Plasma Arc Welding

Plasma Arc Welding Process

The plasma arc welding (PAW) process is sometimes compared to gas tungsten arc welding (GTAW), and there are some similarities, such as the use of a nonconsumable tungsten electrode, low heat input and weld quality, but the PAW process has unique characteristics that make it distinct from GTAW.

The electrode with the PAW process is recessed in a constricting nozzle. Pressurised gas is forced through a small orifice at the base of the nozzle. This orifice gas, in conjunction with the current flow from the electrode, creates a highly charged ionized plasma for current conducting. Around this constricting nozzle is an outer gas nozzle that directs a shielding gas (Fig.1).

This setup provides PAW with some of the distinct characteristics that separate it from GTAW: the arc is narrow and directional; the weld is penetrating; width of the heat-affected zone is narrow; sensitivity to standoff distance is reduced; and the possibility of the electrode touching the workpiece and subsequent contamination is eliminated.

Plasma arc welding lends itself to two different arc modes: transferred and nontransferred (Fig.2). With the transferred arc, the workpiece is part of the circuit, but that is not so with the nontransferred arc. In the transferred mode, the arc is established between the electrode and the workpiece, but in the nontransferred mode, the arc is established between the electrode and the constricting orifice with the force of the plasma gas directing heat to the workpiece. This arc is good for cutting or for joining a nonconductive workpiece. The transferred arc is the most commonly used mode since it generates the most energy into the workpiece.

Torches designed for PAW are more complex GTAW torches. The PAW torch requires a chamber feed line for the orifice gas, as well as a separate passage for the shielding gas. There is also a need for coolant circulation to reduce the heat at the constricting nozzle. Torches for both manual and automatic operations are available.

This process is often used in applications that demand high quality such as medical instruments, bellows, turbine blades and diaphragms. It can be operated at high currents or very low currents, making it suitable for materials that are relatively thick or very thin. Starting is by a pilot arc, making it more reliable at low current levels than GTAW. The process operates over a current range of 0.1 to 500 A. There is a generous latitude in adjusting arc length with lengths of up to 1/4 in. producing acceptable welds on thin material. This process requires very good joint alignment.

It lends itself to the keyhole technique. With this technique, the arc penetrates the workpiece creating a small hole around which the molten metal travels to solidify behind the arc. Its advantage is the production of sound welds in a single pass. Aluminum up to 1/2 in. is joined in a single pass with this technique.

FIG. 1

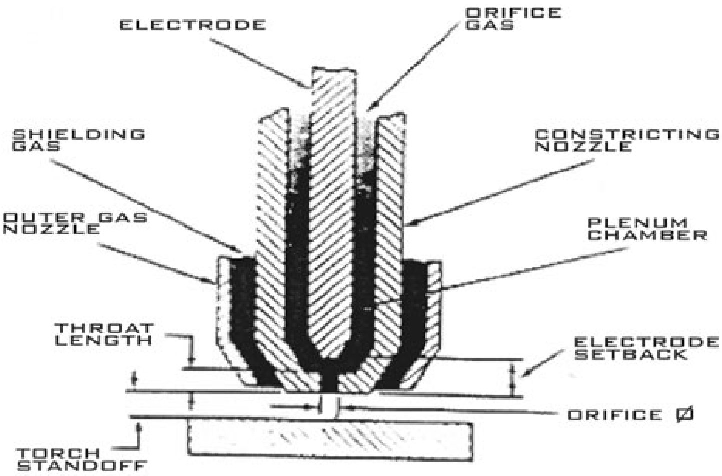
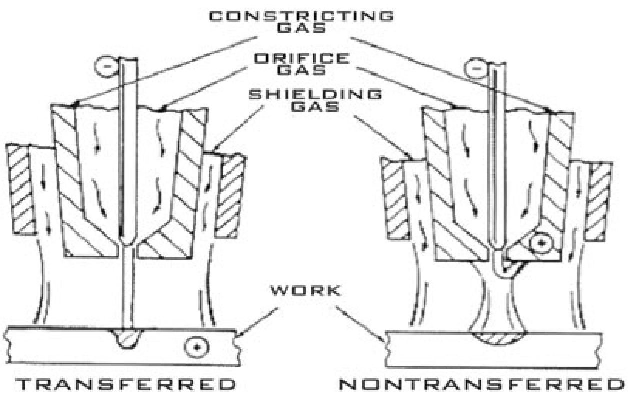


FIG. 2



Electrodes of pure tungsten or tungsten with additions of thoria, zirconia or ceria are used with PAW. Direct current electrode negative (DCEN) is used for most applications since the heat generated is very high at the electrode tip, and when positive, the electrode will quickly deteriorate at currents in excess of 100 A. Pulsed current is often used. Operation on AC for oxide removal on aluminium or magnesium is possible, but here again, currents in excess of 100 A damage the electrode.

