

WELDING TECHNOLOGY:



Aircraft welders are using manual TIG, metal inert gas (MIG) or oxy acetylene torches, all of which have been available for many years. Lincoln Electric Photo.



Slow but Steady Improvements

By Charlotte Adams

Welding hasn't changed in decades or welding hasn't changed at all. That's what you hear from veteran practitioners. Many of them have been using the same oxy acetylene or tungsten inert gas (TIG) equipment for decades, and have seen no need to change. But the industry has not been static: there has been a steady stream of innovations and new products.

Change probably occurs at a faster pace in more high-volume, production scenarios. Automated welding, once properly set up, can all but guarantee the quality and the repeatability of welds on a job. Military contractors are using friction stir welding, which doesn't require any kind of torch. It generates heat by the high-speed spinning of a cylindrically shaped tool.

For lower-volume applications like aircraft maintenance, automated welding probably would be the exception to the rule. Welders use manual TIG, metal inert gas (MIG) or oxy acetylene torches, all of which have been available for many years.

Although oxy acetylene is the process that is tested for in the Federal Aviation Administration (FAA) exam for candidate airframe and powerplant (A&P) mechanics, the TIG process is generally viewed as relatively more advanced. For one thing, TIG is more controllable in real time. As an electrical process, TIG has benefited from advances in the manipulation of electrical current—such as wave shaping and high-frequency switching—that help to fine-tune characteristics of the arc such as the heat output, cleaning vs. penetration, arc stability and directional control for difficult-to-weld materials such as aluminum, titanium and magnesium.

The technologies are very different. TIG uses an electrical arc to create heat and shields the weld puddle with inert argon gas. With oxy acetylene, the welder ignites acetylene gas with a handheld striker and feeds the acetylene with oxygen to create a high-temperature flame. The acetylene flame melts the metal with the intense heat of the inner cone, approximately 5,600 degrees F, and then shields the molten puddle with the flame's outer envelope until cooled. Oxy acetylene is also a dirtier process, as the burning acetylene creates carbon soot if the right mixture is not achieved, says Dave Duhon, a recently retired welder with a major airline.

Oxy acetylene is better for cutting and brazing than for welding, says Ray Bacon, an instructor at the A&P school within Tarrant County College in Fort Worth, Texas. "It takes a lot of heat for a gas flame to





Multiplaz uses a mixture of tap water and rubbing alcohol, considered more environmentally friendly than gas-shielded arc welding. See sidebar below for more info. (Multiplaz Photo)

make steel molten, and the heat spreads too far, so you wind up really heating up your work and could punch a hole in it or distort it.” More modern techniques concentrate heat in a tiny area, he says, so that even though the temperatures are higher, the material cools quickly without a lot of distortion.

With oxy acetylene or other processes, the welder can control the heat by turning the torch aside from the project and then turning it back to the metal again. Or, before starting the weld, the oxy acetylene user can adjust the flow of oxygen from the gas canister or simply choose a smaller tip. TIG, however, offers more fine-grained, real-time control.

The oxy acetylene process, which is taught at A&P schools, is more difficult than gas-shielded arc processes to become expert at. But since oxy acetylene has fewer variables than TIG and is much less expensive than the electrical processes, oxy acetylene may be more appropriate for inexperienced welders to start with in order to pick up the basics. TIG, on the other hand, is regarded as the most difficult manual welding process to learn because it requires considerable dexterity to manipulate the torch, apply the filler rod and control the heat output via a foot pedal or a button on the torch that adjusts the amperage.

Multiplaz

For something really different, readers need look no further than Multiplaz, a Russian-headquartered company with branches located worldwide. The Multiplaz 3500, invented in 2008, is an all-in-one welder, cutter, solderer and brazer, the company says. But what’s really different is its fuel—a mixture of tap water and rubbing alcohol, so the company considers it much more environmentally friendly than gas-shielded arc welding. The equipment weighs about 30 pounds and is priced at about \$2,000.

The company is reluctant to describe the inner workings of its technology, but the process is not—as some welders have speculated on Internet forums—electrolysis, says Patricia Lewis-Hansen, CEO of Multiplaz North America. She says that the company demonstrated the technology at a Los Angeles area chapter of the Experimental Aircraft Association and that the technology generated a lot of interest there.

The equipment runs on DC current and operates in two modes. In Mode 1, it’s more like an oxy acetylene torch and in Mode 2, it’s more like a tungsten inert gas (TIG) torch, says Angel Villanueva, the company’s senior welding tech.

Mode 1, which offers lower current settings, would probably be used for welding aluminum, depending on the thickness of the metal. In Mode 1 an arc is created inside of the torch in order to ignite the alcohol/water mixture and create a plasma, some 14,400 degrees F, which melts the metal. (The temperature can be reduced by turning the starter button/dial on the torch.) For welding aluminum, a 50/50 alcohol/water solution is recommended.

In Mode 2, intended for heavier metals and thicker metals, the arc is projected from the nozzle of the welder and melts the metal. The plasma vapor protects the weld area, Lewis-Hansen explains. The plasma also “pushes away and disintegrates much of the micro particulum users [would otherwise often] breathe into their lungs, which is why it is a great tool for low ventilation areas,” she says.

