Resistance Welding Aluminum

Shopping for a spot welder for aluminum applications

For a trained engineer, scientist, or technically minded person, shopping for a resistance welder to weld aluminum can be a startlingly subjective task. Like studying history, religion, or politics, it can be that, the more you learn about it, the more confusing it becomes.

Gathering opinions from the various experts and sales people in the field will also yield very different results. You may find one company offering an inexpensive hand-held welder and another company offering a six-figure floor-mounted machine, both for the same application.

If you are shopping for a spot welder to weld aluminum and you work for McDonnell Douglas, Boeing, Pratt & Whitney, or other aerospace manufacturer, a large, heavy-duty (and expensive) machine is required. However, for others who are simply welding an architectural mount, display rack, sound enclosure, cooking utensil, or other more common applications, it is possible to use a smaller machine.

Set-up Sheets

Typically, an objective way of shopping for equipment is to use set-up sheets. Set-up sheets can help determine the size of machine you will need for your given application. Spot welders are the same way. If you are welding two thicknesses of 0.060" galvanized steel, you can look that up on a table and determine what weld Current, weld Time, and weld Force is required. Armed with the Current, Time, and Force requirements, you would normally be able to determine the best machine for your application (as well as primary voltage and throat depth).

Set-up sheets are often used in the resistance welding industry. These sheets will tell you, for a given material and material thickness, what your weld settings should be. The most reliable and up-to-date settings are typically published by the AWS (American Welding Society) and the RWMA (Resistance Welding Manufacturer's Association). But even if you reference the AWS/RWMA settings, you will find large variations in recommended settings based on the welding technology available for aluminum. You will also find the most recent and readily available Inverter technology is simply absent from the AWS specifications.

You can find some common set-up guides here.
http://spotweldinc.com/set_up_guide.html

So why is this so confusing?
To put it very simply, it is relatively easy to "stick" aluminum together. However, to weld with a repeatable and robust process, to do many thousands of welds continuously without interruption, it is considerably more complicated.

So where do you go, and what is a person suppose to do?
First, try and get a reasonable understanding of the application you're welding. Once you understand "how good" your weld needs to be, you will be on the road to finding the right equipment.

Some questions to ask yourself:

- Is this a structural application where human safety is a factor? Airplane fuselages, jet engine cowlings, and wing struts are some examples
- Will the weld joint be approaching near yield-strength loads? Aerospace, automotive
- Will the weld joint be seeing cyclical loads or vibration?
- Does the print call out a Mil-Spec 6858D or a specification AWS D17.2? (AWS D17.2/D17.2M:2007 or more recent)?

If you answered "Yes" to any of the above questions, it's likely you would want a machine that meets the AWS "Frequency Converter" settings, or a large custom Inverter.

If you answered "No" to all of the above, it's Good-News, Bad-News. The Bad-News is that you're going to have a harder time shopping because there is a much wider selection to chose from. The Good-News is that you can save a significant amount of money.

Where do I start?
When you're shopping for a resistance welder to weld aluminum (and you have determined there is no human-safety factor), typically the most important thing to know is your *worst-case* material thickness. Here are some important things to know about aluminum:

- The gauge thickness of aluminum is different than the corresponding gauge thickness of steel or other materials (12-

gauge steel is 0.105" thick, 12-gauge aluminum is 0.081" thick). For this reason, it is best to talk in terms of actual material thickness measurements, in inches or millimeters.

- When welding two different material thicknesses to one another (0.060" to 0.125", for example), go by the *thinner* of the two materials. You are essentially welding the *thin* to the *thick* material. This works to your advantage as you can use a smaller machine than you may think.
- It is common among manufacturers and sales people to refer to "welding eighth-inch" or "welding 0.060". Note that this assumes you are welding *two thicknesses* of that material (as opposed to the stack-up height). In the preceding example, "welding eighth-inch" is referring to welding two pieces of 0.125" aluminum to one another.
- When welding more than two thicknesses (3T or more), you will not find any published data. The best you can do is add up all your thicknesses and divide by two to approximate welding two thicknesses. (Example: If you must weld two thicknesses of 0.015" to 0.020". [0.015 + 0.015 + 0.020 = 0.050"/2 = 0.025"])

Another thing a knowledgeable source should ask you is your duty cycle. This is simply how often you weld in a given period of time. The more often you weld, the greater heat is generated and the larger machine you need to be able to handle that heat. Duty cycle can be calculated using this formula:

$$Percent\ Duty\ Cycle = \frac{[weld\ time\ (in\ cycles)]\ X\ [number\ of\ welds\ per\ minute]}{36}$$

What's next?

Generally speaking, you will find three basic technologies offered.

1. Single-phase AC spot welders
2. Three-phase AC Frequency Converter type spot welder (these will most likely be offered only as Refurbished)
3. 3-phase DC Inverter, a.k.a, Mid-Frequency Direct Current (MFDC) welders

The first technology listed above, **single-phase AC**, is the most common. It's also the least expensive, and the least likely to perform consistent quality welds if you are welding anything over about 0.040" thick material.

