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A Study on Automatic Drilling Machine for Manufacturing the Truck Cargo Box

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Abstract

In this paper, we show the design and contents on the developments of the apparatus for manufacturing the cargo box gate panel. This automation apparatus was developed to substitute for human labor. This is driven on the rail. After detecting the location of hinge and adjusting the drilling location by manual, the automation apparatus carries out drilling automatically. Multi axis drilling unit is used to get 3 holes with 1 operation at once. At recent manufacturing sites, the introduction of automation equipment is broadly being attempted for saving labor costs, alleviating work intensity, and improving productivity in various areas. As for the manufacturing factory for cargo box of large-sized trucks, the entire process depends on labor at this high-intensity manufacturing site. Especially, the gate fixing on both sides of the cargo box takes about 7 people who execute drilling and assembly. The purpose of this study is to design and produce such series of tasks which can be completed by two laborers. In this report, the apparatus and system design, control method to develop auto-drilling machine is introduced.

Keywords: *Automatic Drilling , Truck Cargo Box, Structure Design , Control Program, Manufacturing process*

1. Introduction

At recent manufacturing sites, the introduction of automation equipment is broadly being attempted for saving labor costs, alleviating work intensity, and improving productivity in various areas. As for the manufacturing factory for cargo box of large-sized trucks, the entire process depends on labor at this high-intensity manufacturing site. Especially, the gate fixing on both sides of the cargo box takes about 7 people who execute drilling and assembly. The purpose of this study is to design and produce such series of tasks which can be completed by two laborers. In this report, the apparatus and system design, control method to develop auto-drilling machine is introduced [1-3].

The truck cargo box consists of cross sil which is placed on top of the frame as the framework, floor board arranged on top of the cross sil, side frame fixing the form of floor board, and gate which combines to side frame. The left photo of Figure 1 shows fixing the gate to the floor using clamp in order to bind cargo box gate and floor. Here, the stick hanging

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vertically down is hinge. On the right is the cargo box gate completed with hinge binding works.

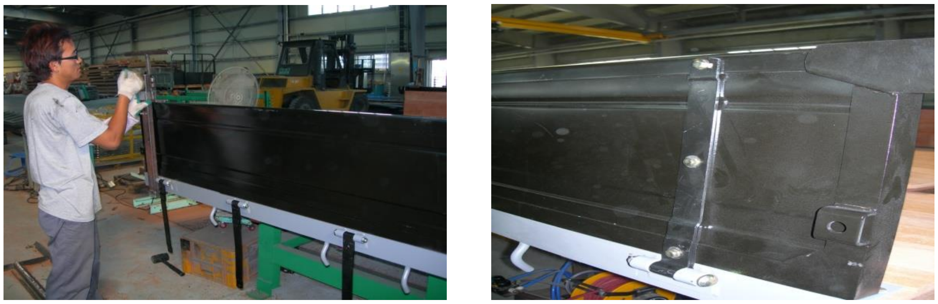

Figure 1. A hinged gate of truck cargo box

In this study, the auto-processing device for fixing vertical position of hinge and processing hinge hole is developed. Figure 2 shows the order of cargo box processing. This study developed an automation equipment for automation of manual labor for gate and body assembly process among the truck cargo box manufacturing process.

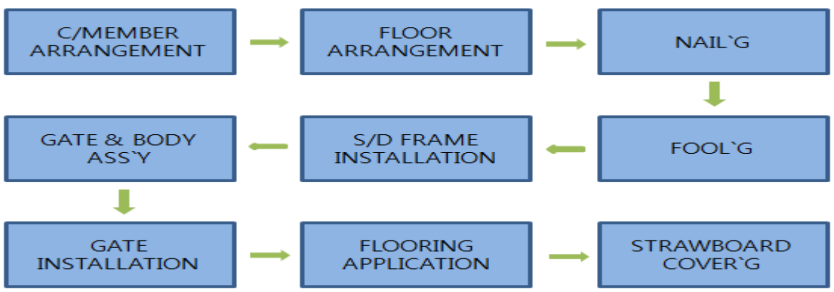

Figure 2. Manufacturing process of truck cargo box

The manual labor process of gate & body assembly is shown in Figure 3. The cargo box gate is fixed to the floor with clamp (Figure 1) and the hinge hanging downward is lifted manually, and after marking the vertical position, a hole is bored on the gate to pass through the hinge hole using a manual drill. The drilling is executed for the number of holes on the hinge, and through bolting on the bored holes, the hinge is fixed to the gate. In this study, the process of Figure 3 by manual labor (hinge loading, hinge drilling position marking, drilling, and bolting) is automated using dedicated equipment [4-6].

