CMT A THIN SHEET WELDING PROCESS? WELDING APPLICATIONS WITH THE CMT PROCESS IN THE FIELD OF POWER GENERATION

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Abstract:

In the past the CMT process was known for thin sheet applications. Especial the car and car supplying industry took advantages of this process due to high welding speed, low heat input stable arc and a gap bridging. This paper investigates applications in the field of power generation and gives a new perspective to the possibilities which can be achieved with the CMT process.Weld overlay on membrane walls with alloy 625, pipe welding of high pressure steam pipes and welding offshore jacket structures for wind turbines in horizontal position , will be explained and described.

1. INTRODUCTION

The CMT process was launched in the year 2005. At the beginning it was used for joining thin Aluminum sheets (1- 1,5 mm thickness) and brazing applications with gap tolerances up to 2 mm. The Car industry was the clear focus at that time, its total potential was not predictable. Bit by bit CMT developed its advantages. This paper will describe 3 different welding applications where CMT is used in the field of power generation. Weldoverlayespeciallywith the Alloy 625 showed that the low fusion depth of the process offers a new possibility to achieve a low and homogenous Fe Content. The second topic was root and filler welding of steam tubes.It was necessary to change a heat exchanger in a power plant. Therefore steam pipes which connect to the steam turbine need to be replaced under fitting conditions.A Gap tolerance up to 3 mm and High Low of +/-1 are common for such applications. Welding offshoreTripods for wind turbines is the last issue in this paper where the new CMT high deposition process CMT Twin has achieved welding speeds in PC position similar to SAW.

2. COLD METAL TRANSFER (CMT)

CMT stands for Cold Metal Transfer. As its name makes clear, the process makes it possible for metal to be transferred "cold" in the course of welding or brazing. Compared to conventional GMAW processes, considerably less heat is put in.CMTprovides its user with an entirely new way of droplet detachment, from the wire electrode toward the weld pool. That allows the process to be applied in areas, as yet unreachable to conventional GMAW.Figure 2 below shows the different arc modes and the position of the CMT arc with regard to its performance limit.

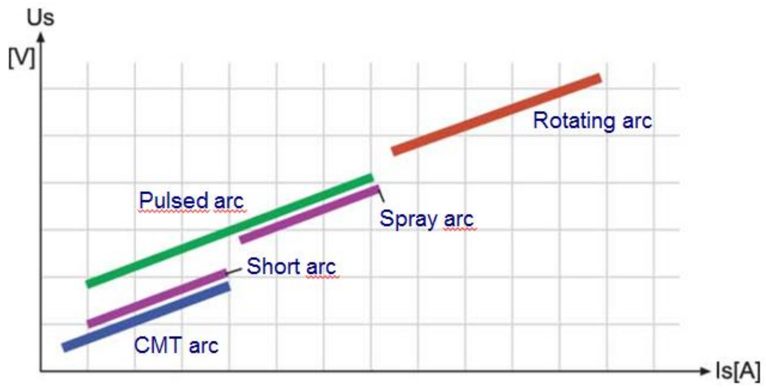


***Figure 1:** Positioning of the CMT arc in relation to the weldperformance*

3. CMT VS SHORT ARC COMPARISON

Short Arc mode

The standard short arc modehas continuous wire feeding. Process regulation parameters are welding voltage and welding current. Therefore the high current causes the material transfer.Following explained the process sequence.The wire end is melted and forming a drop, due to influence of the arc during the arc period. At the beginning of the short circuit the drop is contacting the surface of the work piece. To break up the short circuit and restart the arc, a relatively high short circuit current is necessary. Due to the surface tension and the high current creating the so called ´pinch effect´a drop at the end of the wire will be detached. The arc will be ignited at the current peak (1).Figure 3 schematically depicts both current – and voltage through droplet detachment plotted against time.

