e-Weldone
February 2018 Vol.28

Transforming the welding landscape…

The article introduces certain innovative technologies being developed for advanced welding processes, and comparisons in terms of experimental results using these technologies

Resistance spot welding (RSW) equipped with intermediate layers (process tape) in between the electrodes and the workpieces is a further development of the conventional resistance spot welding process. The presence of the intermediate layers, available in a range of different alloys with different electrical and thermal conductivities, enables to gain substantially more control on the heat input and the welding output. The latter improvement in combination with the servo-electric mechanical actuator and the powerful MFDC interactive process control increases the range of successful applications of the spot welding process in a wide variety of material combinations. In the schematic representation of the process, the presence of additional resistances can be noticed in the immediate vicinity of the materials to be welded. The resulting heat generation can be seen in the right side of the image with (red curve) and without (black curve) the application of a process tape.

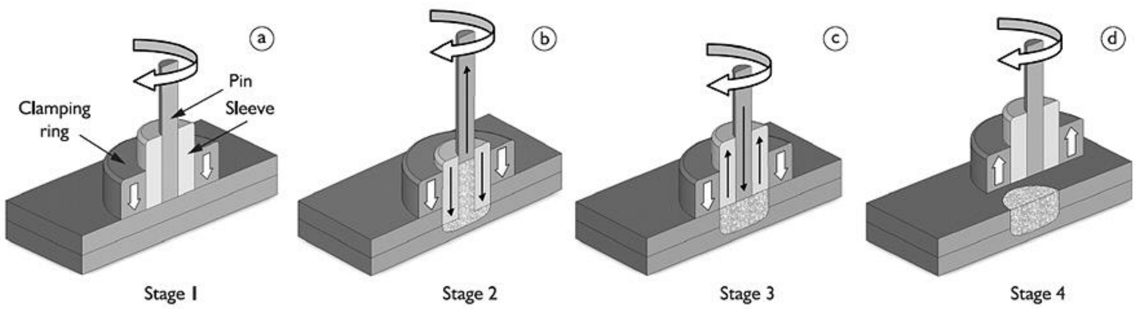

Fig.Working principle of friction spot welding

Friction spot welding

A three-component tool comprising a pin, sleeve and clamping ring is used to join two or more sheets in the overlap configuration. The clamping ring initially fixes the sheets against a backing plate while the pin and sleeve begin to rotate in the same direction, while pressing on the upper surface. The rotating pin and sleeve are moved in opposite direction of each other

(one is plunged into the material while the other moves upwards), creating a cavity where the plasticised material through frictional heat is accommodated. After reaching the pre-set plunge depth, the pin and sleeve return to their initial position forcing the displaced material to completely refill the keyhole. Finally, the tool rotation is stopped and the tool is withdrawn from the joint leaving a flat surface with minimum material loss.
The most important process parameters of this process are the rotational speed, the axial load, the plunge depth, the welding time as well as the pin and sleeve position.

Friction stir welding and friction stir spot welding

Friction stir welding (FSW) is a solid-state joining method meaning that no melting occurs during the process. A rotating tool, composed of a pin and a shoulder, is positioned on the top sheet and is pushed into the material. The frictional heat generated by this penetration action softens the workpiece material to a plastic condition, making it flow around the pin. The tool is then moved along the joint line while maintaining the downward pressure, thus, plastically deforming the material around the tool and intimately stirring the welding zone. After cooling down, the components are welded together. One of the variants of conventional FSW is friction stir spot welding (FSSW) where no longitudinal movement is applied, but only a rotation and an up-and-down movement (material entry and exit). Although this process was originally developed for joining non-ferrous materials, machine and tool material developments have made it possible to apply this welding method to other materials like steel and titanium and material combinations like aluminium to steel or copper to aluminium.
Since the workpiece materials don't melt during the process, this method is very appropriate for joining of dissimilar metals, where metallurgical issues or different melting temperatures might be problematic. Welding equipment using this process is typically CNC or robot based, resulting in an automated process which is robust and productive. The main machine settings and parameters are:

- Penetration depth or pressure setting (interaction between tool and workpiece)
- Rotation speed and dwell time
- Penetration speed and welding speed

With this spot welding method, also certain geometrical forms can be followed by the tool during welding, thereby, influencing the weld quality and process performance.

