MIG brazing of galvanised light-gauge sheets

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GENERAL POINTS

The increasing demands being made nowadays for a reduction in the risk of corrosion damage have led many branches of industry to make much more extensive use of coated sheets. Of all the available methods of protecting steel against corrosion, zinc takes pride of place - both for its very favourable corrosion properties and for its low price.

It is, of course, possible to use a zinc surface to protect steel against corrosion by hot-dip galvanising completely machined components or assemblies. However, this requires very thorough preparation and careful clamping of the items to be galvanised.
Another possibility is to manufacture these items from flat-steel products that are ready-treated (i.e. already galvanised).

These pre-treated “flats” can be produced either electrolytically or by hot-dip galvanisation.
The zinc layer applied to the base metal will typically be between 1 and 20 mm thick, depending upon the process used.

Large quantities of galvanised light-gauge sheet are used in automobile engineering, in the construction industry, in the ventilation and heating field, for technical installations inside buildings, for manufacturing white goods and in the furniture-manufacturing industry.

Zinc, then, has the ability to form a protective barrier coating that has to corrode away first before there is any risk of the steel beneath it starting to rust. However, it is not only on account of this ability that zinc has become so important for protecting steel from corrosion, but also because of its cathodic protection effect.
If the protective zinc layer is damaged, the zinc coating on the ferrous base-metal will still provide cathodic protection.
This protective effect extends between 1 and 2 mm into the uncoated area.
These cathodic tele-protection properties of the zinc apply both to the non-coated cut edges of the sheets and to micro-fissures caused by cold-forming, as well as to the zones adjoining weld-seams, where zinc vaporisation takes place. The cathodic protection also prevents rust starting from the cut edge and spreading beneath the zinc layer.

MIG BRAZING OF GALVANISED SHEETS

Zinc starts to melt at temperatures of around 420° C, and to vaporise at around 906° C. These properties of zinc have an unfavourable effect on the welding process, as the zinc starts to vaporise as soon as the arc is struck.
The zinc vapours and oxides can lead to pores, inadequate fusion, cracking and to an unsteady arc. For this reason, it is better for galvanised sheets if the heat input can be reduced.

An alternative method when welding galvanised sheets is to use bronze welding wires. The most commonly used such wires are ones with copper-silicon alloys, (e.g. CuSi 3) and aluminium-bronze alloys.
The following advantages may result from the use of these alloys:
no corrosion of the weld seam
minimal spatter ejection
low coating burn-off
low heat input
easy after-weld machining of the seam
cathodic protection of the base metal in the immediate vicinity of the seam

Due to their high copper content, these bronze wires have a relatively low melting point (around 1000 to 1080°C, depending on the alloy constituents). There is no fusion of the base metal, i.e. the join has more in common with a brazed joint than with a welded one.
As a rule, the recommended shielding gas is argon. However, trials have shown that the CuSi 3 can also be welded with low-O_2 or low-CO2 content shielding gases. This helps the arc to become more stable. [1]

DIP-TRANSFER AND SPRAY ARC

Thicker zinc layers (15mm and upward) generate larger quantities of zinc vapour, leading in turn to marked instability in the braze-welding process. For this reason, it is often better to use the dip-transfer or spray arc for these applications, with a very short arc length. This short arc length makes it possible to keep the arc more steady. In this case, too, very exacting requirements are made of the power source and its control characteristics.

PULSED ARC

When welding under argon-rich shielding gases, it is possible to obtain controlled, short-circuit free metal transfer by selecting suitable parameters for the background and pulsing current.

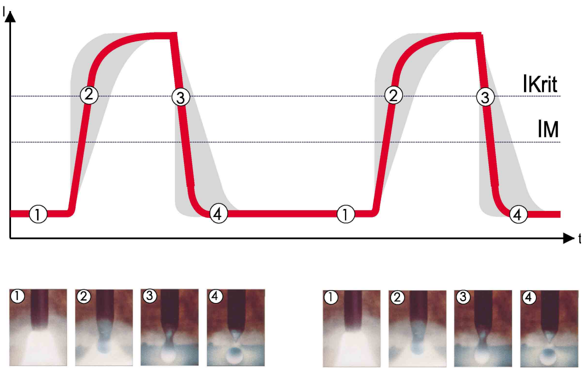

Fig.1: Variable pulse form

Where optimum parameter selections have been made, exactly one drop of filler metal per pulse is detached from the wire electrode. This results in virtually spatter-free welding.
Investigations carried out by the Fronius company have shown that it is necessary to have a differentiated pulse form for different filler metals and shielding gases.
This has led to a “tailor-made” pulse form being used for each separate filler metal. This is particularly true in the case of bronze wires.
In order to keep zinc vaporisation from light-gauge sheets as low as possible, they must be MIG-brazed at low power. This is why the central requirement is that the power source must deliver a particularly stable arc in the lower power range. For keeping the arc-length short, it is just as important to be able to set a low background-current amperage as it is to have a rapid-reaction arc-length control.
The result is low heat input into the base metal, and reduced zinc vaporisation. Both these effects result in there being low porosity. This, in turn, has a positive impact in terms of both after-weld machining (grinding) of the seam, and of enhancing the strength values of the brazed joint.

Fig.2: MIG-brazed fillet weld with pulsed arc, sheet thickness 1.5 mm

When changes occur in the stick-out - i.e. the length of the wire between the contact tip and the arc - there should be no (or at most only minimal) spattering.
This is only possible if the process control continues to ensure “one-droplet-per-pulse” metal transfer even in the event of stick-out changes.

