# AUTOMATIC MULTITORCH WELDING SYSTEM WITH HIGH SPEED

Moon, H.S. [1*], Kim, J.S.[1], Jung, M.Y.[1], Kweon, H.J.[1], Kim, H.S.[1], and Youn, J.G.[2]

[1]Automation Department, Hyundai Heavy Industries,
1-Dong, Chen-Ha, Ulsan, 682-060, Korea, hsmoon@hhi.co.kr
[2] Material Department, Hyundai Heavy Industries

**ABSTRACT**

This paper presents a new generation of system for pressure vessel and shipbuilding. Typical pressure vessel and ship building weld joint preparations are either traditional V, butt, fillet grooves or have narrow or semi narrow gap profiles. The fillet and U groove are prevalently used in heavy industries and shipbuilding to melt and join the parts. Since the wall thickness can be up to 6" or greater, welds must be made in many layers, each layer containing several passes. However, the welding time for the conventional processes such as SAW(Submerged Arc Welding) and FCAW(Flux Cored Arc Welding) can be many hours.

Although SAW and FCAW are normally a mechanized process, pressure vessel and ship structures welding up to now have usually been controlled by a full time operator. The operator has typically been responsible for positioning each individual weld run, for setting weld process parameters, for maintaining flux and wire levels, for removing slag and so on.

The aim of the system is to develop a high speed welding system with multitorch for increasing the production speed on the line and to remove the need for the operator so that the system can run automatically for the complete multi-torch multi-layer weld. To achieve this, a laser vision sensor, a rotating torch and an image processing algorithm have been made. Also, the multitorch welding system can be applicable for the fine grained steel because of the high welding speed and lower heat input compare to a conventional welding process.

**KEYWORDS**
Vision sensor, Multitorch welding system, Seam tracking

## 1. Introduction

In the metal fabrication industry, arc welding has been playing an important role in automated and robotic arc welding processes. The need of welding automation has been requested because of the harsh environments resulting from the intense heat and fumes generated by the welding process and the extreme physical demands.

As the need of high speed welding system grows, many companies have to shift the orientation of development strategy for welding system. A simply way to accomplish the above object is to develop multitorch welding system. Yet, as the welding speed is higher, the robust weld seam tracking sensor and the automatic welding condition control system are urgently needed because the manual welder can't adjust the exact weld line for welding torches and welding conditions by manual due to the high welding speed[1][2].

The sensors for welding automation have been developed but only a small number has been successfully applied to the industrial area. Techniques used have been based on mechanical, electrical, sonic, magnetic and optical sensor, each method having advantages and disadvantages in given production situations.

In this paper, application results for SAW with five welding torch and FCAW with six welding torch systems in addition to the laser vision sensor are discussed. First, however, characteristics of the multitorch SAW process is reviewed. Also a laser vision sensor system developed for high speed welding is described.

## 2. Overall system architecture

The overall architecture of the multitorch SAW and FCAW system is shown in Fig. 1. In this case, it is assumed that the system is using three welding torches in a manner of DC/AC/AC configuration for SAW, DC/DC/DC for FCAW. The actual welding systems of SAW developed, however, has three and five welding torches for the pressure vessel fabrication and shipbuilding. Fig.2, Fig.3 and Fig.4 show three SAW system for pressure vessel, five SAW and six FCAW system for general shipbuilding respectively. As usual, each torch is supplied by a suitable power source. In this type of application, especially for SAW, a DC power source for stable arc, while the trailing torches arc AC powered. In addition to the electrical connection, a torch arrangement such as horizontal distance and relative height between each torch and welding conditions play an important role in stable arc. Sometimes, an improper torch arrangement may cause open arcs and bad bead appearances. To achieve a sound bead appearance and qualities, an adequate combination of welding current, voltage and torch setup should be considered. Based on experience, it took several months to get the appropriate welding conditions and suitable torch arrangement for the multitorch welding system.

