# WELDING AUTOMATION TECHNOLOGIES IN SHIPBUILDING INDUSTRY

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**ABSTRACT**

In manufacturing of ships, problems to be solved are improvement of productivity and stabilization of quality due to the shortage of skilled workers. Working environment, in particular welding environment, is also to be improved. One solution among these problems is to rationalize and automate these working. This paper is focused on the welding automation technologies in shipbuilding industry. The features of shipbuilding in the aspect of automation are described, and the main welding robot systems to be developed by SHI are introduced in each working stages.

**KEYWORDS**

Welding, Welding automation, Welding robot, Carriage, Shipbuilding

## 1. Introduction

Welding is one of the most important technologies in shipbuilding, and many efforts have been made and achieved to mechanize and robotize the welding process. **Fig. 1** shows the composition ratio of working hour based on VLCC construction. Many kinds of welding devices and robots have been applied in each working stage such as from sub-assembly to erection stage of shipbuilding. The need of high and uniform welding quality and work efficiency is the main motivation of the automation, and the shortage of skilled man power and high labor costs is also driving heavy industries to automation. However, the requirement of various welding processes in each working stage, and the variety of the size and shape of welding objects make it difficult to automate welding process. Moreover, narrow space and limited accessibility in working area require to develop compact automatic equipments. Some welding robot systems and measurement devices made by SHI are introduced. **Fig. 2** illustrates the overall flow of shipbuilding processes.

