Proceedings of the 17th World Congress
The International Federation of Automatic Control
Seoul, Korea, July 6-11, 2008

Development of Carriage-type Welding Robot for Double Hull Assembly Line in Shipbuilding

Ji-hyoung Lee*. Jong-jun Kim*, Jae-kwon Kim, and Jong-ryon Park****

**Automation Dep't., Industrial Research Institute, Hyundai Heavy Industries Co., Ltd.*
1, Cheonha-dong, Dong-gu, Ulsan,682-792, Korea
(Tel:+82-52-202-3213, e-mail: { jihylee,jjkim,kim,pakim}@hhi.co.kr)

Abstract: This paper introduces a carriage-type welding robot which is to implement into double hull assembly line in shipbuilding. The developed robot consists of 5-axis carriage-type body, a controller, and a welding power supply and is capable of welding fully automatically such as a commercial industrial robot system without any interruption by an operator in a cell which consists of vertical weld-line and horizontal one. This is also characterized by not only automatic seam tracking ability and automatic feature-point detection function, but also an automatic generation function of job program. This system was already tested in a field and their performance had been proven successfully.

1. INTRODUCTION

For decades, welding carriages are variously used for the purpose of increasing productivity, reducing the cost of labor, and gaining uniform weld quality in the shipbuilding industry. Nevertheless, major issues of welding carriages have been mostly focused on reducing their weight in order to be handled conveniently by operators. Along with the rapid growth in micro-electronics and power electronics technologies, however, it becomes a turning point to the development of high functional and intelligent welding carriages performing complicated and difficult tasks. Some applications(JH.Lee *et al*., 2007) are introduced.

The shipbuilding industry is currently faced with the problems of an increase of the average age of employees, work-related musculoskeletal disorders of workers, a shortage of skilled workers, and environmental protection-related issues. To overcome these problems, the shipbuilding industry is steadily increasing the use of automated equipment such as industrial robots and portable welding carriage systems(JH.Lee *et al*., 2005, Ogasawara *et al*., 1998, Okumoto *et al*., 1997). Especially, the use of welding robots in the open hull assembly lines has yielded a big productivity improvement and has partially solved above problems. For the double hull type assembly line, however, the need of a portable welding robot arises because it is very difficult for an automated system(especially commercial industrial robots) to apply into the closed block(double hull type). The commercial industrial robot, that is, can not be accessible to the double hull type blocks. The block size is around 20m(L) x 20m(W) and composed of numerous cells.

In this paper, we proposed and developed a carriage-type welding robot which is able to weld a cell depicted in Fig. 1. The robot has the intelligent sensing functions such as arc sensor and touch sensor as well as runs on the job program including movement macro and welding condition macro.

2. SYSTEM DESCRIPTION

2.1 Specifications

a) Block

b) Cell

Fig. 1 Photo of a block and a cell

A block consists of a number of longitudinal stiffeners and transverse stiffeners. On the other hand, a cell is composed of two longitudinal stiffeners and a transverse, and so the weld lines of the cell are two vertical lines and a horizontal one as depicted in Fig. 2. Therefore a robot shown in Fig. 3 should carry out welding for all weld lines once it is placed onto the cell. The robot, 5-axis carriage-type manipulator, is controlled by servo motors and can do synchronous motion except the X-axis. The specifications are shown in Table 1.

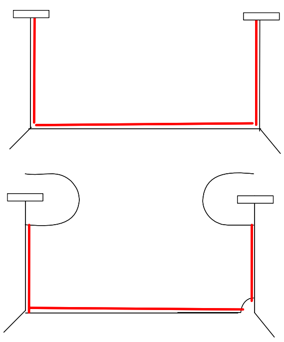


Fig. 2 Weld lines in a cell

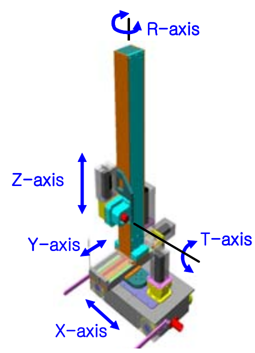


Fig. 3 Carriage-type robot

978-1-1234-7890-2/08/$20.00 © 2008 IFAC 10.3182/20080706-5-KR-1001.1219

Table 1 The specifications of the robot

Items	Contents
Axes	Total 5 axes
Control method	Servo control with absolute serial encoder
Weight, kgf	23
Dimension, mm	400(L) x 220(W) x 780(H)
Trajectory control	PTP & CP
Sensors	Touch sensor, Arc sensor Automatic end-point detection
Teaching method	Automatic job program generation
Controller type	Industrial PC based

2.2 Control system

Fig. 4 shows the hardware structure of the robot controller. The controller based on an industrial PC has several control boards including a motion board, a data acquisition board, and a CAN communication converter. The application software compiled by Microsoft Visual C++™ is running on the Windows XP® and has the highest priority in order to realize real-time execution like a real-time OS. And the robot's job program can be automatically generated if some dimensions of a cell are simply inputted as shown in Fig. 5.

