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Automation and Control Systems Technology in Korean Shipbuilding Industry: The State of the Art and the Future Perspectives

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Abstract: Owing to the steep rising of marine cargo transportation with the growth of global economy and the increasing demands for replacing overage vessels, the shipbuilding industry meets historic boom days with record-breaking order backlog. To fortify the leading position in the market with improved productivity and high quality, Korean ship construction companies vigorously pursue researches on shipbuilding automation and ship automation technologies. This talk introduces the recent issues and efforts on automation and control system technology in Korean shipbuilding industry.

1. INTRODUCTION

Today's shipbuilding industry has been gradually transformed into technology driven industry from labor intensive one due to the growing needs to meet environmental regulations on ship operations, increased technological requirements of the clients, and extremely enlarged size of vessels. On the other hand, the global market becomes severely competitive due to latecomers armed with cheaper labor cost and expanded production facilities. Under these circumstances, Korean shipbuilding companies are seeking effective ways to strengthen their competitiveness in quality, cost, and delivery, and ultimately to benefit the customers.

Fig. 1. Commercial vessels

To this end, not only researches on high value-added ships but also much R&D efforts on production automation and optimization of logistics are being conducted. Through these efforts they try to construct high quality ships and to reduce the term of production with increased productivity and reliability in ship-manufacturing processes. In order to accelerate technological discrimination over foreign competitors, Korean shipbuilders are endeavouring to develop automation technologies which derive high level functionality, improved performance, reduced cost, and easy maintenance in ship operation.

Fig. 2. Shipbuilding in a shipyard

As an integrated manufacturing industry, from cutting steel plates to building up ship operating software, shipbuilding industry has close connections with diverse technological fields. Automation technology is one of the key fields of them. This talk covers the current trends and future directions of shipbuilding automation and control systems technologies in Korean shipbuilding industry.

2. SHIPBUILDING AUTOMATION TECHNOLOGIES

Automating the manufacturing process is strongly needed in order to increase productivity and reliability in shipbuilding process. Automation in shipbuilding affects every step of ship production and requires wide range of technologies.

2.1 Production Planning and Control

Improvement of productivity and flexibility of shipbuilding can be accelerated by the advancement of production planning and control technologies. Shipbuilding industry has very complex system of production because there are various types of vessels and those vessels are constructed from numerous parts, blocks and subsystems. Thus, accurate planning and control of production are closely related to the productivity. Besides, limited space of the shipyard and frequent block transfer demand optimized logistics.

Automation technologies for production planning and control in shipbuilding industry have been remarkably improved in these days. The R&D efforts for integration of the material resource planning (MRP), the computer Integrated manufacturing (CIM), and the electric commerce (EC) show noticeable progress. They could not be fully used in the early stage of introduction because of technical limitations. But now this problem is being solved by intensive researches in this area.

The enterprise resource planning (ERP) system as shown in Fig. 3 is being applied to many shipbuilding companies. Also new logistics management system is adopted, which employs ubiquitous technology such as the global positioning system (GPS) and the radio frequency identification (RFID).

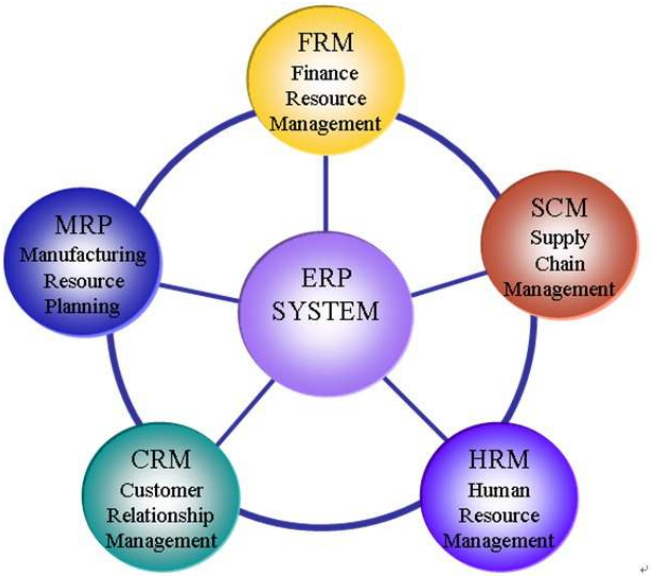

Fig. 3. Production management through ERP system

Fig. 4 illustrates an example of the automation in logistics management of the blocks with sophisticated algorithms. Every block is systematically arranged on the shipyard for easy access of transporters and minimization of transportation time.

