DEVELOPMENT OF ONE-SIDE WELDING IN SHIPBUILDING

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SYNOPSIS

One-side welding in shipbuilding is adopted not only for improvement of working efficiency and environment but also for systematic operation in the whole production line of a process. Application of this method covers plate jointing of panels at fabrication stage, curved shell plate jointing at assembly stage and, furthermore, fixing skin plate and stiffeners for block joint weld at erection stage. One-side welding is done by use of the special automatic welder including the backing equipment and the specific jig. Welding at erection stage, however, presents a problem of how to transfer this equipment. The Ishikawajima-Harima Heavy Industries Company, hereinafter referred to simply as IHI, succeeded in developing a "work unit", thereby making it possible to instal a special automatic welder with an oil hydraulic jig for fitting, and automatic welding method, including one-side welding, for block joint has become possible. This report summarizes practical use of the one-side welding method developed by the IHI.

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1. DEVELOPMENT OF ONE-SIDE WELDING IN SHIPBUILDING

It is a long cherished desire among people concerned to have a weld completed from one side. As a first attempt to achieve this desire, a method of TIG welding using insert rings was applied to the joining of pipe whose interior could not be welded. Following this, one-sided manual welding by the use of the low hydrogen type of covered electrode was attempted as a trial. This failed to be of normal use because the extent of the weldable condition is limited and a special skill was required for the jointing bead. With development of backing materials, this method was superseded by automatic welding.

The one-side submerged arc welding process was developed for flat panel joints and rapidly came into practical use. Initially, the study and application of automatic production systems came into the reach of fabrication shops. For flat panels one-side welding is done by the use of large size equipment including the backing unit. For inclined weld joints of curved shell plate, one-side automatic welding is carried out with a portable backing material. This method also applies, at erection stage, to block joints by use of the same portable backing materials. One-side automatic welding also applies to block jointing of stiffeners for example in the side longitudinal joints of a tanker.

2. THE METHOD AND APPLICATION OF ONE-SIDE WELDING

2.1 One-side weld for flat panel jointing is divided largely into three kinds depending upon the kind of backing material to be used for the weld; namely, Flux backing, Flux-copper backing and the other. At five (5) shipyards of the IHI, both the Flux backing and Flux-copper backing are being used. The RF method, which belongs to the category of flux backing, makes use of two kinds of backing flux in segregate layers as shown in Figure 1, the upper part of which becomes solid from arc heat. Welding is done by submerged arc welding of the two-electrode or three-electrode type. An example of the welding conditions and mechanical properties of the joint are shown in Tables 1 and 2.

This method of welding has the following advantages:-

1) It has large adaptability to distortion, misalignment and differences in plate thickness.

2) The shape of the back bead becomes uniform since flux is melted and then re-solidified due to arc heat.

3) It has a wide range of allowance for any change in the shape of of the groove and the welding conditions.

The flux-copper backing method employs flux scattered over a copper plate to be used as backing material as shown in Figure 2. This method of welding is characterised by the following advantages:-

1) The height of the reinforcement of the back bead can remain unchanged, even though welding conditions may change, because of the copper plate existing under the backing flux.

2) Relatively large electric current is available for welding with a resultant improved efficiency because of flux and copper being used for backing.

Either one of the two methods above makes it possible to adjust the welding position freely because the backing equipment is connected to the joint to be welded. Normally, welding is done by travelling the welding carriage on the steel plate. Often, the automatic flux supply and return unit is interlocked with the welding carriage. Steel plate is delivered by conveyor to the welding machine and fixed firmly at the time of welding. After welding is finished, it is carried to the next position to check the back-bead and for non-destructive inspection. Owing to these methods, four panels containing four welding joints of 18 meter lengths are welded in a day and welding efficiency is increased by a factor of three compared to welding on both sides.

