PROCESS PARAMETERS FOR CMT ROBOTIC CORROSION RESISTANT OVERLAY WELDING OF WATER TUBE MEMBRANE WALLS

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Abstract

Cold Metal Transfer (CMT) welding technology represents an important improvement of classical MIG/MAG welding process. Among its many advantages one of the most important is ease of robotization and automatization. In boiler manufacturing corrosion resistant overlay welding is extremely labour-intensive process. When cladding large areas human workforce would be extremely slow. All these issues can be solved with proper utilization of robotic CMT welding process. This paper will attempt to determine optimal welding process parameters for CMT technology. Stated process parameters are utilised and tested during manufacturing process of water tube boiler membrane walls in Đuro Đaković Termoenergetska postrojenja d.o.o. For the purpose of generating heat water tube boilers often use natural gas as fuel. Manufacturing high quality boiler components represents an important part of natural gas economy.

Keywords: Welding, Cold Metal Transfer (CMT), Welding process parameters, Robotization and automatization, Water tube boilers; membrane walls

1. Introduction

Input of heat and energy in both welds and parent metals has important effects on material characteristics, residual stresses and both dimensional and shape accuracy of welded products [1]. There are even some materials and applications where having a low as possible thermal input is required. Cold metal transfer (CMT) welding process represents an improvement of classical MIG/MAG technologies considering reduced heat and energy input. Invented by Fronius of Austria in 2004., CMT has several important characteristics [2]:

- Controlled material deposition by utilizing both wire feed system and the cyclic arching phase,

- Low thermal input,
- Retraction of the wire assists droplet detachment during the short circuit,
- Current of the short circuit is kept small, which results in spatter-free welds,
- Stable arc, in CMT the arc length is acquired and adjusted automatically.

Figure 1 shows the start of the arcing period. Welding wire is moved towards the weld pool.

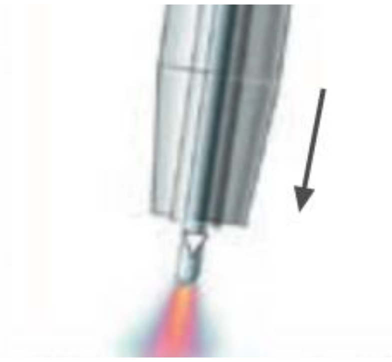

Figure 1 Start of the arcing period [3]

When the wire dips into the weld-pool, welding current is lowered, and arc is extinguished (Figure 2).

Figure 2 Extinguishing of the arc [3]

During the short circuit, retraction of the wire assists filler material detachment. Short circuit current is kept as small as possible (Figure 3).

Figure 3 Retraction of the wire [3]

Wire reverses its motion and process starts again (Figure 4).

Figure 4 Re-starting the cycle [3]

Peak current phase on Figure 5, corresponds to a high pulse of current sufficient to ignite a welding arc, and heats the wire to form a droplet. Background time represents an interval of reduced current, intended to prevent globular transfer of the droplet on the wire tip, and it continues until short circuit occurs. In the short-circuiting time arc voltage is zero, and the signal for the return of the wire is provided to the wire feeder. Retraction of the wire assists in the liquid fracture and transfer of molten material into the welding pool.

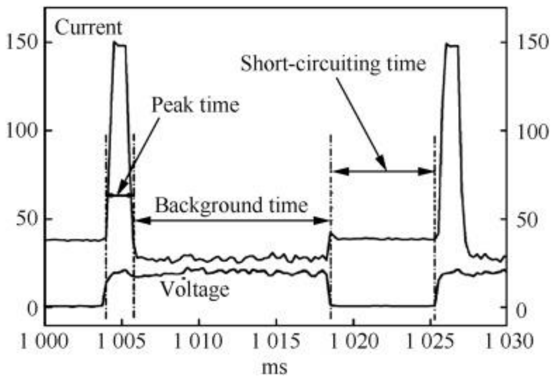

Figure 5 CMT welding electrical signal cycle [2]

High productivity and flexibility of welding performance, especially when used in combination with welding robots make CMT well suited for modern manufacturing conditions. Such is also the case with corrosion resistant overlay welding during manufacturing process of water tube boiler membrane walls in ĐĐ TEP d.o.o. In every water tube boiler process of creating steam starts with the burning of fuel within the furnace. Fuel varies depending on the type of boiler but most commonly used are: natural gas, propane, heating oil, coal or various types of waste products. Since burning of fuel creates high temperatures it is necessary to protect some parts of the boiler (mostly membrane wall and headers) with cladding. Cladding process is synonymous with overlay welding process. Robotized CMT welding technology represents an efficient and cost effective way of cladding large areas of water tube boiler components.