Electromagnetic pulse sheet welding

This joining technology uses electromagnetic forces for deformation and joining of workpieces. Electromagnetic Pulse Welding (EMPS) is an automatic welding process, which can be used for tubular and sheet metal applications, placed in the overlap configuration. Electromagnetic pulse welding belongs to the group of pressure welding processes. A power supply is used to charge a capacitor bank; when the required amount of energy is stored in the capacitors, it is instantaneously released into a coil, during a very short period of time (typically 10-15μs). The discharge current induces a strong transient magnetic field in the coil, which generates a magnetic pressure, which causes one workpiece to impact with another workpiece. The deformation takes place at a very high velocity, like in explosive welding. The explosive deformation force is, however, created in a safe way, by using electromagnetic forces generated by an induction coil. It is also a solid-state welding process, which means that the materials do not melt during the creation of a bond, which provides the opportunity to join dissimilar materials. The process parameters of the magnetic pulse welding process are:

- Geometrical parameters, such as the air gap between both sheets, the axial position of work pieces in the coil or the overlap distance of the workpieces to be joined.

- Electrical parameters, such as the charging voltage defining the energy level, the discharge frequency (adjustable by using a transformer or other coils).

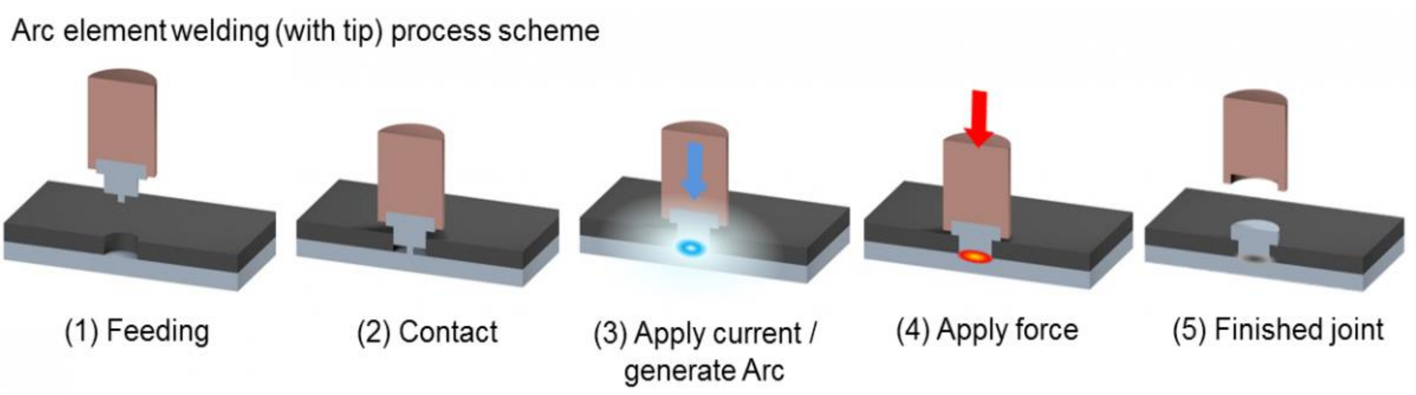

Fig. Process principle of arc element welding with an auxiliary joining part

Advantages

Since this technology doesn’t use heat but pressure to realise the bond, it offers important advantages compared to the conventional thermal welding processes:

- Joining of conventionally non-weldable materials, in a quick and cost-effective manner, such as dissimilar material joints.
- Development of complex workpieces or new products, which were previously not possible with conventional joining processes.
- Magnetic pulse welding is a ‘cold’ joining process. Temperature increase is very local (in the order of 50µm), so the workpieces reach no more than 30-50°C at the outer surfaces. This means that after welding, parts can immediately be unloaded and further processed with other equipment.
- High repeatability; constant joint quality.
- High production rate possible.
- Contact-free: no marks of forming tools, making processing of coated or sensitive materials possible.

The technology has a much lower negative environmental impact and is much more environmentally friendly compared to conventional welding technologies:

- There is no heat, radiation, gas or smoke, shielding gas, which is less harmful for the operator.
- In hostile environments machines can perform the joining operation, avoiding supplementary investments in operator safety.
- It is possible to improve the work conditions of the welder or operator, since the technology is environmentally clean.
- The magnetic pulse welding process consumes less energy.

Arc element welding with an auxiliary joining part

In arc element welding (AEW), a short auxiliary joining part (the so-called element) is used. The top sheet must be perforated. There is no direct joint between the top sheet and the bottom sheet, but the auxiliary joining part guarantees the fixing of the top sheet onto the bottom sheet in a mainly form-fitting and partial force-fitting joint. In this respect, a welded joint is created only between the auxiliary joining part and the bottom sheet. The existing welding process variants are drawn-arc stud welding and the process variants with initial-contact capacitor discharge. In this respect, the auxiliary joining part is a constituent of the development work.