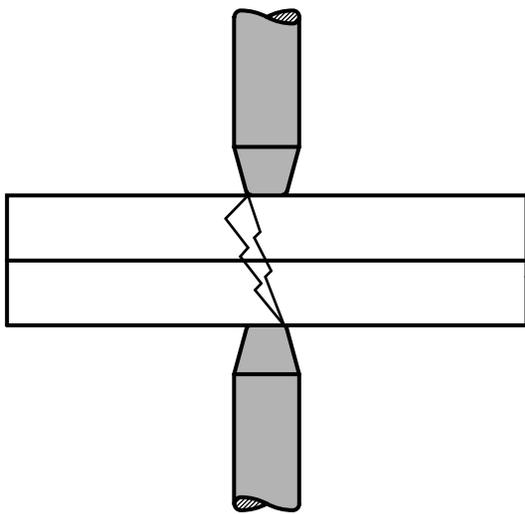


What You Should Know About Resistance Welding

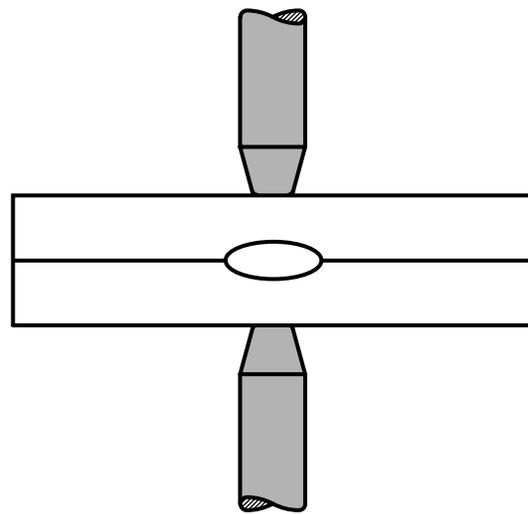
Most welding applies heat to join two pieces of metal. Gas welding produces molten metal through the use of a gas flame. When the molten metal cools, the pieces are joined. Arc welding uses an electric arc between the electrode and the work to melt the metal. Both processes use “consumables” such as gasses, fluxes, electrodes, etc. and add metal to make the weld.

Resistance welding joins two pieces of sheet metal without adding anything. Resistance welding relies on the application of heat (electrical current), time and pressure to make a weld. When an electrical current is applied to the work pieces, for a predetermined time a nugget of molten metal is created between the two pieces. When the nugget cools, the pieces are joined.

The electrical current is transmitted through two copper alloy electrodes, as shown:



When the electrical current is applied, the electricity goes through two electrodes and creates the nugget of molten metal as shown:



The nugget is created at the point where the two pieces interface because this is the point of maximum heat generation. The heat producing the melting process is caused by the metals' electrical resistance to the current flow.

The word “resistance” in Resistance Welding describes the characteristic reaction of the metal to electricity. For example, copper has a lower resistance to electricity than steel. Most Resistance Welding electrodes are made of copper alloys to permit good current flow. The pieces to be joined (generally steel) have a higher resistance to electricity. As the current is applied, the electricity goes through the copper electrodes easily, but encounters resistance as it passes through the steel. The resistance is usually highest at the interface of the two pieces to be joined. This causes the steel at the point of contact to melt, creating the nugget of molten metal mentioned above. In addition to the flow of electrical current, the copper alloy electrodes also transmit a mechanical force or pressure. This force is necessary for a number of reasons, the most important being to prevent the expulsion of molten metal from the weld nugget.

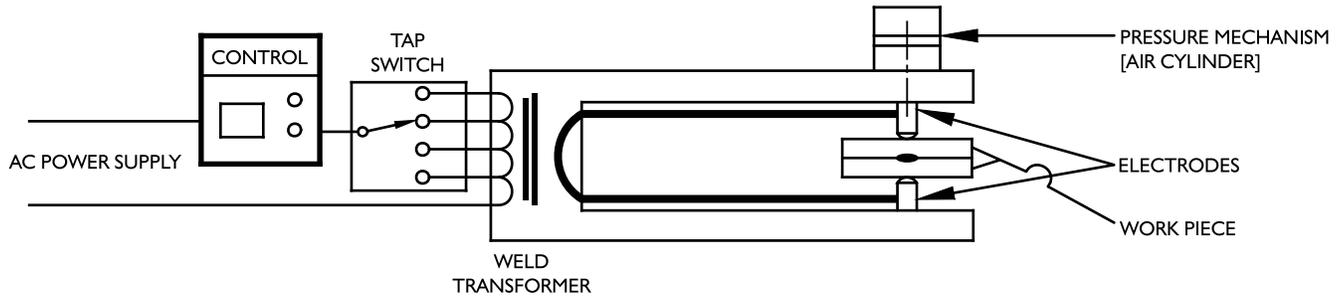
The time involved is very brief. The thickness and type of material to be joined determine the amount of time required for the flow of electrical current. Usually this “weld time” is less than one second.