2.2 One-side weld for curved shell plate at assembly stage.

Plate joints in curved shell plate is made by the method of one-side submerged arc welding making use of a portable backing material named FAB. With this method, a maximum limit of 7 degrees in vertical inclination of the joint and also 7 degrees horizontal inclination applies. Beyond these limits in degree of inclination multi-pass welding or semi-automatic CO_2 welding is used. Since FAB backing material is of a flexible nature, it can be fitted tightly to any curve by use of magnetic clamps.

2.3 One-side welding at erection stage.

Application of one-side welding to block joints began with the aim of improving work efficiency and quality by eliminating the undesirable work environment of overhead manual welding. For example, one-side submerged arc welding is done by use of the FAB method for certain work portions of the tanker such as the block seam joint between upper deck and bottom shell. The FAB backing material is fixed in position by either magnetic clamping or other available jigging. Similiarly, a specific backing material named KATAFLUX is also used for inner bottom joints in double bottoms.

Automatic welding is very hard to apply to each stiffener joint because the length to be welded is quite short and consequently there is little work to be done. However, in many situations, such joints are to be welded in confined spaces thus leading to a demand for the application of the one-side welding method. To meet this demand IHI has succeeded in developing welding equipment combining both an hydraulic (oil) jig and welder into one unit. One-side welding of such joints can now be done with the help of the 'work unit' to move and set up this equipment. Some examples of the application of this method are: side longitudinals of the side shell and longitudinal bulkhead. That is, the PP-ARC method to the face plate and the CBS method to the web plate with the welding order being face plate followed by the web.

The PP-ARC method has been newly developed to improve the workability of the CES welding method and is applied to vertical butt joint welding of small weld lengths. In a similar fashion to the CES method, welding is done with a wire through the inside of the groove together with a consumable nozzle and filled with a special flux. The special flux generates both a shielding gas and slag. That is to say, this welding process has intermediate characteristics between the electroslag and electro-gas welding processes. In one complete unit this welder combines the oil hydraulic unit for longitudinal and the CBS backing equipment.

The advantages of this welding method are as follows:-

1) No carriage is required to raise the welding position. The wire feeder can be designed for compact size and lighter weight than the CES method because the wire used is of smaller diameter.

2) Additional supply of flux during welding is never required.

3) Water cooling is not required for copper plate.

Welding conditions and mechanical properties of PP-ARC welds are shown in Tables 3 and 4 respectively.

The CBS method is of submerged arc welding by the fire cracker welding process. Insulating tape is set in the groove, a triangulated electrode set in a horizontal position and a conductor bar put at the end of the electrode to be connected to the secondary side of the welding transformer. Flux is scattered all over the surface and welding done by generating an arc between the base metal and the electrode. This welding method can be used for one-side welding by use of a backing bar composed of copper plate with glass tape fixed to the joint by an oil hydraulic fitting jig. This welding method has the following advantages:-

1) High working efficiency can be obtained for example in 12 mm plate, a speed of 60 cm per minute is possible.

2) The equipment is of a compact size and has been devised for easy handling since a wire supply system is not required.

Examples of welding conditions and mechanical properties applicable to the CBS method are shown in Tables 5 and 6 respectively. With this method, welding efficiency is about 50% higher than that for manual welding.

In addition to all the above mentioned methods, there are several other methods of one-side welding currently being applied. Examples of these other methods are the OEG process for transverse deck joints and the KOB-BL method for bottom longitudinals.

The OEG method is on the CO_2 type one-side weld and uses an on-rail travelling welding carriage, fixed copper plate for the backing side and sliding copper plate for the opposite side. Preparatory work for this method is quite simple. The welder is only required to set a separated rail and carriage to the exact position of the joint with the welding transformer and wire feeder left on the 'work unit". The wire feeder is of the push-pull type so designed that the system itself is fixed and the torch alone is moved to the required positions. An example of the welding conditions for this method is shown in Table 7. This method is suitable for application to one-side welding of thin plates to which the electro-gas welding process is hardly acceptable.

The KOB-BL method has been developed for continuous welding of both the bottom longitudinal web and face by use of the same welding equipment. The welder is loaded on a carriage which travels on the bottom longitudinal and its copper backing plate is included in one unit with an oil hydraulic jig.

