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Technological Conditions of Mechanised TIG Welding using Various Systems Adjusting Current and Electrode Wire Feeding Parameters

Abstract: The study described in the article involved technological tests of mechanised TIG welding with an electrode wire fed at a possibly low angle in relation to a welding arc and based on various wire feeding control systems, e.g. enabling the adjustment of wire feeding rate pulsation and synchronisation of wire feeding rate with current impulses. The article also presents differences in sets of technological parameters of welding performed using such control systems.

Keywords: mechanised TIG welding, welding parameters, wire feeding parameters

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Standard mechanised TIG welding with wire (process 141) involves wire feeding to the rear zone of the weld pool directly behind the arc, at an angle of 40°-60°, where the wire can be fed in a continuous or pulsed manner [1]. A recently applied TopTIG method [2-4] is based on mechanised wire feeding integrated with a gas nozzle in a manner enabling the obtainment of an angle between the wire and the axis of a tungsten electrode amounting to only 20° (Fig. 1).

The design of the TopTIG welding torch enables mechanised welding in areas of restricted accessibility, where the use of a traditional TIG welding torch, i.e. with side wire feeding, is impossible. The wire feeding conduit is permanently fixed to the gas nozzle (Fig. 2a), precluding an undesired change of wire position in relation to the welding arc during welding.

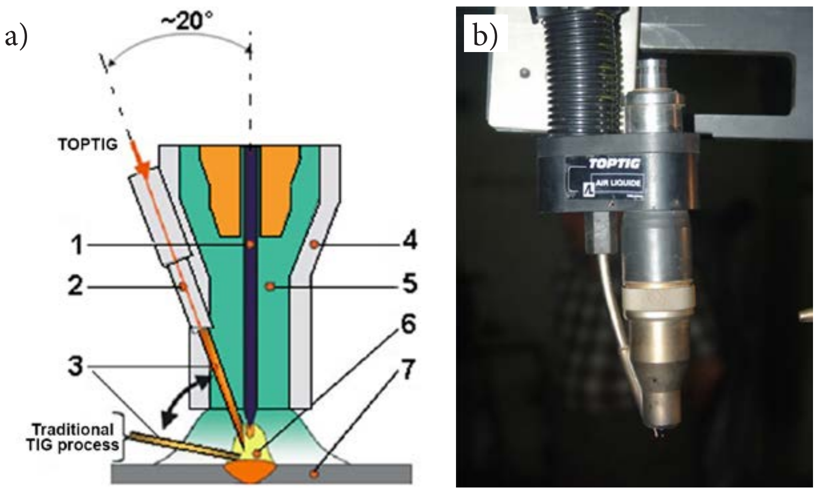

Fig. 1. (a) - Standard TIG welding torch with side wire feeding and TopTIG welding torch: 1: tungsten electrode, 2: wire feeding conduit, 3: electrode wire, 4: gas nozzle, 5: shielding gas, 6: electric arc, 7: element being welded; (b) – TopTIG welding torch

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The wire is fed to the welding arc zone using a push-push system operating in a continuous or pulsed manner. The control of the push wire feeder located between a reel of wire and the Toptig welding torch is synchronised with the wire feeding push module located in the upper part of the Toptig welding torch (Fig. 2b) [3, 4].

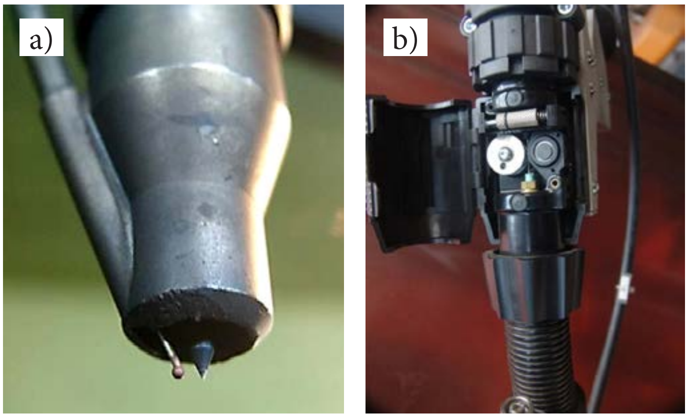

Fig. 2. View: a) gas nozzle of the Toptig welding torch with the wire feeding conduit; b) wire feeder in the upper part of the Toptig welding torch

Other mechanised Tig welding solutions involve wire fed at an angle possibly low in relation to the welding arc and based on various wire feeding control systems. This study discusses such solutions used in laboratory tests involving mechanised Tig welding of thin-walled elements using model stations and a robotic experimental station as well as presents exemplary technological conditions when welding using such systems and the Toptig welding machine.

