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선박건조 과정에서 효율적인 전장시스템 설치를 위한 3D 훈련자료에 관한 연구

(A Study on 3D Training Material for Efficient Production of Electrical Systems in the Shipbuilding)

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요 약 본 논문에서는 선박 건조 과정에서 전기/전장 시스템의 생산을 담당하게 될 신규 입사자의 훈련에 3D 기반의 학습자료를 적용하는 방법에 대하여 연구하였다. 대부분의 신규 채용자나 전직자들은 설치도면을 해석하는 능력이 부족하여 첫 업무를 수행할 때 큰 어려움을 겪는다. 이런 현상은 도면에 애매모호한 기호들이 너무 많아서 전기 장비 및 케이블 설치에 필요한 부품들의 특성을 명확하게 나타내지 못하는데서 기인한다. 이런 문제를 해결하기 위해, 본 연구는 선박 내 전기/전장 시스템의 생산에 요구되는 주요 부품들의 3D모델을 활용하여 신규 입사자들의 도면 해석 능력을 향상시킬 수 있는 새로운 교육 훈련 방법을 제안하였다.

핵심주제어: 3D 모델, 2D 도면, 3D 학습자료, 선박건조, 신규훈련생

Abstract In this study, we have investigated potential application of 3D model-based learning material in training of new workers for production of electrical systems in the ship-building. Most of new trainees such as new employees or workers on job-transition have lots of difficulty when given the first task due to their poor ability to understand related engineering drawings. This is mainly caused by the fact that drawings are loaded with too many ambiguous symbols to precisely describe the characteristics of components required for installation of electrical equipments and cables. As one way to improve the ability of new employees to read drawings, we have suggested a new training method based on 3D models of major components required for production of the electrical systems in the ship.

Keywords: 3D model, 2D engineering drawings, 3D learning material, Ship-building, New trainees

1. Introduction

Shipbuilding industry in Korea experienced explosive growth through a "state-led development strategy" in the 1970s with the country's push to industrialize heavy &

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chemical industries. With such strategic investments, Korea was able to cope with a surge in global demand for ships, following the explosive expansion of the Chinese economy and the recovery of the U.S. economy in the 2000s.

However, the global financial crisis of 2009 has led to drastic decline in exports, long dampening workforce and investment in the shipbuilding industry in large magnitude (Ministry of Trade, Industry and Energy, 2018).

Fortunately, orders for ship building have been on the rise again since 2017 due to increased demand for new ships to match strengthened international environmental standards (POSCO Management Research Institute, 2019). It has become urgent matter to expand capability of skilled work forces to maintain Korea's dominant position in the world's shipbuilding industry.

In Korea, jobs related to the ship building is categorized in accordance with NCS (National Competency Standards). According to the NCS_KECO interface table provided by the Korea Employment Information Service (2018), the work required for shipbuilding is classified into seven groups (ship-design, ship-building, ship fitting, ship production, ship quality control, commissioning, and ship maintenance) as shown in Fig.1, which in turn are divided into 29 detailed tasks.

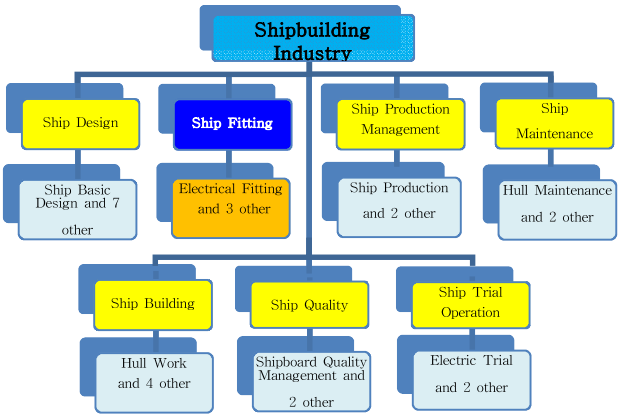


Fig. 1 Classification of Works in the Shipbuilding Industry

In this study, we have suggested potential implementation of 3D-based learning material in on-site training of new employees or workers on job transition to enhance worker's ability to read engineering drawings required for accurate installation of electrical systems in the shipbuilding (Žiha and Skala, 2010).

Manufacturing electrical systems in the ship building includes installation of various devices and cables according to 2D drawings such as shown in Fig. 2. Accordingly, learning material for the training specified by NCS is also based and fully dependent on 2D drawings only.

