10th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

COST EFFECTIVE AUTOMATION OF PIPE TO PIPE CHAMBER WELDING PROCESS IN STEAMBOILERS PRODUCTION

Dr.sc. Marko Dunđer
HOLDINA d.o.o. Sarajevo
BiH

Prof.dr.sc. Ivan Samardžić
Mr.sc. Štefanija Klarić
Mechanical Engineering Faculty Slavonski Brod
Trg I.B. Mazuranić 2, Slavonski Brod
Croatia

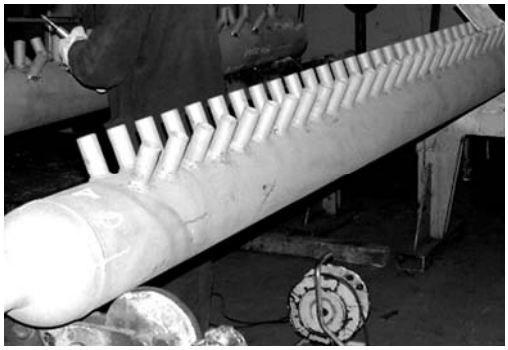
ABSTRACT
The paper explains the automation of welding process in steam boiler production – pipe to pipe chamber automatic orbital GTAW welding + automatic SAW process. New approach to welding in production has significant benefits in relation to previous processes. Authors explain the welding procedure and equipment involved and successfully implemented in production process. Beside that, authors preset an experimental specimen obtained during welding process verification.
Keywords: steam boiler plants, automatic welding, orbital GTAW process, automatic SAW process

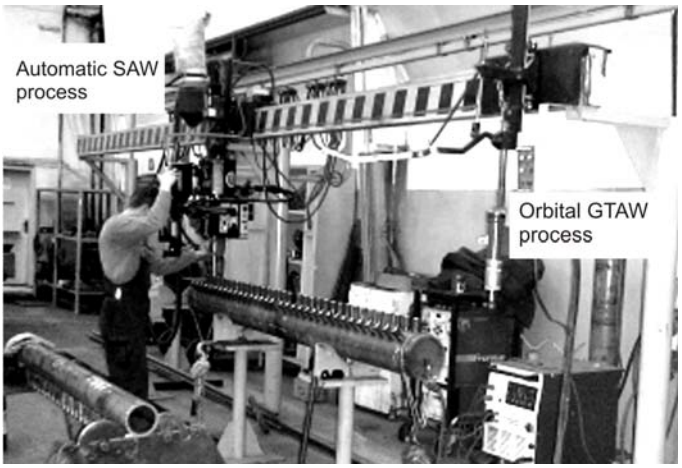
1. INTRODUCTION
Due to fact that the main mission of steam boiler plants is transformation of fuel energy to heat energy of working fluid, and that in exploitation, these plants work in high temperature and pressure conditions, the quality and reliability demands for welded joints on pressure exposed parts are very high.

The typical representative of welded joints on steam boiler plants is pipe connectors to pipe chamber welded joint (figure 1 a). That is fillet weld of two cylindrical parts with specially defined groove shape. Initially, these joints were made by GTAW process (Gas Tungsten Arc Welding) - welding of root pass) and SMAW (Shielded Metal Arc Welding) process – welding of the fill and cap passes.

In order to increase productivity and quality of welded joints and to decrease welding costs during production of steam boiler plants, the automation of welding process of joining pipe connectors to pipe chamber is implemented in company AEE ĐĐ Termoenergetska postrojenja d.o.o., Slavonski Brod, Croatia. Automated welding processes for joining pipe connectors to pipe chamber are orbital GTAW process and automatic SAW (Submerged Arc Welding) process. The both processes are connected in one welding production line shown in figure 1 b.

