TimeTwin Digital
Top deposition rate thanks to two wire electrodes

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1. Introduction

Demand is increasing steadily for welding processes that assure superlative welding quality and simultaneously boost profitability and cost-effectiveness. This is feeding the development of high-performance welding processes having an increased deposition rate. These methods are characterised by a deposition rate of more than 8 kg / h in the case of steel. Users are converting this greater deposition rate either into larger seam cross-sections or into greater welding speeds. Higher deposition rates can be achieved by enlarging the cross-sectional area of the wire or by using more than one flash-butt electrode at the same time. The tandem process, in which two electrodes weld simultaneously, falls into the second category and is the subject of this article.

2. Welding process

If two simultaneously welding wire electrodes are employed in MSG welding, then basically two variants are possible:

- In twin-wire welding, the two wire electrodes are guided jointly through the same contact tube which means that both electrodes have same electrical potential on a continuous basis.
- In the case of tandem welding on the other hand, each electrode has a separate contact tube. The contact tubes are electrically insulated from each other. It is thus altogether possible that the two electrodes have different electrical potentials.

These two variants are illustrated schematically in Figure 1.

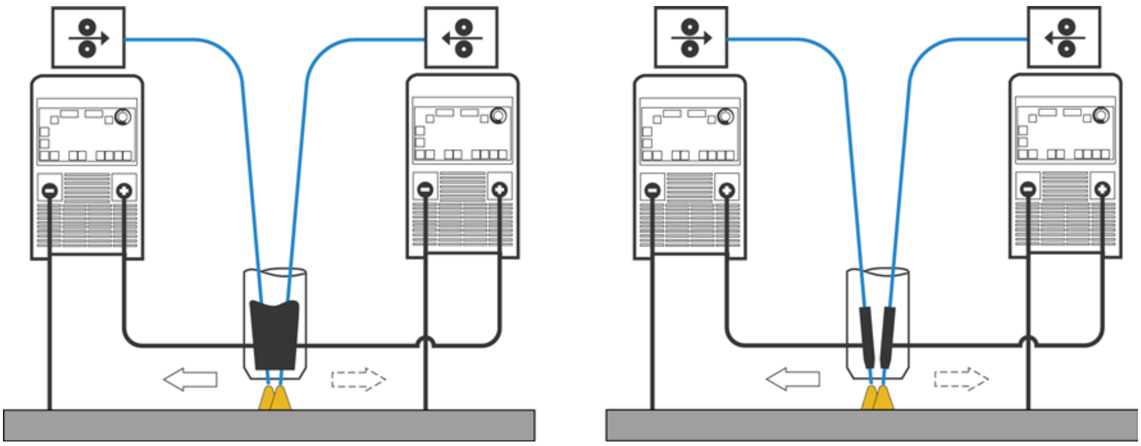

Fig. 1: Twin-wire welding with a common contact tube (left) and tandem welding (right) in which the two contact tubes are electrically insulated from one another.

TimeTwin by Fronius is a tandem welding process. On account of the electrical insulation of the two electrodes, two electric arcs are generated that can be adjusted and optimised independently of one another. Both the performance and additional parameters - such as, for instance, the lengths of the two electric arcs - can be controlled separately, which means that it is possible to achieve a stable electric arc and perfect drop release for both electric arcs.
A further advantage of this principle is the fact that either of the two electrodes can be defined as the master or the slave. This means that the electrode which has the leading role in the welding process is not defined unalterably. As a result of that, both welding directions are possible and this in turn enables a reduction in the cycle time. Apart from that, it is also possible to use just one electric arc, i.e. to perform single-wire welding.
By virtue of the electrical insulation of the two electrodes, it is also possible to choose the type of electric arc (standard electric arc or pulsed electric arc) of the two electrodes independently. In essence, there are four variants:

- Pulsed electric arc in one electrode / pulsed electric arc in the other electrode (most common variant)

- Pulsed electric arc in one electrode / standard electric arc in the other electrode (for achieving maximum welding speed and gap bridging)
- Standard electric arc in one electrode / pulsed electric arc in the other electrode (for deep penetration)
- Standard electric arc in one electrode / standard electric arc in the other electrode (least common variant)

In standard practice, TimeTwin is only used in automated applications. The first of the above-mentioned variants, i.e. two pulsed electric arcs, is realised in the majority of applications. Apart from that, the construction-material transitions are usually phase-shifted by 180°. That means that the first electrode is in the base-signal phase while the second electrode is in the pulse-signal phase and vice versa. This sequence is shown in Figure 2.

