

TECHNOLOGICAL ISSUES IN MECHANISED FEED WIG/TIG WELDING SURFACING OF WELDING

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Abstract—WIG welding research is currently oriented twofold namely: increasing the performance of welding equipment, and increasing both the quality of welds and welding productivity. The research aims to achieve some deposits and make some mechanised wire feed based WIG manual welding tests in the light of using the process for welding surfacing being known that in such applications mechanised operations are recommended whenever possible given the latter strengths i.e. increased productivity and quality deposits. The research also aims at achieving a comparative study between wire mechanised feed based WIG manual welding and the manual rod entry based manual welding in terms of geometry deposits, deposits aesthetics, operating technique, productivity, etc ... In this regard deposits were made by means of two welding procedures, and subsequently welding surfacing was made with the optimum values of the welding parameters in this case.

Keywords—About WIG welding, WIG mechanization, WIG surfacing, mechanical feeding of wire, dilution

I. INTRODUCTION

WIG welding research is currently oriented twofold namely: increasing the performance of welding equipment, and increasing both the quality of welds and welding productivity while being aware of the fact that one of the feature of WIG welding, especially in filler metal based manual welding, is the low productivity because of the operating procedures which requires a regular dipping of welding wire in the metal bath.

A measure towards increasing productivity in WIG welding is the welding wire feed rate mechanization by using specialized devices. In this regard the best-known procedure is WIG orbital of pipes where both the rate of welding and the feed rate of the welding wire are carried out mechanically [1], [2].

Worldwide major manufacturers of welding equipment are producing currently specialized welding systems for *WIG welding with mechanised wire feed* for wire small diameters i.e. 0.8mm, 1.0mm, and 1.2mm respectively. For driving the wire one use specialized devices to be mounted on the welding equipment or facilities which allow WIG welding process mechanization, automation

or robotics. The main disadvantage of the welding equipment and facilities aforementioned is their relatively high cost price [7].

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The research also aims at achieving a comparative study between wire mechanised feed based WIG manual welding and the manual rod entry based manual welding in terms of geometry deposits, deposits aesthetics, operating technique, productivity, etc ... In this regard deposits were made by means of two welding procedures, and subsequently welding surfacing was made with the optimum values of the welding parameters in this case

II. WELDING PLANT

A. Making of mechanised wire feed based WIG welding plant

In order to carry out experimental research a mechanised wire feed based WIG welding plant was developed using the equipment and facilities available in the laboratory of welding technologies, see Fig. 1. below.

The plant consists of the following equipment and components:

- 1)TIG - MAGIC WAVE 300 (Fronius) universal welding source as a power source for electric arc;
- 2)MIG/MAG - ARISTO 500 (ESAB) universal welding source with MED 44 feed device mechanised feed of the electrode wire;
- 3)TUT welding and cutting tractor for rate of welding mechanisation; and
- 4)TIG welding torch with electrode wire mechanized feed, made in-house.

MAGIC 300 WAVE welding power source - see (Fig. 1.) above - is the power source for the WIG electric arc that generates the heating and melting of the base (parent) metal and filler metal as an electrode wire with a

diameter < 1.6 mm, mechanically driven in the electric arc column. Being an inverter based modern welding source it ensures a precise adjustment and control of the welding power (current) and the safe starting of electric arc using the OIF oscillator.



Fig. 1. Mechanised wire feed based WIG welding plant

For the electrode wire mechanized driving we used the inverter based Aristo 500 modern welding plant. The plant is equipped with a MED 44 high-performance wire feed device which provides wire feed evenly and securely which is very important in the case of mechanized welding. To this end the device is provided with a feed system based on 4 drive rollers driven simultaneously by two DC motors synchronized with each other. Moreover and most important in the Mechanised wire feed based WIG welding is that the device allows wire feed rate digital adjustment with a high accuracy ranging between 0.2 and 22m/min and with an increment of 0.1m/min.

(Fig. 2.) below shows the setting and positioning of WIG welding head in the case of electrode wire mechanised feed based welding.



Fig. 2. Preparing WIG welding head for mechanized feed based welding

A proper welding involves the timing of standard WIG welding cycle with the specific electrode wire driving based standard welding cycle.

