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전자장비와 컴퓨터기술을 이용한 산업시스템의 생산성 개선에 관한 연구

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A Study of Improvement the Productivity of the Industrial System using Electronics and Computer Technology

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요 약 조선업종은 숙련공의 감소와 노동력 부족을 해결하기 위해 자동화와 기계화가 필요하다. 특히 조선용 핸드레일 제조공정은 표준화된 타 분야와 달리 자동화가 낙후되어 있다. 본 논문에서는 조선용 핸드레일 제작에 사용할 수 있는 평철 자동화시스템을 컴퓨터 융합기술을 활용하여 설계하고 개발하였다. 시스템 기구부는 절단공정의 효율성, 생산성, 안정성 등을 고려하여 설계하였고, CATIA 와 ANSYS를 사용하여 구조물의 안정성을 확인하였다. 시스템 제어부는 개방성과 확장성을 제공하는 PCNC 콘트롤러를 사용하였고, 터치스크린 방식의 화면 조작을 통해 시스템의 제어 및 모니터링을 할 수 있도록 구축하였다. 평철 자동화시스템은 기계, 전자 그리고 컴퓨터 기술을 융합하여 산업체의 생산성을 향상시킬 수 있도록 개발하였다.

주제어 : 절단자동, 공학분석, 씨앤씨 기계, 네스팅, 산업

Abstract To solve the labor shortage of skilled workers, the ship building industry needs the automation and mechanization. Especially, compared with other process, handrail manufacturing process of ship building falls behind the automation. In this paper, we designed and implemented a flat-iron automation system using computer convergence technology that can be used in the production of handrails in shipbuilding. The system's machine part was designed by considering the efficiency, productivity, and stability of the cutting process, and checked the stability of the structure using CATIA and ANSYS. The system's control part was used the PCNC controller to provide openness and scalability. And the part was made for system control and monitoring the system through screen manipulation with touch-screen form. A flat-iron automatic system was developed by converging the mechanics, electronics and computer technology and it will contribute to improve the productivity of the industrial system.

Key Words : Cutting automation, Engineering analysis, CNC Machine, Nesting, Industrial

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1. Introduction

To solve the labor shortage of skilled workers, the ship building industry needs the automation and mechanization. Especially, compared with other process, handrail manufacturing process of ship building falls behind the automation. The handrail installed on the edge of the stairs or bridges for pedestrian to prevent from falling accident is directly related to the safety and also used of decoration.

The handrail is used to social sectors, such as shipbuilding, construction and industrial machinery and structure thus the size of the market and the demand is huge[1],[2].

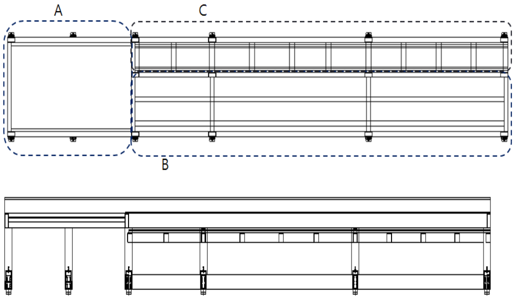
In this paper, we designed and implemented a flat-iron automation system using computer convergence technology that can be used in the production of handrails in shipbuilding. The flat-iron system consists of a machine part and a control part. We performed the structural analysis to design a optimized device structure and to prevent the problem of structural defects. Modeling used CATIA and the structural analysis was carried out with the commercial analysis program ANSYS. The control unit which controls each parts and monitors cutting process was designed to provide accurate control performance and high quality of cutting through velocity control and cutting/machining process control.

2. Design of System's Driving Part

2.1 Design of body frame unit

Flat-iron system consists of a machine part and a control part[3]. The machine part consists of body frame, material supply and transport unit, part of the plasma torch holder. The body frame is configured so that the present of 6000x65x16t 8 can be transferred. The body frame was designed to support 12 fixed to the factory floor. It must be robust and reliable design to play the role of

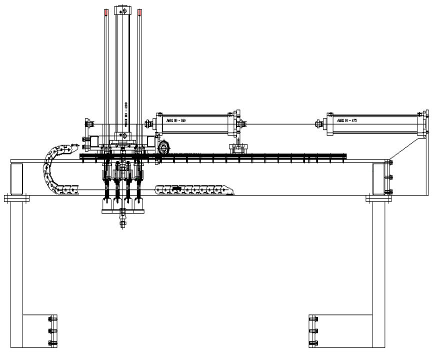
plasma cutting table and material transport unit. Fig 1. is a front and side view of flat-iron automation system.