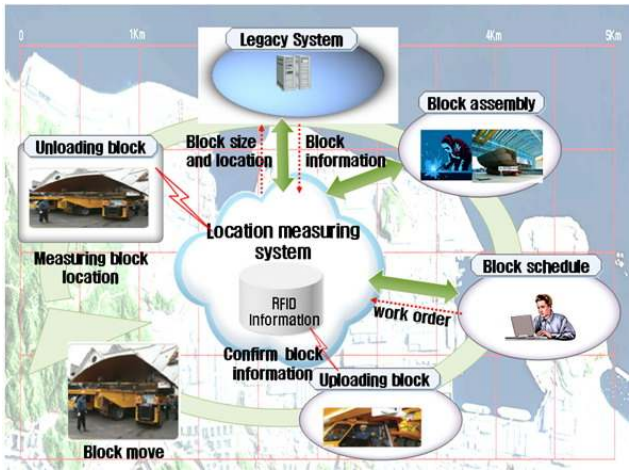

Fig. 4. Block logistics & storage management in shipyard

2.2 Automated Manufacturing Systems

In shipbuilding industry, so many kinds of manufacturing processes are used. Cutting, welding, grinding, measuring, and painting are used in the shipyard, casting, forging, and machining are carried in the engine shop, and many other processes are used in the other shops.

Since there are numerous sizes and shapes of parts to be treated, the shipbuilding processes are extremely difficult to be automated. But, rigorous requirements to increase productivity and to enhance work environment have made many sorts of automated manufacturing technologies be realized. Fig. 5 shows representative automated processes in shipbuilding industry.

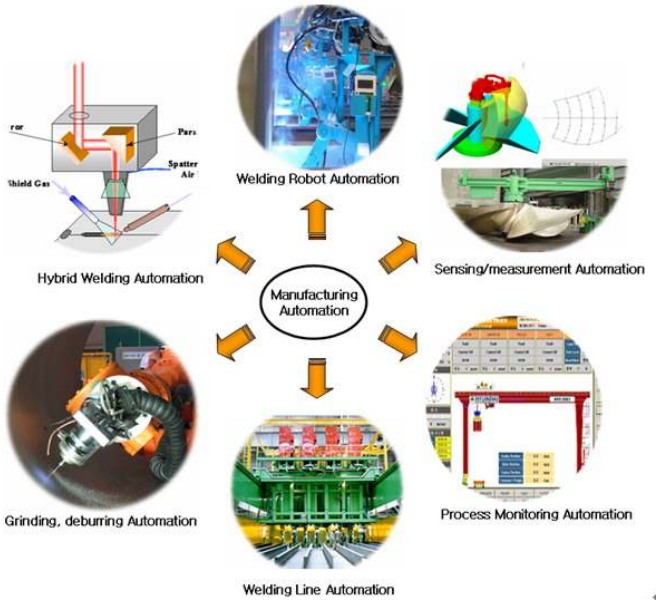

Fig. 5. Manufacturing automation in shipbuilding

For decades, automation technologies for the cutting and welding process have been evolving from manual operation into automatic one, and eventually, into the unmanned operation system. Fig. 6 shows the welding robot system for panel assembly. Improvement of productivity and quality in

the open and simple block assembly process can be achieved by employing multiple welding robots.

Fig. 6. Automatic panel welding robot system

To enhance the productivity of welding process, many shipyards are seeking for an automated welding system which has automatic seam tracking and adaptive control function. Sensing technology plays an important role in satisfying these requirements. Fig. 7 shows a sensor application for membrane tank fabrication process.