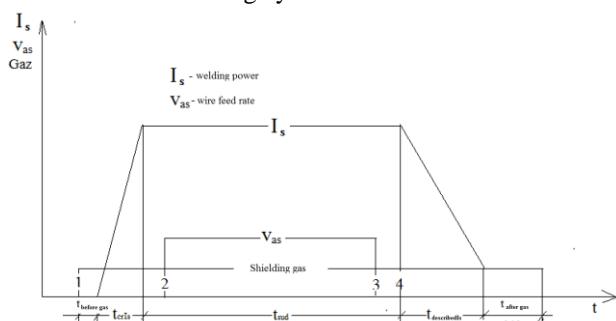


Fig. 3. WIG welding plant oscillogram above shows the welding oscillogram for the mechanised wire feed based WIG welding plant.

Before starting the welding process the two welding power sources are fired up and the welding power is adjusted in the WIG MW 300 device and the feed rate of the welding wire in the MED 44 DAS of the MIG/MAG Aristo 500 plant; subsequently the welding torch is positioned on the sample (workpiece) to be welded for the ignition of the electric arc with OIF oscillator.

B. Welding is carried out according to the following tacts or steps [4].

Stage 1: Welding power (current) is connected by pressing the welding torch button or the foot pedal; shielding gas starts to flow and the starting of electric arc occurs with a delay of 1-2 seconds and produces the local melting of the sample and the forming of metal bath; WIG welding torch is oriented at an angle of approx. 10° as against the normal to the sample surface in the welding direction, and perpendicular to the sample surface; welding power (current) is adjusted to the required level for welding and the metal bath on the sample is accomplished by keeping the welding torch steady.

Stage 2: welding wire feed is coupled by pressing the power switch located on the welding torch (note: other than the start button of WIG welding); the welding wire advances with the default feed rate and is dipped into the metal bath where its tip is melted by the heat from the bath; the welding torch is moving manually to the left or right depending on the welding technique chosen, by pushing and pulling respectively, with the adequate rate of welding; the bead is formed at the same time with the cooling and solidification of the metal bath on the entire length of the sample or weld.

Stage 3: welding torch stops its movement and simultaneously or with a slight delay for closing the crater, the wire feed is disengaged by pressing the power button (power button has two positions: i.e. O-OFF, I - ON) on the welding torch; feed device decouples the welding wire feed;

Stage 4: the power supply of electric is disconnected by pressing the WIG welding torch button or by releasing its foot pedal; a slow decreasing of welding power (current) occurs until the extinguishing of the electric arc to reducing the size of the final weld crater; the metal bath is cooled and solidified slowly; with a delay of a few seconds shielding gas interruption occurs for the metal bath and tungsten electrode.

III. EXPERIMENTAL RESEARCH

Experimental research has pursued the following:

- 1)mechanised feed WIG welding surfacing of welding wire; and
- 2)comparative study between standard WIG manual welding and mechanised feed WIG welding.

The tests consisted of performing in both cases semi-mechanised WIG welding and WIG manual welding of some deposits on non-alloy steel boards while observing some welding parameters considered optimal for this case. In both cases, the two welding techniques were applied i.e Swiss welding method or by pushing the metal bath and back-hand welding by pulling the metal

bath, respectively. One aimed to ensuring the stability of the electric arc and the technological peculiarities in the two welding methods. It is well-known that in the case of technical surfacing it is recommended the Swiss welding method or by pushing the metal bath that best controls dilution and ensures the best aesthetic of loaded surface. The surface of samples was processed by metallic lustre grinding.

Working Conditions:

- 1) Samples base metal: S235J2 (SR EN 10025/2-2009);
- 2) Base material thickness: $s = 8$ (mm);
- 3) Samples size: $100 \times 70 \times 8$ (mm);
- 4) Rod diameter: $d_v = 2.4$ (mm);
- 5) Filler metal: W3Si1 (SR EN 440/96), [5];
- 6) Tungsten electrode diameter: $D_{ew} = 3.2$ (mm);
- 7) Tungsten electrode type: EWTh 20 (marked red);
- 8) Shielding gas: argon 100% (SR EN 439/96), [6];
- 9) Gas flow $Q = 8$ (l/min); and
- 10) Welding source MAGIC WAVE300 (Fronius).