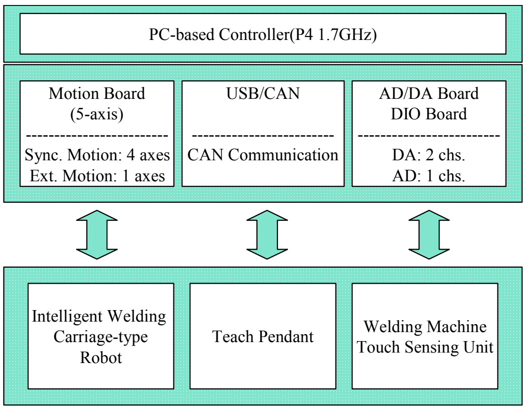


Fig. 4 The hardware structure of the robot controller

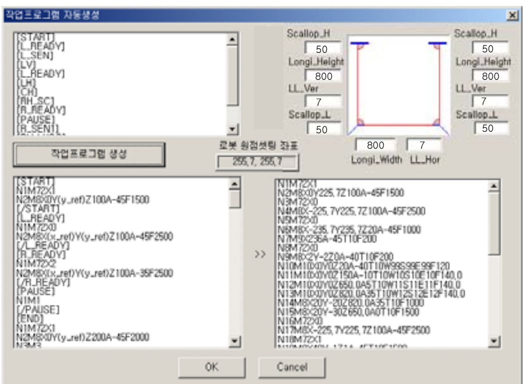
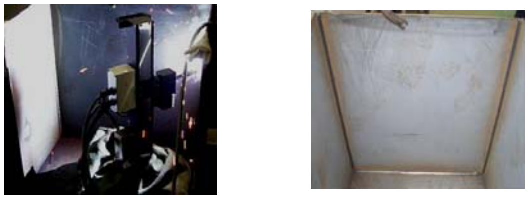


Fig. 5 GUI for automatic job program generation

3. EXPERIMENTS

The general view of the carriage-type welding robot(a) during welding and the bead appearance of a test work-piece(b) after welding are shown in Fig. 6, respectively. All sequences are executed automatically for around 15 minutes without any interruption by an operator. Welding current and welding voltage are 220A and 26V for the vertical welding and 320A and 32V for the horizontal welding, respectively. The start point of each weld line is detected by the touch sensor and the end point of that detected automatically by the thru-the-arc signal during welding. All motions are realized by synchronous movement.



a) Welding scene b) Bead appearance

Fig. 6 Experimental results

4. CONCLUSIONS

The carriage-type welding robot has been developed for double hull assembly line in shipbuilding. The features of the system can be summarized as follows;

1) The developed robot weighing 23kgf could be easily installed by an operator without any external handling equipment, which is much lighter than commercial welding robot weighing over 100kgf.

2) All functions related on sensors were well run. It gave that all sequences were executed automatically.

3) The PC based controller having highest priority on the Windows XP was tested and proved with real-time execution.

4) The welding performance of the robot comparing to other commercial robots was nearly same.

REFERENCES

J.H. Lee, J.C. Kim, J.R. Park, and J.G. Kim(2007), "Technical Trend of Automatic Welding Carriage Built by High Technology Functions," *HHI Engineering Review*, **vol. 27. no. 2**, pp. 82-89.

J.H. Lee, C.S. Kim, and K.S. Hong(2005), "Off-Line Programming in the Shipbuilding Industry: Open Architecture and Semi-Automatic Approach," *Int. J. of Control, Automation, and Systems*, **vol. 3, no. 1**, pp. 32-42.

T. Ogasawara, K. Hashimoto, M. Tabata, M. Komatsu, T. Hara, and Y. Kanjo(1998), "Application of Multi-robots Control Technology to Shipbuilding Panels," *Journal of the Robotics Society of Japan*, **vol. 16, no. 1**, pp. 46-47.

Y. Okumoto(1997), "Advanced Welding Robot System to Ship Hull Assembly," *Journal of Ship Production*, **vol. 13, no. 2**, pp. 101-110.