Cold Metal Transfer

CMT is controlled by current, voltage *and* wirefeed speed. The current in the plasma phase is considerably reduced compared to conventional short arc. This period is basically used to maintain a stable arc, because the drop at the end of the wire has been created already in the earlier boost period (see figure 3). Hence the current can be reduced to a minimum value to prevent uncontrolled drop detachments and droplets before the wire will contact the work piece. The conventional short arc creates droplets during the whole arc period. At the medium power range (transition of short arc to globular transfer) uncontrolled drops can be detached due to the high current. This leads to undesirable creation of spatter. With the CMT Process an unexpected droplet detachment in the plasma phase is hardly possible.

Material Transfer:At the end of the burning period the welding wire contacts the work piece. The wirefeed direction will be reversed and the wire is pulled back. Simultaneously the current is reduced and kept accordingly low until the wire is drawn out of the weldpool. With the reignition of the arc the transition into the boost period starts and the wire is moved forward to the weld pool. At the same time a new drop for the next material transfer is created under influence of the boost current

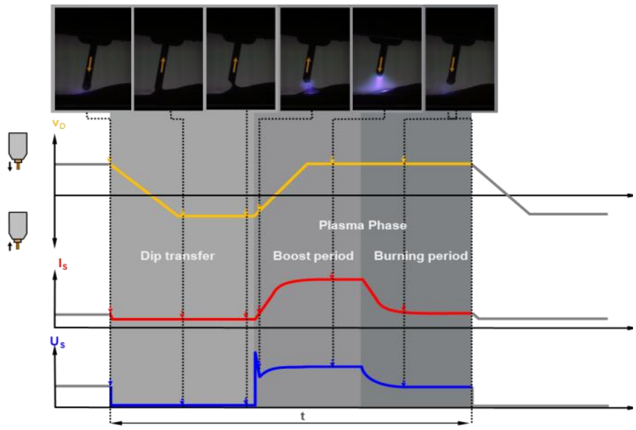


Figure 2 : *The conventional short arc sequence*

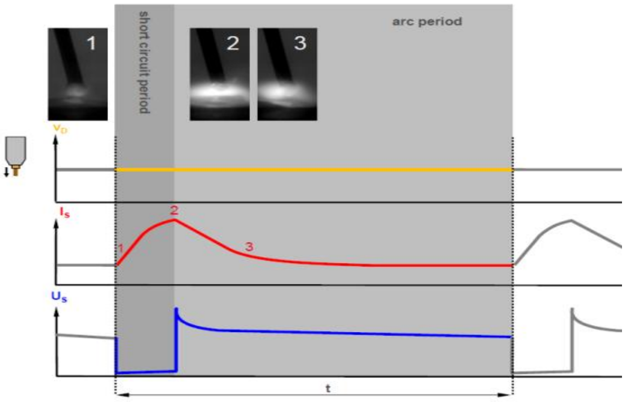
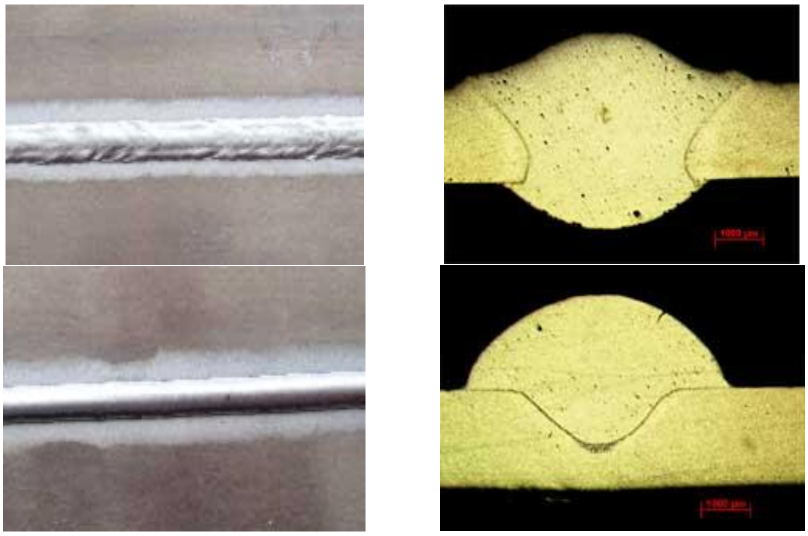


Figure 3: *The CMT arc sequence*

Heat Input comparison

Figure 4 shows the welding result comparison of CMT and the conventional short arc mode. Carried out as a bead on plate weld uponaluminum (AA 60 83). Aluminum is not a common in boiler applications, but to explain the big difference in heat input it is a convincing example and helps to understand the CMT process better.