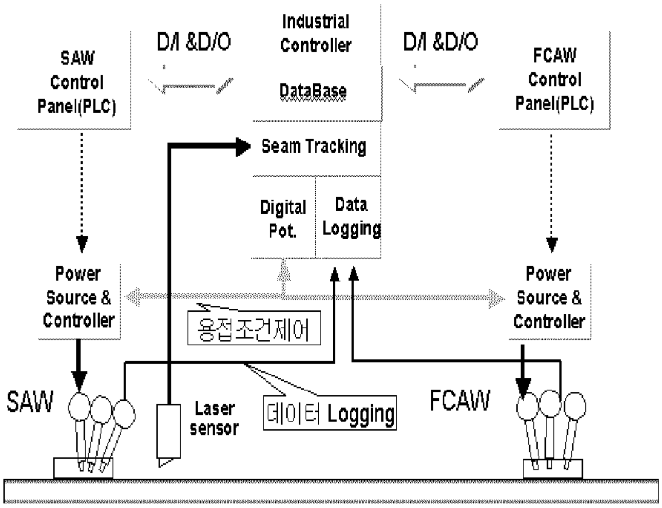


Fig.1 Overall system architecture

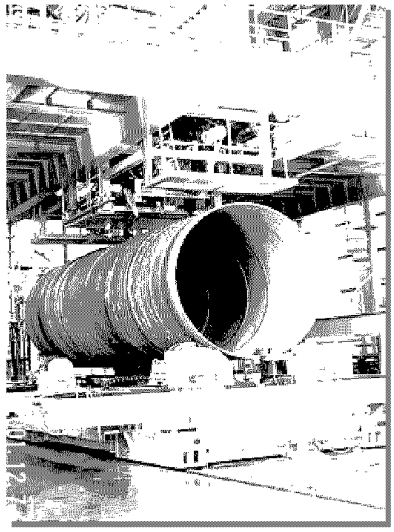

Fig.2 Pressure vessel welding system

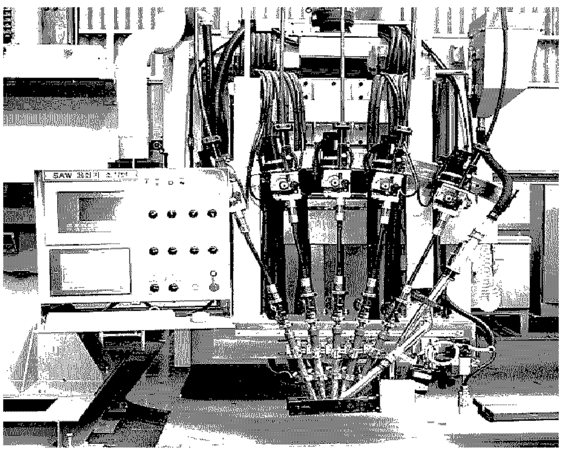

Fig.3 Five SAW system

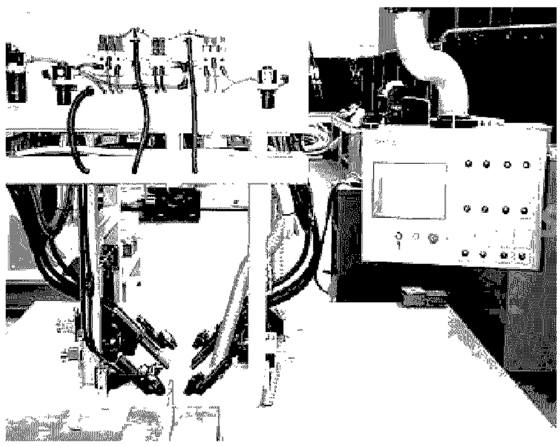

Fig.4 Six FCAW system

This multitorch system can accomplish high production speed compared with single welding torch system. In general, 30 or 40 cm/min can do welding speed of single torch system, however, welding speed up to 2500 cm/min can be possible in case of five SAW torch system.

With the welding equipment used, two different interface systems have been developed. In each case, each wirefeeder is augmented with a digital potentiometer as shown in Fig.1. The electronic potentiometers are controlled directly by the sensor controller. The number of torches that has been controlled successfully in this manner is up to five.