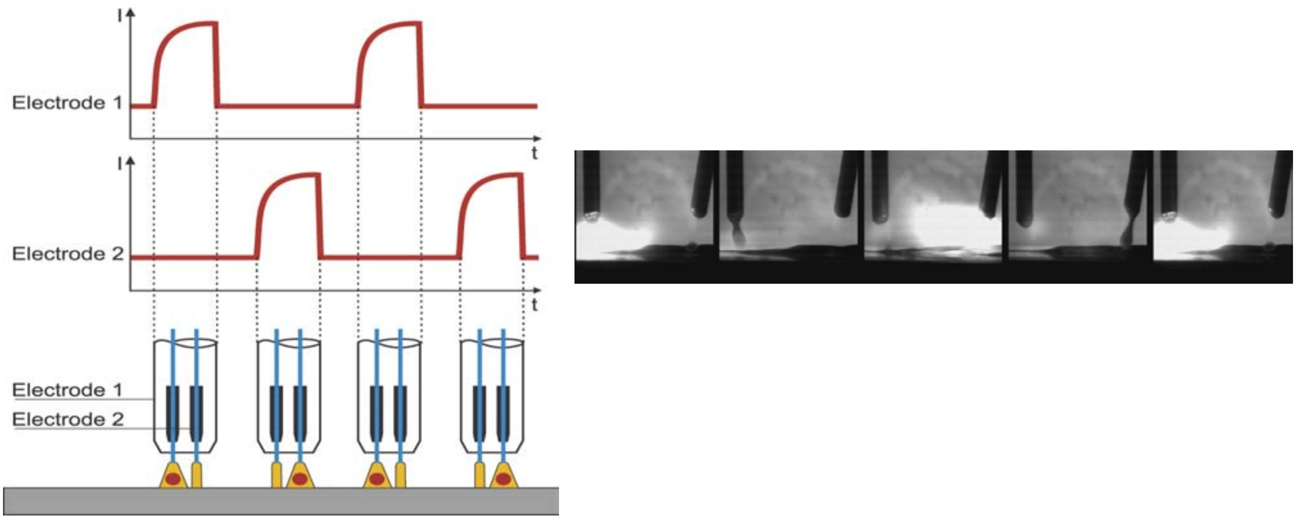

Fig. 2: Tandem process. The two electrodes in the pulsed electric arc (180° phase-shifted). Principle and construction-material transition.

3. Welding equipment

For the tandem process TimeTwin, the availability of two power sources is essential because two electric arcs need to be powered. However, it is not sufficient to simply adapt the power sources to this process. Instead, all the equipment must be adapted. Basically, that includes the welding torch, the wire advancing mechanism and the cooling circuit. Basic diagrams of these components are shown in Figure 3 and they are described in detail below.

