sapa:

Friction
Stir
Welding

Increased
strength

Improved
leakproofness

Improved
repeatability

Reduced
heat distortion

Panels up to 14.5 m in length

FSW is an established technique

FSW was invented by The Welding Institute (TWI) in Cambridge, England.

Sapa has played an active part in the process of converting theory and laboratory experiments into full-scale production.

Sapa started series production in 1996, and can supply panels in widths of up to three metres, consisting of profiles that are joined together using FSW. The panels can be cut to a customer's desired length.

After extensive tests, several leading Classification Associations have approved deliveries from the process for demanding tasks within railway and marine applications.

The Sapa production line

The structure of the joint

The FSW weld is homogenous and void-free without any oxide inclusions

To provide a picture of FSW, we have decided to compare it with the most commonly used method of welding – fusion welding.

As we show in this brochure, FSW provides advantages which can be exploited in a variety of designs.

At the same time we must stress that we often use fusion welding (MIG) in the further refinement of aluminium profiles. This procedure does have its place in production.

Fusion welding, MIG for example, uses filler material and shielding gas.

The filler material and the parent metal are melted and produce a weld with a different solidification structure.

With MIG and TIG welding it is necessary to protect the metal from reaction with the atmosphere since the rapidly formed oxide can cause failure in the weld. The oxide is heavier than the molten metal, and may form inclusions.

There is also a risk of porosity.

FSW is created without fluxes, and no shielding gas is used.

The joint is made subject to the influence of friction heat, and severe plastic deformation. The material which will be joined never reaches the melting point, but the profiles are welded together in the same way as in the case of the extrusion of hollow profiles.

The result is a homogenous and void-free weld without inclusions.

The FSW process is marked by its limited number of variables, which are easy to monitor. This gives the same results from one weld to the next.

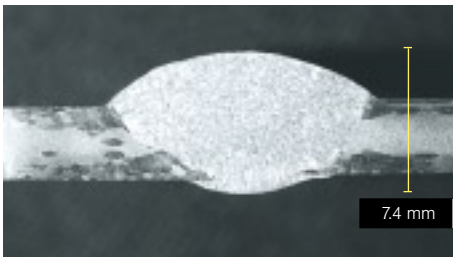
Fusion welding is a more complicated process, which means that results often vary.

In this folder we have decided to carry out a comparison with high-quality fusion-welded joints.

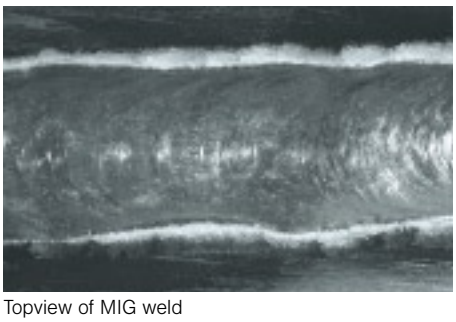
MIG

Precipitation structure in a MIG weld

50 µm



The MIG weld builds up. The filler material has a different chemical composition compared to the parent material.

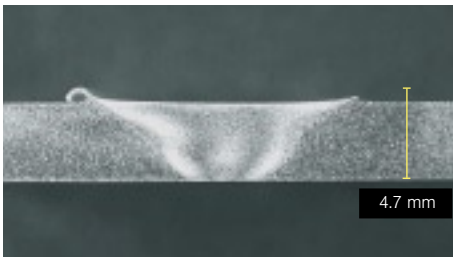


Topview of MIG weld

FSW

Precipitation structure in a FSW weld

50 µm

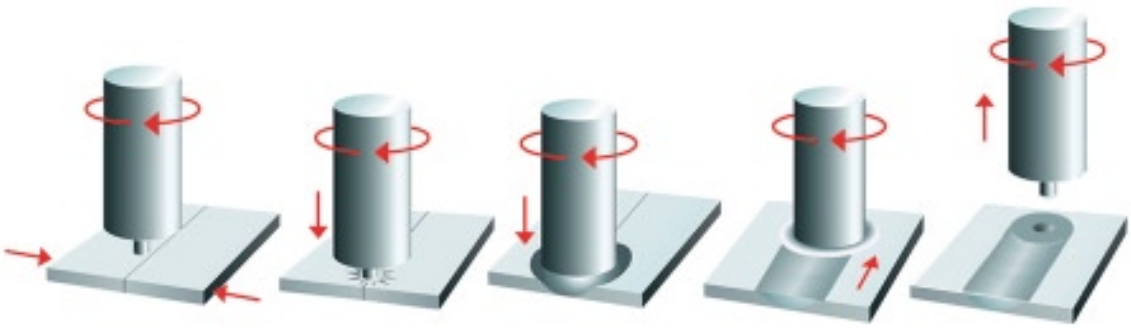


The FSW weld: The weld is in principle flush with the material which is being welded. No filler material is used.

