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Development of Automatic Welding System for Multi-Layer and Multi-Pass Welding

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Abstract: According to increase of ultra-large containerships, the improvement of welding productivity and efficiency for thick plate welding become an important factor to reduce production time and costs. In the block assembly process at a shipbuilding yard or in a dock, manual welding or semi automatic welding that adopt small welding carriage is applied to the multi-layer weld. In this study, we had developed an automatic multi-layer welding system that full automatic welding is available for welding productivity and weld quality improvement. The system can weld automatically without additional welder's operation by using a touch sensor which can generate welding conditions based on the predefined weld database.

1. INTRODUCTION

Recently, as the size of the ultra-large containership is getting bigger, thickness of the steel plate becomes thicker. Therefore welding of the thick plates needs much time and costs for it. For the higher welding productivity, in general, Submerged Arc Welding (SAW) is used in flat horizontal welding position. On the other hand, during the block assembly process at the shipbuilding yard or in the dock, there are some joints where SAW can not be applied. In that case, manual welding or semi-automatic welding that uses rail guided small weld carriage and requires manual adjustment of the welding parameters is adapted.

Manual welding shows less arc time than automatic welding and cause musculoskeletal disorders. In order to increase welding productivity, an automatic welding carriage system with automatic welding sequences for multi-pass and multi-layer will be a solution. Some studies for these areas have been conducted (Y.B. Kim et al.,2005, H.S. Moon et al., 2005). The developed system using the vision sensor or the arc sensor and adaptive control is too heavy and complicate to be applied to the block assembly process.

Fig. 1 shows some application areas for multi-layer and multi-pass welding, which can be used for a block assembly of the hatch coaming region of containerships. The thickness of the plates is more than 60mm and the length is less than 1000mm. In this case, multi-pass welding over 20 passes is needed.

In this paper, we had developed the automatic welding system, which is capable of multi-layer and multi-pass welding. The developed system is a carriage based system. And we focused on having a light weight rating of less than 10kg for easy and convenient handling.

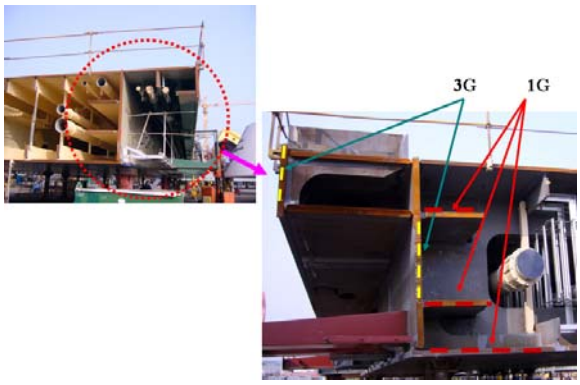

Fig. 1. Hatch coaming region of the containership

2. SYSTEM CONFIGURATION

The developed system consists of portable welding carriage, main controller, welding machine, touch sensor unit and wire feeder system (Fig. 2). The joint shape including gap size, groove angle and thickness of plate is detected by touch sensing algorithm at the welding start and end point (Fig. 3). According to the detected joint shape, basic weld parameters such as current, voltage and pass information are generated automatically with referring to predefined weld database. And specific parameters such as weaving width and welding speed are interpolated for that interval.

2.1 Carriage

The carriage consists of 4 axes, and each axis has its own motion controller operated by a field bus communication. The weight of carriage is crucial because it is handled by operator more than 30m away from the weld machine. So the weight of carriage was designed under 10kg.