[Fig. 1] Front and side view of flat-iron automation system

2.2 Design of Automatic Feed Gear Unit

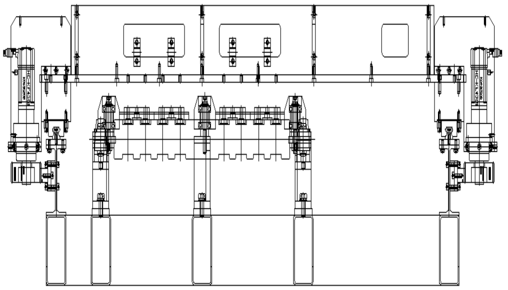
The system was designed using electromagnetic and pneumatic cylinders to automatically supply iron sheets. It converts manual material supply method with automatic material supply method to reduce worker's labor intensity and factory accident. The unit was designed to sit on the system's alignment guide roller 2 cycles per each 4 ps. The basic frame is integrally connected to the body frame, and a total of 24 iron sheets to the electromagnet can be fixed. Electromagnet fixed part consists of 8 electromagnets that is moved up and down by the pneumatic cylinder, and it's maximum stoke is 249.7mm. The figure 2 is showing a front view of the system's automatic feeding unit.



[Fig. 2] Front view of the automatic feeding unit

2.3 Design of Material Supply and Transport Unit

Iron sheets that are mounted on the system's guide rollers are required a device that supplies Iron sheets to the plasma cutter unit in regular intervals. The unit supplies iron sheets from the end of the unit to the possible cutting point with constant power but it is difficult to ensure accurate alignment at the end point by the inertia that is caused by guide rollers. The automatic feed unit is designed to secure reliability of cutting and to reduce costs by stable supply of Iron sheets. This unit was designed to be installed at the end of the frame and to driven by the two pneumatic motors. This unit was designed to minimize backlash that is between rack and pinion gear and then the rack gear that is installed in H-beams was designed to maximize usage.



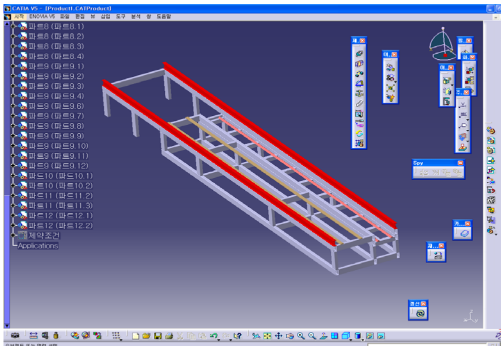
[Fig. 3] Front view of flat-iron auto supply and transport unit

3. Structural Analysis for Design Optimization

The automatic transfer unit is equipped with a total of 40 iron sheets. It is 6000x65x16t in size and approximately amounting to 3 ton in weight. The system's main frame is manufactured by square pipes, but the system cannot perform normally in occur corresponding to approximately 3 ton load variations. In this paper, we performed the structural analysis to design a optimized device structure and to prevent the problem of structural defects. The modeling was used for CATIA[4] and the structural analysis was carried out with the commercial analysis program ANSYS[5][6].

3.1 Modeling of Body Frame Unit

We practiced 3D modeling through CATIA based on drawing which was designed by AutoCAD to determine the strain and stress distribution of the main frame. Figure 4 shows a process of the system's body frame unit modeling by CATIA, the picture at the top left shows the tree structure of the system. The system's main frame unit is assembled with a total of 61 parts. We used assembly design supported from CATIA program to assemble main frame parts[7][8]. To assemble each part as close as possible to the actual figure, we applied a total of 160 figure constraints. After we assembled each part by inputting property, represent the load and color of the structure and the real actual figure was confirmed by the design.

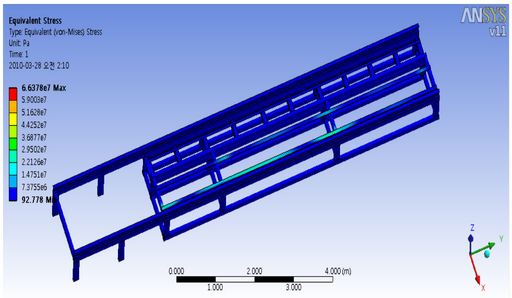


[Fig. 4] Body frame unit modeling by CATIA

3.2 Analysis of Stress Concentration

By using ANSYS we performed structure analysis, the cart of rail equipped with iron sheet bundle. The stress analysis is the task of determining dimensions by calculating the stress applied to structure and considering both types and kinds of damage so that applied stress have a value below the allowable stress [9].

Through the analysis, the result of stress concentration is below 3.5 pa and we could see that quite stable. Furthermore, after the analysis of deformation and stress distribution caused by supported 8 iron sheets loads to the system's driving unit, the maximum value of Equivalent stress was calculated approximately 29.5Mpa and it was significantly smaller than 250Mpa, yield strength of material. This result shows the deformation and stress distribution on the driving unit belong to stress range, and proves that the design has secured enough. Figure 5 shows the analysis of stress distribution of flat iron supply unit.

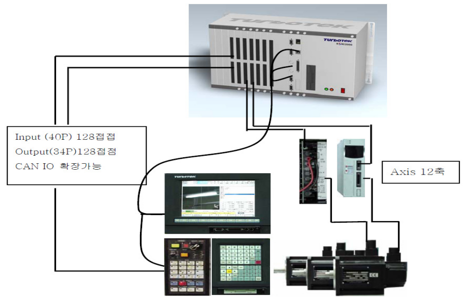


[Fig. 5] Analysis of stress distribution of flat iron supply part

4. Design and Production of Control Device

4.1 PCNC Controller

Existing NC machine designates figure at specific computer and then it operates such as NC lathes and machining centers in the limited program. On the other hand, PCNC(Personal Computer based Numerical Control is next-generation numerical control machine, which has unlimited scalability, openness and user-friendly of PC[10]. In this paper, HX-Deluxe PCNC of Turbo Tech was adopted as NC controller to guarantee the openness, scalability and high-speed/ high-precision control, and those are suitable to a general purpose machine. Figure 6 shows the configuration of PCNC.