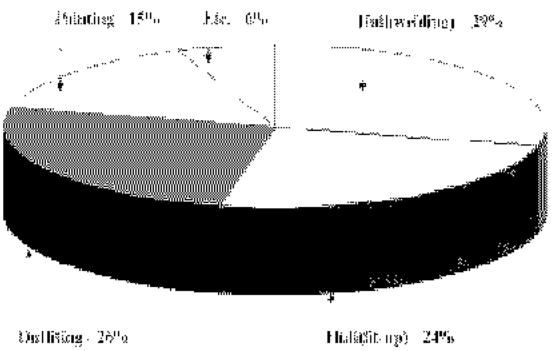


**Fig. 1** The composition ratio of working hour based on VLCC

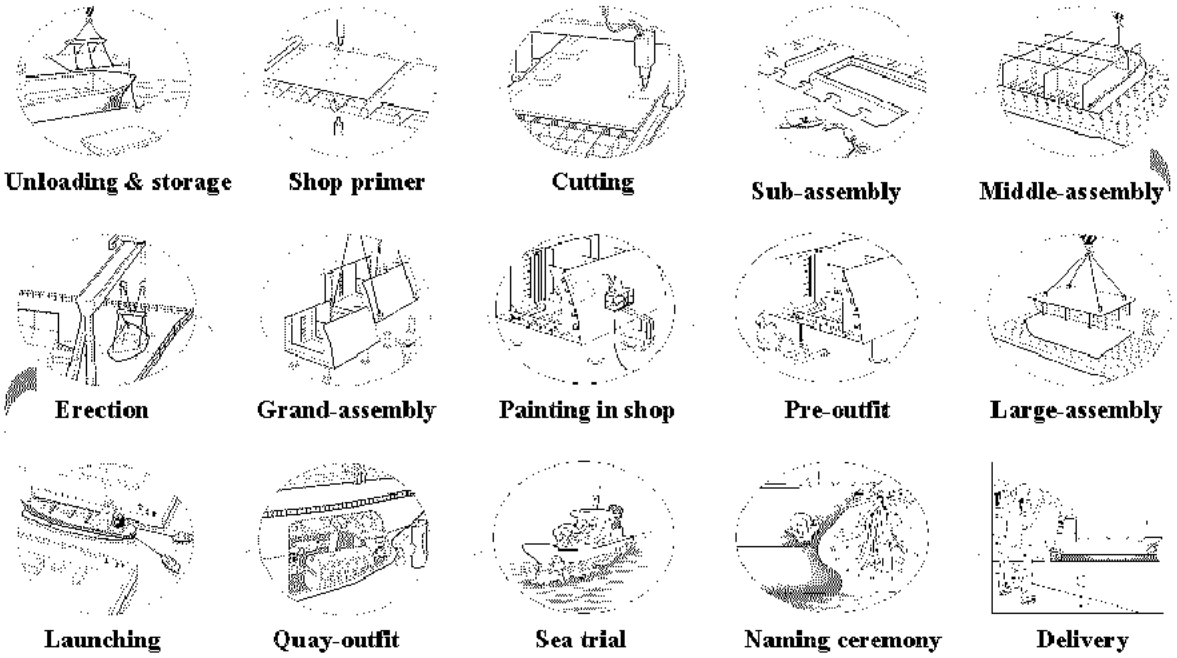



**Fig. 2** The flow of shipbuilding processes

## 2. On-going and coming of welding automation

The mechanization and robotization of welding was carried out in each working stage from sub-assembly to erection. The systemization of welding process which mainly focusing on the development of the high speed welding process and portable carriage assures the improvement of productivity. **Fig. 3** shows the trend of application and mechanization of welding process in shipbuilding. Welding robot systems have been developed and mainly applied to indoor production line. On the other hand, the portable automatic carriage and portable robot have been applied to butt joint of erection stage. However, the integration of each automation system based on computer network could be main project to enhance the efficiency of automation in the future. Besides, more compact and intelligent automatic device should be developed to expand the application of automation to narrow work space such as inside of block at erection stage. **Fig. 4** shows the development steps of welding automation.

