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Processes of Arc Welding

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Introduction

Welding is a powerful technological advance. It allows for things to be conjoined that may have not been thought to be possible. Welding is the most economical and efficient way of joining things together permanently. It is vital to our economy and therefore vital information for all engineers, specifically, structural, industrial, and material engineers. [1]

The process of welding is the coalescence of metals through atom-to-atom contact. In laymen terms, welding is a sculptural process that joins materials together. The history of welding dates all the way back to 310 AD when welding was used in the construction of the Iron Pillar of Delhi. Although, the processes have without a doubt been altered and improved, welding is still used in industry today. [2]

Figure 1: Arc Welding

Arc welding is a type of welding that uses a welding power supply to create an electric arc. This arc is formed between the base metal and the electrode, which is a stick or wire. This electrode can either be manually or mechanically guided along the weld joint. Each process uses either a non-consumable or a consumable electrode. Non-consumable electrode processes have no metal transfer since the electrode establishes the arc but it does not melt throughout the process. Inert gases are used in these processes for shielding. Consumable electrode processes, again, have the electrode establish the arc, however, the electrode also melts throughout the weld, providing a filler metal. Both inert gases and fluxes are used in these processes for shielding. Consumable electrodes can cause some challenges such as higher disposition rates and trouble controlling the arc for the operator. [3] [4]

Of the six common arc welding methods, Gas Metal-Arc Welding (GMAW), Shielded-Metal Arc Welding (SMAW), and Fluxed-Cored Arc Welding are all examples of non-consumable electrode processes, while Gas-Tungsten Arc Welding (GTAW) is an example of a consumable electrode process. The other two processes to be discussed, Resistance Spot

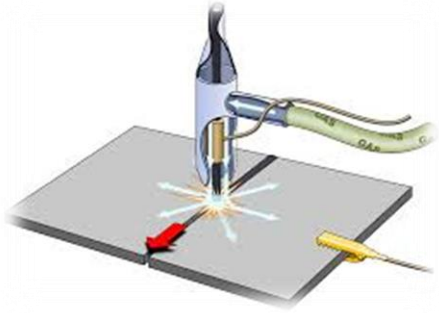

Figure 2: Arc Welding Circuit

Welding (RSW), and Plasma-Arc Welding (PAW), do not utilize electrodes so are not depicted as consumable or non-consumable.

TIG (GTAW)

Gas-Tungsten Arc Welding (GTAW), or Tungsten- Inert Gas Welding (TIG) “is most commonly used to weld thin sections of stainless steel and non-ferrous metals, such as aluminum, magnesium, and copper alloys” [2]. However, it also requires the highest operator skill level. It is a non-consumable process, meaning that the tungsten electrode that is used, does not get used up in the process. The inert gas, either argon or helium, is used as a shielding gas. It shields the electric arc, the space between the electrode and the base material, from any atmospheric contamination. This also provides the welder with control of the arc. TIG welding is considered a more expensive welding process due to the use of the inert gas. However, it can produce high quality welds if the welding materials are clean.

Figure 3: TIG Weld

MIG (GMAW)

Gas Metal-Arc Welding (GMAW), or Metal-Inert Gas Welding (MIG) is the most popular semi-automatic welding process used today, requiring little operator skill. It uses a consumable electrode of a spool of wire that is continuously fed throughout the process. Since the electrode is consumed, the process can deliver medium-high deposit rates. The inert gas used in MIG is argon or a mixture of argon and carbon dioxide to shield the weld puddle from atmospheric contamination. MIG can be performed on both ferrous and non-ferrous materials, as well as thin and think materials due to its ease of arc control. MIG involves high capital investment and also requires clean materials to produce the most efficient welds. [2]

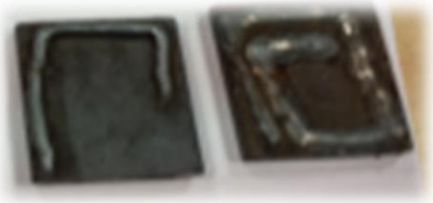

Figure 4: MIG Weld

STICK (SMAW)

Shielded-Metal Arc Welding (SMAW), or Stick welding is the most versatile of all welding methods since it can be used in any environment. However, it also requires the most training to develop total proficiency. Stick welding uses a consumable electrode of filler material covered in flux, which is a chemical cleaning agent. This flux burns off during the process, creating a gaseous envelope around the arc and oxidizes the metals being joined together. The flux also creates a black layer of slag that needs to be chipped off after each weld. This process is primarily used on steels. Stick requires low capital investment, with low deposition rates on welds. [2]

Figure 5: STICK Weld

FCAW

Fluxed-Cored Arc Welding, or FCAW is a hybrid between Stick and MIG welding. It can also be referred to as continuous Stick welding since it is a semi-automated process. Both flux and a shielding gas can be present during this process. The flux is in the center of the electrode while the outside is the filler material, this being opposite of the Stick electrode. The flux is often enough protection from the atmosphere, but depending on the filler material being used, additional shielding gas is sometimes used for further protection. This process is also primarily used on steels. This process is suitable for all position welding and can tolerate mill scale, meaning that the base materials do not need to be clean to produce efficient welds. [2] [5]

Figure 6: Flux-cored electrodes

SPOT (RSW)

Resistance Spot Welding (RSW) is a fast, automated process where metal surfaces are joined by a heat input. The pieces are held together under pressure exerted by the electrodes. The produced weld nugget has a center fusion zone and a surrounding heat affected zone. [6]

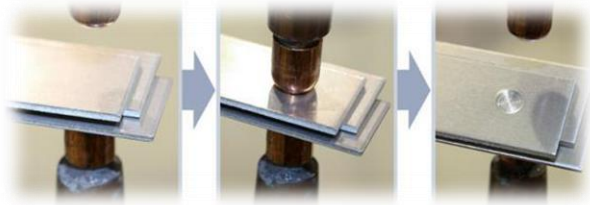

Figure 7: SPOT weld process

PLASMA (PAW)

Plasma-Arc Welding (PAW) is somewhat similar to GTAW and can be referred to as 'high tech TIG' welding. It uses a non-consumable tungsten electrode and heat is transferred through an ionized inert gas, called plasma. This process is more commonly used for cutting, instead of welding. In fact, its competing process is water cutting.

Figure 8: Plasma Weld

Conclusion

Since welding is such a widely used process with multiple methods, differentiating between techniques can be difficult. Now you have knowledge of the six most common methods of arc welding; Gas-Tungsten Arc Welding (GTAW), Gas Metal-Arc Welding (GMAW), Shielded-Metal Arc Welding (SMAW), Fluxed-Cored Arc Welding (FCAW), Spot Welding (RSW), and Plasma Welding (PAW)

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7. Figures 1-2, 6-8 taken from PSU media commons

8. Figures 3-5, taken by myself, Kate Gilland