## 3. Sensors

Manufacturing operations such as robotic welding and general welding equipment require trajectory control of the welding torch mounted on the end-effector of the robot or welding head. A tactile sensor can track the weld line in case of low welding speed and smooth weld surface. In case of multitorch welding system, however, the tactile sensor is inadequate because the sensor can be damaged due to the high welding speed. To overcome this disadvantage, the vision sensor and reliable joint detection algorithm are urgently needed.

A variety of machine vision techniques have been developed for the determination of 3D scene geometric information from 2D images. In this paper, the structured light laser sensor was adopted to acquire the 2D images from camera. Two laser vision sensors were developed, one for large field of view, the other small field of view. The large field structured light sensor and the narrow depth of field sensor are shown in Fig.5 and Fig.6 respectively. Fig.7 shows the developed graphic user interface program for the vision sensor.

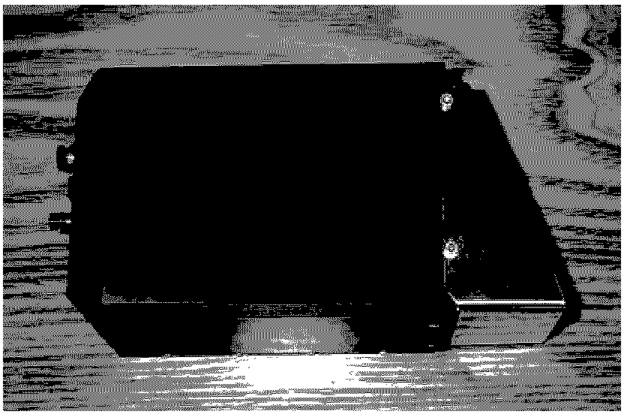

Fig.6 Large depth of field structured light sensor

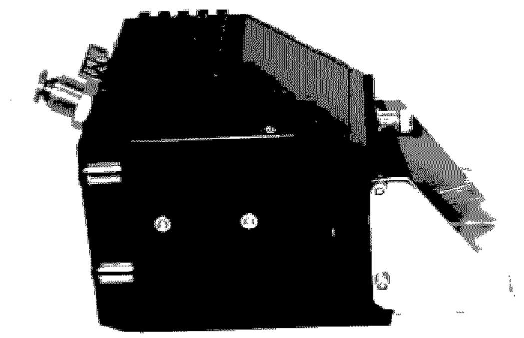

Fig.7 Narrow depth of field structured light sensor

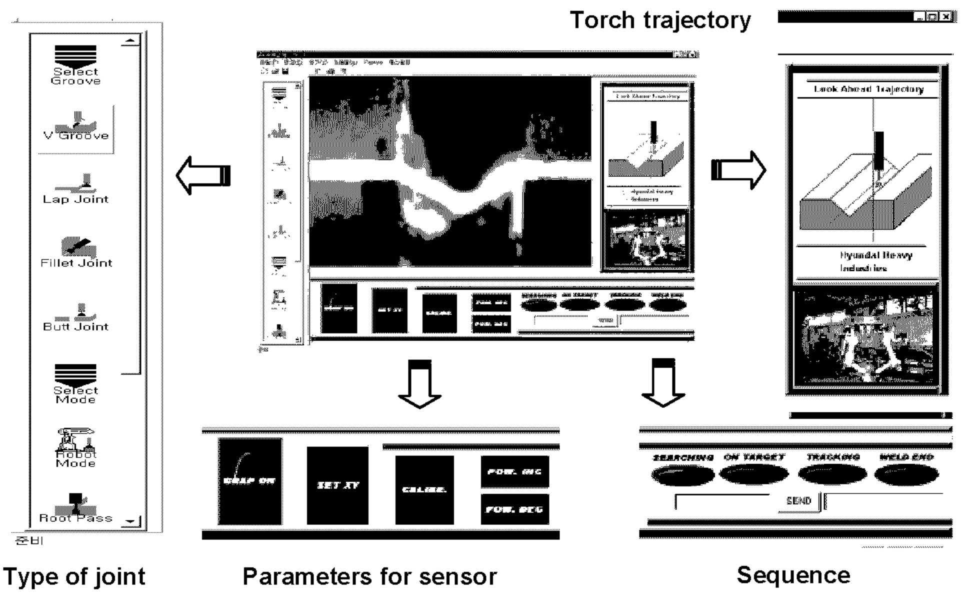


