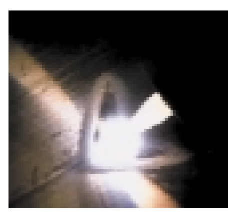
Extending the Dynasty's balance control to 90% EN narrowed the etched zone.

EP does not create a well-defined arc cone because the electricity wanders slightly while it searches for the path to the tungsten. Adding more EP provides shallower penetration, a wider bead, more cleaning and a bigger etched zone.

Frequency and Fillet Welds

Frequency, or Hz, is the number of times the arc switches between EP and EN in one second. The Dynasty permits adjusting output frequency from 20 to 250 Hz. Conventional TIG machines have a frequency fixed to that of the primary power (e.g., 60 Hz). Frequencies below 60 Hz transfer more energy into the work and create a wider bead with decent penetration — an ideal combination for build-up work or to catch both edges of an outside corner while maintaining travel speed.

Increasing the frequency ("constricting the nozzle") narrows the shape of the arc cone and increases the arc force. This stabilizes the arc, reduces arc wandering and provides excellent directional control over the arc (in fact, it might remind you of the DC arc used on steel). On lap and T-joints, using a higher frequency lets you establish the weld puddle exactly at the root. This can ensure good penetration, control bead width and minimize the etched zone. With a 60 Hz output on fillet welds, the wider arc dances from plate to plate. The puddle starts at the toes of the weld and flows toward the center; on some joints, you're almost compelled to over-weld to ensure penetration at the root.



This high-speed photograph shows how a 200 Hz output eliminates arc wandering.

For a free technical article on how TIG inverter technology helps solve welding challenges, call 1-800-4-A-MILLER (1-800-426-4553) or visit www.MillerWelds.com

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