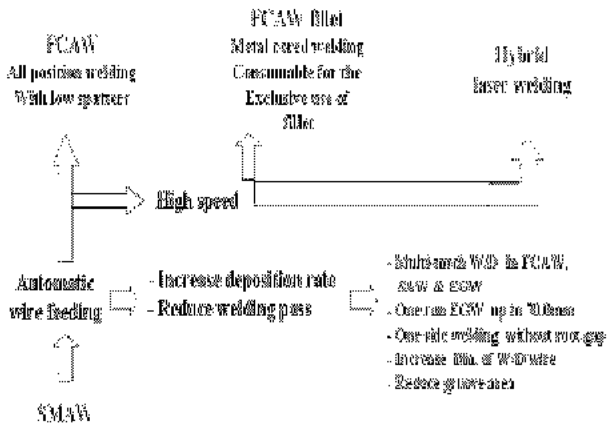



**Fig. 3** The trend of application and mechanization of welding process

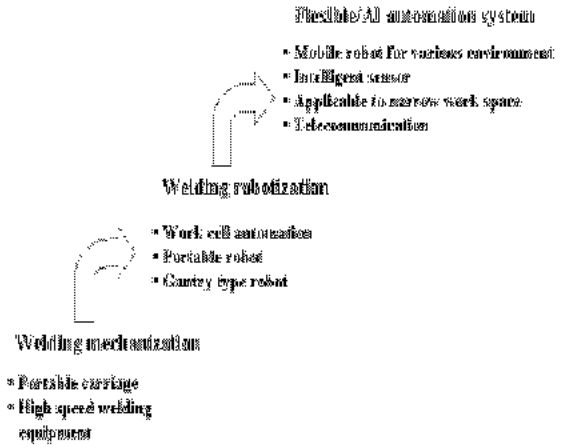


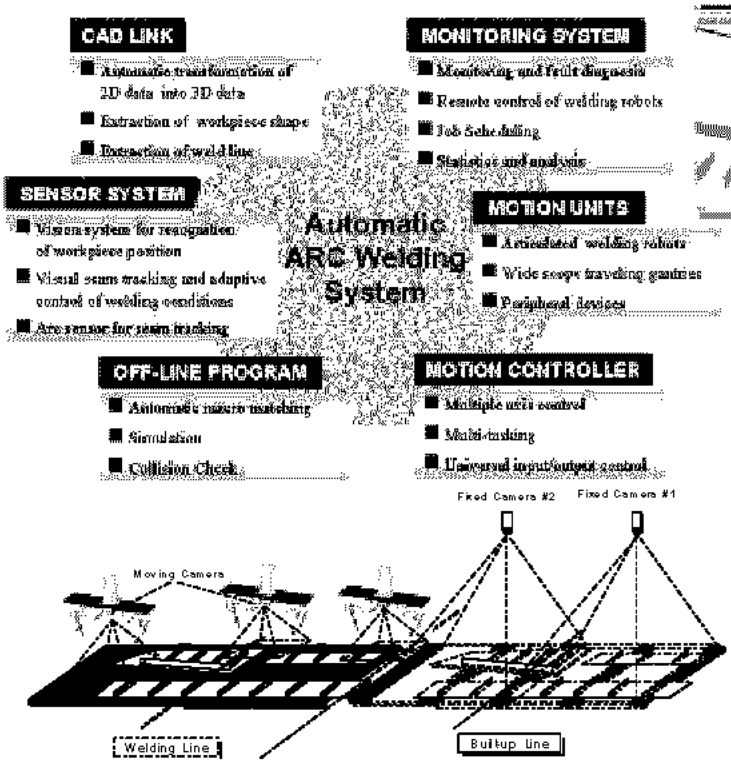

**Fig. 4** The development steps of welding automation

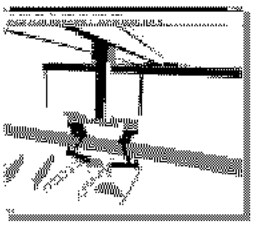
**3. Cases of application**

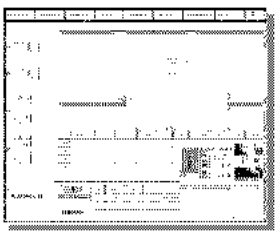
Many mechanized welding equipment are being applied to production line in SHI. Particularly, the main welding robot systems under the development by SHI are described for each working stage.

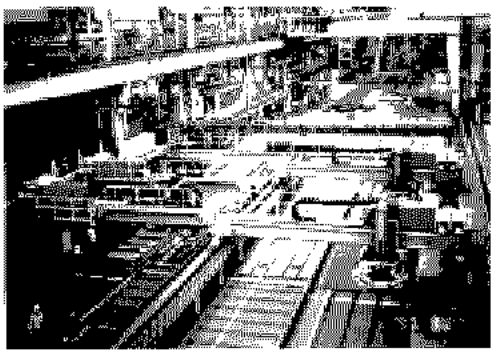
3.1 Welding robot system in fabrication stage

The welding robot system is applicable to the fabrication of large steel structures such as ship, barge, building column and girder, steel bridge panel and so on. The versatility of robot system comes from off-line robot teaching method in conjunction with various intelligent sensors. In order to maximize the productivity of welding process, various process control modules are included, i.e., main controller, sensing system, monitoring and fault diagnosis system. **Fig. 5** shows the perspective view of system, the specifications and key features.







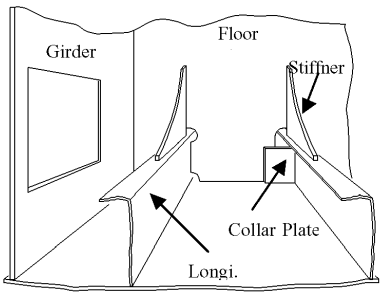
| Key Features |
|---|
| ▶Application: Fabrication of large steel structure<br>▶Fully automated flexible manufacturing system |