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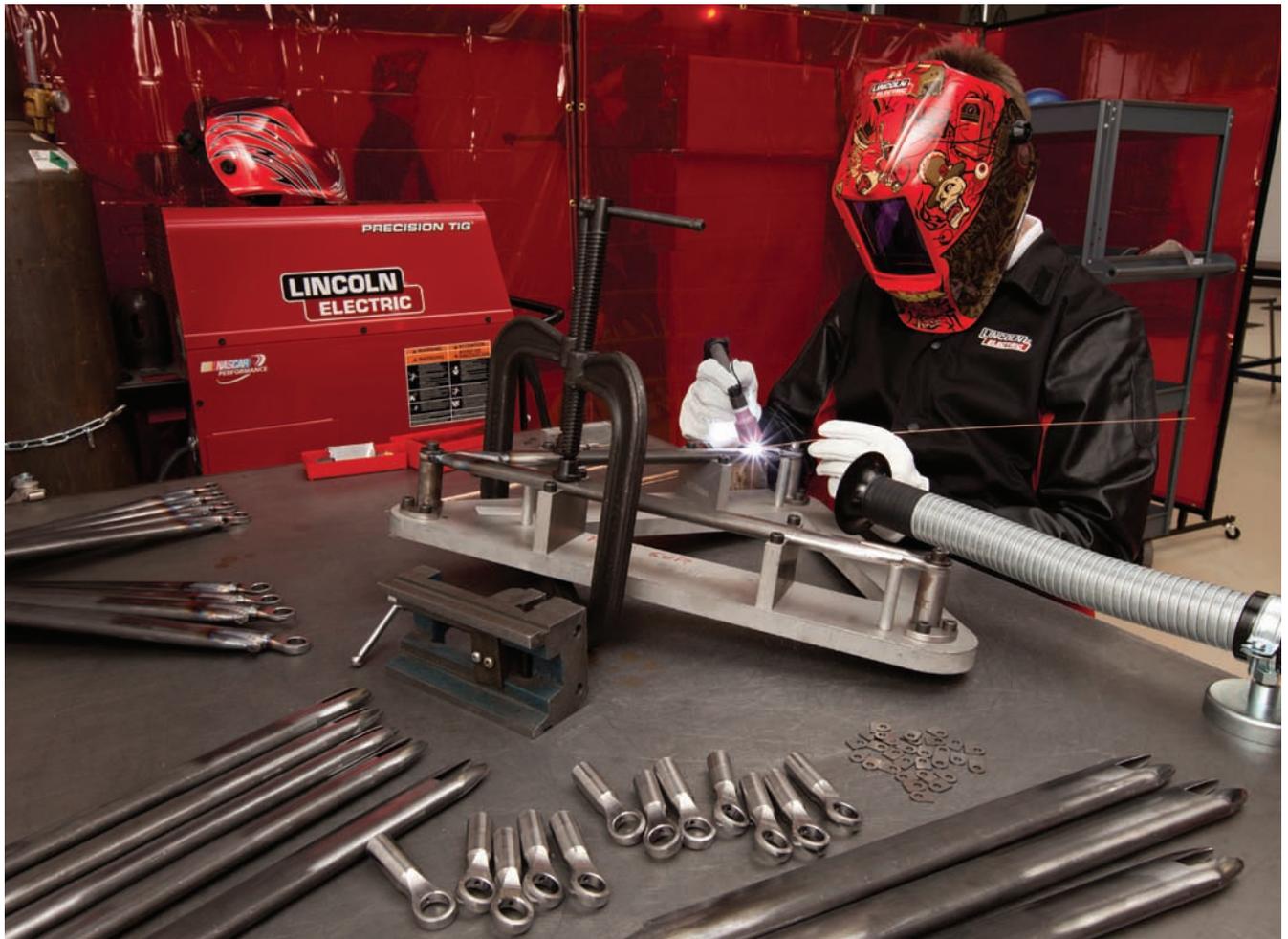
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During welding training students are taught the theory of welding, welding equipment, safety procedures and techniques, and enough of the manual skill to perform basic operations but not how to repair an aircraft via welding so that it can be returned to service (see sidebar). Lincoln Electric.

TIG Evolution

The TIG process was invented in the late 19th century and was matured in the 1930s and 1940s, explains Andrew Pfaller, product manager for Miller Electric, one of the major TIG welding equipment makers in the U.S. A driver behind TIG's development was the aviation industry's need in World War II to weld magnesium parts, he says. Miller Electric and Lincoln Electric are the two largest TIG welding equipment manufacturers in the U.S.

TIG technology has improved over time. Manufacturers now offer "square wave" systems, for example, which literally make the AC sine wave into more of a square shape, preventing the "migration" of tungsten from the electrode to the work piece. The artificial square wave form also enables very fast transitions from positive to negative polarities—less time at or near "zero," producing a more stable arc. The square wave's rapid zero crossings also maximize the energy in each cycle, allowing fast travel speeds, adds Ivan Gracic, Lincoln Electric's TIG product manager.