(a) (b)

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(c)

(d)

Figure 3. Manufacturing process of handwork

Figure 4 shows the order to task using auto-drilling machine developed in this study. It was designed so that the control panel for control and operation of the device is loaded on the device, and the worker follows along and manually manipulates and makes corrections where safety is needed.

The auto-drilling machine developed in this study employed AC motor and rail for operation, and pneumatic cylinder, ball screw, and L/M guides were used. For sensing, contactless close-range sensor was used. PLC program was used to control overall behavior [7-9].

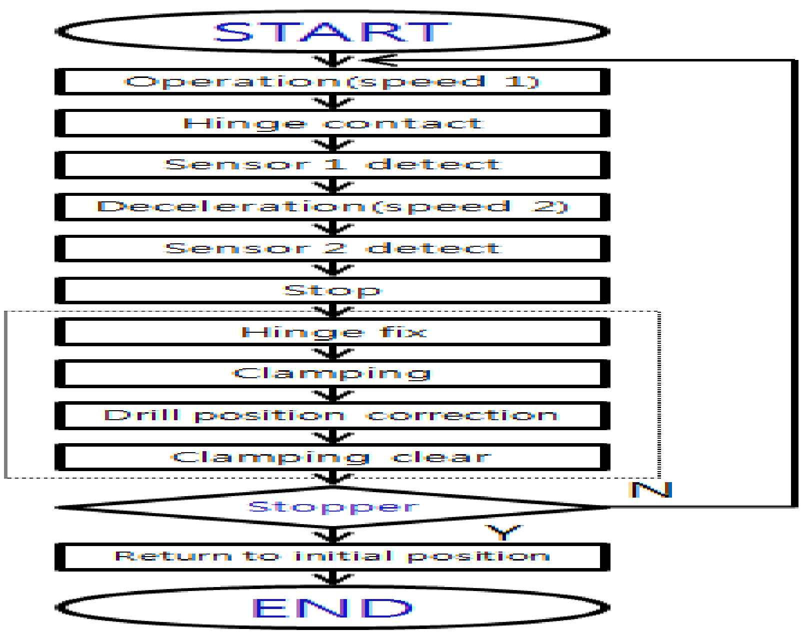

Figure 4. Working process for automatic drilling machine

2. Apparatus and Structure Design

2.1 Structure Design

The structure design employed 3D design software CATIA V5. Figure 5 shows 3D design blueprints. Each is the front view and the side view.

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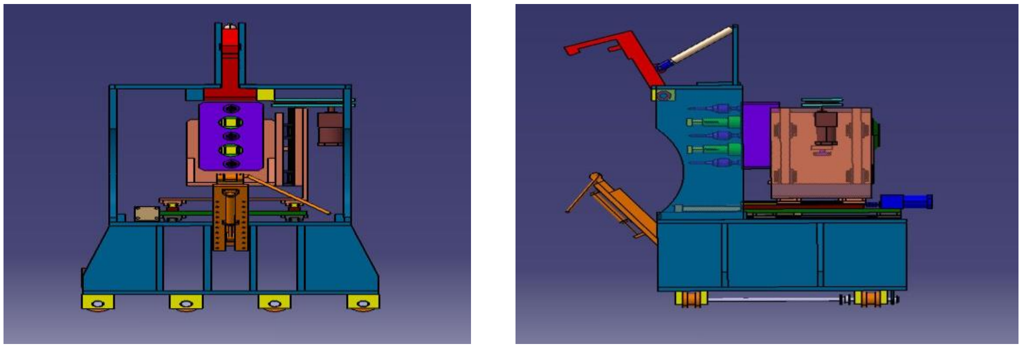

Figure 5. The shape of three dimension for automatic drilling machine

2.2 Operative Component Design

The operation involved usage of 3-phase 220V motor (1.5 horsepower). The power delivery for the axis used a chain, and total of four operative axes were taken so that it can pass smoothly even through where the rail is disconnected on the rail in the process.