Resistance welding equipment consists of all or most of the following:

1. A rigid frame which houses a welding transformer to convert high primary voltage and low primary amperage to low secondary voltage and high secondary amperage needed for welding.

2. The electrodes for passing the current through the work pieces.
3. The conductors which connect these electrodes to the welding transformer.
4. A device for exerting electrode force on the work.
5. A method of regulating the electrical current.
6. A contactor to interrupt the power to the welder transformer.
7. A timer which is capable of controlling the action of the contactor within the limits of accuracy required to produce the desired weld characteristics.
8. A method of cooling the electrodes with water.

Following is a schematic drawing of these components:



Every metal has its own characteristic resistance to electrical current. The amount of heat generated by a given resistance is expressed by this formula:

$$W = I^2 R t$$

“W” is the heat in Watt seconds

“I” is the current Ampere flowing through the work

“R” is the resistance of the metal in ohms

“t” is the time in seconds

The amount of heat required to make a weld could also be expressed by a formula, but the important thing to remember is that the heat is directly proportional to the material’s resistance, the time of current flow, and the square of the amount of current.

TIME

In resistance welding, there are four basic stages of time:

1. **Squeeze time** - The time between the initial application of the electrode force on the work and the first application of electrical current.
2. **Weld time** - The time that welding current is applied to the work.
3. **Hold time** - The time during which force is applied at the point of welding after the last pulse of current ceases.
4. **Off time** - The time during which the electrodes are off the work. (“Off Time” is an optional timing function used for automatic-repeat operation and is not necessary to produce a weld.)

Other timing sequences and control functions may be required for specific applications.

ALTERNATING CURRENT

The majority of resistance welding machines operate on single phase, alternating current of the power line frequency, usually 60Hz (cycles per second). This method incorporates a single phase welding transformer to convert the high power line voltage to a low secondary voltage, normally in the range of 1.0 to 25.0 volts. Depending on the thickness and type of material to be welded, secondary current may be from 1,000 to as much as 100,000 amperes or more.

DIRECT CURRENT

Some resistance welders are designed to operate on a 3-Phase primary electrical service and will rectify the current from alternating current (AC) to direct current (DC). A 3-Phase DC resistance welder is electrically more efficient than a single phase AC resistance welder. This is because it usually produces more welding amperage per KVA and requires less demand on the primary electrical service. Due to significantly higher costs, 3-phase resistance welders account for only a small percentage of new resistance welder sales.

TIME CONTROL

The duration of current application referred to as time, weld time, heat time, weld count or current count, is generally controlled by electronic, mechanical or manual means. Times ranging down to one half-cycle of 60-cycle frequency are used for the thinnest sheets, and longer for thicker plates, depending also on the metal being welded. The best welds are made in relatively short times, usually less than one second. Weld times of more than one second indicate, in most cases, too small a welder is being used.

ELECTRODE FORCE

Completion of the electrical circuit between the electrodes and through the work is assured by the continuous application of pressure. For a given material's composition and thickness, the higher the magnitude of the applied force the more it serves to:

1. Bring the two surfaces into close contact.
2. Reduce initial contact resistance between the surfaces and the contacting electrodes.
3. Permit the use of higher secondary current.
4. Reduce internal cracking of the "nugget" between the joined metals.

Too great a force will produce excessive marking of the material surfaces and, ultimately, produce a weaker weld.