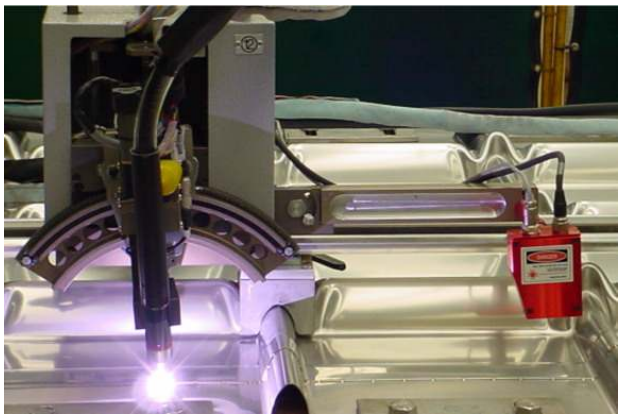

Fig. 7. Sensor application for membrane tank fabrication

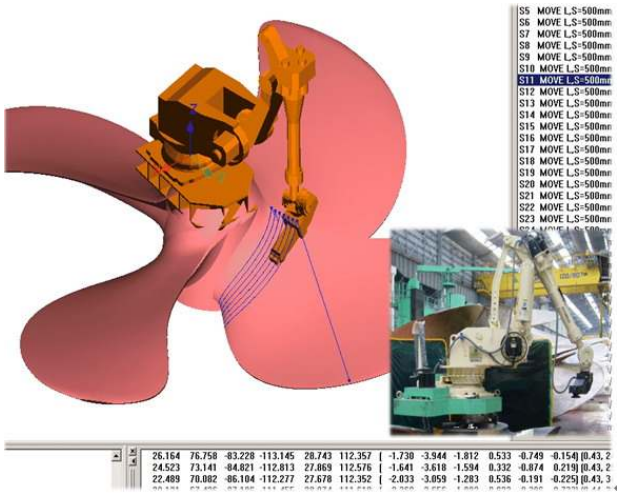

Fig. 8. Propeller grinding process by robotic automation

In general, grinding is one of the important processes, but the working environment of the grinding process is harmful to workers due to noisy sound, dust, and heavy duty. An automated grinding system can be strongly helpful to overcome these circumstances. Fig. 8 shows an example of the automated robot system for propeller grinding process.

Meanwhile, highly automated painting has not been achieved yet because of the difficulty of fine spraying control and on-line quality measurement; even though paining automation is strongly needed, as the painting process is very dangerous and hazardous to workers.

2.3 Perspectives of Shipbuilding Automation

In the near future, rapid convergence of information technology (IT) and process technologies for shipbuilding automation is expected. IT can systematically combine key technologies of shipbuilding such as design automation, production management and logistics automation, and manufacturing automation. In this process, the automation and control technologies will play an important role.

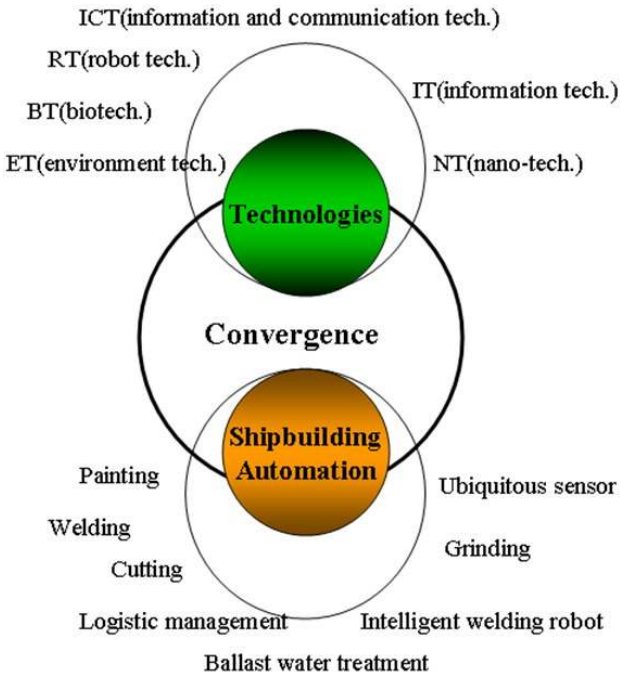

Fig. 9. Technology convergence in shipbuilding

Some automation technologies expected to be appear in the near future are as follows:

- Hybrid laser welding technology in panel assembly lines
- Intelligent welding carriage system for curved block and double hull structure
- Redundant and multiple robot application technology for handling, grinding, and welding automation

- Remote controlled or operated robot system for hazardous environment applications
- Network based real time monitoring and control technology in manufacturing process
- Applications of ubiquitous sensor network
- Safety u-helmet (ubiquitous helmet) for group communications and position recognition of workers.

3. SHIP AUTOMATION TECHNOLOGIES

High performance and quality of the ship itself by adopting advanced ship automation technologies are also essential issues to the shipbuilders. Automatic ship operation systems have reduced the number of officers and ensured the security of ships. As shown in Fig. 10, this section introduces major automatic ship operation technologies for integrated bridge, alarm and monitoring, electric power management, and engine state monitoring.