Welding was carried out according to the following steps:

- 1) WIG manual welding with filler metal: pull deposit-push deposit;
- 2) WIG manual welding with filler metal: push surfacing;
- 3) mechanised wire feed based WIG welding; pull deposit – push deposit; and
- 4) mechanised wire feed based WIG welding; push surfacing.

The external appearance of the deposits is shown in (Fig. 3.) below, as follows:

- 1) Sample 1: WIG manual welding deposits;
- 2) Sample 2: WIG manual welding surfacing;
- 3) Sample 3: deposits through mechanised wire feed based WIG semi-mechanised welding; and
- 4) Sample 4: surfacing through mechanised wire feed based WIG semi-mechanised welding.

In all cases both the Swiss welding method i.e. push (symbol - I) and back-hand welding method i.e. pull (symbol - T) were applied.



Fig. 3. The appearance of deposits and surfacing

Welding technologies used in the case of four deposits and surfacing are analyzed below.

1) WIG manual welding deposits - Sample 1:

a) Push deposits:

Technological parameters of welding: $I_s = 170$ (A), $U_a = (10 + 0.04I_s) / 1.7 = 10$ (V), $L_s = 95$ (mm), $t_s = 32$ (s), $v_s = L_s/t_s = 17.76$ (cm/min), $v_s = 18$ (cm/min). (I_s - Welding current; U_a - Arc voltage; L_s - Weld length; t_s - Welding time; v_s - Rate of welding)

b) Pulled arc deposits:

Technological parameters of welding: $I_s = 170$ (A), U_a

$$= (10 + 0.04I_s) / 1.7 = 10(V), L_s = 70(mm), t_s = 22s, v_s = L_s/t_s = 19.1(cm/min), v_s = 19(cm/min).$$

The geometry of deposits in the two cases above is shown in (Fig. 4.) below.

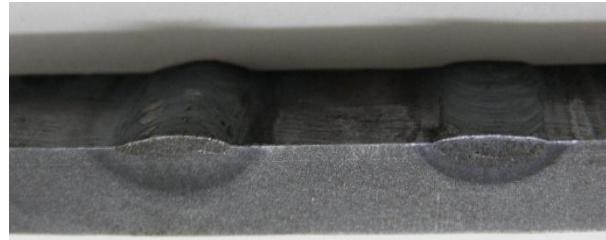


Fig. 4. Geometry of deposits – WIG manual welding

2) WIG manual welding surfacing – Sample 2:

Technological parameters of welding: $I_s = 170$ (A), $U_a = (10 + 0.04I_s) / 1.7 = 10$ (V), $L_s = 95$ (mm), $t_s = 36$ (s), $v_s = L_s/t_s = 15.6$ (cm/min), $v_s = 16$ (cm/min), push.

The geometry of surfacing is shown in (Fig. 5.) below.

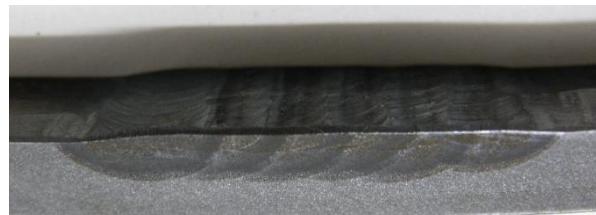


Fig. 5. Geometry of surfacing in WIG manual welding – push

The analysis of both outer surface and geometry of surfacing and deposits leads to the following conclusions:

a) In the case of WIG manual welding surfacing and deposits by arc push, the appearance of the surface is smooth with fine and regular scales and a small height increase and large width and an uniform and reduced penetration with good crossing overlaps, with no surface or internal flaws, no marginal grooves between passes, and showing the best aesthetic; control of the welding process is the best; however the productivity is low and it is specific to WIG manual welding with filler metal;

b) Push is recommended for surfacing which requires a minimum dilution in welding;

c) Weld penetration is deeper in the case of pull than in the case of push yet these differences are not no significant and the weld penetration is concave when maximum in the core of deposit;

d) Operating technique is more difficult in the case of pull due to the difficulty of dipping the metal rod in the metal bath; it is recommended when welding thicker material.