2.3 Multi-Axis Operative Component

Multi-axis drill was designed so that three drills can rotate at the same time. Multi-axis drill has the capacity of 220V 3-phase 5kW, and was designed to be controlled by PLC. It was designed so that forward/backward primarily used pneumatic cylinder, and the thrust needed for actual drilling was achieved at the secondary forward/backward process using ball screw.

2.4 Top Fixture

It was designed so that cargo box gate is fixed at the work position, clamp is installed at the top to generate reaction by thrust according to drilling, and as the position is determined, the pneumatic cylinder can be manipulated to fix the gate. The clamp shape was designed to be able to support the lumber behind the gate.

2.5 Hinge Fixture

The hinge fixture consists of cylinder operative component and arm which lifts the hinge and brings it up to the ascension position according to the progress of the device.

3. Sensing and Control Unit Design

The control unit is attached to the side of the machinery, and includes PLC unit. Figure 6 shows the machinery with the control panel attached and the control panel itself.

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Figure 6. The mounted panel for control

3.1 Control Program

The sensing united of this development consists of stopper to stop the device at the start and end of the rail, contactless sensor for primary detection of hinge, secondary sensor to detect the hinge rotation position, contactless sensor to detect the final forward/backword position of the multi-axis drill, contactless sensor to detect the upper/lower transportation limit of multi-axis drill, and forward/backward position detection sensor of each cylinder. The control program for the device control was created with PLC. Figure 7 shows the detailed flowchart of sensing and motor control including transportation between hinges.

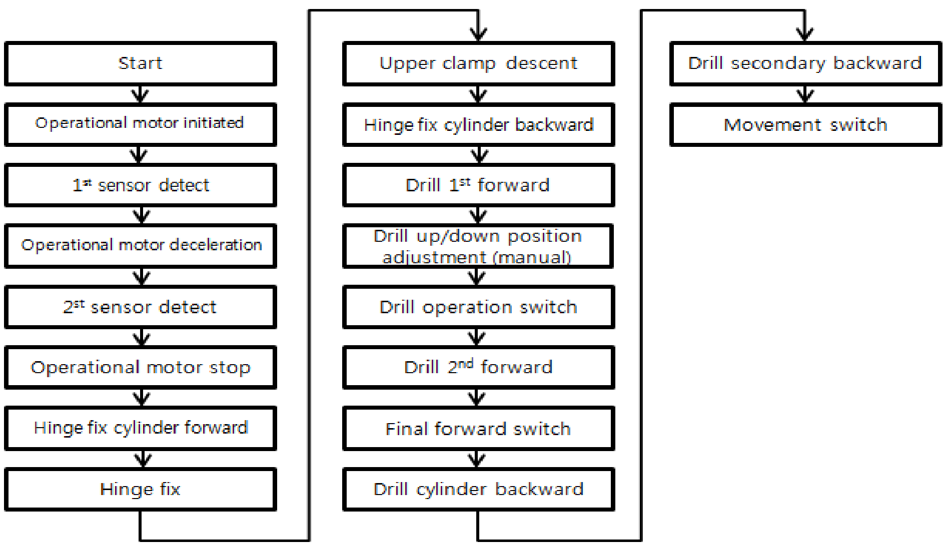

Figure 7. The flowchart of working process

4. Conclusion and Considerations

The device developed here was produced one each for left and right of cargo box, and was installed on site. Figure 8 shows the site installation. The effect of productivity improvement and work intensity reduction through this development is as organized in Table 1. For gate and floor assembly, the input manpower was reduced from 5~6 to 2 excluding bolting job, and the entire job duration including bolting was reduced from 30~40 minutes to 25~30 minutes.

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Figure 8. The shape of mounted panel

Table 1. improve effect of automatic drilling machine

Classification	Original Manual Labor	After Application of Developed Equipment
Number of Resources (excluding bolting)	5～6	2
Hole Precision (mm)	11.2±0.8	11.2±0.3
Task Hours	35～40 min	25～30 min
Task Intensity	Very high	Low
Risk of Industrial Accident	Exists	Almost none

As the result of performing this technology development, the cycle time it takes for a single hole for the task duration of hinge (hole) was measured, and it can be seen that all are completed within 3 minutes (semi-automatic). It took total of 1621 seconds for 14 hinges, and the task between hinges took average 115.8 seconds, which is about 2 minutes.