2. Methodology

Experimental investigation was performed during cladding of panels 1 and 2 (Figure 6, Figure 7) in the workshop of ĐĐ TEP d.o.o.

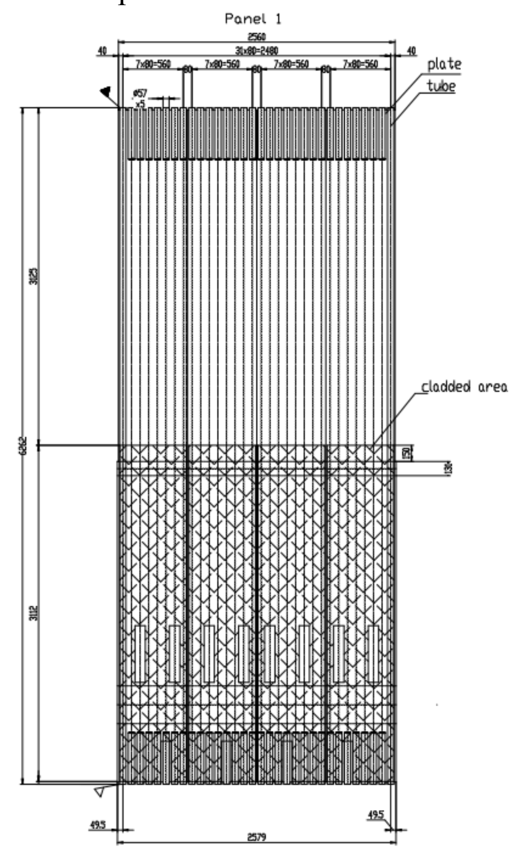

Figure 6 Representation of cladded area – panel 1 [4]

Table 1. Panel 1 technical details

Panel dimensions, LxW/mm	6262x2560
Dimensions of cladded area, LxW/mm	3112x2560
No. of tubes / Tube dimensions	32 ϕ57x5
Tube material	16Mo3
No. of steel plates / plate dimensions	175 ≠5
Steel plate material	16Mo3

Figure 6 represents a technical drawing of cladded area for panel 1. Cladded area is marked with "X" type hatch. Table 1 specifies technical details of the panel, including dimensions, dimensions of cladded area etc.

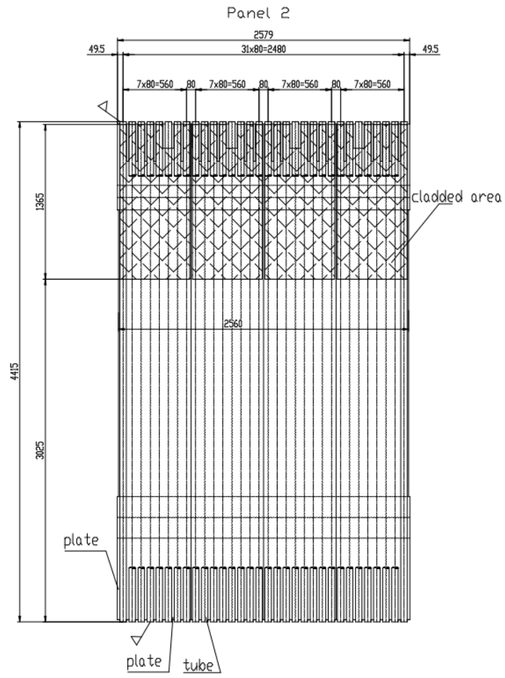

Figure 7 Representation of cladded area – panel 2 [4]

Table 2. Panel 2 technical details

Panel dimensions, LxW/mm	4415x2560
Dimensions of cladded area, LxW/mm	1365x2560
No. of tubes / Tube dimensions	32 ϕ57x5
Tube material	16Mo3
No. of steel plates / plate dimensions	170 ≠5
Steel plate material	16Mo3

Similar to the panel 1, Figure 7 is a technical drawing of panel 2 and Table 2 specifies its technical details. Total cladded area can be easily calculated and amounts to:

$$A_{total\ cladded\ area} \approx 350\ m^2$$

Cladding was performed on the CMT TransPuls Synergic 5000 power source (Figure 8 and Figure 9) by Fronius.