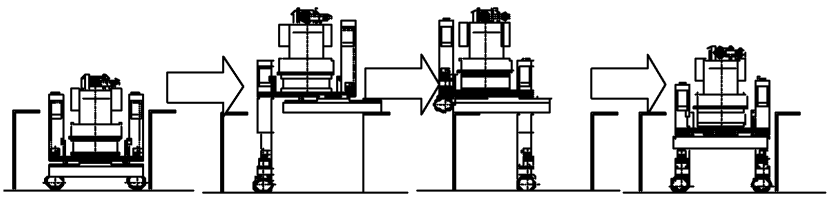
| Specifications | |
|---|---|
| Robot | Weight:50kg<br>Payload:Max.6kg<br>Axis: 6 dof<br>Position: ±0.05mm |
| Gantry | Weight:4,000kg<br>Payload:300kg<br>Position: ±0.1mm |

**Fig. 5** Perspective view of system in fabrication stage

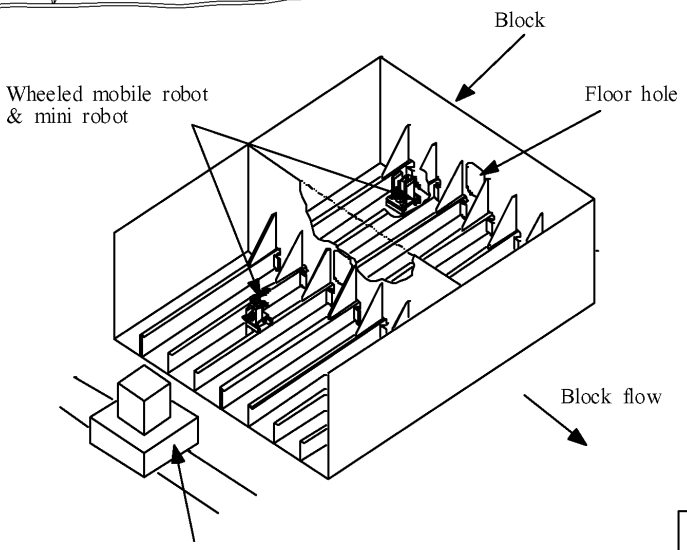
3.2 Welding automation system in assembly stage

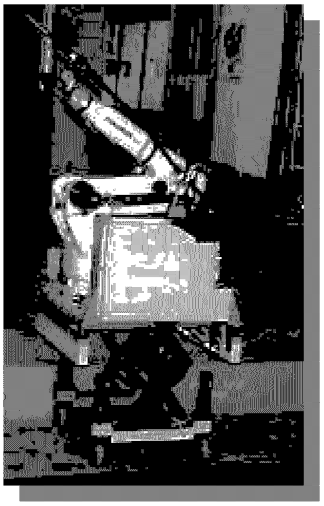
The welding automation system is applicable to the assembly of open block, closed block (for double hull) and steel bridge panel. The versatility of this system comes from "going-over a wall" mechanism and omni-directional mobile robot for autonomous navigation in the interior of welding block. Similar to the fabrication stage, various process control modules are included, i.e., main controller, sensing system, monitoring and fault diagnosis system. **Fig. 6** shows the perspective view of system, the specifications and key features.



"Going-over a wall" Procedure



| Key Features |
|---|
| ▶Application: Open & closed block, steel bridge panel<br>▶Two stage vision system |

| Specifications | |
|---|---|
| Robot | Weight:50kg<br>Payload:Max.6kg<br>Axis: 6 d.o.f<br>Position: ±0.1mm |
| Carriage | Weight:200kg<br>Payload:100kg<br>Speed:Max.8.5m/min |

**Fig. 6** Perspective view of system in assembly stage

3.3 Potable EGW system in erection stage

The EGW system is applicable to the automation of EGW welding process for vertical butt joint in the erection stage. The main feature of this system is 35m long continuous welding without a rail and ceramic backing material. On run welding process for square groove and "V" groove joint was developed up to the plate of 70.0mm thickness, which innovated welding productivity and assured stable welding quality **Fig. 7** shows the specifications and key features, the perspective view of system.