Topview of FSW weld

FSW: the joining method which **exploits the laws of nature.** All we add is mechanical effort.

A rotating tool is plunged into the joint line and moved along the joint. Neither flux nor filler material are used.



The Friction Stir Welding method of joining is based on the fact that the metal is subjected to heavy plastic deformation at high temperatures, but lower than the melting point.

When the rotating tool is plunged into the metal, friction heat is generated. The tool produces severe plastic deformation under high pressure, during which the weld interfaces are stirred together and a homogenous structure is formed.

Compared with fusion welding, Friction Stir Welding provides:

- **increased** strength
- **improved** sealing. Completely void-free, leakproof joints with greater strength than fusion-welded joints
- the weld is in principle flush with the parent material
- **reduced** heat distortion
- **improved** repeatability. The FSW operation comprises a small number of variables which it is easy to monitor: tools, feeding rate, rpm, and position of tool. This also permits close tolerances.

Strength

Experience and extensive testing show that a FSW joint is usually stronger than a fusion weld.

The table below shows the standardised joint efficiency factor *T* for arc-welded butt joints as specified in SS-EN 288-4.

The values given for FSW joints are based on a large number of measurements, and should be regarded as standard values.

Since standards do not yet exist for FSW joints, the values for fusion-welded joints will be used to calculate strength in standardised designs.

Weld factor for the **ultimate tensile strength of butt welds,** Al-Mg-Si alloys

Condition of parent metal material before welding	Ageing after welding	$T = \frac{R_m\,(w)}{R_m\,(pm)}$	
		Arc welding [1]	**FSW** [2]
T4	Cold-ageing	0.9	0.9
T4	Heat-ageing	0.7	≥ 0.9
T5-T6	Cold-ageing	0.6	≥ 0.7
T5-T6	Heat-ageing	0.7	≥ 0.8

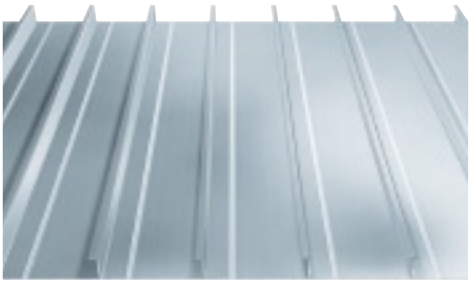
1. e.g. MIG or TIG. 2. standard value only.

The tensile strength (R_m (w)) of the welded specimen shall satisfy the following requirements:

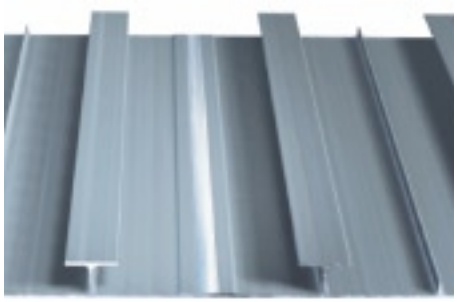
R_m (w) = R_m (pm) x T,

where R_m (pm) is the specified minimum tensile strength of the parent material and *T* is the joints efficiency factor.

Sapa joins profiles measuring up to 400 mm across for panels with a high level of mechanical strength.



Deck panels: Profiles joined together to panels up to 3 m in width and 14.5 m in length.



Roof of train: A number of leading Classification Associations have approved deliveries from the process for demanding tasks within railway and marine applications.

Leakproofness

The joint will be absolutely leakproof. The material is welded together to form a homogenous unit.

When we test the leakproofness we are therefore testing the reliability of the manufacturing process.

Some 25,000 units of the heat sink (figures below) have been supplied to the customer ABB Semiconductors AG.

Method of leak testing: helium leak detection. Result: no leaks due to welding defect. FSW joints have also been tested using the water-pressure test.

The results are clear: the process ensures a joint which can be used in components with the greatest requirement for leakproofness.

A **leakproof** heat sink

The parent material is a solid profile which has been CNC processed by Sapa.

