Catapult ARC welding capability

Process Summary of Gas Metal Arc Welding

Gas Metal Arc welding (GMAW), also known as either metal inert gas (MIG) welding or metal active gas (MAG), is a welding process in which an electric arc forms between a consumable wire electrode and the workpiece metal(s), which heats the workpiece metal(s) causing them to heat and join. Shielding gasses typically used are argon and/or carbon dioxide mixed with smaller proportions of oxygen, helium hydrogen and nitrogen. These gases are normally selected according to the material type to be welded. **Cold Metal transfer (CMT**) is a further development from GMAW. CMT provides digital control of the wire delivery process resulting in reduced thermal process and spatter-free metal transfer. Ideally suited to welding of ultra-light gauge steel sheets from 0.3mm, and welded joints between steel and aluminium.

Process Advantages for GMAW

- The GMAW process can be widely applied to a variety of metals (i.e. ferritic steel, stainless steel, nickel, copper and aluminium alloys) including dissimilar metal weld applications (ferritic steel to stainless steel and ferritic steel to aluminium weld brazing).
- GMAW is the most widely used welding process, both industrially and also in the amateur market.
- It is relatively simple to learn the process, and is extremely versatile.
- It is a clean process, and efficient, enabling higher productivty with faster welding speeds.
- Advancements in power supplies and electronic control by equipment manufacturers have improved the process, offering a wide range of alternative processes, based on the basic GMAW system.
- These additional benefits have enabled GMAW to be automated (mechanical and robotics).
- The GMAW process has developed broadly and is now available in a variety of technology themes (i.e cold metal transfer, (Fronius), ColdArc (EWM), Surface Tension Transfer (Lincoln) FastROOT (kemppii), and Qset (ESAB), to name but a few.
- Increased deposition is the aim in high-performance welding, and many manufacturers now offer twin systems, with two power sources and two welding torches such as Time Twin (Fronius) and Tandem MIG (Lincoln).
- New methods of wire delivery including SpinArc from Abicor Binzell offer yet further development to advance the GMAW process.

Typical Applications for GMAW

- Assembly of white goods and office furniture.
- Bridge building and wind turbine towers.
- Widely used in the shipbuilding and construction industries for general fabrication.
- Extensively used in the process industry for pipework and the fabrication of vessels.

- Recent developments in power sources have enabled more efficient delivery of the process to improve speed and quality.
- Wide variety of filler wire for applications such as hard facing or repair of worn track in the rail industry.
- Flux cored wire, both shielded and self-shielding, can provide benefits, including advantages when welding in certain environments including welding outdoors or in windy conditions.
- Corrosion resistant overlays (nuclear application).

Process Summary of Gas Tungsten Arc Welding

Gas Tungsten Arc welding (GTAW) also know as tungsten inert gas (TIG) welding, is an arc process using a non-consumble tungsten electrode. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium) and a filler wire is normally used. A constant current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionised gas and metal vapours known as plasma.

Process Advantages for GTAW

- The GTAW process can be widely applied to almost all metals (i.e. ferritic steel, stainless steel, nickel, aluminium, copper and titanium alloys).
- GTAW is widely used where very high quality, clean welds are required.
- Advancements in power supplies and electronic control by equipment manufacturers have improved the process, offering a wide range of alternative processes, based on the basic GMAW system.
- These additional benefits have enabled GMAW to be automated (mechanical and robotics).
- The GTAW process has developed broadly and is now available in a variety of technology themes (e.g TransTig (Fronius), MagicWave (Fronius), ColdArc (EWM), Surface Tension Transfer (Lincoln) FastROOT (kemppii), and Qset (ESAB), to name but a few.

Typical Applications for GTAW

- Recent developments in power sources have enables more efficient delivery of the process to improve speed and quality.
- Narrow groove welding of heavy wall sections e.g. pressure vessel circumferential seams.
- Orbital pipe welding, standard/narrow gap grooves e.g. nuclear plant primary circuit pipework.
- Orbital tube welding e.g. aerospace, pharmaceutical and semi-conductor applications.
- Dissimilar metal welding e.g. safe end welding within nuclear industry.
- Buttering and weld build-ups e.g. steam generator face end buttering.
- Corrosion resistant overlays e.g. oil and gas pipelines and valve bore cladding applications.
- Tubesheet welding (seal and strength welds) e.g. heat exchanger manufacture.
- Internal bore welding e.g. heat exchanger manufacture, tube sheet bore/back plate welding.