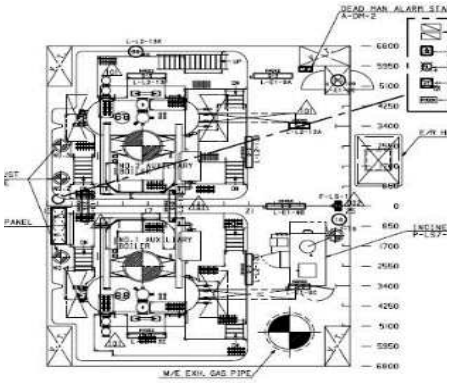
Various equipments and cables should be installed based on the engineering drawings licensed to the shipper. In addition, these drawings are derived from the NCS (National Competency Standards) and are given only in 2D as shown in Fig. 2.

A ship is complex of various systems and countless facilities. For example, one super - large LNG ship requires more than 300,000 meters of cables and thousands of devices and equipments.

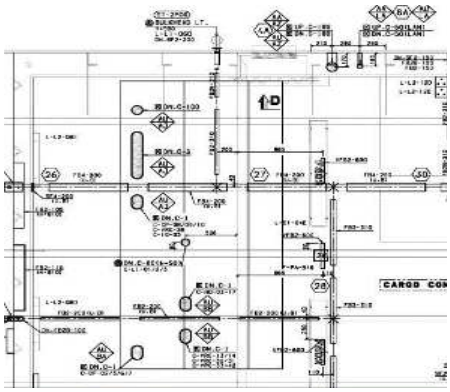
Production of electrical systems for a ship consists of four major tasks such as cable pulling and binding, coaming filling, electrical equipment installation and cable connection (Lee et al., 2012). Regardless of task configuration, it is very important to provide solid foundation for further works.

On the other hand, it is expected that there will be less difficulty in carrying out the work, if the foundation is established correctly. Since most of the tasks should be done in accordance with engineering drawings, poor or incomplete understanding of drawings may cause serious problems in the further stages.

Up to a few years back, severe long-term



(a) Layout Diagram



(b) Installation Diagram

Fig. 2 Layout and Installation Diagram for Production of Electrical Systems

recession of the global economy accelerated the pace of exodus of core technical workers from the shipbuilding industry as well as restructuring industry, which resulted in huge decrease in number of skilled workers and sharp increase in number of retired workers at early ages. Since 2017, when the shipbuilding industry has been on the rise, serious problems have arisen due to poor work efficiency of the newly recruited workforce.

New employees or new trainees on the job transition would often face huge difficulties performing their first job due to poor understanding of drawings. One of the most important reasons for this is that many symbols in engineering drawings do not provide detailed information to describe the components required to achieve a goal. To make matter worse, this makes many more workers to avoid reading the drawings, which is mandatory for efficient work, and furthermore provokes passive behavior of workers towards tasks.

2. Research Methods

Production of electrical systems is classified into 3 major groups such as pulling, connection, and welding. Among these, pulling and connection comprises more than 90% of the total electrical tasks described above. Pulling includes cable pulling, binding, and cable piercing and filling specified by the drawings approved by the owner. Connection task is to install electrical devices and various equipments as specified by drawings and to make cable connection including earth work. Finally, welding task involves installation of cables and electrical devices in accordance with drawings. For reference, firearm refers to all devices that could generate flames or sparks during tasks such as welding, polishing, drilling, etc.

As seen above, production of electrical systems in the shipbuilding should be done in accordance with the engineering drawings approved by the ship owners. Therefore, it is extremely important to have complete and precise understanding of these drawings for successful electrical installation.

For more efficient production of electrical systems, it is essential to have skilled workforce who could understand blueprints from this perspective. Unfortunately, however, considerable portion of electrical workers is composed by new employees or workers on job transition as discussed. It is not difficult to

see that these new workers would have considerable difficulties understanding drawings. In addition, most of drawings are not friendly enough to these types of workers. There is a huge gap between what is needed on field and what is available in the industry in terms of worker's ability to read engineering drawings.

By closely looking into the detailed work scope of producing electrical systems for a ship, we could easily identify the amount of workload needed to accomplish all the task specified by the drawings approved by the ship owners. Through analysis of the major components, it is found that there are certain drawings common to three major tasks in the production of electrical systems in the ship building.

In order to improve new trainee's ability to read drawings precisely and more easily, one must have a closer look at what makes workers avoid reading drawings, which may cause other serious problems in the further works.

Firstly, there are too many ambiguous symbols for new trainees to read and precisely understand the drawings. Secondly, necessary information on the path of cable installation is not sufficiently provided. Thirdly, it is also very difficult to find the location of the installed equipments because the system is not distinctively described in the drawings.

Fig. 3 is a laboratory booth built by XX heavy industry in 2016 for more effective training of electrical workers for production of electrical systems in the shipbuilding. This booth is designed to facilitate laying and finishing practice in one spot. One laboratory could accommodate six booths for practice of multiple workers simultaneously in the limited space.