Teaching Welding

Airframe and powerplant (A&P) schools are required by the Federal Aviation Administration (FAA) to teach the subject of welding, and the agency closely controls the curriculum, down to the what's and even the how's of the job.

Instructors are required to teach the subject to "Level 2," which means that students learn the subject well enough to explain it thoroughly to another person, says Ray Bacon, an instructor in the A&P school at Tarrant County College in Fort Worth, Texas. Students, for example, learn about the theory of welding, welding equipment, safety procedures and techniques, and enough of the manual skill to perform basic operations. The exact number of hours spent on the subject is negotiable between the schools and the FAA when the school is originally certified to teach, Bacon says. At Tarrant County College 48 hours are devoted to the subject. Students spend 16 hours in lectures and 32 hours practicing welding pieces of metal in a lab. They are not building a "project" or a part for an airplane. They are just learning the do's and don'ts, the rudiments of welding, by hands-on experience. They use oxy acetylene equipment because that is the technology the FAA asks about in the A&P exam.

Students essentially are taught what welding is and how to visually evaluate the integrity of a weld, but not how to repair an aircraft via welding so that it can be returned to service, Bacon says. The student, for example, should be able to recognize the proper dimensions and the proper finish of the weld bead.



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The most recent advance in TIG welding is the wireless foot pedal, which allows the welder to work at some distance from the power source.
Lincoln Electric Photo.

Another improvement was the development of AC balancing, which adjusts the time spent at the positive and negative polarities of the AC wave. A high percentage of electrode negative (EN) results in greater penetration, while a high percentage at electrode positive (EP) results in greater oxide removal or “cleaning.” Cleaning is important in the welding of aluminum, for example, because aluminum oxide—which can impair the weld—melts at a much higher temperature than the base metal itself. Nevertheless, excessive oxide removal is undesirable, so the balance is typically set to relatively higher EN percentages. This also reduces the heat on the tungsten, Pfaller says. Tungsten will slowly erode with the arc heat and contaminate the weld, Bacon adds.

But probably the biggest advancement in TIG welding to date was the invention of inverter-based power sources. Inverter technology allows AC frequency switching at much higher speeds than the 60 Hz one gets from outlet power in North America. Frequency control improves the quality of the arc and helps adjust the heat output to the material being welded. The arc can be more narrowly focused with better directional control. Both Miller and Lincoln see customers switching from transformer-based to inverter-based products. Inverter-based equipment is also more power-efficient, smaller and more portable. Although the newer technology is more expensive up front, it may be cheaper in the long run through power savings.

The most recent advance in TIG welding is the wireless foot pedal, which allows the welder to work at some distance from the power source. This could be helpful to aviation welders, for example, who might be working up the fuselage, away from the power source. There is also a trend toward more user-friendly interfaces to the equipment.

Products

Lincoln Electric and Miller Electric, between them, offer a wide range of welding technologies. They offer six families of established products—both transformer- and

inverter-based—and are introducing new features and lines.

In the older, transformer-based technology, Lincoln Electric offers its Precision TIG and Square Wave lines and Miller Electric offers the Syncrowave line. In the newer, inverter-based technology, Lincoln offers the Invertec line and Miller offers the Dynasty and Maxstar lines. Miller is thought to have invented the square wave technique back in the 1970s, but the approach is now widely used in the industry.

Lincoln’s Precision TIG products “offer the widest amperage range,” according to Gracic. The Precision TIG 375, for example, provides an output range of 2 to 375 amps, he says.

Both companies have their own brands of arc-starting technologies. Miller’s Blue Lightning arc starter—available with its Dynasty and Maxstar inverter products—allows a more consistent arc start and more precise control of heat output, the company says. Lincoln’s Micro-Start II technology, on the other hand, delivers stable, low-amperage starts for both AC and DC welding, Gracic says. These “soft starts” are beneficial in welding thin material because amperage builds up and is tightly controlled, minimizing material distortion in the weld, he adds.

Both companies also offer wireless foot

pedals. Miller’s was introduced several years ago and has a 90-foot range. Lincoln’s is expected soon. The Lincoln product will work with both the Precision TIG and Invertec lines, as well as with the company’s new Aspect 375. The product will have a range of 100 feet and will include a battery life indicator and an attachment that allows for height adjustment.

Miller’s newest product is the Dynasty 280, which will meet the needs of customers using the older Syncrowave 250, Pfaller says. It offers a range of 1 to 280 amps, filling the gap between the Dynasty 200 and the Dynasty 350, he says. The Dynasty 280 is also significantly lighter than the older machines, making it much more portable and versatile for maintenance applications, he says. The user interface of the new product is also easier to understand and the machine is faster to set up, he adds.

Lincoln Electric plans to introduce a new product next year, the Aspect 375, which will be the flagship of a new TIG welding inverter line. This machine will have a wide amperage range—2 to 375 amps—and faster switching speeds than the company’s current lineup to provide the welder with more precise arc control. This machine is also designed for ease of use with a simplified interface. **AM**