Toptig Welding

Technological tests involving the Toptig method were performed using a robotic station equipped with a Toptig welding machine provided with a Toptig 220 DC welding power source manufactured by Air Liquide. The control system enables wire feeding with adjustable wire feeding rate pulsation and the synchronisation of the wire feeding rate with current impulses. Similar to other arc welding processes, technological conditions of Toptig welding depend on base materials, thickness of elements to be joined, types of welded joints, shapes and dimensional tolerance of the preparation of edges to be joined, welding positions and weld quality-related requirements. The technological conditions determined during the tests and related to the welding of T-joints made of 1.5 mm thick Inconel 718 alloy sheets ensuring the proper course of the process and proper formation of joints are presented in Table 1; the welded joint macrostructure is presented in Figure 3.

Exemplary technological conditions concerning the welding of the T-joint made of 1.5 mm thick Inconel 718 alloy sheets in the flat position are presented in Table 2. The welded joint macrostructure is presented in Figure 4.

Mechanised TIG Welding performed using the Push type Wire Feeding System Combined with the Toptig Welding Torch and the MC 1540 Polysoude Programmer

Technological tests of this system were performed using the model laboratory station equipped with a PS 256 welding power source, an MC 1540 orbital welding programmer, manufactured by Polysoude S.A.S. and a push type

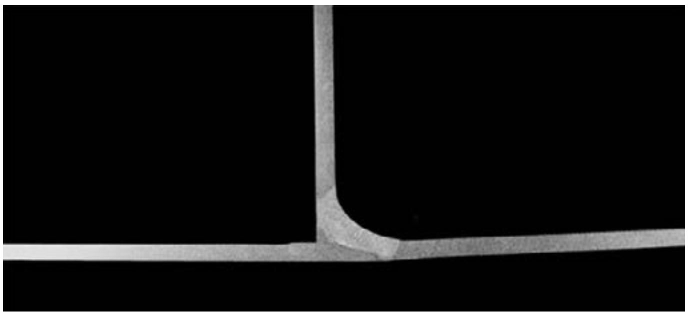

Fig. 3. Macrostructure of the T-joint made of 1.5 mm thick sheets using the Toptig method and the parameters presented in Table 1

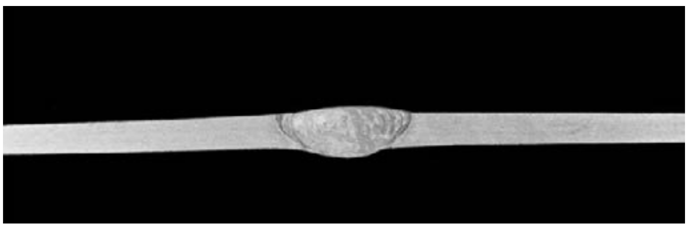

Fig. 4. Macrostructure of the T-joint made of 1.5 mm thick sheets using the Toptig method and the parameters presented in Table 2

Table 1. Technological conditions of making the T-joint of 1.5 mm thick sheets using the TopTIG 220 DC welding machine; horizontal welding position

