NO ROOT GAP HORIZONTAL BUTT-WELDING WITH MAG PROCESS

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ABSTRACT

It has been used many kinds of horizontal butt-welding methods at block-to-block erection stage in shipbuilding companies. For examples, some companies use conventional FCAW process with one side or both sides groove joint welding, others use carriage with torch holder type mechanized welding method. Although lots of efforts were done until now, some problems in quality and productivity still remain in ship's hull welding.

In this study, we have attempted to raise productivity and quality on horizontal position of welding with following 3 items.

1) Prepare groove condition with no root gap for making easy fit-up work.
2) Develop improved MAG (100% CO_2 gas shielding) welding process with solid wire for making sound root bead from one side.
3) Develop and apply quite new automatic welding carriage.

The stability of new welding process was confirmed by conducting mechanical tests of weldments to verify the soundness of weldments.

KEYWORDS

Horizontal welding, GMAW, No root gap, Solid wire, Automation

1. Introduction

One of the most difficult welding in the shipbuilding is the horizontal butt joint welding of hull side at the erection stage in a dry dock[1]. Because of the welding direction that is parallel to the longitudinal line of ship and the gravity operates downward, the molten welding pool is hanging down in the groove cross to the horizontal seam of the hull. Thus, it is hard to control the molten pool and make surface bead of welding part that contains various kinds of defects at the inside of the weldments after welding[2-3]. Probably, it can be reduced to a certain extent not by weaving but straight going method of the torch, but these skills are limited to the amount of welding pool and also the part of horizontal welding is usually used with multi-pass welding[4].

Fig. 1 Photograph of horizontal welding seam of the ship

2. Status of fabrication

2-1. Specification of the object.

This new methods can be used at the part of the following diagram. That is, side shell, longitudinal bulkhead, trans and center line bulkhead at the stage of erection and pre-erection. Not only mild steel but also hi-tensile steel can be used and the specification of this plate is classified in ASTM A131 that contains 0.09~0.30% carbon as one of the primary chemical composition.[5]

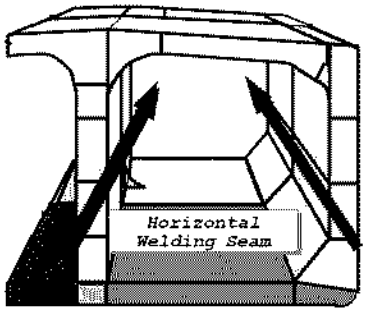

Fig. 2 Schematic diagram of the horizontal seam in the block

Table. 1 Specification of the plate

	Standard condition
Plate Specification	ASTM A131
Class Grade of Plate	A, B, D, AH32, DH32, AH36, DH36
Mechanical Properties	235 < Y.P < 355N/mm^2
Chemical Composition (wt%)	0.18C - 1.6Mn - 0.5Si - 0.03P,S
Thickness Range	8 ~ 32 mm

2-2. Previous welding process

One of the methods to the horizontal seam welding is shown as below sketch. At first, welding inside of the hull with FCAW (flux cored arc welding) process about 7~10 passes and then grinding the backside of the groove after gouging out the defects that are contained at the part at the root side of the groove. Finally, it should be welded with FCAW about 3~6 passes to finish the full penetration of the bead. It has demerit to take too much time and endeavor. Most of all, it is highly like to danger, because the weldment have many kinds of defects between each passes, for example, lack of fusion, slag inclusion, etc.[6]