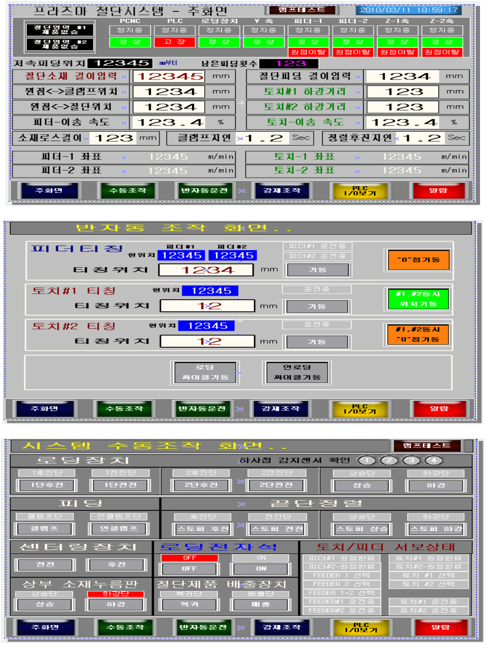
[Fig. 6] System configuration using PCNC

4.2 Control Panel Program

PCNC control panel display let operator monitor the status of the system efficiently, and the display should be operated easily in the right time. We consider the convenience of operator and divide the display into main screen, manually operated screen, semi-automatic operated screen and system control operated screen. The each screen with touch-screen system was designed to operate the various parameter setting, monitoring, failure display function, and automatic operation pattern registration function which are necessary to system operation. When each button is clicked in display, considering the convenience of beginners and operator, the appropriate screen is shown.

Figure 7 shows the main screen of control panel developed to operate and monitor the system. When the system is started after power on, the main screen is shown. Status display informing behavior of the control system is shown at the top of the screen, and there is a part to set important information in the middle of screen such as cutting material, cutting starting point, feeder feed rate and coordinate, the torch falling away, the torch traverse speed and coordinates.

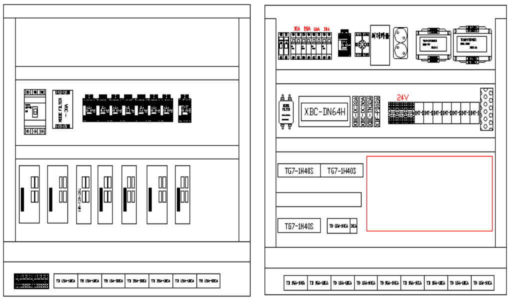
Also the buttons for the PCNC operation were placed at bottom of screen.



[Fig. 7] Snapshots of Control Panel Screen

4.3 Control Unit

The control unit which controls each parts and monitors cutting process was designed to provide accurate control performance and high quality of cutting through velocity control and cutting/machining process control[11]. The control device consists of input and output part, math control part and servo control part. The input and output part performs NC program input, conversion and distribution of inputted information and external input / output signal processing. The math control part performs positioning, feed rate, performing operations and interpolation through NC program from input/output part. And the control part consists of microprocessors, memory storing various data and programs and PLC operating the machine by sequence program. The developed control configuration is shown in Figure 8.



[Fig. 8] Internal configuration of CNC Control Module

5. Field application

The system consists of a machine part and a control part, also two plasma cutting machines are equipped. For the performance test of developed system, the basic driving test and cutting test were conducted. The driving test was conducted to confirm moving of every machine part except cutting work and we examined the each part through manual control of control panel. After we loaded 40 iron steels to cart, we carried out iron sheet transfer, sort, auto supply and the process of plasma cutting work in order. In one cycle, transferring 8 iron sheets took 22 seconds, sorting process took 3 seconds and auto supply process took 12 seconds so the results were to shorten the initially planned supply time of the system. Figure 9 shows a cutting test of the system in field and Table 1 shows productivity of before and after by using of the flat-iron system.

[Fig. 9] Cutting test of the flat-iron system in field

〈Table 1〉 Compared to the productivity

Factor	Before	After
Worker	5	1
Process	LOT × process	4
Lead time	LOT × C/T	Track time
Workspace	15m×10m	3m×15m
Track time	32 seconds	8 seconds

6. Conclusion

In this paper, we designed and developed of a flat-iron automation system to improve the productivity of small ship building manufacturer. The developed system for flat-iron was able to design the optimal products by converging machinery, computer and electronic technology. CATIA and ANSYS package was used for the optimal design of the system's machine part and PCNC-based control device was made and equipped with nesting program for the automated cutting. The flat-iron automation system have achieved the effect which increases productivity through the reduction of manufacturing costs, improve processing quality and the working environment of workers in the field of shipbuilding.

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