Each booth has three sides. The front side is provided with a sample view of the lab results and other two sides are allocated for practice of trainees. For more efficient training, each side has the same configuration.

Although we provided previously taught 2D drawings while using this laboratory facility for training of electrical installation, most of trainees had hard time understanding the meanings of lines and symbols in the drawing.

A Laboratory Booth for training of Production of Electrical Systems

Front view

Fig. 3 Photographs of a Laboratory Booth for Training of Installing Electrical Systems in the Shipbuilding

One distinct solution to this problem is to provide new trainees with drawings which they could easily understand meanings of such lines and symbols. It is not easy to find out correlation among parts from 2D drawings since each part is represented only by lines and points. 3D drawings would have more vivid visual effects than 2D because they could show faces in addition to lines and points.

Therefore, based on the lab booth described above, most of components have been modeled in 3D instead of 2D using 3D modeling SW such as Solidworks to mitigate problems in reading drawings among workers. First of all, each device comprising the laboratory facility is modeled in 3D using Soildworks. Then each device is located in the same spot as in the real position so that new trainees could easily see what lines and symbols in the drawing has meant. For more efficient training, 3D PDFs have also been created to facilitate application of 3D learning material in the class without installing

expensive 3D modeling SW.

As seen in Fig. 4, parts shown in 2D are not easily recognizable since they are represented only by lines and many ambiguous symbols. On the contrary, real shapes of each part is shown in the developed 3D material, therefore it would take much less effort to understand drawings.

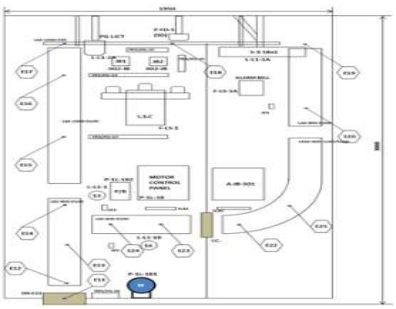
3. Results & Discussion

It is expected that 3D training materials in Fig. 5 might help trainees accurately interpret drawings by observing the actual features of the devices described in 2D. In addition, cable pulling job requires exact interpretation of drawings such as the flying diagram, device diagram, and cable schedule provided in the design (Fig. 6).

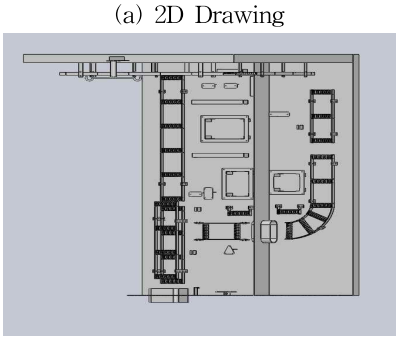
Therefore, it is expected to be accurate and easy to understand the characteristics of components by comparing engineering drawings with their counterpart 3D models.

With 3D modeling of components, a different color is allocated for a different system (Fig. 7) for easier distinction. As shown in Table 1, A different color implies a different purpose of installed electrical devices.

For better comparison, real pictures of electrical devices (Fig. 8) are also shown side by side to find out the installation location of electrical equipments at once.