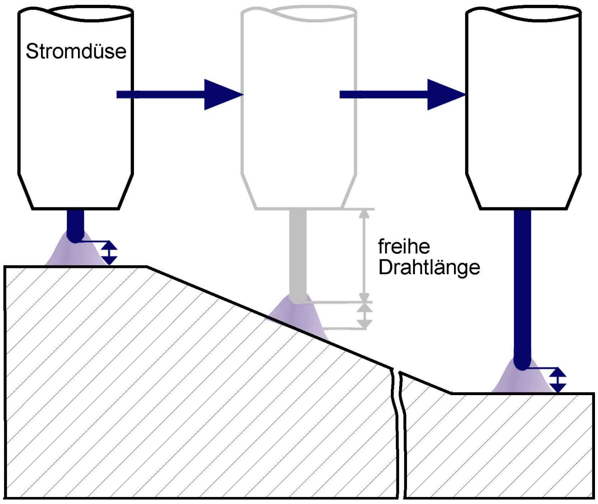

Fig. 3: Welding-over-step test

Fig. 4: Weld seam appearance where contact-tube-to-work distance was changed from 8 to 35 mm. Thanks to the exact arc-length control, virtually no spattering occurs

SYNERGIC OPERATION

Good welding (i.e. brazing) results on galvanised sheets can only be achieved with a power source that gives the welder a high degree of freedom in his selection of parameters.
By having a large number of continuously adjustable parameters (around 30 parameters), it is possible to improve droplet detachment in pulsed-arc welding, and the treatment of short-circuits in dip-transfer welding, for a wide spectrum of filler metals.
However, these additional parameters would make the power sources very much more difficult to operate and would mean that only a handful of experts would be able to use them.

This is where synergic (or “single-dial”) operation comes in. By providing pre-programmed parameters for any combination of wire and shielding gas, synergic operation makes the machine very easy for the welder to use.

In effect, the job of optimising the parameters for many different base and filler metals and shielding gases is done for the user by the equipment manufacturer.
These empirical results are stored in an EPROM - an electronic memory module - in the form of a databank. The user selects the filler metal directly on the power source.

The integrated microprocessor enables the desired power to be selected on a continuous scale from minimum through to maximum.

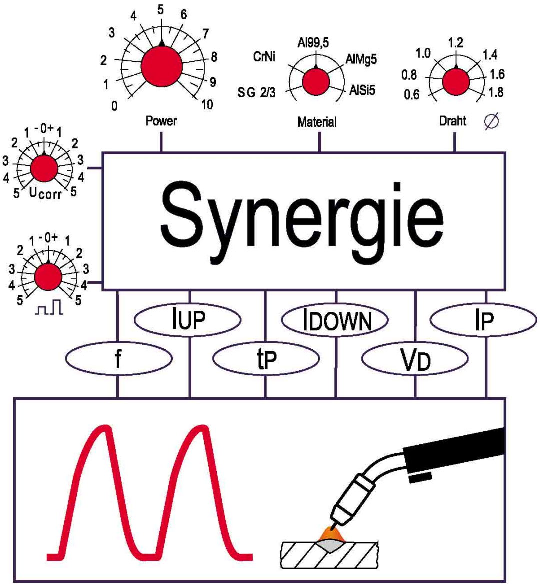

Fig. 5: Synergic operation

WIREFEED

Unlike steel wires, bronze wires are very soft. This makes very special demands upon the wirefeed system. There must not be any abrasion of the wire when it is fed.

Fig.6: 4-roller drive with optimised wire infeed and Fronius central connector

Even where the contact pressures are not very high, a 4-roller drive can still apply sufficient force to the wire if the drive is equipped with suitable feed rollers. Normally, smooth, polished semicircular-grooved rollers are used.

Another basic requirement for troublefree wirefeed is that the wire is fed into the hosepack smoothly and precisely.

In order to keep the abrasion resistance in the hosepack low, a Teflon or plastic-graphite inner liner must be used. A solid, generously sized contact tube in the torch makes for reliable current transfer to the bronze wire.

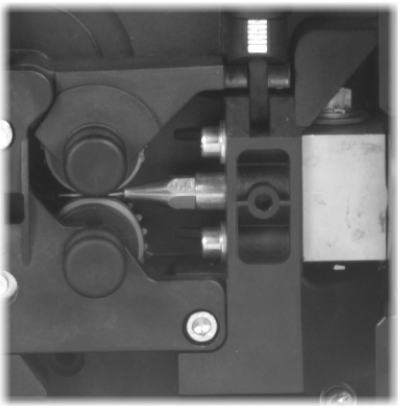

Fig.7: Precision wire infeed

TORCH INCLINATION

Where the sheets are brazed with a ‘pushing’ torch motion, the zinc layer is pre-heated by the background current of the arc to a temperature which is sufficient to vaporise it - apart from a residual zinc layer - immediately before the droplet is shed from the filler wire. The thermal energy from the molten filler-wire droplet then vaporises the residual zinc layer. As there are only very small quantities of zinc vapour in the still-molten brazing solder, the degassing time until solidification sets in is sufficient to produce welds with very few pores, or none at all.
Where the sheets are brazed with a ‘pulling’ torch motion, the pre-heating effect is not sufficient to enable the vaporisation temperature of zinc to be reached.
This means that very much more zinc vapour can penetrate into the already detached, but still-molten filler-wire droplet. Although the post-heating occurring in this torch position prolongs the degassing time, this is still not long enough to permit the much higher zinc vapour content to escape from the molten seam. Moreover, arc stability is impaired much more seriously by the zinc vapours when the weld is executed with a ‘pulling’ motion than when the torch is held in a ‘pushing’ position. [2]

Fig. 8: Fronius TPS 330/450 pulsed-arc power source for MIG brazing

LITERATURE

[1] A. Kersche:
Selecting shielding gases for MAG welding of unalloyed structural steels
[2]G. Groten:
Paper on GMA pulsed-arc welding of uncoated and galvanised light-gauge sheets

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