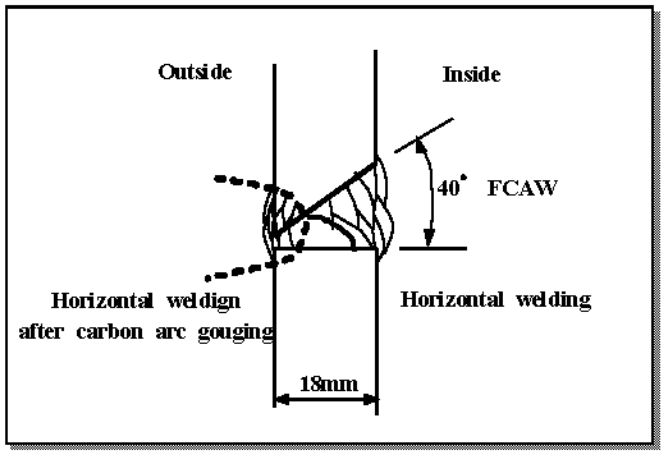

Fig. 3 Schematic diagram of previous used horizontal welding process

3. New welding process

To solve the problems and difficulties of the above process, we have prepared as follows. At first, change the direction of angle in the groove from inside to outside for the convenience of attaching and operating the automatic welding carriage. On this outside groove of plate, automatic machine will be progressed with feeder gun that is equipped with solid wire in GMAW system. This welding process has advantages in no slag inclusions on the first bead that can make a trouble at the ends of horizontal welding bead. And also, this process is useful for making a satisfactory backside bead, because it is possible that the GMAW process using a solid wire can form a deep penetration on the steel plate within the range of 0mm to 3mm root gap. Secondly, the FCAW process will be followed to fill the remains of groove. At this stage, the ceramic material on the groove surface has a key role to form a good surface bead appearance and to reduce weld passes by blocking the weld

pool's flow into the downward of the groove. Actually from the experience, it is enough to finish only 4 passages of the horizontal welding in 16mm thickness plate.

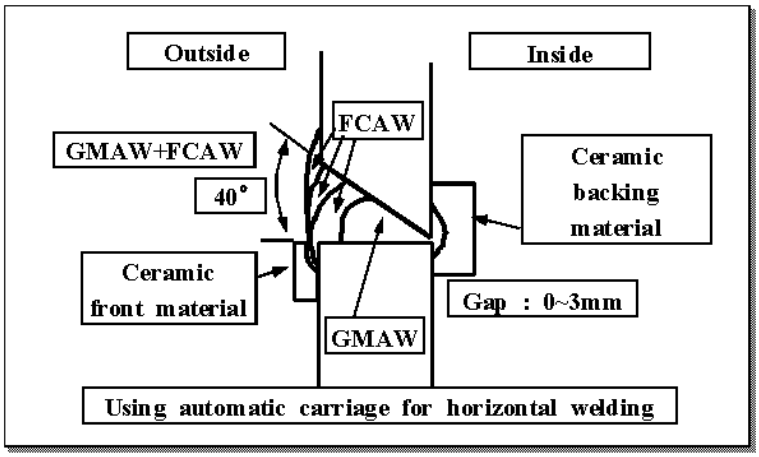

Fig. 4 Schematic diagram of new developed horizontal welding process

4. System & Application

To enhance the advantages of new GMAW process, no root gap of plate fitting system has been adopted. It means that the stage of the setting system for shipbuilding is much easier to prepare for the joining of blocks. If the welder has to maintain a uniform root gap between blocks, it needs much time to fit them and the quantity of welding pool is much more than no root gap condition. Thus, we select no root gap condition for the regular root gap condition in automatic welding. It means that, for the automatic carriage welding, constant groove opening should be taken when the automatic welding feeder weave along the seam of welding.

Fig. 5 Test of no root gap horizontal welding process

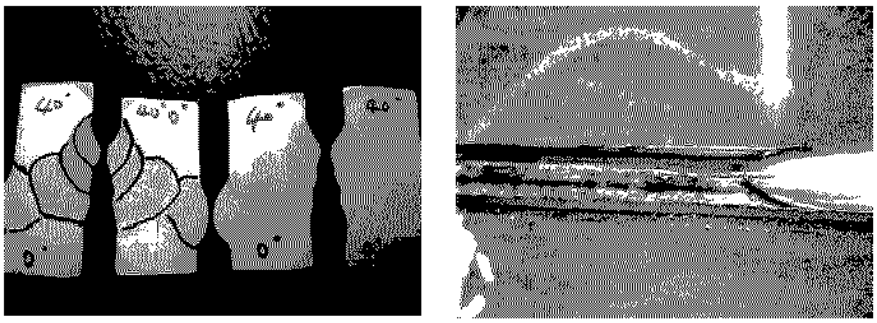

Fig. 6 Test specimen & backside bead of the new horizontal welding process

From the above macro specimens, totally 4 passes welding can sufficiently fill the 40-angle groove until 16mm thickness of plate. And also, new GMAW process can make a good quality of shape in the backside bead and front side without defects of surface like the undercut or blowhole.