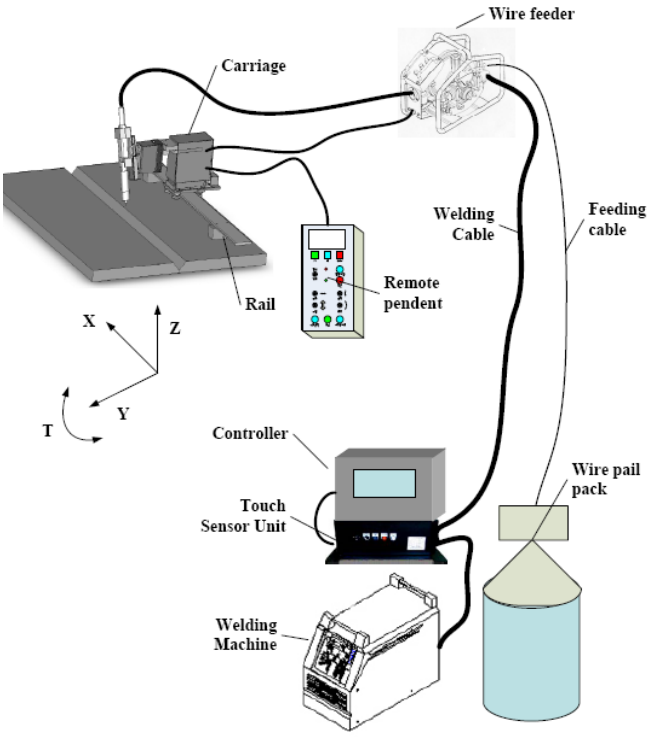

Fig. 2. Configuration of the developed system

2.2 Controller

The controller is based on a DSP (Digital Signal Processing) processor for high speed motion control and welding sequence control. The controller consists of a DSP processor board, a weld database control board, a base board, a touch screen and LAN(Local Area Network) interface module. The weld database control board manages and generates welding conditions, especially including path-and-layer information according to the joint shape found by the touch sensing algorithm. The base board manages analogue and digital input/output signals for welding machine control. The DSP board controls carriage motion and main sequence such as joint shape detection and generation of multi-pass weld sequence.

3. EXPERIMENTS

The developed system is applied to the block assembly process in the yard. We used three work pieces to guarantee and prove the performance of the system. Each joint shape was detected by shape detecting algorithm using touch sensor. And weld pass and layer are generated by the weld database control board based on the predefined database. After starting the weld, all welding sequences for multi-pass and multi-layer are executed automatically without additional operation. The welding conditions are shown in Table 1. Total working time takes 390 minutes for three work pieces with 50mm thickness. Welding productivity was improved about 26% higher than semi-automatic welding for the same welding groove.

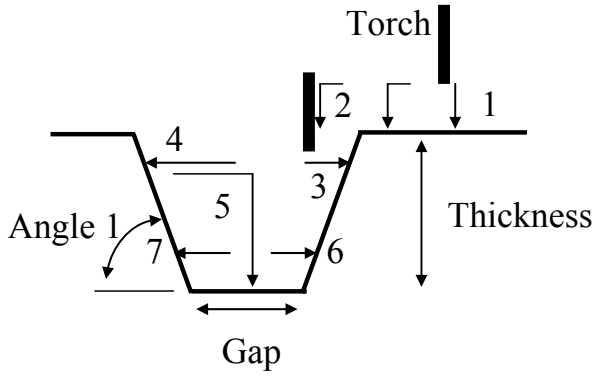

Fig. 3. Touch sensing algorithm

Table 1. Welding Conditions

Test work pieces length	#1-540mm #2-540mm #3-1,000mm
Welding Current	280~300A
Welding Voltage	34~36V
Welding Speed	15~30CPM

4. CONCLUSIONS

The automatic welding system for multi-pass and multi-layer has been developed and applied to the block assembly process of the containership in the shipbuilding yard.

The mechanized carriage has been designed to have a slim design and less weight so that the operator can install it inside of the block more easily.

The developed shape detecting algorithm using the touch sensor and welding pass and layer generation algorithm based on welding database were well operated. So we could optimize the system without additional sensors such like vision sensors and optical sensors.

The developed automatic welding system could improve welding productivity and efficiency compared with semi-automatic welding and manual welding. And it could improve welding quality and working environment for welders working inside of the block.

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