| Specifications | |
|---|---|
| Movable Range | X:Max.35m<br>Y:±15mm<br>Z:±20mm<br>R:±45° |
| Maximum Speed | X:530mm/min<br>Y:750mm/min<br>Z:750mm/min<br>R:360°/sec |

| Key Features |
|---|
| ▶Application: Horizontal,Vertical and Curved Butt Joint Welding Processes<br>▶35m long continuous welding without a rail and ceramic backing material |

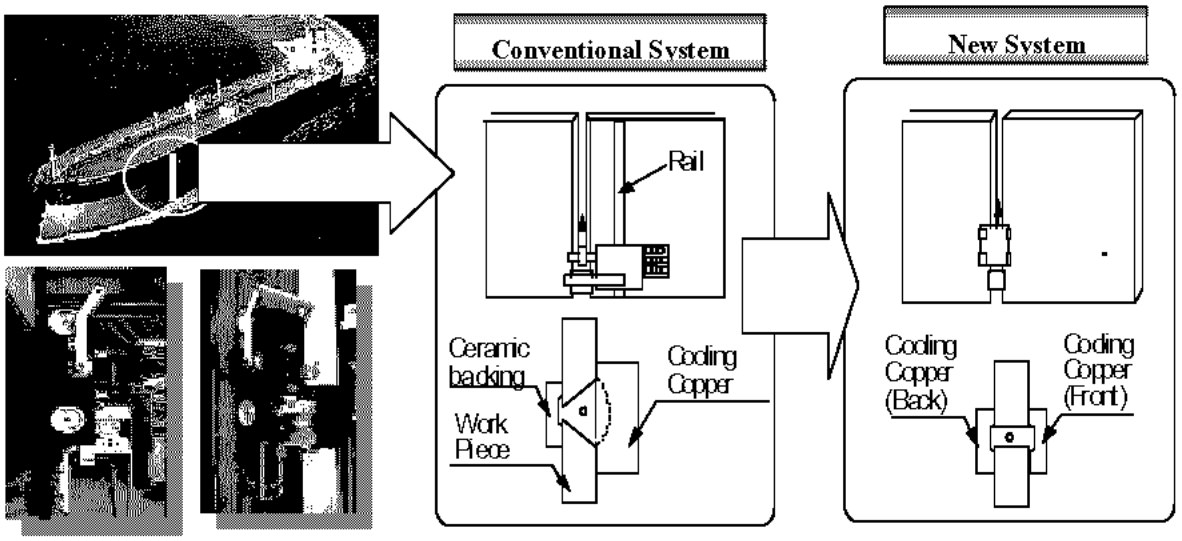


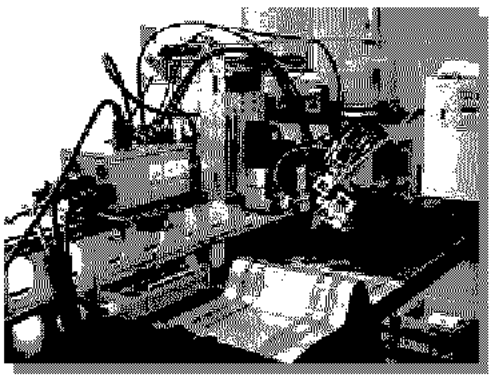

**Fig. 7** Perspective view of system in erection stage

3.4 Portable LNG membrane welding system

The automatic TIG welding carriage is applied to the lap joint of membrane of cargo containment. **Fig. 8** the specifications and key features, the perspective view of system.

| Specifications | |
|---|---|
| Movable Range | X:Depend on rail<br>Y:±75mm<br>Z:+200mm,-50mm<br>R:±85° |
| Maximum Speed | X:70mm/sec<br>Y:125mm/sec<br>Z:125mm/sec<br>R:360°/sec |

| Key Features |
|---|
| ▶Application: Horizontal,vertical and overhead and flat welding processes<br>▶Single or multi pass welding |