As is shown in Figure 3, CES welding is done after insertion of a consumable nozzle into an enclosure formed by the copper plates around the web and face of the longitudinal. When the weld reaches the face plate, the nozzle beginns to move to the left and the electroslag weld (KOB-BL) is done in the enclosure of the face. This operation starts by switching on at the face position and then goes into automatic sequential order. Welding is terminated after treatment of the crater. Such continuous welding by use of the same welding equipment for structural members which are closely adjoining, can both reduce the amount of preparatory work and improve work efficiency to a great extent. This idea also applies to the joint weld of horizontal girders where CES welding is used for the face plate and FAB welding for the web plate with both methods using the same welding equipment.

Together with the methods described above, other automatic welding methods are also used. For instance, electro-gas welding of block joints of side shells and bulkheads and CES welding of deck longitudinals. As a result, calculated on a welding material basis, the rate of automatic welding has now reached thirty per cent of the total welding.

We are fully confident that the efforts being made towards increasing the use of automatic welding systems in shipbuilding will both stabilize the quality of weld joints and improve efficiency without dependence on the workmanship of each individual welder.

3. EFFECT OF ONE-SIDE AUTOMATIC WELDING

Today, one-side welding is being developed for the purposes of improving work efficiency and environment and also, from the viewpoint that it consitutes part of automatic production control engineering in the whole production line of shipbuilding processes. The efficiency of one-side welding is 1.5 to 2.5 times higher than manual welding as shown in Table 8. Also, greater effect is exerted upon related jobs scheduled before and after welding work.

At IHI the problems of automatic welding are challenged on the basis of further development of one-side welding. It is our sincere desire to improve efficiency and quality by further rationalization of all the working associated with welding including handling of welding equipment.

Acknowledgement

Materials for one-side welding referred to in this report are the products of Kobe Steel Ltd., who kindly granted us permission to quote a part of their relevant data.

Reference

A summary on the present status of one-side submerged arc welding in Japan. (IIW Doc. XLL-471-69)

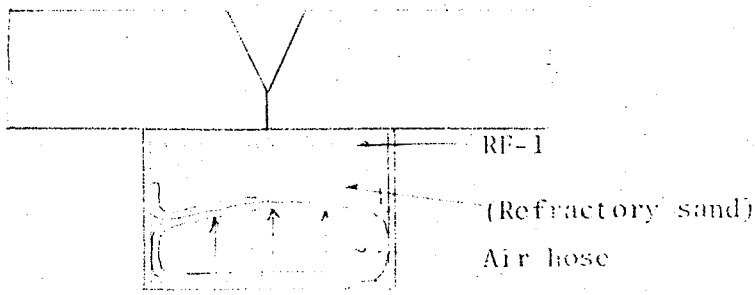


Fig. 1 RF one side submerged arc welding

Table 1. Welding conditions for RF process

Welding material Flux x Wire x Backing flux	Welding condition				
	layer		Current A	Voltage V	Speed cm/min
For 50 kg/mm^2 high strength steel (32mm) PFH - 60A x US43 x RF - 1	1st	L	1100	25	38
		T	1000	38	
	2nd	L	900	35	38
		T	950	35	

Table 2. Mechanical property of welding joint

Base material	Cross weld kg/mm2 tension test	Side bend test	Charpy -10°C kg-m
ADS (32mm)	55.6 55.2	good	Av. 6.1

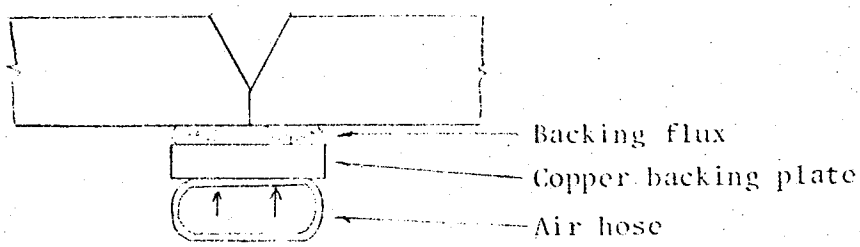


Fig. 2 FCB one side submerged arc welding

Table 5. Welding condition for PP-ARC method

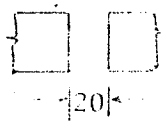
Plate thickness	Edge preparation	Welding material	Current (A)	Voltage (V)	Speed (cm/min)
35mm		Wire: MG-50T PA-nozzle Flux: PFA-50	400 - 440	36	1.0