Short Arc
Wire feed speed 5,0 m/min
Welding current 96 A
Welding voltage 17,0 V

CMT
Wirefeedspeed 5,0 m/min
Welding current 84 A
Weldingvoltage 13,5 V

Figure 4:*Heat input comparison of CMT and conventional short arc*

This trial was carried out with a constant amount of filler metal. CMT shows at the same wirefeed value a much lower nominal electrical power input (CMT 1134 W, short arc 1632W these values are not equal with the final welding result, but the give a general indication). Thus CMT enables small seams with very low heat input. Cladding with CMT takes its advantage out of this circumstance.

4. WELD OVERLAY OF MEMBRANE WALLS WITH CMT

The major goal in overlay cladding is to keep the dilution of the base material as low as possible, thus to achieve adequate resistance to corrosion. As indicator for the dilution the Fe content in the overlay was measured (2).The result of the following experimental setup should show the difference in Fe content and Fe concentration across the weld bead height between CMT and GMAW-P, measurements are taken in the first but also in the second layer.Both trials were carried outmaintaining similar experimental conditions (basematerial, shieldinggas, fillermaterial), welded with an automatic overlay system including an oscillation unit in vertical down position(see figure 5). Watercooling for the membrane walls was applied and it is mandatory.

Experimental Setup:

The weld test were carried out on a fin tube panel,size: 400 X 800 mm,
innerdiameter of the boilertube 50 mm,
outer diameter of the boiler tube 60mm
Cooling water temperature for the boiler tubes 25 -27 °
CBase material: P 265 GHShielding gas: 30 % Helium, 2 % H2, 550 ppm CO2/Rest Argon
Filler material: Alloy 625 diameter 1,2 mm
Welding position: Vertical down PG (3G downhill)

Welding parameters CMT:
Wire feed speed 9,4 m/min
Welding current 238 A
Welding voltage 16,4 V
Welding speed 60 cm/min
Oscillation width 10 mm
Oscillation frequency 4 Hz

Welding parameters GMAW-P:
Wire feed speed 6,5 m/min
Welding current 164 A
Welding voltage 18,0 V
Welding speed 42 cm/min
Oscillation width 10 mm
Oscillation frequency 3 Hz

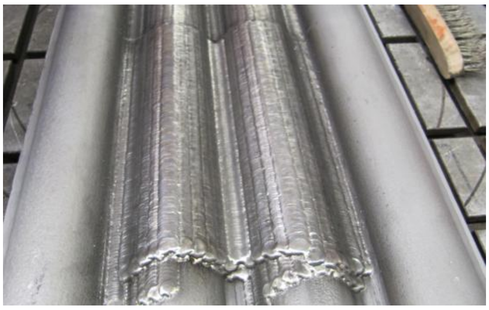


Figure 6: *Fintube panel with 2 layers of weld overlaywelded with CMT*

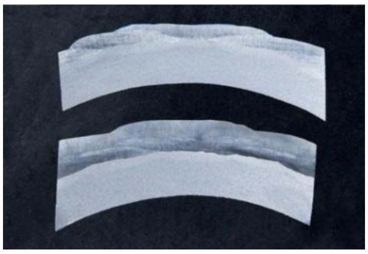


Figure7:*Transversal macro section single and double weld overlay welded with CMT 1 layer 3,14 %, 2 layer 0,47 Fe content*