5. Quality & Deformation

To confirm the quality of the weld metal & heat affected zone from a heat input of new process, it needs to verify the mechanical properties of material. For example, NDT(non-destructive test), Tensile test, Bend test, Charpy V norch impact test, Hardness and marco test. We took all above tests to satisfy the class rule of shipping and the results are like below.

Table. 2 Test results of new developed process

TEST	RESULT	RULE
NDT	ULTRASONIC & RADIOGRAPHY TEST 100% NO DEFECT	NO DEFECT
TENSILE	529 ~ 531 N/mm2	Min.490 N/mm2
BENDING	FACE / ROOT DIRECTION NO DEFECT	NO DEFECT
IMPACT	WELD METAL : min 89J	Min 34J (0 ℃)
	FUSION LINE : min 156J	
	FUSION LINE + 1mm : min 281J	
HARDNESS	WELD METAL : max 244Hv	Max 260Hv
	HAZ : max 205Hv	Max 340Hv
MACRO	NO DEFECT	NO DEFECT
※PLATE GRADE : DH36 (Yield strength : above 355N/mm^2, Hi-tensile steel usually used for (0 ℃) design temperature)		

The new process has a merit in the point of deformation after welding. Due to decrease of passes and the amount of heat input, the GMAW process with no root gap is expected to reduce the angular distortion. To expect the amount of distortion, we have analyzed the amount of deformation by using commercial tool 'SYSWELD 2002'. From this, we can get distortion results in Fig.7.

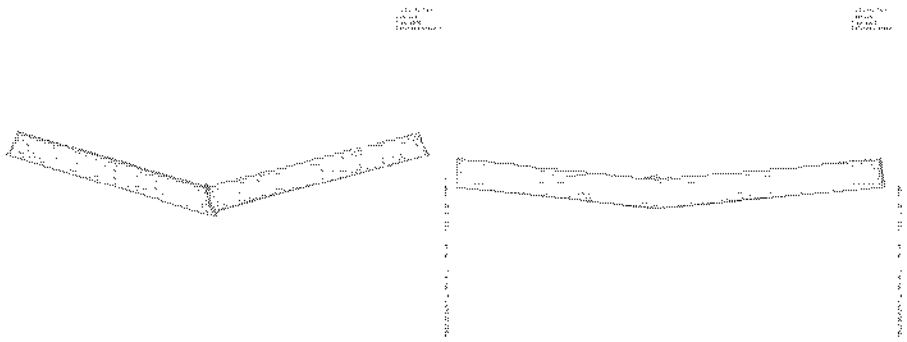

Fig. 7 Geometric representation of residual angular distortion
(Left: 5mm root gap FCAW, Right: No-root gap GMAW + FCAW)

6. Conclusion

By using GMAW process with no root gap, it is possible to obtain as a useful process in horizontal seam welding. This method has advantages in reducing the working time, decreasing angular distortion, improvement of quality against defects of weldment and easier fitting condition for automatic welding, etc. Therefore, it can be assured that more productive and superior quality of the weldment can be taken from this study results.

References

[1] Nisiura, et all: "The defect of automatic welding of horizontal seam part in Mistubisi Heavy Industries Co.,LTD." , KOBE steel annual report, April, 1999, No. 011999-F001.

[2] "Horizontal automatic welding method in IHI", IHI-KURE monthly report, March, 2001.

[3] Gobayasi, et all: "Development of High-Deposition Rate Horizontal Welding Process with Electro magnetically Controlled Molten Pool", Mistubishi Heavy Industries Co., Ltd Monthly Report, Vol.37, No.3,

2000-5, p.126-129.
[4] Yukio Manabe et all: "Development of Horizontal Electro gas Arc Welding Process with magnetic Control", Journal of Japan welding society, 1998-10, p.426-427.
[5] "High Efficiency Horizontal Mag Welding Process And Equipment", KOBE Steel Ltd., Monthly report, November, 1995, No.0895-141.
[6] "Automatic Horizontal Welding Process", Nippon Steel Welding Products & Engineering Co., Ltd. report, May, 9, No. H6-018.