Table 4. Mechanical property of PP-ARC welding joint

Base material	Tensile strength kg/mm^2	Side bend test	Charpy 0°C kg-m
ARS (35mm)	51.7 52.3	good	Av. 4.9

Table 5. Welding condition for CBS method

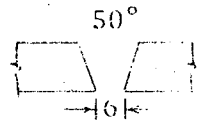
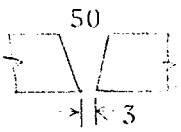
Plate thickness	Edge preparation	Welding material	Current (A)	Voltage (V)	Speed (cm/min)
12.5mm		Electrode BS-1 Flux PFI-CB Backing IT-CB	1600	35-40	60

Table 6. Mechanical property of CBS welding joint

Base material	Tensile strength kg/mm^2	Bend test	Charpy 0°C kg-m
AAM (12.5mm)	45.9 48.1	good	Av. 5.4

Table 7. Welding condition for OEG method

Plate thickness	Edge preparation	Welding material	Current (A)	Voltage (V)	Speed cm/min
14mm	50  3	Wire 1.6ø PWS-43G	400	33	8.1

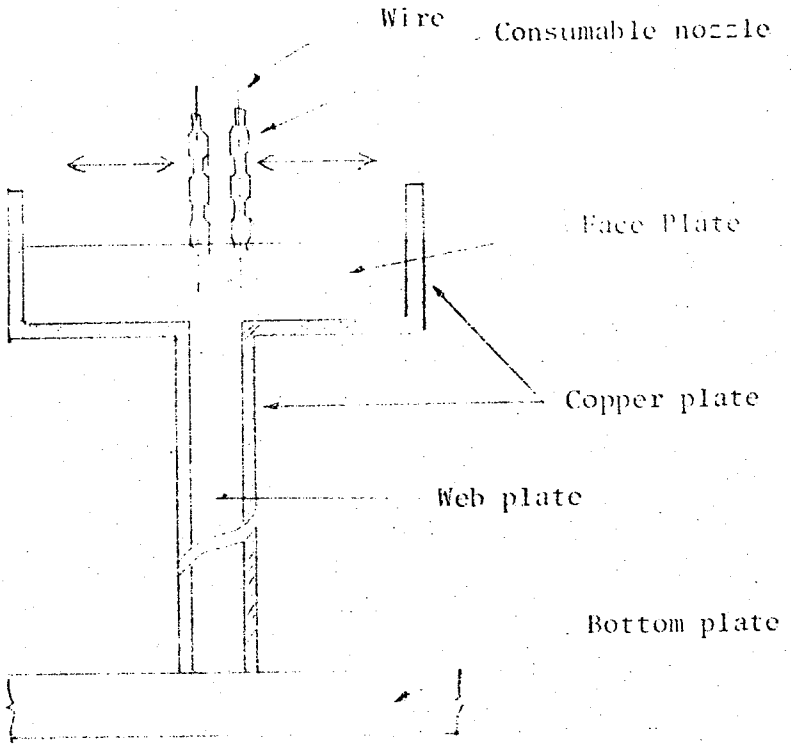


Fig. 3 KOB-BL Welding Process

Table 8. Efficiency of welding

Joint	Welding method	Ratio of efficiency
Bottom long.	CES + CO_2 Weld ⟶ KOB-BL	2.4
Deck trans.	Shielded metal arc ⟶ OEG	1.4
Trans. BHD	Shielded metal arc ⟶ EG	2.6