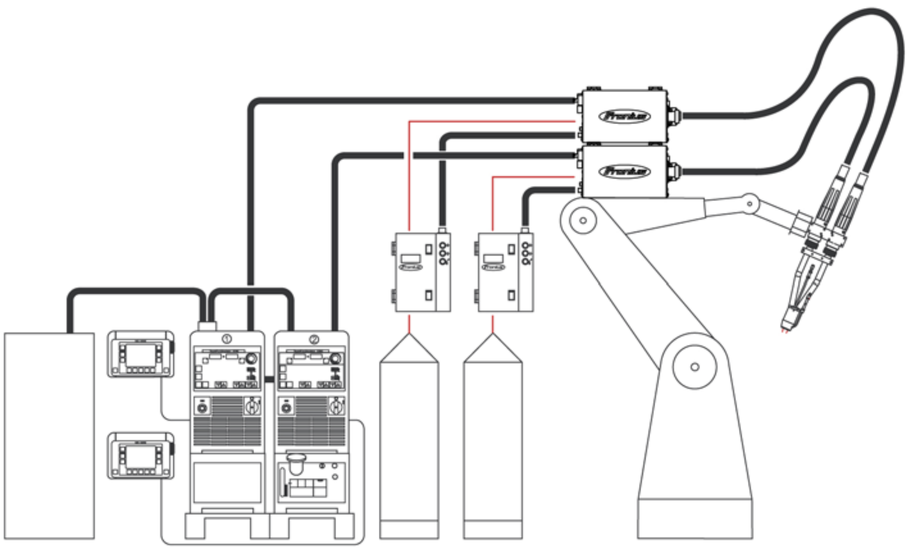

Fig. 3: TimeTwin basic diagrams. In standard practice, this process is only used in automated applications.

In general, Fronius sees itself as a company offering complete welding systems which are constructed modularly. Fronius welding systems are highly robust and enable "plug and weld".

3.a. Power source

A substantial enhancement was realised in the power sources for the tandem process TimeTwin: Compared with the power sources previously used, the new power source series TimeTwin Digital 4000 / 5000 was converted to all-digital technology. The innovative feature of this is that, now, it is also possible to control the welding process in a completely digital manner. A digital signal processor (DSP) takes care of this control. The analogue welding voltage / analogue welding current are registered on the electric arc. These analogue values are converted to digital signals by an analogue-to-digital converter which feeds the digital signals to the DSP. The DSP then controls the welding process so as to adjust the actual values to the desired / nominal values. This all-digital control principle yields considerable benefits:

- The electronic control circuits are now very small and compact because the entire control is handled by one electronic module, the DSP. Along with the inverter technology, this entails that all the power sources can be very lightweight and compact.
- System control can be very quick and flexible - which strongly influences the welding result. It is possible, for example, to react very quickly to changes in the separation distance between the contact tube to the work piece so that the length of the electric arc can be controlled very flexibly.
- The digital control is not vulnerable to any temperature drifts etc. As a result, the all-digital control is characterised by outstanding long-term stability.

Apart from that, it is vital that the two power sources communicate with each other. This is essential for the synchronisation of the two electric arcs and consequently the construction-material transitions. There was a technical innovation here too: In the device range TimeTwin Digital 4000 / 5000, the communication between the power sources takes place via a data bus on which data transmission rates of up to 10 Mbits per second are possible.

The two power sources for this process are standard power sources which have an installation set for the data bus and the appropriate software. This brings with it the considerable advantage that the two power sources can be disconnected again at any time and can thus be used as separate power sources. In this way also, the spare parts do not differ from those of standard power sources - which substantially simplifies the logistics.

Figure 4 shows the power source TimeTwin Digital 4000 with wire advancing mechanisms, a remote-control unit, a welding torch and a torch-cleaning station.

Fig. 4: Complete welding system based on the power source TimeTwin Digital 4000.

An additional advantage of this system is the fact that, in the case of automated applications, the robot can activate the two power sources as a single power source - which simplifies practical use considerably. An enhancement compared with previous systems was also introduced in the communication between the robot interface and the power source: Whereas, in previous systems, up to 40 lines ran in parallel between the power source and the robot interface, communication in the new range of devices TimeTwin Digital 4000 / 5000 takes place via a LocalNet or a field bus. Both the LocalNet and field bus solutions minimise the wiring costs and also reduces interference from noise signals.

3.b. Welding torch

In the tandem process, two wire electrodes must be maintained for the welding process. Although in this process the contact tubes of the two electrodes are electrically insulated from one another, they also run through a common gas nozzle which entails that the two electrodes must share a common welding torch. Figure 5 shows a schematic representation of the foremost section of the torch. Here, the electrical insulation of the two contact tubes can be seen very clearly.