Fig.8 Graphic user interface program developed

Laser Vision sensors can be split into two categories : those that use a light stripe or those that use a scanning laser spot. The reliability of image profile directly reflected from surface depends on the conditions of surface, type and depth of groove. In general, the scanning laser spot sensor is much better than the light stripe sensor especially in deep groove and shiny surface. The main motivation why this paper presents the light stripe sensor is easy to develop, and many technologies related with this kind of sensor are published. The weakness of this approach lies in its high sensitivity to the environment. For example, image data reflected from shiny surface and deep groove is unreliable because of the specular reflection. Thus many image processing steps such as filtering, thresholding, and thinning are required to obtain reliable range information. To overcome these problems, the segmentation algorithm developed earlier [3] and many heuristic approaches were employed in this paper for ensuring the reliability of image processing results. Fig.9 shows the results of image processing by using above algorithms.

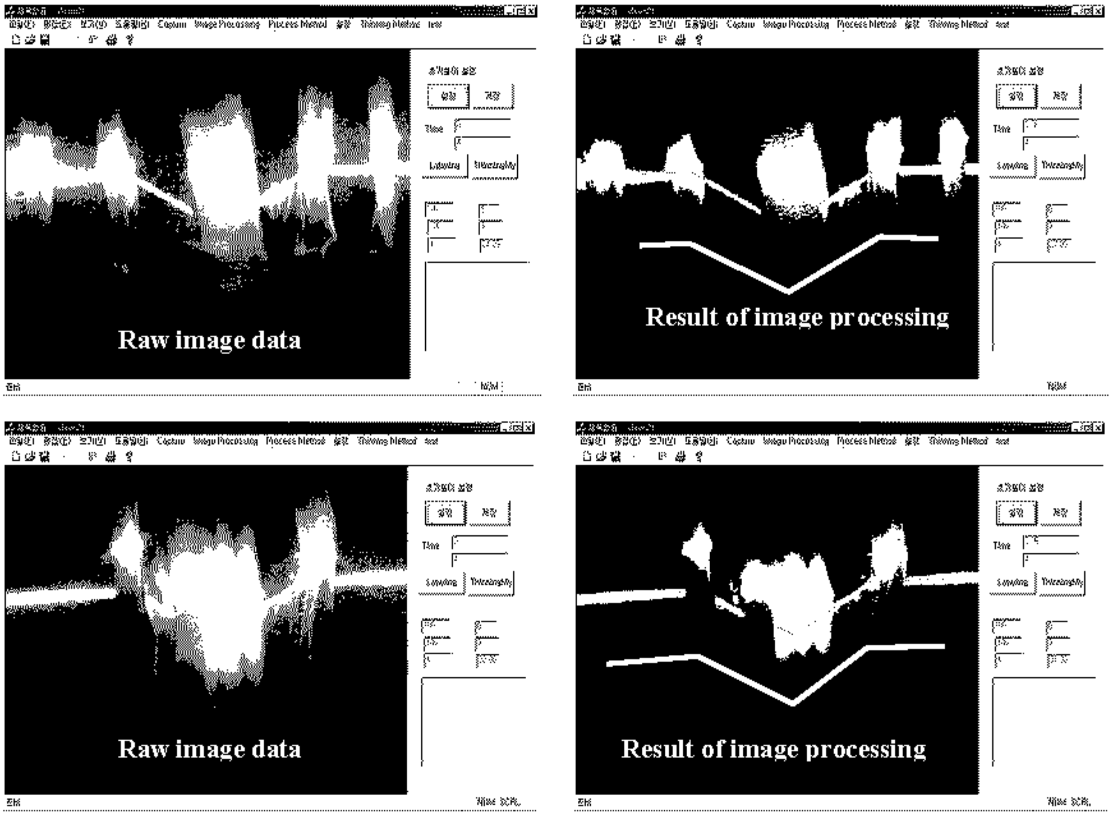


Fig.9 Results of advanced image processing algorithm

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