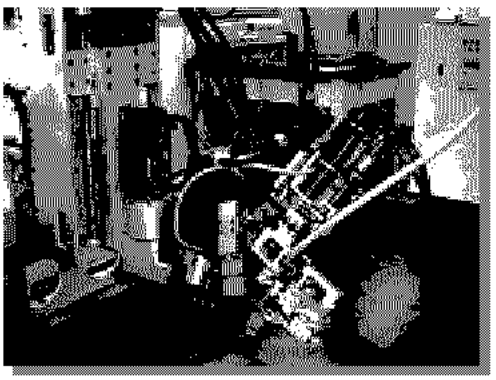


**Fig. 8** Perspective view of system

3.5 Inspection and measurement device for welding

The merits of this system can be found from the saving of welding consumables and working time by employing the exact and simple management of weld size and defect data, Also this can reduce the official welding inspection and waiting time. **Fig. 9** the specifications and key features, the perspective view of system.

| Specifications | |
|---|---|
| **Measuring range** | **28mm X 54mm (H X V)** |
| **System resolution** | **0.1mm** |

| Key Features |
|---|
| ▶**Measurement of welding**<br>→**leg length: 4mm ~ 13mm (User spec.)**<br>→**Undercut size: > 0.1mm**<br>→**Chamfer size: 1 ~ 3 mm** |

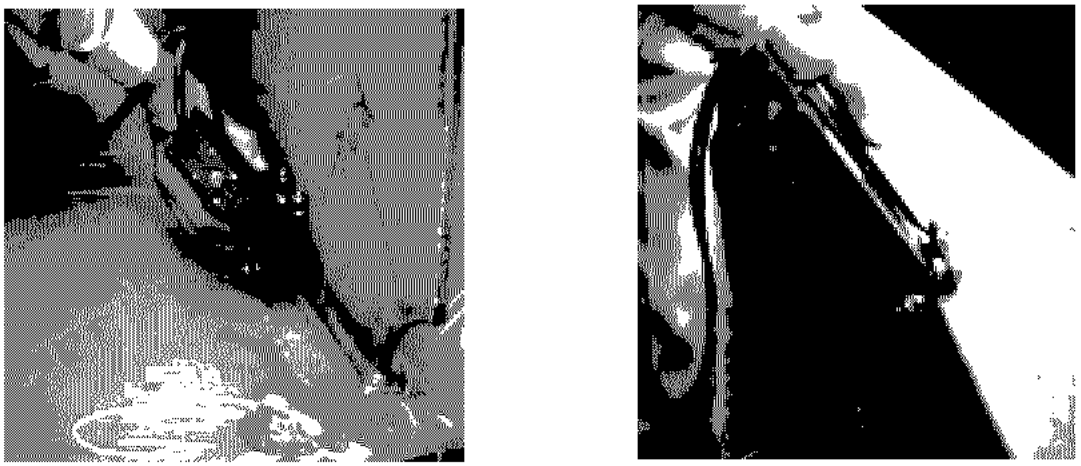


**Fig. 9** Perspective view of system

**4. Conclusions**

High and uniform welding quality and work efficiency is the main motive of welding automation, and the shortage of skilled man power and high labor costs are another reasons. The increasing requirement of new kind of ship products has led to the change of production pattern such as multi-kind and small lot, which demands more advanced automation system and more accurate production control system . In other words, the automation system including welding is to be multi-functional and integrated on the basis of computer network for importing 3D CAD data and product model and for the control of actual production process. The high density energy welding process such as hybrid laser welding will be applied to more production line in order to improve productivity and decrease welding distortion of thin plates. Further more, the increasing number of cruise ships demands the development of the control of distortion caused from cutting and welding. These technologies are effectively to be developed by joint research consortium with universities and relevant institutes.