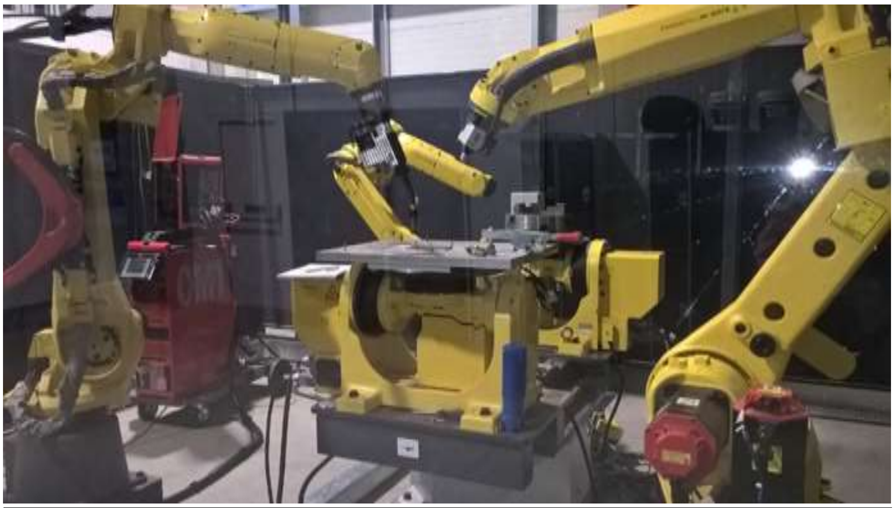

Figure 1 Robotic GTAW and CMT welding cell

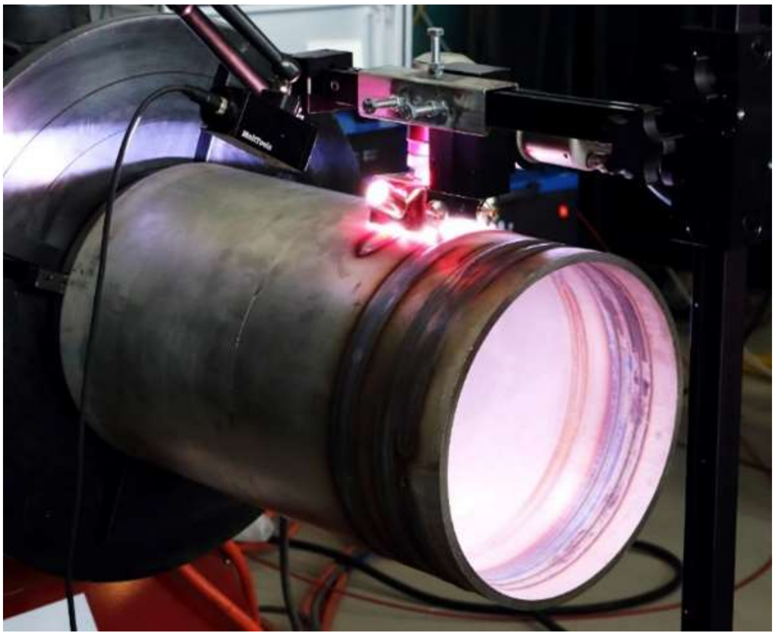

Figure 2 K-TIG pipe trial

Process summary of Plasma Transferred Arc (PTA)

Plasma Transferred Arc (**PTA**) welding is an arc welding process similar to gas tungsten arc welding (GTAW). The electric arc is formed between an electrode (which is usually but not always made of sintered tungsten) and the work piece. The key difference from GTAW is that in PTA, by positioning the electrode within the body of the torch, the plasma arc can be separated from the shielding gas envelope. The plasma is then forced through a fine-bore copper nozzle which constricts the arc and the plasma exits the orifice at high velocities (approaching the speed of sound) and a temperature approaching 28,000 °C (50,000 °F) or higher.

Process Advantages for PTA

Plasma arc welding is an advancement over the GTAW process. This process uses a non-consumable tungsten electrode and an arc constricted through a fine-bore copper nozzle. PAW can be used to join all metals that are weldable with GTAW (i.e., most commercial metals and alloys). Difficult-to-weld in metals by PTA include bronze, cast iron, lead and magnesium. Several basic PTA process variations are possible by varying the current, plasma gas flow rate, and the orifice diameter, including

- Can be used to join all metals (similar to GTAW (TIG))
- Suitable for micro-plasma welding (< 15 Amperes)
- Very low dilution
- PTA has a greater energy concentration as compared to GTAW.
- A deep, narrow penetration is achievable, with a maximum depth of 12 to 18 mm (0.47 to 0.71 in) depending on the materials.
- Greater arc stability allows a much longer arc length (stand-off), and much greater tolerance to arc length changes.