Parameter	
WTh electrode extension, mm	46,0
Distance between the nozzle and the horizontal/vertical element, mm	3/3
Angle β between the WTh electrode and the T-joint vertical wall, °	40
Wire diameter, mm	1.0
Gas flow time before arc ignition, s (programmer: Prgas Tim)	1.0
Preheating time, s (programmer: Prheat Tim)	1.4
Preheating current, A (programmer: Prheat Cur)	100
Up-slope time before the start of welding, s (programmer: Upslop Tim)	0.5
Impulse current, A (programmer: Welding Cur)	140
Basic current (base), A (programmer: PLS Low Cur)	70
Impulse operation cycle, % (programmer: PLS Duty Cy)	60
Impulse frequency, Hz (programmer: PLS Freq)	7
Welding rate, cm/min	26
Arc termination time, s (programmer: Dw slop Tim)	1.0
Gas flow time after arc termination, s (programmer: Pst Gas Tim)	19
Delay of wire feeding start, s (programmer: Start Wire)	1.0
Wire feeding rate related to impulse, m/min (programmer: Spd Wire)	2.0
Wire feeding rate related to basic current, m/min (programmer: Spd W Lw)	1.5
Delay of wire feeding stop related to arc termination, s (programmer: Stop Wire)	0.1

Table 2. Technological conditions of making the T-joint using the TopTIG method

Parameter	
WTh electrode extension, mm	46,5
Angle α between the WTh electrode and the welding direction, °	0
Wire diameter, mm	1.0
Gas flow time before arc ignition, s (programmer: Prgas Tim)	1.0
Preheating time, s (programmer: Prheat Tim)	1.4
Preheating current, A (programmer: Prheat Cur)	70
Up-slope time before the start of welding, s (programmer: Upslop Tim)	0.5
Impulse current, A (programmer: Welding Cur)	130
Basic current (base), A (programmer: PLS Low Cur)	66
Impulse operation cycle, % (programmer: PLS Duty Cy)	60
Impulse frequency, Hz (programmer: PLS Freq)	7
Welding rate, cm/min	29
Arc termination time, s (programmer: Dw slop Tim)	1.0
Gas flow time after arc termination, s (programmer: Pst Gas Tim)	19
Delay of wire feeding start, s (programmer: Start Wire)	1.0
Wire feeding rate related to impulse, m/min (programmer: Spd Wire)	1.2
Wire feeding rate related to basic current, m/min (programmer: Spd W Lw)	0.8
Delay of wire feeding stop related to arc termination, s (programmer: Stop Wire)	0.1

system enabling the adjustment of wire feeding rate pulsation and the synchronisation of a wire feeding rate with current impulses. During the tests, the push module in the Toptig welding torch remained inactive. Exemplary welding parameters related to welding T-joints of 1.5 mm thick Inconel 718 alloy sheets using the Toptig welding torch and the solution presented above are presented in Table 3; the welded joint macrostructure is presented in Figure 5.

Mechanised TIG welding using the Lorch V40 AC/DC Welding Machine

The Lorch V40 ac/dc welding machine provided with the Feed 1 electrode wire feeder, manufactured by Lorch Schweißtechnik GmbH, is used for standard and pulsed arc Tig welding, where the welding process can be performed with continuous or pulsed wire feeding (adjustable time of wire feeding and pullback) [5, 6].

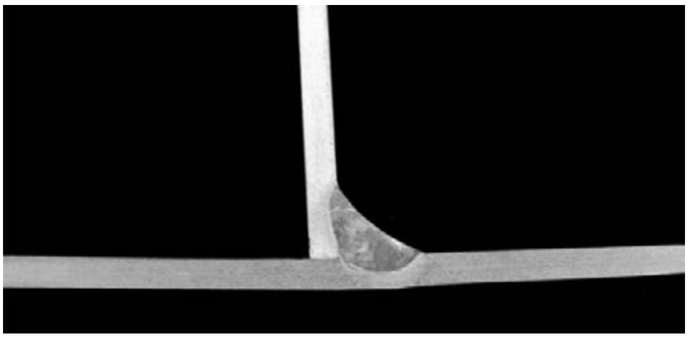

Fig. 5. Macrostructure of the T-joint made of 1.5 mm thick sheets using the parameters presented in Table 3

The device enables Tig welding performed with side wire feeding in the classical variant, with an angle between the wire fed to the welding arc zone and the tungsten electrode axis of 60-80°. The positioning of the wire fed to the welding arc zone at a lower angle in relation to the tungsten electrode axis required the use of the modernised wire feeder fixing solution and an extended ceramic gas nozzle on the model station. As a result, it was possible to obtain an angle between the wire and the tungsten electrode axis of 25° (Fig. 6).