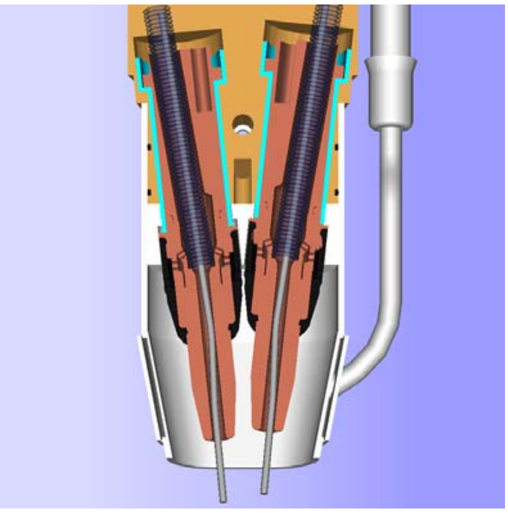

Fig. 5: Detailed view of the welding torch for the tandem process TimeTwin. Here, the two contact tubes are electrically insulated from one another.

A major feature of the welding torch for TimeTwin is the cooling of the torch. Because a lot of heat is generated in this process and this heat must be subsequently dissipated, the gas nozzle is cooled all the way to the front and good heat dissipation is also ensured in the area of the contact tubes.
There are two types of welding torch: The Robacta Drive Twin is a push-pull torch having an additional wire advancing unit in the torch. In it, two flexible tube packages are guided between the two wire advancing mechanisms and the torch. This torch is used specifically in the case of soft and fine wires, making high-precision wire advancement possible. Besides that, a push-pull torch is required if splash-free ignition SFI is to be used. In addition to the Robacta Drive Twin, the welding torch Robacta Twin Compact is available in which the two electrodes are guided between the wire advancing mechanisms and the welding torch in a common flexible tube package. Although the latter torch is not a push-pull torch, its slim-line construction does however bring considerable advantages as far as accessibility is concerned.
Figure 6 shows the welding torch Robacta Twin, which is a push-pull torch, and the welding torch Robacta Twin Compact which is distinguished by its good accessibility.

Fig. 6: Welding torches Robacta Drive Twin and Robacta Twin Compact.

The technical data of these two torches are summarised in Table 1.

	Robacta Drive Twin	Robacta Twin Compact
Weight including flexible tube package	7.6 kg	5.5 kg
Wire advancement speed	Up to 2x 22 m/min.	Up to 2x 30 m/min.
Welding current (100% ED)	2x 450 A	2x 450 A
Wire diameter	0.8 - 1.6 mm	0.8 - 1.6 mm

Table 1: Technical data of the welding torches Robacta Twin and Robacta Drive Twin

3.c. Wire advancement

Because the tandem process uses two welding wire electrodes, it also requires two wire advancing mechanisms which each advance one electrode. Here too, depending on the application, there are various different alternatives for the automated area and thus various different wire advancing mechanisms.

- VR 1500: The VR 1500 is usually mounted on the third robot axis, which results in a relatively short separation distance between the wire advancing mechanism and the torch. The weight of the wire advancing mechanism must be supported by the robot and that must be taken into account when dimensioning the robot.
- VR 1530 PD: This wire advancing mechanism is used to unwind wires from large and drum coils. It is equipped with a planetary drive that, in addition to the advancement of the welding wire, also has the effect of straightening the wire - which is of very great importance specifically for automated applications. In most cases, the VR 1500 is used jointly with the VR 1530 PD or the Robacta Drive Twin.
- VR 4040: In addition to the typical basket coils, aluminium wires are also often wound on 40 kg coils in order to reduce the frequency of the wire roll changes. On account of the large dimensions of these coils, it is not possible to employ standard wire advancing mechanisms. The VR 4040 has a certain storage pool of wire in order to compensate the delayed acceleration / retardation of these wire coils and thus ensure constant wire advancement from the commencement until the completion of welding. The VR 4040 is an unwinding mechanism that is usually used in combination with the VR 1500.
- VR 7000: The VR 7000 is a self-contained wire advancing case that in most applications is set up separately beside the robot. The essential advantage of this wire advancing mechanism is the fact that the wire coil is protected from environmental factors of influences.