Figure 9 is the result of measurement and evaluation of processed holes. As the result of three repeated measurements, it can be seen that all were within the range of 11.0 to 11.3 mm. It can be seen that there is no large deviation by the hole position. As for the upper hole, the average was 11.19 mm, middle hole was 11.18 mm, and lower hole was 11.19 mm, showing that the average values are almost the same. This implies that because the processing is achieved not manually but fixed with a mechanical device, there was almost no deviation of hole sizes.

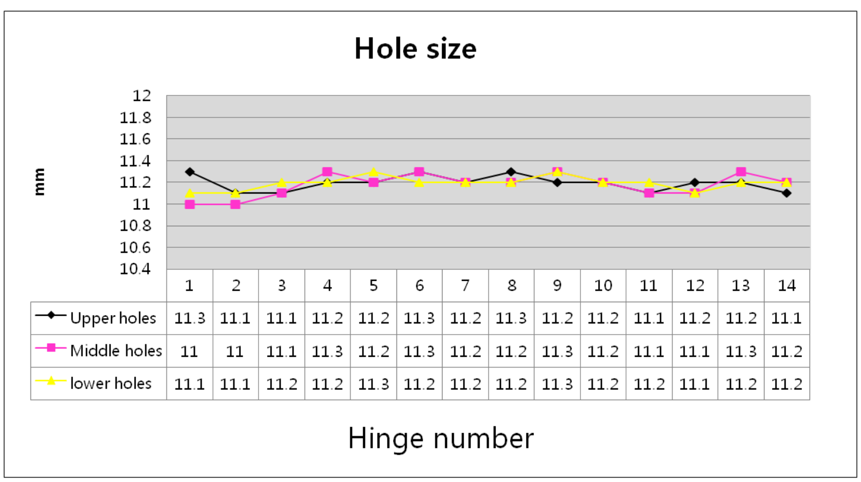

Figure 9. The relation between working hole and hole size

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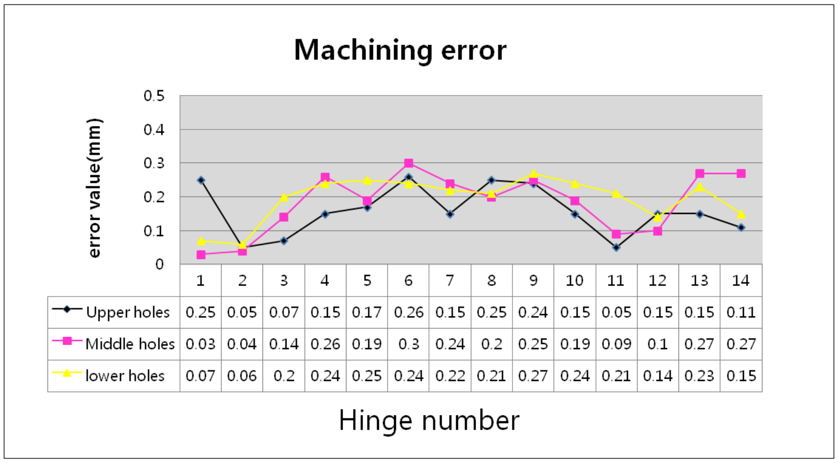
Figure 10 shows the position precision measurement result. The measurements at each hinge shows that all are within 0.3mm of error bound. The position error was 0.16mm on average for the upper holes, 0.18mm on average for middle holes, and 0.2mm on average for lower holes, which is very minimal. Unlike manual labor, the automatic job has the drill attached to a single body so that only insignificant errors occur.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper holes	0.25	0.05	0.07	0.15	0.17	0.26	0.15	0.25	0.24	0.15	0.05	0.15	0.15	0.11
Middle holes	0.03	0.04	0.14	0.26	0.19	0.3	0.24	0.2	0.25	0.19	0.09	0.1	0.27	0.27
lower holes	0.07	0.06	0.2	0.24	0.25	0.24	0.22	0.21	0.27	0.24	0.21	0.14	0.23	0.15

Figure 10. The relation between working hole and observational error

5. Conclusion

The conclusion of this study is as follows.

1. The production of equipment for originally labor-dependent task of processing cargo box of commercial vehicles was able to save labor and greatly reduce the task intensity.
2. The introduction of dedicated automation equipment greatly reduced the potential for safety accidents from tasks.
3. The introduction of dedicated automation equipment improved productivity, reduced defect rate, and reduced quality dispersion.

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