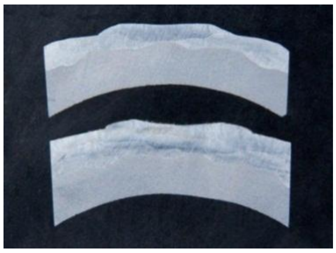


Figure 8:*Transversal macro section single and double weld overlay welded with GMAWP 1 layer 5,56 %, 2 layer 0,47 % Fe content*

Figure 9 shows a line chart representing an EDX line scan through two layers of overlay for both methods, GMAW- P and CMT. The red line stands for CMT, the blue one for GMAW-P.In generalCMT achieves asignificant lower Fe content than the conventional GMAW-Pprocess. Another interesting aspect on the CMT process is the constancy of the Fe content through the overlay. Underneath the surface the Fe content keeps below 5% to an overlay thickness of 2,5mm. With the conventional GMAW- P process, the Fe content starts to increase remarkably already at a layer thickness of 1,5 mm. The low fusion depths of CMT explains this phenomena.See also Table 1 for detailed values(3).

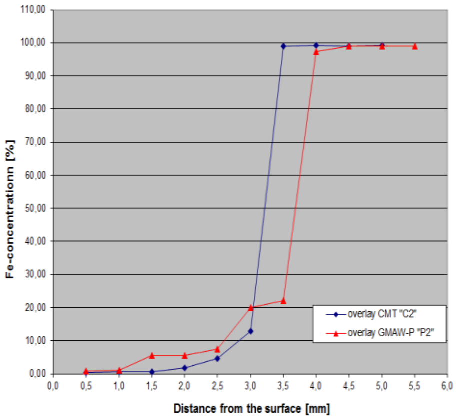


Figure9: *Iron concentration profile comparison of two layersof overlay welded with CMT (C2) and GMAW-P (P2)*

Table 1: *Iron concentration profile comparison of two layers of overlay welded with CMT (C2) and GMAW-P (P2)*

Distance from the surface [mm]	Fe-concentration "weld overlay"	
	"C2"	"P2"
0,5	0,47	0,87
1,0	0,56	0,95
1,5	0,70	5,66
2,0	1,82	5,59
2,5	4,67	7,57
3,0	12,92	19,95
3,5	99,02	22,20
4,0	99,19	97,26
4,5	98,97	99,05
5,0	99,12	99,11
5,5		99,01

5. STEAM TUBE WELDING USING THE CMT PROCESS

The Task for this welding set up was to investigate, if the mechanized GMAW with CMT is reliable and safe enough compared to manual GTAW. Joining steam pipes under onsite conditions a mismatch and a gap inconsistency occur. With manual GTWA these difficulties can be overcome by modulating the weld pool due to the welders skill. For mechanized GMAW weprocesses it is almost impossible to reach a fully penetrated root and avoid lack of fusion on the sidewalls under these conditions. In practice the gap varies on the circumference from 0 – 3 mm. The Assumption for the experimental setup was to grind it to the maximum gap distance, that occurs. In this particular case it was 2 mm.

Experimental Setup:

The weld test were carried on a tube size:
Diameter 457 X 36 mm,
Base material: P 280 GH/16 MND5
Shielding gas: M 21 82 % Argon, 18 % CO2
Filler Wire diameter : 1,2 mm
Welding position: PG (5Gd)
Gap: 2 mm
High low: +/- 1 mm

Welding parameters
Wire feed speed 7,2 m/min
Welding current 173 A
Welding voltage 13,0 V
Welding speed 40 cm/min