Figure 7 shows the wire advancing mechanisms VR 1500 and VR 1530 PD in which the planetary drive can be seen very clearly.

Fig. 7: Wire advancing mechanisms VR 1500 and VR 1530 PD in which the planetary drive both advances and straightens the wire.

4. Welding speed and deposition rate

Using the TimeTwin, it is possible to achieve considerable increases in the deposition rate compared with conventional electric arc welding processes. The user can convert this higher deposition rate either into a

higher welding speed or into a greater cross-sectional area of the seam. In most applications, the increase in welding speed is of chief significance. The exact factor by which the welding speed can be increased depends on the material, the thickness of the sheet metal, the geometry of the seam, the welding positions etc.
Tables 2 and 3 specify the possible welding speeds and deposition rates for various different basic materials, seam types and welding positions.

	Shouldered overlap joint	Overlap joint	Throat seam, horizontal	Throat seam, horizontal
Sheet metal thickness (mm)	2	3	6	10
Welding position	PA	PB	PB	PB
Wire diameter	1.2	1.2	1.2	1.2
Wire advancement speed (m / min.) single-wire / twin-wire	10-12 / 9-11	10-13 / 9-12	12-14 / 11-13	16-18 / 15-17
Welding speed (cm/min.)	250-300	150-250	120-150	100-120
Protective gas in accordance with EN 439	I 1 or I3 (argon or argon-helium mixtures)	I 1 or I3 (argon or argon-helium mixtures)	I 1 or I3 (argon or argon-helium mixtures)	I 1 or I3 (argon or argon-helium mixtures)

Table 2: Typical values for welding speed and deposition rate. Basic material: Aluminium.

	Shouldered overlap joint	Overlap joint	Butt joint	Throat seam, horizontal	Throat seam, downhand position
Sheet metal thickness (mm)	2	3	3	10	10-20
Welding position	PA	PB	PA	PB	PA
Wire diameter	1.0	1.2	1.2	1.2	1.2
Wire advancement speed (m / min.) single-wire / twin-wire	14-16 / 12-14	9-12 / 7-10	9-12 / 7-10	12-14 / 11-13	15-18 / 14-17
Welding speed (cm/min.)	250-350	150-250	150-200	100-120	60-160
Protective gas in accordance with EN 439	All M2s, with or without He M 21 or M21(1) having approx. 10% Co_2	All M2s, with or without He M 21 or M21(1) having approx. 10% Co_2	All M2s, with or without He M 21 or M21(1) having approx. 10% Co_2	All M2s, with or without He M 21 or M21(1) having approx. 10% Co_2	All M2s, with or without He M 21 or M21(1) having approx. 10% Co_2

Table 3: Typical values for welding speed and deposition rate. Basic material: Steel.

In general, it can be said that the welding speed using TimeTwin can be increased by a factor of approximately 2-3 compared with that of MSG processes and by a factor of 2 with respect to the Time process. The exact increase depends on the specific application. In the case of TimeTwin, it is possible to accomplish welding speeds of up to 7 m / min. and deposition rates of up to 30 kg / h in the case of steel.

5. Applications

TimeTwin is already being used in a large number of applications. These applications fall into the categories joint welding, welding-to-order and MIG soldering. There are also many areas in which TimeTwin can be used, including for instance the following:

- Rail vehicle construction
- Shipbuilding
- Automotive engineering
- Tank construction
- Plant construction
- Digging machines and special mechanical engineering
- Pipeline construction

The TimeTwin process can be used with all standard auxiliary construction materials. In addition to welding, the TimeTwin can also be used in MIG soldering for which only the auxiliary construction material, not however the basic material, is melted.
In general, the following wires can be used in the TimeTwin process:

- Aluminium and its alloys
- Steel
- CrNi
- Filler wires
- Copper-base wires for MIG soldering