The second technology most commonly available is a **Frequency Converter**. These were very popular machines with the military and with aerospace manufacturers. They were very expensive when they were new; they were typically built like brick outhouses (very sturdy). They are very large and heavy (some weighing 15,000lbs or more). They are often made from enormous copper castings that provide very low resistance. Many aerospace Frequency Converters were built with a special type of diaphragm air system that was able to provide fast follow up and very high forge forces (on the order of 10,000lbsf). No one is building these machines any longer, new. There are, however, many on the used market in various states of dis-repair. They can be purchased as-is or refurbished often for small fractions of their original selling cost. It is best to purchase a refurbished machine with a warranty, as Frequency Converters can be very costly and time consuming to fix.

Inverters or **Mid-Frequency DC welders** (MFDC) have largely taken the place of the Frequency Converters. They are smaller, components are readily available, and they use closed loop feedback for optimum weld quality. The major downside of MFDC is it's initial expense. Very large IGBT's are required for the magnitude of current needed. These IGBTs are relatively rare and expensive.

Why do I need such expensive equipment?
Aluminum is very electrically conductive. It is often used in high-voltage power lines in place of copper. Resistance welding uses electrical current to heat up the material you are welding (just like the coils on an old electric stove top). With the high electrical conductivity of aluminum (compared to ferrous alloys, stainless, Titanium, and many other weldable materials), you need to pass a lot of current in a short period of time to weld it properly. The only way to pass a lot of current in a short amount of time is to have a large machine (compared to it's equivalent for steel or other material).

Aluminum welding spectrum
Imagine a spectrum, an aluminum welding spectrum, going from "easy to weld", out to "hard to weld".

Resistance Welding Equipment
Refurbished Equipment
Custom Design Services
Spot Welding Electrodes
Water Chillers & Coolers
Nut Feeders
Special Tooling
Bar Stock
Holders
Transformers
SCR's
Special Forgings
Elkonite
Seam Welder Wheels
Force Gauges
Electrode Dressers
Tensile Testers
Weld Controls & Systems
Stud Welding Equipment
Repair and Service
Educational Programs

The easy stuff is welding an aluminum architectural mount, display rack, sound enclosure, cooking utensil, or other more common application. This does not require the sophisticated settings, or even the weld current that a more critical application may warrant.

The hard stuff is the Mil-Spec, aerospace grade, Commercial-grade. Those machines are offered with many features that allow a skilled operator to use various functions such as forge, upslope, downslope, impulsing, and other features. These features are required if you are examining weld characteristics closely, mounting, polishing, and etching samples extensively, reviewing weld bonds with powerful microscopes, and performing thousands of destructive tests on a calibrated tensile tester. These systems are in place for aluminum welding applications that are critical to human safety; airplane fuselages, jet engine cowlings, wing struts, etc.

So how do I choose?

Here are some common examples.

- If you are a job-shop, doing contract work, and you never know what you're welding until you get the work, the most versatile machine is an inverter.
- If you are doing 1st Tier or contract work for an aerospace company, if you need to meet American or European military-grade or commercial-grade specifications, you will need either a Frequency Converter or a large Inverter.
- If you are a manufacturer of a product or sub-assembly which you want to weld effectively but want the most cost effective equipment to get the job done, you will want a Frequency Converter.
- If floor space is an issue, you need an Inverter (MFDC)
- If you have limited electrical power in your facility, you will want a 3-phase machine (the Inverter [MFDC] or the Frequency Converter)
- If you want feedback from the welder (data logging or other characteristics), you should get an Inverter
- If you want the least expensive option, don't have any appearance or surface finish specifications, if you have an abundance of electricity in your plant, time to dress your electrodes every 5-10 welds, and you can handle a few broken welds here and there, get a big single-phase AC welder.

To make matters more complicated…
This document is only intended for those customers at the very early stages of shopping for a spot welder. Once you have settled on any of the welding technologies, there is a great deal more information required before a quote can be generated.

The Mil-Spec commercial-grade welders are often required to have a "fast follow up" weld head, requiring a special diaphragm and lightweight ram (weighing less than 5-10% of the output force of the weld).

Throat depth of the welder and the gap between the weld arms will change the weld current at the electrodes.

Electrodes must be dressed with high frequency, in some cases up to every 5-10 welds.

Electrode shape and copper alloy selection is very important.

Tooling life and weld quality will greatly improve with cool electrodes. Water-cooling is imperative. A large water chiller is often required. Water temperature must be monitored closely; if cooling water dips below dew point, the water-cooled electronics can develop condensation and cause an electrical short (often catastrophically).

If part geometry warrants a different style of machine, seam welders, rocker arm spot welders, portable welders, and custom equipment can be made with any of the above technologies.

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