GMA welding using strip-wire electrodes

1. Introduction

There continues to be growing demand for welding processes which boost output and reduce costs, yet still ensure perfect-quality welded joins. It was demands such as these which prompted the development of high-performance welding processes with enhanced wirefeed speeds and deposition rates. A process is regarded as a “high-performance” welding process if it achieves a deposition rate (meaning the rate of filler metal melt-off) that is greater than 8 kg/h.

Following the huge increases in the wirefeed speeds that can be achieved in single-wire welding, the concept of “tandem” welding was developed, involving simultaneous melt-off from two wire electrodes. Whereas in single-wire welding with high deposition rates, problems may occur with the “cutting effect”, in the case of tandem welding there are more problems with guiding the torch – especially along curved welding tracks – as the relative positions of the leading and trailing wires have to be maintained vis-à-vis the direction of welding.

A new approach to boosting the performance of GMA welding is to use flat strip-wires, with which deposition rates of over 11 kg/h can be achieved. The advantages over tandem welding are, firstly, the fact that only one power source is needed, and secondly, that it is considerably easier to set the welding parameters. Set against these advantages, there are the difficulties that may be encountered with the wirefeed, as a result of hosepack-twisting in robot applications, for instance.

An essential prerequisite for using strip wires is that there must be a suitably “matching” trio of power source, wirefeeder and torch.

2. Strip-wire electrodes

Table 1 shows the types of solid strip-wire electrode that are most frequently welded. Strip-wire electrodes range from 4.0 mm to 4.5 mm in width, while their thickness varies between 0.5 mm and 0.6 mm. The result is an extreme width-to-thickness ratio of approximately 9:1.

Strip-wire electrodes are produced either by additional rolling of round wires, or by slitting wide strips. Rolled strip-wires have rounded edges, while slit strip-wires tend to be sharp-edged. From the wirefeed point of view, then, rolled strip-wires are preferable. For the quality of the welding results, however, it is important that the strip-wires are straight, and this can be better ensured by the strip-slitting method.

Whichever method is used, the fact remains that flat strip-wires have a larger ratio of surface to cross-section than do round wires, and these larger surfaces lead to increased oxide adhesion. In general, then, the quality of the strip-wire electrodes will be crucial to the quality of the welding results.

3. Welding torch and power source

Optimum welding results can only be obtained in mechanised welding applications with high tracking accuracy. Particularly when using soft aluminium strip-wires, it is essential to use push-pull wirefeed systems in order to ensure constant wire travel.

Fig. 1 shows the strip-wire torch that is used here. This is a push-pull torch that has been specially adapted for strip-wires. The contact tube is designed in such a way that the strip-wire is correctly guided along both the longitudinal and transverse axes. The gas nozzle is water-cooled, and this cooling system is of very great importance, particularly when welding is being carried out at high amperages.

Owing to the complicated wirefeed arrangements, the best way to weld flat strip-wire is with a permanently mounted strip-wire torch and a handling robot to manipulate the weldments. Where straight weld-seams need to be welded, it is also possible to move the weldment or the strip-wire torch on a travel carriage.

For welding the strip-wire electrodes, a 900 A Fronius power source is used, the reason being that in pulsed-arc welding of steel wires, for example, pulsing currents of up to 1200 A are needed. For aluminium wires, the necessary pulsing currents are around 500 A, meaning that it is sufficient to use a 500 A power source in this case.

4. Welding parameters and shielding gas

In the welding of steel wires, the average value of the welding current is as much as 420 A (current density 190 A/mm^2). With wirefeed speeds of up to 11 m/min, the deposition rate exceeds 11 kg/h. A mixed gas of 82%Ar / 18%CO_2 can be used as the shielding gas. Mixed gases with a lower CO_2 content result in improved droplet detachment. The gas flow-rate has been set at approx. 20 l/min.

For welding AlMg4.5Mn strip-wires in the pulsed arc, average amperages of up to 260 A are reached (current density 110 A/mm^2). Wirefeed speeds of up to 9 m/min result in deposition rates of up to 4 kg/h. Pure argon or argon-helium mixtures are used as the shielding gas, to increase the welding speed.

5. Metal transfer

The metal particle transfer in strip-wire welding has been investigated with the aid of a high-speed camera. As an example, Fig. 2 shows the results obtained with a pulsed-arc welded AlSi5 strip-wire (wirefeed speed 5 m/min). At its attachment spot to the strip wire, the arc has a pronounced elliptical shape, whereas at the workpiece, it tends to be more circular. It is also noticeable that the detached droplets are not particularly elliptical in shape, but that – as a result of the surface tension – more or less globular droplets are formed.