Typical Applications for PTA

- Depositing high-quality metallurgically fused deposits on relatively low cost surfaces.
- Providing an improved surface to protect against extreme conditions in service.
- Oil and gas industry – depositing cobalt based alloys to combat wear, erosion, abrasion and corrosion
- Automotive industry – Hard facing of engine valve seats
- Mining industry – Repair of worn components
- Nuclear sector - Hard facing and corrosion resistant surfaces

Process Summaries of Submerged Arc Welding (SAW)

SAW involves the formation of an arc between a continuously-fed bare wire electrode and the parent plate. The arc, electrode end and molten weld metal are submerged in a granulated flux blanket which prevents atmospheric gases from contaminating the weld metal and dissolves impurities in the base metal and electrode and floats them to the surface. The flux can also add or remove certain alloying elements to or from the weld metal. As the weld progresses the weld metal and then the liquid flux cool and solidify forming a weld bead and a protective slag shield over it.

SAW lends itself to a wide variety of wire and flux combinations, single and multiple electrode arrangements and use of ac or dc welding power sources. The process has been adapted to a wide range of materials i.e. low- and medium-carbon steels, low-alloy high-strength steels, quenched and tempered steels, and many stainless steels. Metal thicknesses up to 12mm can be welded with no edge preparation. With edge preparation and multi-pass techniques the maximum thickness is practically unlimited. Horizontal fillet welds can be made up to 9.5 mm in a single pass. SAW is normally operated in the automatic or semi-automatic mode however is limited to the flat for groove welding and flat or horizontal/vertical for fillet welding.

Two variants of strip cladding can also be carried out with SAW equipment -Submerged Arc Strip Cladding (SASC) and Electroslag Strip Cladding (ESSC). Both are similar processes, but whereas SASC uses an arc/flux combination as SAW, ESSC utilises resistance heating within the conductive flux, to melt the strip and base metal into the liquid slag, which is then transferred into molten metal that is deposited onto the base material.

Process Advantages for SAW

- High quality welds possessing good uniformity, ductility, impact strength and corrosion resistance are readily achieved in a wide variety of metals.
- High welding speeds and metal depositions rates are achievable.
- Welding is carried out without sparks, smoke, flash or spatter.
- High utilisation of electrode wire/strip
- Less weld operator skill level required than with other weld processes

Typical Applications for SAW

- Groove welding of heavy wall sections e.g. pressure vessel and pipe circumferential and longitudinal seams.
- Application of corrosion resistance overlays to large diameter ferritic steel vessels using the ESSC or SASC processes.
- Boiler fin to tube fillet welding in the horizontal vertical position. Tubesheet welding (seal and strength welds) e.g. heat exchanger manufacture
- Heavy section girth welds in the shipping industry

Figure 3 PEMA Multi-wire SAW system set-up

Figure 4 Miller Electro-Slag Strip Cladding of a vessel internal surface

Catapult ARC Welding capabilities

Weld Type	Welding Equipment	Delivery Systems
GMAW (MIG/MAG)	Lincoln S500CE Fronius MagicWave 4000 Miller Axcess 450CE MIG	Manual Linear track Robotic Manual
CMT	Fronius CMT advanced system Fronius MagicWave 4000	Manual Linear track Robotic
GTAW (TIG)	Miller Dynasty 350 Lincoln Aztec 350 Fronius MagicWave Polysoude (various systems) ARC machines K-TIG	Manual Linear track Robotic Mechanised, column & boom, orbital, tube sheet, SPX, TIGER Mechanised, tube sheet, orbital Mechanised
PTA	EWM Tetrix Plasma system Kennametal Starweld	Linear track Robotic
SAW	ITW ESAB (Planetary) Lincoln Electric 5 wire	Mechanised, strip cladding, electro slag, tandem wire Mechanised, planetary, nozzle welder Mechanised, multi wire, strip cladding, electro slag

Associated Systems		
BOC AVANTO	Advanced cloud based weld management system	-Defines and manages -Welding procedures. -Reports -Materials data. .
Cryogenic cleaning **BOC snow cleaning**	High velocity CO2 cleaning	Surface cleaner for lacquering pre-treatment. Pre-treatment in joining processes.