Standard protective gases are also used for this process. That enables a high level of flexibility and the simple upgrading of an existing single-wire plant to TimeTwin. Table 4 summarises the protective gases used for various basic materials and types of electric arc:

Basic material	**Protective gas**
Non-alloy and low-alloy steel / pulse welding	90% Ar / 10% CO_2 or 82% Ar / 18% CO_2
Non-alloy and low-alloy steel / standard welding	95-98% Ar / 2-5% O_2
Aluminium / pulse welding	Ar or Ar / He mixture
Stainless steel / pulse welding	97.5% Ar / 2.5% CO_2

Table 4: Protective gases used for various basic materials and electric arc types

The remaining sections provide in-depth outlines of three applications.

5.a. Application in the area of pipeline construction

At Cranfield University, a feasibility study was carried out on the economising potential achievable by using automated welding processes for pipeline construction (as a replacement for manual cellulose welding). Using TimeTwin, welding is now taking place on gas-line pipes of large diameters (1800 mm) and over extremely long distances. Specifically, a 3200 km long pipeline is under construction between Alaska and Chicago. A major part of the Alaska construction will be laid during the winter at very extreme temperatures as low as -50 °C.

This application is in fact a twin tandem process with four electric arcs simultaneously welding on all sides of the pipeline. The outcome was that it was possible to reduce the welding duration per joint from 4 hours in the manual case to 20 minutes. By virtue of this enormous increase in welding speed, it was possible to considerably reduce the costs for structural parts.

The most important welding parameters:

- Seam type: V seams
- Basic construction material: X100
- Auxiliary construction material: Mn3Ni1Mo
- Welding speed: 130 cm / min.
- Deposition rate: 12 kg / h
- Welding position: PA, PB, PC, PD

Figure 8 shows a part of the pipeline with the protective housing acclimatised to -20°C and also shows the twin tandem welding process.

Fig. 8: Application in the area of pipeline construction. The pipelines are welded at very extreme temperatures. Reduction by a factor of 12 in the processing time per joint.

5.b. Application in the area of rail vehicle construction

Alstom Ferroviaria, known until 2001 as Fiat Ferroviaria, is an Italian rail vehicle manufacturer which, among other things, manufactures the Italian high-speed train called Bendolino. Extruded aluminium sections for floor, side and roof construction of the high-performance train are welded using the TimeTwin process.

The challenge in this application was on the one hand a high welding speed and on the other hand a reduction in undue delays. However, excellent seam quality was also a fundamental requirement for these applications because the seams are visible seams.
The TimeTwin plants are mounted on a longitudinal chassis with a length of approx. 10 m. The section profiles being welded have a length of approx. 27 m and in the process two seams are always welded simultaneously. A tactile sensor is employed as a seam guiding system.
Between January 2000 and November 2001, i.e. in less than 2 years, a total welding-seam length of 3000 km had already been welded on the Fronius TimeTwin plants - equivalent to the distance between Stockholm and Rome.
The most important welding parameters:

- Seam type: V seams, throat seams
- Basic construction material: AlMgSi0.7
- Auxiliary construction material: AlMg4.5 mn0.7
- Welding speed: 250 cm / min.
- Deposition rate: 7 kg / h
- Welding position: PA

Figure 9 shows the extruded sections to be welded and the welding which is performed simultaneously with two TimeTwin torches.

Fig. 9: Tandem welding in rail vehicle construction. Welding speed achieved: 250 cm / min.

6. Summary

This article presented the tandem process TimeTwin. By contrast to twin-wire welding, this process is distinguished by two contact tubes which are electrically insulated from one another so that the two electrodes can have different electrical potentials. On the one hand, two power sources are required for this process and these communicate via a data bus so as to synchronise the construction-material transition. At the same time, welding torches, wire advancing mechanisms etc. must also be adapted for this process.

The TimeTwin process is characterised by a high welding speed, a high deposition rate, reduced thermal input and less splashing. Apart from that, welding in both directions and also single-wire welding are possible. Furthermore, this article presented three different applications in which it was possible to achieve top welding speeds and, at the same time, excellent welding quality.