Figure 8 CMT TransPuls Synergic 5000 Serial number

Figure 9 CMT TransPuls Synergic 5000 power source

Process was fully automated, with two Reis robotic units and a platform (Figure 10 and Figure 11).

Figure 10 REIS robotic unit 1 with a platform

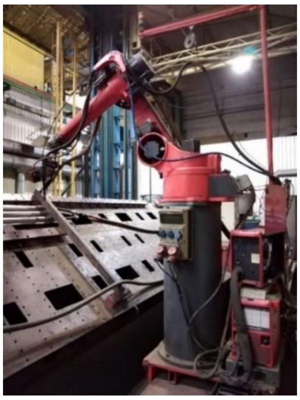

Figure 11 REIS robotic unit 2 with a platform

3. Experimental investigation – optimal process parameters

Experimental investigation was limited to determining optimal process parameters for CMT overlay welding including: welding sequence, welding position, welding filler material, diameter of the wire, current, voltage, travel speed and expected heat input. Figure 12 gives a graphical overview of the welding sequence. During cladding tubes were cooled from the inside with cooling fluid.
Welding direction, nozzle – tube distance and width of the cladding line were given in Figure 13. Prior to the welding, joint was prepared by sand blasting. Base material was used as backing. Maximum width of run was 20 [mm], and maximum run thickness 4 [mm]. Presentation of optimal process parameters as confirmed during CMT overlay welding in ĐĐ TEP d.o.o. is given in tables 3 to 6. Each welding sequence or a group of welding sequences as defined in Figure 12, have their own table with their technical details. It must be noted that most values have their upper and lower limits specified, optimal parameters belonging to specified intervals.

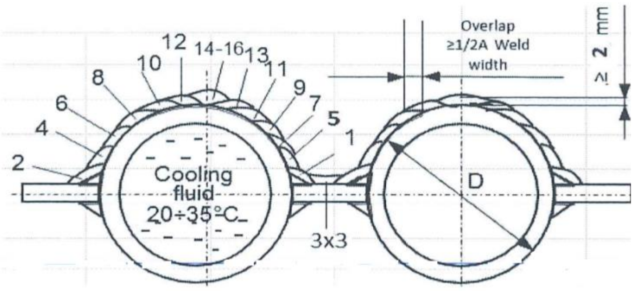

Figure 12 Welding sequence

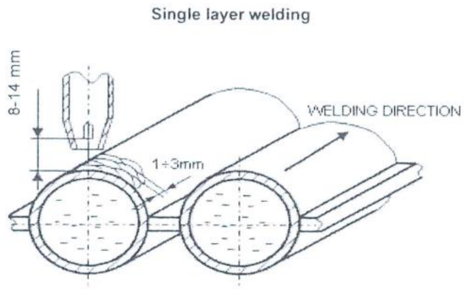

Figure 13 Isometric view of the welding direction

Table 3. Welding process parameters for sequence 1÷4

Welding sequence No.	1÷4
Object of welding	Cover
Process (EN ISO 4063)	135 Robotized
Welding position (EN ISO 6947)	PA
Welding filler material EN class	S Ni 6625 (NiCr22Mo9Nb) Inconel 625, Daiko SF 625 Special Metals, Nicros
Diameter [mm]	1,2
Current [A]	170±10 Pulsed
Type of current/Polarity [DC, +-AC]	DC+ CMT
Voltage [V]	16±5
Travel speed [cm/min]	24÷30,15
Heat input [kJ/mm] (EN 1011-1)	0,23÷0,60