3) Deposits through mechanised wire feed based WIG welding - Sample 3

Additional working conditions:

a) Welding wire brand: G3Si1;

b) Wire diameter: 1.0(mm);

c) Welding wire feed rate: 1.8 (m/min).

i) Push welding deposits:

Technological parameters of welding: $I_s = 170$ (A), $U_a = (10 + 0.04I_s) / 1.7 = 10$ (V), $L_s = 95$ (mm), $t_s = 31$ (s),

$v_s = L/t_s = 18.36(\text{cm}/\text{min})$, $v_s = 18.5(\text{cm}/\text{min})$.

ii) Pull welding deposits:

Technological parameters of welding: $I_s = 170(\text{A})$, $U_a = (10 + 0.04I_s)/1.7 = 10(\text{V})$, $L_s = 95(\text{mm})$, $t_s = 31\text{s}$, $v_s = L/t_s = 18.36(\text{cm}/\text{min})$, $v_s = 18.5(\text{cm}/\text{min})$.

The geometry of the deposits in the two cases is shown in (Fig. 6.) below.



Push – left Pilled welding - right

Fig. 6. The geometry of deposits in semi-mechanised welding

4) Surfacing through mechanised wire feed based WIG welding – Sample 4

Technological parameters of welding: $I_s = 170(\text{A})$, $U_a = (10 + 0.04I_s)/1.7 = 10(\text{V})$, $L_s = 95(\text{mm})$, $t_s = 29(\text{s})$, $v_s = L/t_s = 18.36(\text{cm}/\text{min})$, $v_s = 20(\text{cm}/\text{min})$, push.

The geometry of surfacing is shown in the (Fig. 7.) below.



Fig. 7. The geometry of surfacing of mechanised wire feed based WIG welding

The analysis of both outer surface and geometry of surfacing and deposits leads to the following conclusions:

- 1) *Surface appearance is smoother in the case of push arc welding than in the case of pull arc welding and showing a more favourable geometry;*
- 2) *The unique appearance of the welding wire in mechanised feed based WIG welding compared to the one in the case of WIG manual welding occurs in penetration geometry, in the sense that it is not at maximum in the core of deposit as usual but on the edges of the deposit, the deposit core penetration is minimal; a possible explanation of this curious and inexplicable phenomenon, at first glance, is as follows: due to dipping the welding wire in the middle of the metal bath an intense cooling of the metal bath in this area occurs, part of the heat being dissipated for the purposes of melting filler metal i.e. the wire electrode; this leads to cooling the middle of the bath with consequences in terms of reducing penetration; therefore this time geometry of penetration is convex;*
- 3) *The phenomenon described above causes the decrease of dilution in welding as compared with standard WIG manual welding; for high feed rate of the wire electrode it may sometimes occur danger of*

a lack of connection with the molten metal, bath is virtually cooling so much that the melting of the base metal is unlikely to occur; penetration in this case can be controlled by the electrode wire feed rate, not only by the welding current (power) value;

- 4) *The phenomenon described above is stronger in the case of push arc welding when compared to pull arc welding and this can be explained by the tendency of the flow of the metal bath in front of the arc, and thus reducing its performance;*
- 5) *When surfacing through mechanized feed wire based WIG welding the penetration is uneven with obvious grooves from place to place in the edge of each pass;*
- 6) *The operating technique is easier when compared to standard WIG manual welding, differences being irrelevant between the push arc welding and pull arc welding methods, which is not the case when carrying out a manual welding;*
- 7) *Productivity of wire mechanised feed based WIG welding is higher and this may be explain by increasing deposit rate and by the possibility of higher rates of welding;*
- 8) *There is a lower heating of the base metal in the case of semi-mechanised WIG welding explained by the higher rate of welding used and by reducing the metal bath temperature as an effect of dipping the welding wire into the metal bath.*

IV. CONCLUSION

In conclusion it is considered that mechanised feed WIG welding surfacing of welding wire is an alternative to standard TIG/WIG manual welding surfacing with filler metal which have a significant impact on welding productivity, control of the heat induced in base metal, dilution, operating technique, etc.

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