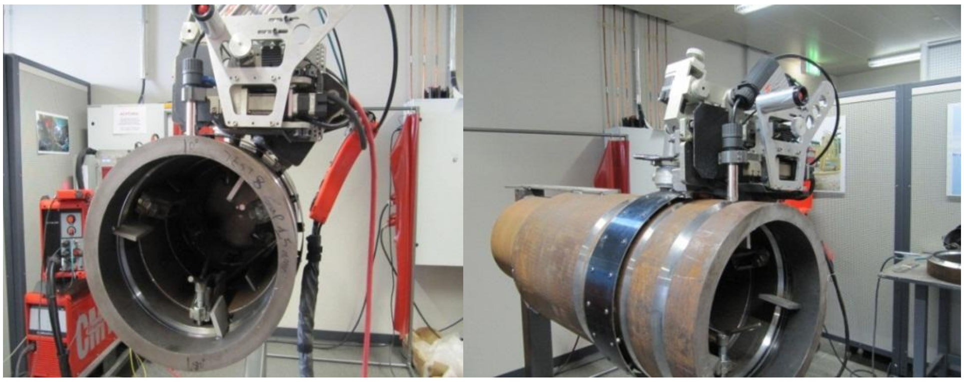


Figure 10: *Welding Setup with CRC P 450*

Figure 11 show the welding position and the root formation. It was possible to weld from 12 to 6 o´clock position with one welding parameter. Figure 12 displays a transversal macro section of the joint in 5 Fu Position. It does not show any defect. In general has to be said the CMT Process provides a large process window. Setting up the welding parameter , it allows to bridge a gap up to 2 mm and its penetration is enough to prevent lack of fusion in the root and hot pass.

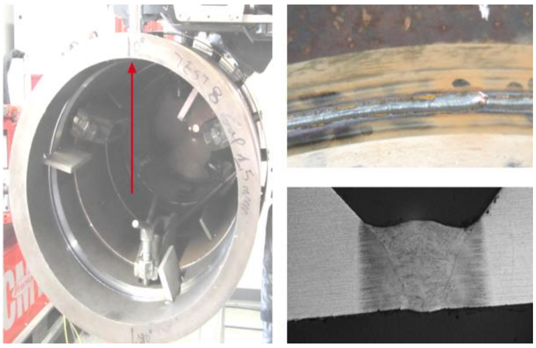


Figure 11. *Welding positon 12 o´clock (5Gd)*

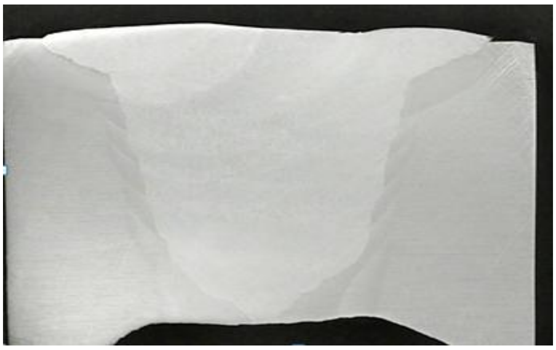


Figure 12. *Transversal macro section*

6. WELDING WITH CMT TWIN IN THE PC POSITION ON THE CENTER TUBE FOR OFFSHORE TRIPODS

Tripods are a common foundation structures for windturbines in offshore windparks. Figure 13 shows the tripod structure and the yellow painted centertube, it is welded to the main structure. The red arrow (see figure 13) marks the welding seam which will be investigated and described in this passage. In general SAW is anestablished weldprocess for this weldingapplication. Due to the size of the tripod the centertubeweld has to be weldedin welding position PC.To keep the flux in position and provide sufficient shielding cover for the liquid weld pool a lot of technical efforts have to be taken , with GMAW this difficultydoes not occur.

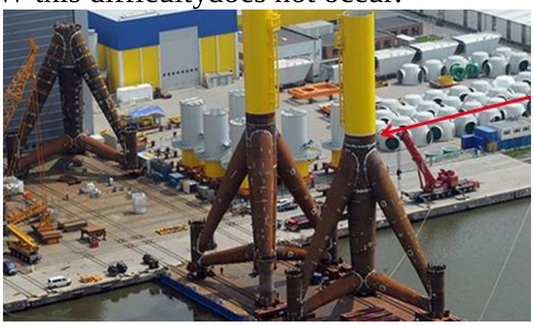


Figure 13. *Tripod*

CMT Twin a tandem GMA welding process was reviewed for this setup. Like any other tandem process it works on twowelding electrode potentials which can be controlled separate from each other. Both arcs work under the same shielding gas atmosphere. The significant difference to similar tandem welding systems is the usage of CMT on one electrode or on both. Figure 15 shows a CMT Twin configuration.

