Plasma Arc Welding (PAW)

Plasma Arc Welding (PAW)

The plasma arc welding (PAW) process is a gas-shielded process that utilizes a constricted arc between a non-consumable tungsten electrode and the workpiece. The transferred arc possesses high energy density and plasma jet velocity. Two distinct operating modes are possible, referred to as melt-in-mode and keyhole mode. The melt-in-mode utilizes lower welding current and generates a weld pool similar to that formed in GTAW, whereby a portion of the workpiece material under the arc is melted. In the keyhole mode, higher welding current is utilized so that the arc fully penetrates the workpiece material to form a concentric hole through the joint thickness. The molten weld metal solidifies behind the keyhole as the torch traverses the workpiece. Shielding of the weld pool is provided by the ionized plasma gas that is issued from the torch orifice, which is supplemented by an auxiliary source of shielding gas. The PAW process can be utilized with or without a filler metal addition.

Since the constricted arc of PAW allows for greater depth of fusion compared to GTAW, PAW is potentially advantageous for autogenous welding (i.e. without the use of filler metal) of Ni-/Co-base material in the thickness range of approximately 0.125 to 0.3 in (3.2 to 7.6 mm). In comparison, filler metal is typically required for GTAW of material greater than about 0.125 in (3.2 mm) thickness. Square-groove weld joints can be utilized up to about 0.3 in (7.6 mm) thickness. While it is possible to weld a wide range of thicknesses with PAW, better results can usually be achieved with other welding processes for thicknesses outside of the 0.125 to 0.3 in (3.2 to 7.6 mm) range. For joint thicknesses greater than 0.3 in (7.6 mm), autogenous keyhole welding can be utilized for the first pass, followed by non-keyhole (melt-in) PAW with filler metal. Another welding process, such as GTAW, could also be utilized for the second and succeeding passes.

Electrical polarity for the PAW process should be direct current electrode negative (DCEN / “straight polarity”). A proper balance must be achieved between welding current, gas flow, and travel speed to provide consistent keyhole welding. An unstable keyhole can result in turbulence in the weld pool. Argon or argon-hydrogen mixtures are normally utilized for the orifice gas and shielding gas. The orifice gas has a strong effect on the penetration depth and profile. Small amounts of hydrogen (~5%) are typically sufficient to increase the arc energy for autogenous keyhole welding, and higher amounts can lead to porosity in the weld metal. For greater joint thicknesses, increased orifice gas flow and upslope of the welding current may be required to initiate the keyhole. To fill the keyhole cavity at the end of the weld, decreased orifice gas flow and downslope of the welding current may be required. Higher travel speeds require higher welding currents to obtain keyhole welding. Excessive travel speeds can produce undercut, which is a groove melted into the base metal adjacent to the weld toe or weld root and left unfilled by weld metal. The welding torch should be held essentially perpendicular to the work piece in both the longitudinal and transverse directions, and maintained on the centerline of the weld joint. Even a slight deviation from this condition can cause incomplete fusion defects in the weld metal.