ELECTRICAL CHARACTERISTICS

Most equipment is rated at a certain KVA (such as 30 KVA). The KVA (kilo-volt-amp) rating is a measure of the amount of power the equipment can handle without excessive internal heating. In most cases, the welding transformer is the limiting factor in the equipment and determines the KVA rating. It is standard practice to rate a welding transformer at a 50% duty cycle. The duty cycle of a transformer is defined as the percentage of time on in each one minute period the transformer is actually carrying current. It is expressed in this formula:

$$\% \text{ DUTY CYCLE} = \frac{\text{WELD TIME} \times \# \text{ WELDS PER MINUTE}}{3600} \times 100$$

In most resistance welding applications, actual duty cycle is much less than the 50% duty cycle used for rating the machine. The higher the KVA, the more power the transformer can carry. The actual welding current produced by a transformer is not directly related to its KVA rating. Transformers made by different manufacturers, but with the same KVA rating, may produce widely different amounts of welding current. It is important to compare not only KVA rating, but welding current when comparing resistance welding machines.

Selecting resistance welding equipment must take all of the following factors into consideration:

1. The amount of voltage and current available in the user's plant.
2. The type and thickness of metal to be welded.
3. The amount of heat to be applied.
4. The amount of weld time necessary to weld the two pieces of metal.
5. The total time required (weld cycle) to apply pressure, flow welding current, forge the weld and open the electrodes.

EFFECTS OF MATERIAL

Cold Rolled Steel (CRS) - Cold rolled steel is the ideal metal for spot welding. Cold rolled steel is not an exact specification for material but is generally taken to mean a clean, non-alloyed, low carbon steel which is free from any surface coatings, rust, scale or any other foreign material on the surface. A light oil coating is not detrimental. All capacities and capabilities quoted for resistance welders refer to cold rolled steel unless otherwise indicated.

Stainless Steel - Most stainless steels are readily welded by spot welding. For equivalent thicknesses of stainless steel compared to CRS, stainless steel requires less weld time (or weld heat where adjustable) and more tip pressure. A few grades of stainless steel will produce poor or brittle welds. When in doubt, make a test weld or consult a material supplier.

Aluminum - Aluminum is more difficult to weld because it is a good conductor of electricity and produces relatively little heat. Depending upon the alloy grade and required weld quality, aluminum alloys may require two to five times the secondary welding amperage needed to weld an equivalent thickness of mild steel. This may dictate the use of a larger, higher KVA rated resistance welder than required for welding steel. Some aluminum alloys are not suitable for resistance welding and will produce poor welds even in thin gauges. Consult your material supplier or make a test weld.

Copper, Brass, Etc. - Copper usually cannot be welded because its electrical conductivity is better than aluminum. Some copper alloys can be welded in thin gauges. Appropriate tests are required.

Coated Steel - To weld a coated steel, the coating must be electrically conductive. Thus, pre-painted or vinyl coated steel for example, cannot be welded without removing the coating at the point of welding.

The most common coating given to steel is a zinc or zinc alloy (galvanized, for example). Other metallic coatings such as tin are also used. Any coating will reduce the capacity of the steel to be welded. In other words, you will not be able to weld a coated heavy material as well as one that is not coated. Actual capabilities must be determined by test. As a rule of thumb, welding capabilities of electro-galvanized steels are reduced by at least 25%. Hot-dipped galvanized reduces welding capacity even more. Regardless of the type of coating or its thickness, it will adhere to and contaminate the electrodes. This will require more frequent electrode dressing than when welding uncoated steel.

Guidelines for Successful Resistance Welding Applications

1. The pieces to be joined should be of compatible metals. Joining dissimilar metals (such as mild steel to aluminum) becomes very difficult because each of the metals has its own resistance factor. These factors cannot be averaged. Like oil and water, some metals or alloys do not mix. Therefore joining dissimilar metals is a very complex process.
2. The primary advantage of resistance welding is in its ease of use and speed. Resistance welding is commonly employed to weld sheet metal of 11 gauge x 11 gauge or lighter. Heavier gauges may be welded but may require a larger, higher KVA rated welder and special techniques.
3. The amount of electrode force is important. Too great a force may damage the material. Too light a force may cause expulsion of the “nugget” producing a weak weld. “Just right” is the force which helps create the nugget of molten metal without excessive marking on the surface of the metal.
4. Before resistance welding, metal surfaces should be cleaned to obtain best results. Dirt or rust on the welding surfaces may not allow the full amount of welding current to pass through the work pieces.