Experimental Setup

The weld test was carried out on a plate
Dimension: 500 x 350 mm
Base material: S 355
Shielding gas: M 21 82 % Argon, 18 % CO2
Filler Wire: EN ISO 17632-A
Filler Wire diameter : 1,2 mm
Welding position: PC
Preheating temperature: 150 ° C

Welding mode	Leading wire GMAW	Trailing CMT
Welding voltage	10 m/min	5,5 m/min
Welding current	310 A	185A
Welding voltage	25,6 V	25,6 V
Welding speed	70 cm/min	70 cm/min

Figure 14. *Welding Setup CMT Twin*

Figure 15. *CMT Twin Setup*

Figure 14 shows the welding Setup. During the whole weld test the workpiece temperature was kept to 150 °C. In total 52 layers were putted down. The build upof the layer sequence is displayed in figure 17. The achieveddepositionrate was 8 kg/h which is in the range of SAW (Submerged arc welding). Like displayed in figure18 the hardness could be kept under 300 HV. Ultra sonic inspection anda transversal macro section (see figure 17) showed no defects.

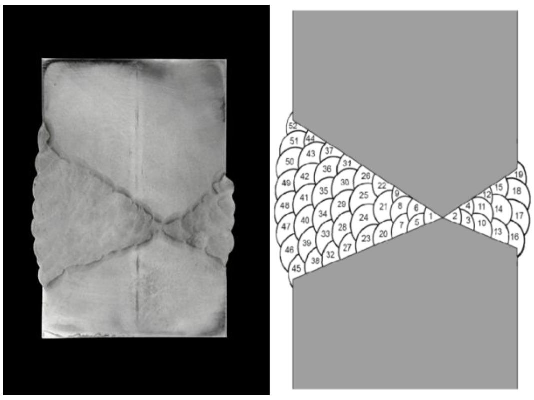


Figure 17. *Transversal macro section and buildup sequence of the welding seam*

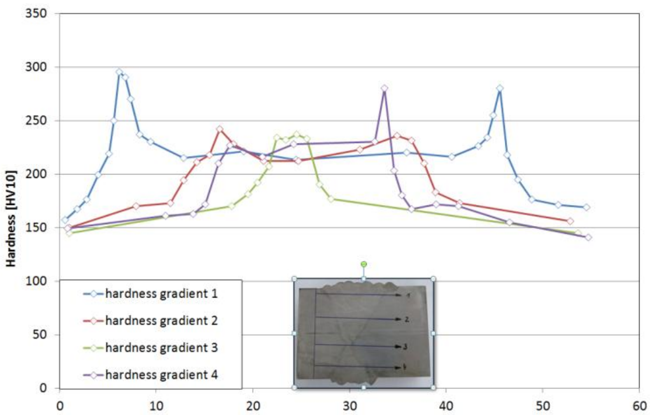


Figure 18. *Hardness gradient*

7. CONCLUSION

The CMT process has successful proven that it is more than a welding process for thin sheet metal. CMT is nowadays a multipurpose GMAW processwhich is used, even in the complex welding field of power generation. Waste to energy plants extend the lifetime of the coating on membrane walls with the low dilutionCMT provides. Reducing the welding time joining steam tubes onsite with tolerances in gap and mismatch , helps the user to secure stable results and effectiveness. CMT twin opened the door to high deposition welding and productivity. Besides its technical benefits,it is an operator friendly GMAW process.

8. REFERENCES

[1] J.Artelsmair, J. Bruckner, J. Kazmaier, Der CMT Prozess in der Fügetechnik
[2] S.Egerland, R. Heimholdt, Overlaying (Cladding)of high temperature affected components by using the CMT Process.
[3] B. Rutzinger Trends in power generation, cladding with CMT in carbon fossil power plants