Often the same gas is used for the plasma and the shielding gas. The plasma gas must be inert to avoid deterioration of the electrode. Argon is commonly used; sometimes mixed with hydrogen or helium.

TYPICAL PLASMA ARC WELDING CONDITIONS FOR BUTT JOINTS IN CARBON AND LOW ALLOY STEELS

	THICKNESS		TRAVEL SPEED		CURRENT (DSCP)	ARC VOLTAGE	NOZZLE	GAS FLOW[b]				
								ORIFICE[c]		SHIELD[c]		
METAL	in.	mm	in./min	mm/s	(A)	(V)	TYPE[a]	ft^3/H	L/min	ft^3/H	L/min	REMARKS[d]
Mild Steel	0.13	3.2	12	5	185	28	111M	13	6	60	28	Keyhole, square-groove weld
4130 Steel	0.17	4.3	10	4	200	29	136M	12	6	60	28	Keyhole, square-groove weld 1.2mm (3/64 in.) Ø filler wire added at 30 in./min (13mm/s)
D6AC Steel	0.25	6.4	14	6	275	33	136M	15	7	60	28	Keyhole, square-groove weld 600°F (315°C) Preheat

a: Nozzle type: number designates orifice diameter in thousandths of an inch; "M" designates design
b: Gas underbed shielding is required for all welds
c: Gas used: Argon
d: Torch standoff: 3/64 in. (1.2mm) for all welds

TYPICAL PLASMA ARC WELDING CONDITIONS FOR BUTT JOINTS IN STAINLESS STEEL

THICKNESS		TRAVEL SPEED		CURRENT (DSCP)	ARC VOLTAGE	NOZZLE	GAS FLOW[b]				
							ORIFICE[c]		SHIELD[c]		
in.	mm	in./min	mm/s	(A)	(V)	TYPE[a]	ft^3/H	L/min	ft^3/H	L/min	REMARKS[d]
0.092	2.4	24	10	115	30	111M	6	3	35	17	Keyhole, square-groove weld
0.125	3.2	30	13	145	32	111M	10	5	35	17	Keyhole, square-groove weld
0.187	4.8	16	7	165	36	136M	13	6	40	21	Keyhole, square-groove weld
0.25	6.4	14	6	240	38	136M	18	8	50	24	Keyhole, square-groove weld

a: Nozzle type: number designates orifice diameter in thousandths of an inch; "M" designates design
b: Gas underbead shielding is required for all welds
c: Gas used: 95% Ar. - 5% H.
d: Torch standoff: 3/16 in. (4.8mm)

TYPICAL PLASMA ARC WELDING CONDITIONS FOR BUTT JOINTS IN TITANIUM

THICKNESS		TRAVEL SPEED		CURRENT (DSCP)	ARC VOLTAGE	NOZZLE	GAS FLOW[b]				
							ORIFICE		SHIELD		
in.	mm	in./min	mm/s	(A)	(V)	TYPE[a]	ft^3/H	L/min	ft^3/H	L/min	REMARKS[c]
0.125	3.2	20	8.5	185	21	111M	8[d]	3.8	60[d]	28	Keyhole, square-groove weld
0.187	4.8	13	5.5	175	25	136M	18[d]	9	60[d]	28	Keyhole, square-groove weld
0.39	9.9	10	4.2	225	38	136M	32[e]	15	60[e]	28	Keyhole, square-groove weld
0.5	12.7	10	4.2	270	36	136M	27[f]	13	60[f]	28	Keyhole, square-groove weld

a: Nozzle type: number designates orifice diameter in thousandths of an inch; "M" designates design
b: Gas underbead shielding is required for all welds
c: Torch standoff: 3/16 in. (4.8mm)
d: Gas used: Argon
e: Gas used: 75% He. - 25% Ar.
f: Gas used: 50% He. - 50% Ar.