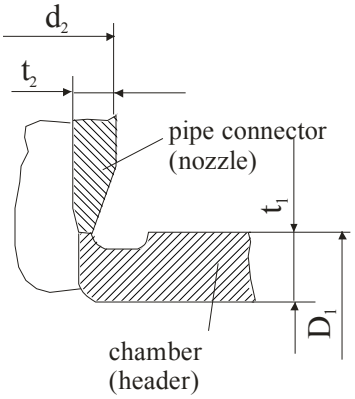
The groove shape preparation for automatic welding of pipe connectors to pipe chamber is shown on figure 2 a. To accomplish appropriate quality of welding groove preparation, before welding, the pipe connectors are machined on CNC turning machine, and pipe chambers are processed on special devices for bore machining (figure 2b).





a) b)

Figure 1. a) steam boiler chamber with pipe connectors (nozzles), b) line for automatic welding of pipe connectors to boil chamber [1]



D_1 – diameter of chamber (header)
t_1 – thickness of chamber
d_2 – diameter of pipe connector (nozzle)
t_2 – thickness of pipe connector (nozzle)

a) b)

Figure 2. a) Weld groove preparation for automatic welding of pipe connectors on pipe steam boiler chamber [2], *b) groove preparation on steam boiler chamber*

2. PROCEDURE AND QUALIFICATION OF AUTOMATIC WELDING OF STEAM BOILER CONNECTORS ON PIPE STEAM BOILER CHAMBERS

As an example of successfully applied welding technology of automatic welding of steam boiler connectors on pipe steam boiler chambers the welding of pipe connector (d_2 = 38 mm, t_2 = 4 mm) to boiler chamber (d_1 = 168,3 mm, t_1 = 16 mm) is described. Both, the pipe connector and boiler chamber are made of low alloyed steel (old designation 15Mo3, DIN 17175), group 1.2 (CR ISO 15608), usually used in production of steam boiler components. The bead sequence for this example is shown on figure 3.

The operation sequence during mechanized welding is following [2]:

1. Manual positioning of pipe connectors on boiler chamber,
2. GTAW appending and welding of root pass (from inside),
3. SAW process of fill and cup pass from outside.

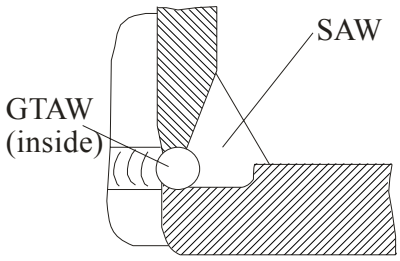
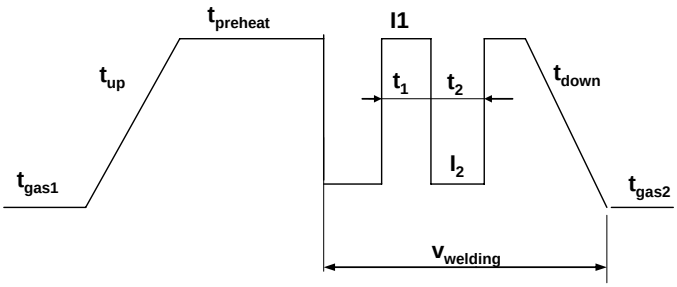


Figure 3. Bead sequence

2.1. GTAW of root pass

The orbital GTAW process of root weld pass is conducted from inside of pipe connectors in horizontal (PC) position without filler metal. The appropriate welding gun is placed inside the pipe connector (figure 4) and performs welding by rotating around it's axis. This orbital welding of pipe connector root pass is performed by impulse welding with parameters shown on figure 5.

Figure 4 Orbital GTAW of root pass



Welding parameters of orbital GTAW (root weld)	
t_{gas1}=2,6 s	I_1=140 A
t_{up} =16 %	I_2=80 A
$t_{preheat}$= 2 s	$v_{welding}$= 6 cm/min.
t_1=520 ms	
t_2=520 ms	
t_{down}=60%	
t_{gas2}=4 s	
Q= 5 l / min. – shielding gas argon flow	

Figure 5 Welding parameters for impulse GTAW of root pass [2]

During and after the welding the welding operator visually controls the inner side of the root pass with mirrors or endoscope.

2.2. SAW of fill and cup pass from outside the pipe connector

Automatic SAW is performed in horizontal PB position (fillet weld). Filler metal used for SAW of pipe connectors on boiler chamber is welding wire EN 12070 - G MoSi (DMo-IG, Böhler) with welding flux DIN-EN 760 - SA CS1 77AC (OP119, Oerlikon) [2]. To reduce the welding deformations, SAW process is performed from the middle of the chamber towards chamber endings. First, one pass is performed on all the pipe connectors on the chamber, and then follows the next pass. The welding process and parameters for SAW of pipe connectors are shown on figure 6 and table 1.