Table 4. Welding process parameters for sequence 5

Welding sequence No.	5
Object of welding	Cover
Process (EN ISO 4063)	135 Robotized
Welding position (EN ISO 6947)	PA
Welding filler material EN class	S Ni 6625 (NiCr22Mo9Nb) Inconel 625, Daiko SF 625 Special Metals, Nicros
Diameter [mm]	1,2
Current [A]	160±10 Pulsed
Type of current/Polarity [DC, +-AC]	DC+ CMT
Voltage [V]	14±3
Travel speed [cm/min]	23,2÷29,36
Heat input [kJ/mm] (EN 1011-1)	0,23÷0,60

Table 5. Welding process parameters for sequence 6÷7

Welding sequence No.	6÷7
Object of welding	Cover
Process (EN ISO 4063)	135 Robotized
Welding position (EN ISO 6947)	PA
Welding filler material EN class	S Ni 6625 (NiCr22Mo9Nb) Inconel 625, Daiko SF 625 Special Metals, Nicros
Diameter [mm]	1,2
Current [A]	120±20 Pulsed
Type of current/Polarity [DC, +-AC]	DC+ CMT
Voltage [V]	15±5
Travel speed [cm/min]	19÷37,7
Heat input [kJ/mm] (EN 1011-1)	0,23÷0,60

Stated process parameters allow for the use of several welding filler materials, depending on the needs of the current manufacturing process. Filler materials most frequently used in ĐĐ TEP d.o.o are: S Ni 6625 (NiCr22Mo9Nb), Inconel 625, Daiko SF 625, Special Metals, Nicros etc.

Table 6. Welding process parameters for sequence 8÷16

Welding sequence No.	8÷16
Object of welding	Cover
Process (EN ISO 4063)	135 Robotized
Welding position (EN ISO 6947)	PA
Welding filler material EN class	S Ni 6625 (NiCr22Mo9Nb) Inconel 625, Daiko SF 625 Special Metals, Nicros
Diameter [mm]	1,2
Current [A]	115±15 Pulsed
Type of current/Polarity [DC, +-AC]	DC+ CMT
Voltage [V]	15±5
Travel speed [cm/min]	21,1÷26,6

During cladding there was no special post-welding heat treatment beside standard preheating as stated in Table 7. Maximum interpass temperature was limited to 35 °C.

Table 7. Heat treatment details

Preheating temperature [°C]	20
Maximum interpass temperature [°C]	35
Cooling before PWHT [°C] [h]	-
Post-heating [°C] [h]	-

Table 8 gives overview of the used shielding gas, being relatively standard mixture of argon, helium, hydrogen and CO2.

Table 8. Shielding gas details

Welding sequence No.	1÷16
Shielding gas (l/min) (EN ISO 14175)	Z-ArHeHC 14÷20
Backing gas (l/min) (EN ISO 14175)	-

Additional information regarding movement and position of nozzle in reference to work piece, wire feed speed and achieved weld material thickness is given in Table 9.

Table 9. Distance from nozzle to work piece [mm]

Welding technique	135/136
Wire speed feed range [m/min]	4÷8
Distance from/Distance tube contact [mm]	8÷14
Mode of metal transfer	CMT Short circuiting
Electrode No., type	Single wire
Additional filler material	-
Nozzle diameter [mm]	15÷23
Weld material thickness per welding process (min./max.)	≥2

4. Conclusions

CMT welding technology has several important advantages over standard MIG/MAG processes. These advantages make it preferable in almost all industrial applications. Another important element is the ease of automatization and robotization. From the point of welding efficiency and welding quality automated systems are necessity for corrosion resistant overlay welding. Quality of the welding process heavily depends on the selection of optimized welding parameters, even though the CMT is regarded as a "cold" welding technology. Manual overlay welding would be extremely labour-intensive process. Among other types of fuel, natural gas is also often used for the purpose of heat generation. Parts of the boiler exposed to the high heat will have their expected life cycle significantly reduced. This puts special importance on technologies which can increase effectiveness and usage of boiler components. CMT overlay welding is technology designed just for that. By welding a layer of heat and corrosion resistant material over standard tube steel it is possible to significantly impact boilers working capacity. For all this reasons welding process parameters and their application remain an important part of every water tube boiler manufacturing company knowledge base. Exact values of process parameters are closely guarded manufacturing secret, and are very rarely shared with the general public. That is a main reason why nearly all parameter values in this paper are stated as intervals.

5. References

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