Exemplary parameters concerning the welding of the T-joint made of 1.5 thick sheets using the standard arc are presented in Table 4. The welded joint macrostructure is presented in Figure 7.

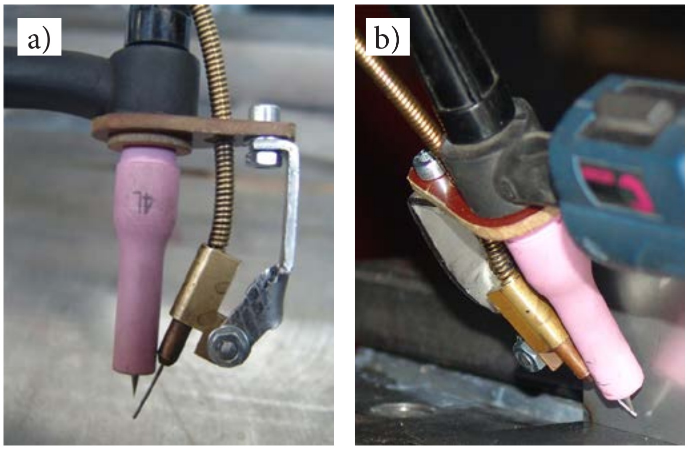

Fig. 6. Modernised wire feeder fixed on the TIG welding torch of the LORCH V40 AC/DC welding machine: a) main view; b) position during the welding of a T-joint

Table 3. Technological conditions of making the T-joint using the MC 1540 programmer, horizontal welding position

Wire diameter, mm	WTh electrode extension, mm	Angle β between WTh and joint vertical wall, °	Welding rate, mm/min
1.0	44.5	45	150

Gas flow time T10, s	Arc initiation current I20, A	Up-slope time T20, s	Wire feeding delay T40, s	Wire initial melting current I21, A
2.0	20	0.3	3.0	100

Initial melting time T21, s	Wire feeding rate related to impulse V42, mm/min	Wire feeding rate related to pause V43, mm/min	Impulse current I22, A
1.5	1300	500	120

Impulse time T22, ms	Basic current I23, A	Basic current time T23, ms	Arc termination time T25, s	Arc termination current I25, A
1000	30	250	3.0	7

Table 4. Technological conditions of making the T-joints using the Lorch V 40 AC/DC welding machine, horizontal welding position

Angle β between the WTh electrode and the T-joint vertical wall	45°
WTh electrode extension outside the gas nozzle	7
Electrode wire diameter, mm	1,0
Welding current, A	70
Wire feeding rate, m/min	1,0
Welding rate, cm/min	15

Table 5. Technological conditions of making the T-joint of 1+2 mm thick sheets using the modernised welding torch Robacta TTW4500

Angle β between the WTh electrode and the T-joint vertical wall	40°
Electrode wire diameter, mm	1.0
Electrode extension, measured from the tip, mm	16.5
Welding rate, cm/min	30
Impulse current, A	140
Basic current (base), A (setting, %)	70 (50%)
Wire feeding rate related to impulse, m/min	2.0
Wire feeding rate related to basic current, setting, %	80

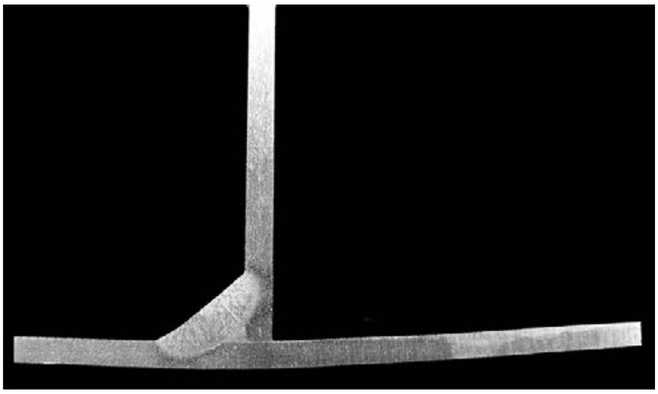

Fig. 7. Macrostructure of the T-joint made of sheets using the Lorch V 40 AC/DC welding machine and the parameters presented in Table 4