6. Welding speed

The enhanced deposition efficiency of high-performance welding processes can be utilised in one of two ways: Either for larger weld cross-sections, or for increased welding speeds. In most applications, priority is given to the second of these.

Fig. 3 shows a lap-weld on two 3 mm aluminium sheets, welded with AlMg4.5Mn as the filler metal. The welding speed here was 165 cm/min. When a round wire is used for this welding operation, it is one of diameter 1.2 mm, and the welding speed achieved is of the order of 80 cm/min. By using strip-wire in this case, then, it is possible to bring about very considerable increases in welding speed.

7. Overlay welding

As well as the joint-welding trials described above, investigations are also being carried out into overlay welding. Because less penetration takes place in strip-wire welding, it is expected that there will also be less dilution – a reduction which is particularly welcome in the case of overlay welding. At the time of this publication, the overlay-welding trials have not yet been completed; the results of these trials will be published separately.

8. Summary

In this article, we have described the strip-wire welding equipment manufactured by Fronius, and presented results from investigations into the metal transfer and welding speed.
In terms of the possible welding speeds, comparisons between strip-wire welding on the one hand, and single-wire welding and tandem welding on the other, indicate that strip-wire welding occupies a position somewhere between single-wire welding (with round wire) and tandem welding. Admittedly, tandem welding can reach even higher welding speeds; however, the greater ease of operation, and the fact that the welding parameters are so much easier to set, are major advantages in favour of strip-wire welding.

Material	G3Si1	AlMg4.5Mn	AlSi5
Cross section	4.5 x 0.5 mm^2	4.0 x 0.6 mm^2	4.0 x 0.6 mm^2
Cross-sectional area	2.3 mm^2	2.4 mm^2	2.4 mm^2
Weight per unit length	17.6 g/m	6.5 g/m	6.6 g/m