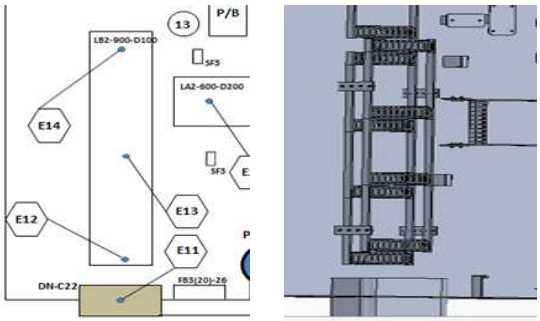


(a) 2D Drawing



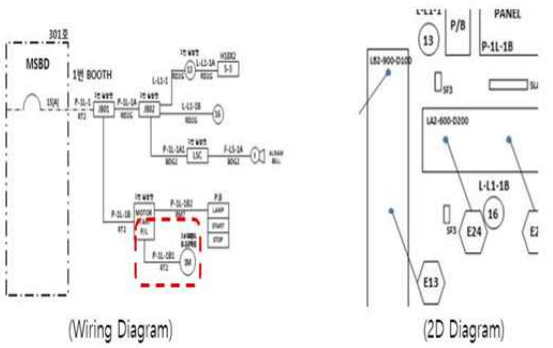
(b) 3D Material

Fig. 4 a) 2D Installation Drawing
b) 3D Training Material



(a) 2D Drawing (b) 3D Material

Fig. 5 a) 2D Installation Drawing
b) 3D Training Material



NO	CIRCUIT	TYPE	기덕	길이	SCHEDULE	TO	FROM
1	P-1L-1	RT2	1	20	··· E31 E32 E33	MSBD	JB01
2	P-1L-1A	RD2G	1	1		JB01	JB02
3	P-1L-1B	RT2	1	5	E33 E32 E39	JB01	PUMP S/T PNL
4	P-1L-1B1	RT2	1	4	E13 E24	MOTOR S/T PNL	MOTOR
5	P-1L-1B2	RM7	1	2	E39 E32	MOTOR S/T PNL	P/B
6	F-LS-1	RD2G	1	4	E33	JB02	LSC

(Cable Schedule)

Fig. 6 Types of Drawings used for Cable Pulling

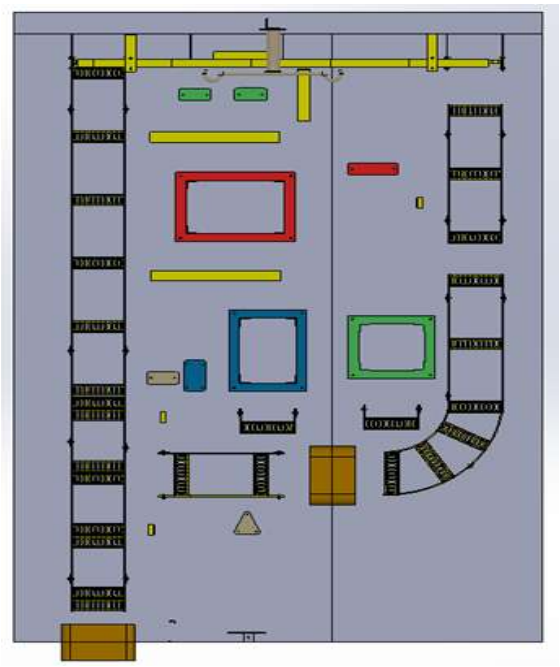


Fig. 7 Allocation of Different Colors for Different Purpose of the Installed Equipments

Table 1 Color Designation for Installation Works

Color	Division designated by color
Yello	Cable Tray
Brown	Coaming
Red	Fire System
Blue	Power System
Dark gray	Lighting System
Green	Junction Box(J.B)

4. Conclusions

In this study, we have suggested potential implementation of 3D learning material in the job training for new employees or workers on job transition as a way to mitigate problems due to low work efficiency of new workforce for production of electrical systems in the shipbuilding.

Advantages of 3D learning material are as follows. First of all, the actual shape of

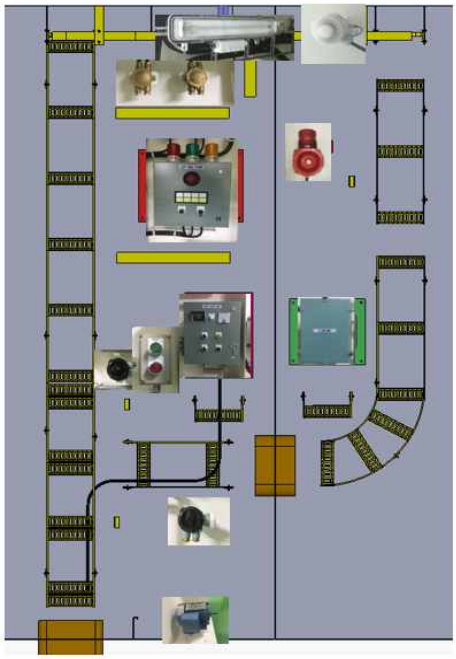


Fig. 8 Photographs of Real Devices are added for Easier Distinction

electrical path and equipments are shown in real pictures instead of ambiguous symbols in 2D drawings. Secondly, it is expected that the appearance of the installed cables could be easily observed, which would help new workers interpret drawings precisely for further works. Thirdly, it is expected that device drawings would become more effective for training by using pictures because precise information on the location of the installed equipment are distinctively shown.

Meanwhile, Fig. 9 shows the parts that secure cables and prevent foreign objects from penetrating cables when cables pass through the electrical equipment with the cable grand. These parts are divided according to environmental factors and conditions. It is also expected that the structure and method of installing components could be easily seen when 3D models are used to describe such components.

Fig. 9 Cable Grands

3D learning material developed in this study could be easily applied in most of training related to the production of electrical systems in the ship building. This training material could also be used to foster skilled workers, and to serve as a means to maintain dominance and competitiveness of Korean shipbuilding industry in the face of renewed demand for more ships.

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