Fig. 9. Macrostructure of the T-joint made using the parameters presented in Table 5

Mechanised Tig welding using the Robacta TTW4500 Welding Torch and the Toptig Gas Nozzle

Mechanised tig welding can be performed using a welding machine provided with the Robacta ttw4500 welding torch manufactured by Fronius International GmbH, intended for welding with side wire feeding in the classical variant, with a built-in wire feeding mechanism (*push-pull system*), or with the same torch available in a modernised version, i.e. having a Toptig type nozzle with

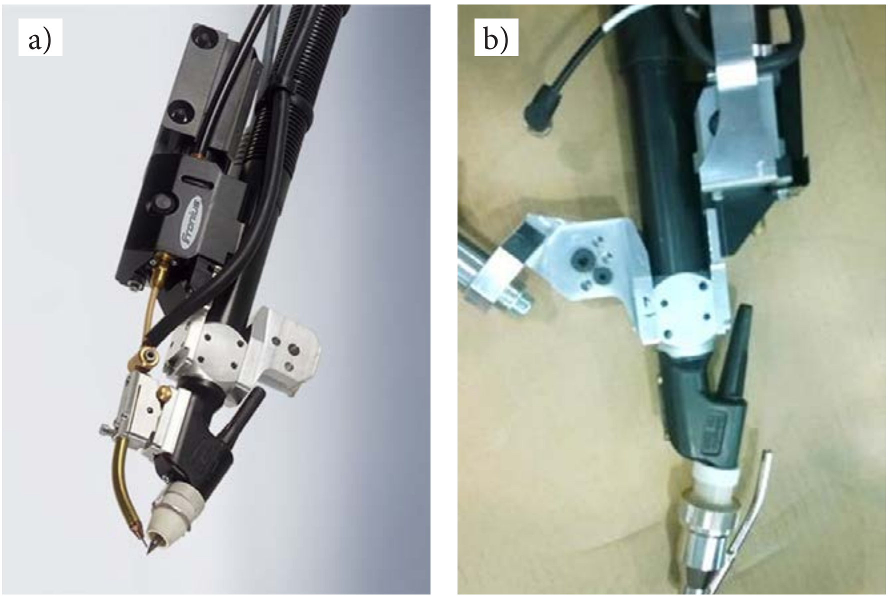

Fig. 8. Machine welding torch Robacta TTW4500: a) with the classical, i.e. side wire feeding [7]; b) after replacing the typical wire feeding unit with the unit incorporating a nozzle with a Toptig type wire feeding conduit

a wire feeding conduit (Fig. 8). The experimental welding station incorporating this machine is also equipped with a Magicwave 4000 welding power source and a KD 1500 D-11 wire feeder, manufactured by Fronius.

Exemplary technological conditions concerning the welding of T-joints using the **experimental** robotic station equipped with the modernised Robacta TTW4500 welding torch (i.e. provided with the Toptig nozzle unit) are presented in Table 5. The welded joint macrostructure is presented in Figure 9.

Summary

The technological tests of mechanised TIG welding with an electrode wire fed at an angle possibly low in relation to a welding arc and based on various wire feeding control systems, e.g. enabling the adjustment of wire feeding rate pulsation and the synchronisation of a wire feeding rate with current impulses were performed on model laboratory stations, a robotic experimental station and a station equipped with a Toptig welding machine. The tests revealed significant differences in sets of technological parameters of welding performed using such control systems (see Tables 1-5). For each of the control systems presented, it is necessary to develop welding technological conditions taking into consideration the specific character of current and wire feeding parameters of a given system.

The results of the technological tests focused on robotic welding using the welding process control systems presented above enabled the determination of technological conditions ensuring the proper course of a welding process and the formation of properly shaped T-joints and butt-welded thin-walled elements using a Toptig welding machine, the model systems tested and the system installed on the test rig.

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