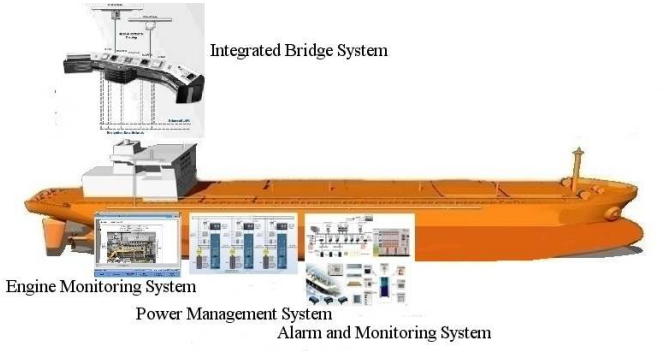

Fig. 10. Automatic ship operation systems

3.1 Integrated Bridge System

International maritime organization (IMO) defines the integrated bridge system (IBS) as a combination of systems which are interconnected in order to allow centralized access to sensor information or command/control from workstations, with the aim of increasing safe and efficient ship's management by suitably qualified personnel. The IBS is designed to improve safety and efficiency at all levels of vessel operation. This integrated bridge solution can be tailored and arranged to fit the specific operational needs of the vessel.

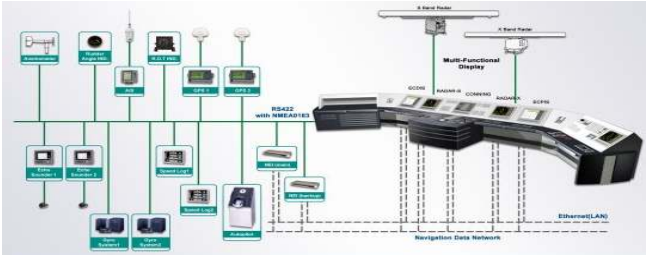

Fig. 11. Integrated bridge system

All required equipments can be positioned within reach of the operator, in order to increase the safety of operations and reduce working stress during intensive operations. Usually the IBS is designed for one-man operation, with functionality that allows the operator as much time as possible for his observation and decision making. The system seamlessly integrates a full range of ship management and automation tasks on navigation and maneuvering into common networks.

Integrated functions include:

- Navigation
- Route Planning
- Automatic route keeping
- ECDIS/Radar shared video and track presentation
- Maneuvering
- Manual levers
- Joystick
- Dynamic positioning
- Radio and inter communications
- Safety system.

3.2 Alarm and Monitoring System

Alarm and monitoring system is a hub system to monitor and control the overall condition of the ship and to keep the cargo safe and sound. This system should be highly integrated to observe various states of the ship and cargo such as level gauging, temperature and pressure monitoring, valve and pump control, and so on.

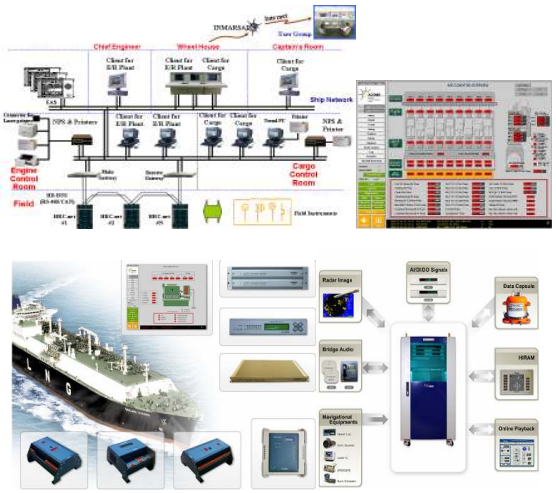

Fig. 12. Alarm and monitoring system

The applications include:

- Cargo tank level monitoring
- Cargo tank pressure monitoring

- Cargo tank temperature monitoring
- Ballast tank level monitoring
- Service tank level monitoring
- Draft, trim and list monitoring.

The software modules for alarm and monitoring system should be specially designed for shipboard operation and ship-specific requirements along the type of ships and cargo. To realize this flexibility, module type standard programs are used for the different functions. The standard program modules consist of:

- Logic operations on signals
- Summation of data(e.g. contents of fuel tanks)
- Fuel consumption
- Output of control signals dependent on limit values, digital signals, measurement data, etc.
- Closed loop controls (e.g. cooling water temperature control)
- Control of pump stand-by systems, valves, etc.
- Control of source-target systems for ballast or fuel oil
- Programming of user-defined requirements with a high level PLC language.

3.3 Power Management System

To avoid black-out due to lack of electric power and also to save fuels, the power management system allows the generators on demand to run. For the safety and economy of ship operation, the power management system needs to handle a wide variety of configurations of generators in the vessel and to utilize extensive monitoring and control functions. Decentralized microprocessor architecture is actively adopted for the automatic power management systems.