The machined cooling channels are closed with a cover. The joining method is FSW.

25,000 produced units. All equally leakproof.

Levelness

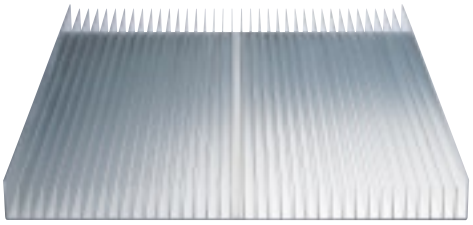
Since the FSW process takes place at a temperature which is lower than the metal's melting point, the result is:

- minimal heat distortion
- low residul stress levels and therefore easier deformation control.

The product in the illustration below is a heat sink panel which is used during the processing of instant coffee (freeze-drying).

The aluminium profiles have been joined using FSW to a tray measuring 530 x 1290 m.

Any deviation in levelness in a FSW panel is less than the combined tolerances for the profiles it contains.



Heat sink panel: Here the heat conductabilty of aluminium is used.

The deviation in levelness of the heat sink panel is less than the tolerance demands for the combined profiles it contains.

Repeatability

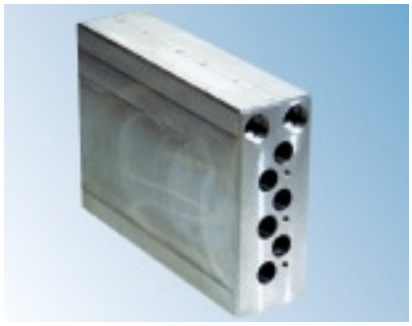
The FSW operation has a small number of variables which are easy to monitor: tools, feeding rate, rpm, and position of tool. This also permits close tolerances.

In addition: with the experience of series production which we have acquired since 1996 we can confidently state that:

– very small differences will be apparent between one joint and another during the production cycle **and** in the case of recurrent orders.

This applies to all variables: the structure of the joint, its strength, leakproofness and levelness.

FSW in the automotive industry: The component produced in a fully automated line.



Heat sink for power electronics: High and uniform quality with extreme requirement for leakproofness.

Panels for multi-plate freezer designed for fish industry: After joining the joint is milled. This gives a completly smooth surface easy to keep clean. The repeatability applies to all variables: the structure of the joint, its strength, leakproofness and panel levelness.

Resistance to corrosion

The chemical composition of the material in the joint is identical to that in the original material. Nothing has been added. Nothing has been removed. Resistance to corrosion thus remains unchanged in principle.

Tests of SS-EN-AW 6082 have shown, for example, that the yield and ultimate strength are not affected after 1,000 hours of SWAAT testing.

Limitations

FSW requires a stable work fixture, and it is therefore at present difficult, for example, to produce a joint at an intersection between profiles.

This means, among other things, that deposit welding on finished designs is seldom possible with FSW. Repairs can, of course, be carried out effectively using traditional methods.

Potential: FSW gives **increased** strength, **improved** leakproofness, **improved** repeatability and **reduced** heat distortion.

How can you take advantage of this?

Sapa: so much more than FSW

Sapa is the leading company in its field of operation and develops, manufactures and markets value-added profiles, profile-based building systems and heat exchanger strip in the light-weight material aluminium.

A company of ideas

Sapa, with operations in Europe, North America and Asia, is divided in the core areas Sapa Profiles, Sapa Building System and Sapa Heat Transfer.

The business concept is built on close cooperation with tion, transport, engineering, telecom and home & office industries. This is for example demonstrated by the business segments Automotive, Mass Transportation and Thermal Management.

Sapa's core values

Entrepreneurial Spirit: To recognize the opportunities in a business venture and have the ability to make it profitable, while recognizing the risk. Sapa supports and encourages the entrepreneurial spirit of its employees.

Commitment: To provide all Sapa employees support and tools to ensure their constant commitment and willingness to always be there.

Honesty: To ensure that all Sapa employees will be honest and responsible in dealing with customers, suppliers, co-workers, shareholders and the communities where Sapa has an impact.

Responsibility: To ensure that Sapa works safely in a manner that promotes the health and well-being of the individual and the environment.

Innovative Focus and Customer Orientation: To identify intelligent solutions to problems and opportunities in a creative work environment and to realize that everything we do must be based on the needs of the customer and the market. Only by being customer-oriented will we obtain true commercial value in our operations.