Table 1: List of the most frequently welded types of solid strip-wire electrode

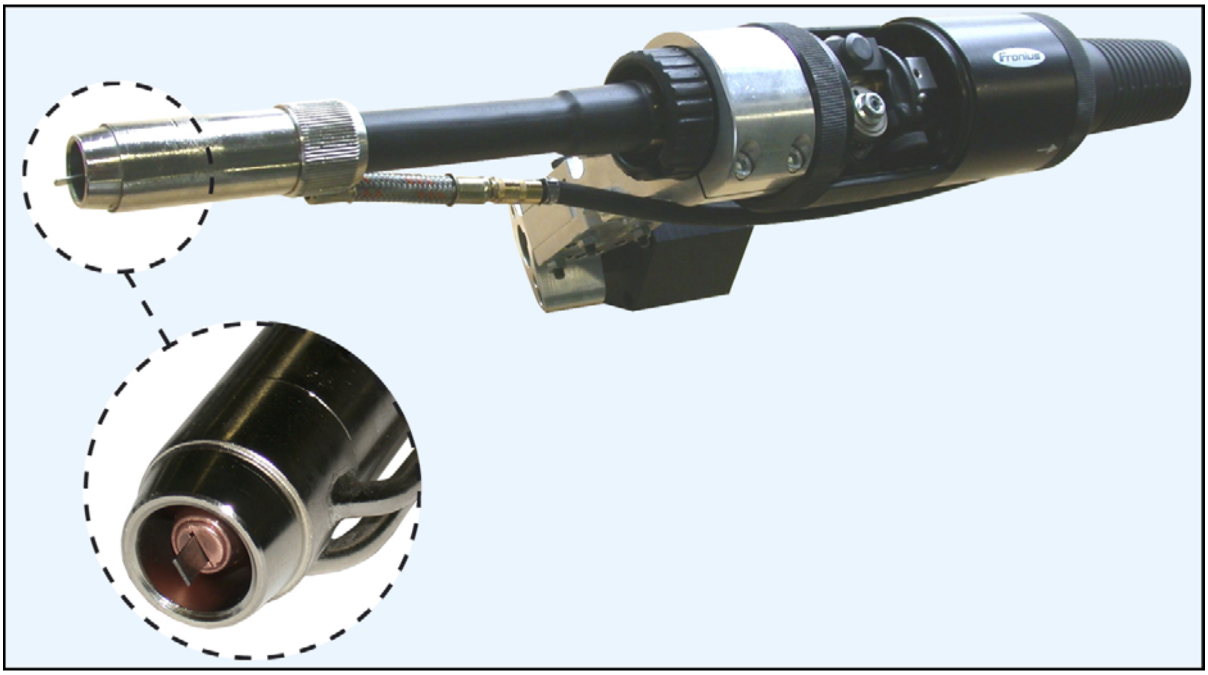

Fig. 1: Push-pull strip-wire torch with water-cooled gas nozzle

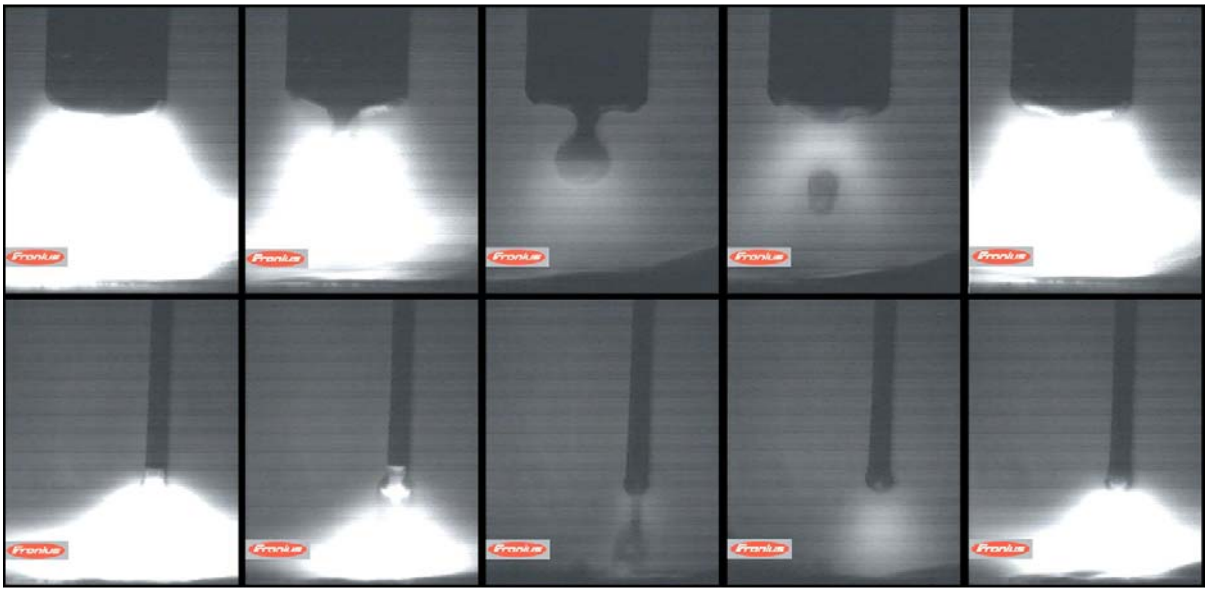

Fig. 2: Metal transfer from AlSi5 strip-wire in pulsed arc (wirefeed speed 5m/min); viewed from the longitudinal and transverse sides

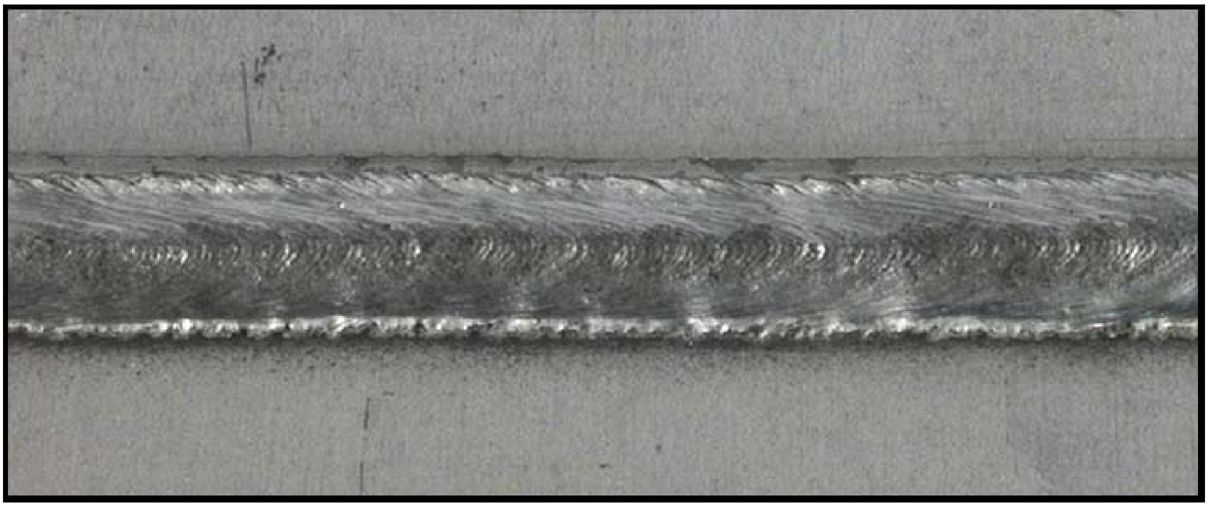

Fig. 3: Lap-weld on two 3 mm aluminium sheets; welding speed 165 cm/min