Key features are as follows:

- Fast load shedding at loss of power supply sources
- Slow load shedding in case of overload (Peak shaving)
- Active and reactive power control
- Power sharing
- Generator synchronization
- Re-acceleration and re-starting
- Generator and turbine control through integration of excitation and governor controller
- Circuit breaker control through integration of protection relays.

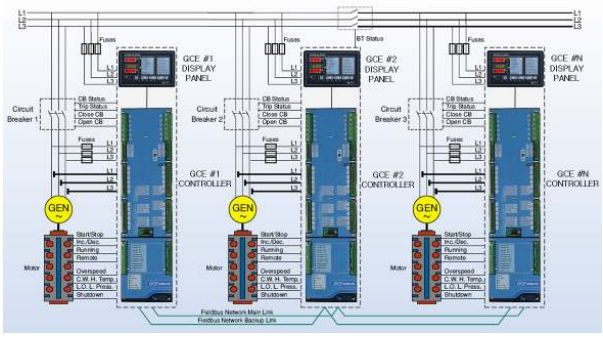

Fig. 13. Power management system

3.4 Engine Monitoring System

As the concerns about environment get growing, new types of engine like electronically-controlled engine are being developed and gradually replace the conventional type engines. Engine monitoring system plays a key role in maintaining the engine in best condition through providing vital information on operating status for operator. Engine monitoring system makes extensive use of various data of performance and condition, and presents effective monitoring environment for operator.

Key features are as follows:

- Load balance inspection
- Fuel ignition quality inspection
- Airflow degradation detection.

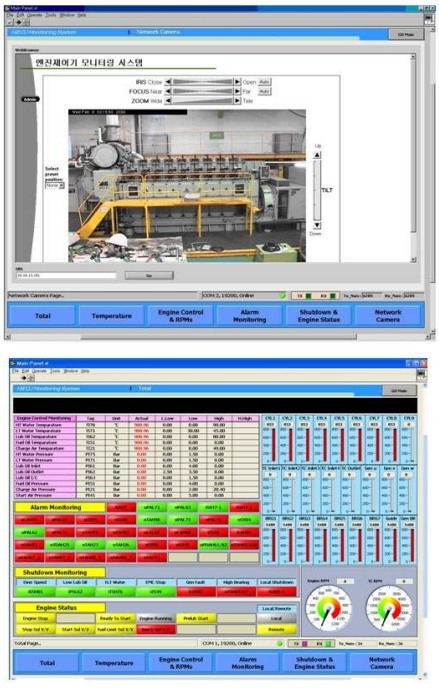

Fig. 14. Engine monitoring system

3.5 Perspectives of Ship Automation Technologies

Recently, several marine accidents of oil tankers and commercial vessels had brought significant environmental disasters. In recent years, researches on the preventive measures against this kind of accidents are expected to be actively carried. More dependable collision avoidance technologies which connect the vessels with the control centers on land through wireless communication are expected.

Researches on intelligent vessel diagnosis which are closely linked with resource management system of shipping firms are also expected to be undertaken in the near future. To maintain safe and efficient operation of the machinery and equipment of the ship, predictive diagnosis and maintenance support system based on artificial intelligence and wireless sensor network techniques will be developed. This system will detect possible problems in the early stage and prevent serious problems of essential machinery such as the main engine and generator engines in the engine room.

These technologies may considerably reduce the heavy burden imposed on engineers by integrating the conditions of planned maintenance. This system will provide customers with the following advantages:

- Saving expenses by expanding the intervals between periodic inspection
- Increasing safety through the avoidance of unexpected serious accidents
- Improvement in operational efficiency through punctual shipping service
- Saving cost of maintenance and spare parts.

4. CONCLUSIONS

The shipbuilding industry in Korea meets historic boom days owing to its timely investment and favorable business environment. To fortify the leading position in the global market, Korean ship construction companies have made hard efforts to improve productivity and quality through technological research and development. Thus, shipbuilding industry in Korea has been gradually transformed to technology driven industry from labor intensive one and it shows large progress in many technological areas. Among these technologies, automation technology is a core field for realizing high productivity, quality and safety of vessels. This talk introduced the recent issues and efforts of Korean shipbuilding industry on production automation and ship automation technologies with some applications at use. In the near future, many innovative changes in shipbuilding are expected to come through convergence of technologies. During this process, the automation technology will play a key role. The future will be a dynamic age with active international trade and vigorous usage of ocean. As a basis industry supporting the progress of the 21st century, Korean shipbuilding industry will do its best on R&D activities of automation and control technologies.

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