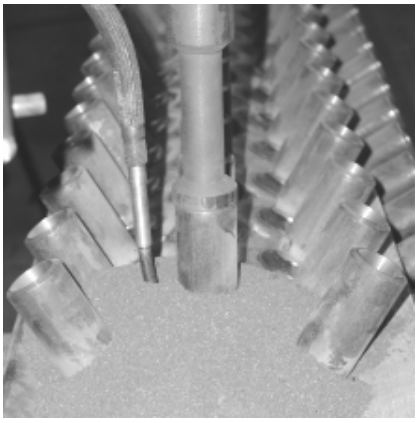


Figure 6 Automatic SAW of fill pass

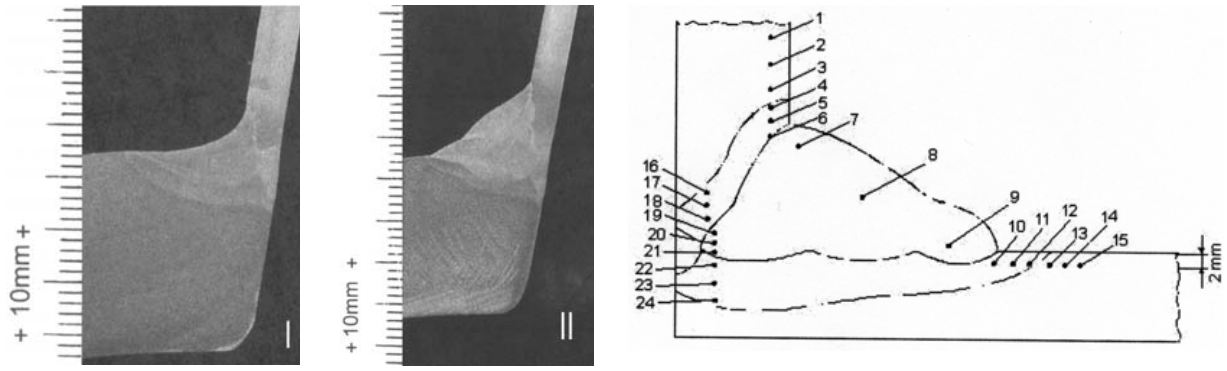
Table 1 Welding parameters for SAW [2]

Welding parameters for SAW welding of fill pass
I =160-190 A
U = 26-28 V
v = 25-30 (15-25 cm/min.)

After welding, follows visual control of welded joints.

2.3. Testing procedure of weld joint

Figure 7 a and b shows macro sections of two welded joint for described welding procedure. SAW process was performed with satisfaction quality of welded joint. The results of the hardness test (HV10) are shown on figure 7 c.



a) *b)* *c)*

Measuring line		Base Material			HAZ			Weld Metal			HAZ			Base Material		
I	1-15	152	150	152	165	184	192	247	248	248	190	174	162	150	149	147
	16-24				160	179	190	228	230	230	188	184	163			
II	1-15	153	152	150	167	180	192	244	246	246	188	176	166	153	149	148
	16-24				162	182	189	232	232	230	190	188	170			

Figure 7. a) Macro sections of welded joint after two SAW passes, b macro section of complete welded joint, c) hardness HV10 of welded joint [3]

3 CONCLUSION

Reduction of welding time and costs is one of the main goals of welding engineers in practice. Good example is replacement of the combination of manual GTAW and SMAW processes with orbital GTAW and automatic SAW process for joining pipe connectors to pipe chamber in steam boilers production. Some of the achieved effects were: significant reduction of welding time, especially with orbital GTAW process (4 times shorter welding time) and better quality of welded joints (i.e. smaller deformations of chamber and connectors). Although described process automation requires more precise joint preparation, it is without question cost effective solution for this type of welded joints.

4. REFERENCES

[1] Despotović B., Samardžić I., Klarić Š., Marsenić T.: Cost effective approach to automation of welding process at pipe connections welding on pipe steam boiler chambers, Savjetovanje sa međunarodnim učešćem "Zavarivanje 2006" Zavarivanje u reparaturi, DUZS, Beograd, Srbija i Crna Gora, 2006.

[2] Marsenić T., Despotović B., Brechelmacher B., Birač B.: Primjena mehaniziranih postupaka TIG-EPP za zavarivanje priključaka na komore, 3rd International scientific-professional conference 50 years of welding tradition for the future, Slavonski Brod, 2005.

[3] Report on testing procedure of weld joint, Faculty of Mechanical Engineering – Slavonski Brod, Croatia, 2004.