Technical Papers

Development of Assembly Work Control System

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Since we cannot expect that the demand for construction machines will greatly increase, we are working on a developing and producing process which can feed back the market needs to the design and manufacturing sections more quickly to increase the throughput. As a part of these activities, various manufacturing field information systems have been developed and introduced in the manufacturing fields.

In this paper, we will report on an assembly work control system that we developed to increase the efficiency of assembly work.

***Key Words**: Information Technology, Build To Order, Working Standard Procedure Sheets, Quality Assurance, Computer Aided Design, Computer Aided Manufacturing*

1. Introduction

We are developing and introducing manufacturing field information systems to construct flexible production systems to be applied to build-to-order service. In this paper, we will report on an assembly work control system as an example of those systems which we developed to increase the efficiency of assembly work.

A large-sized assembly line to manufacture bulldozers, large-sized hydraulic excavators, and mobile crushers is a typical multi-type and small-lot production line on which the products are sent one by one.

In the past, workers had to find applicable sheets in many standard work tables and check the working procedure in those sheets while they were assembling construction machines of various kinds. It was difficult even for a skilled worker to memorize all the working procedures for a machine which is assembled only once a year. Accordingly, workers had to search for and read the standard work table. Naturally, this matter was a large problem in terms of both working efficiency and quality assurance.

To solve this problem, we developed and introduced an assembly work control system with which we were able to make work plans, output detailed work directions, input work result easily, and analyze the collected work results.

2. Features of system

For high throughput by the build-to-order service, the system must have function of efficiently making personnel arrangement plans on a good line balance and eliminating useless work to increase productivity, and assure the quality traceability.

In response to these demands, we developed the system having the following features.

(1) Reading production plan and making work plan

This system reads the production plan from the factory production control system every day and makes a personnel arrangement plan, counting in the line balance. With this function, we can make a work plan containing no process loss and can form the process easily.

(2) Display of work direction easy to understand and information necessary to the field

Products of various types flow on the line. It is difficult even for a skilled worker to memorize all the working procedures for a product which has special specifications and which is assembled only once a year.

Then, this system gives easily-understood work directions using images and voice. Since the correct directions on the assembly procedure and inspection are given, we can assure quality perfectly.

Furthermore, this system can be used with other manufacturing field information systems to reduce useless work processes by displaying information on inspection and missing of parts.

(3) Easy input of work results

Understanding the work results in real time is essential naturally for giving detailed work directions according to the current condition of the manufacturing field where unexpected problems can occur.

To meet this requirement, we designed and built a system with which workers can input the start and completion of each job.

(4) Reflection of measures to solve problems quickly in work directions

If problem such as delay of the work occurs, we can change the arrangement of the workers, work order, etc. quickly in the work directions.

(5) Analysis of collected work results

We can constantly make improvements by analyzing the collected data of past work, extracting points to be improved such as useless work, and correcting standard work.

(6) Wide choice of means to input and output

We can choose proper means to input and output by making program modules for each function and applying those modules to various workplaces where different functions are required. (**Fig. 1**)

In addition, we can minimize the cost of development of additional functions and modification of the existing functions.

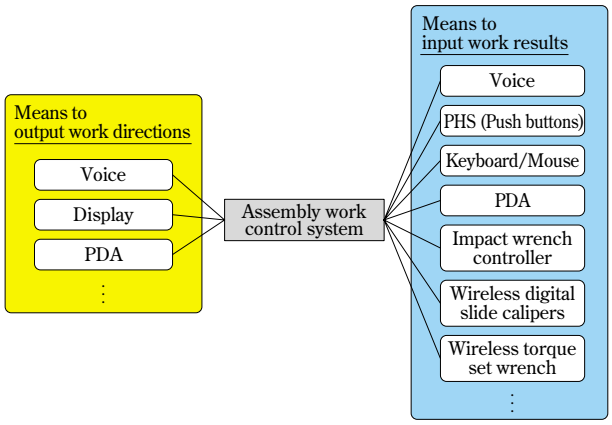

Fig. 1 Modules of application software

3. System configuration

The following is the configuration of the system we constructed. (**Fig. 2**)

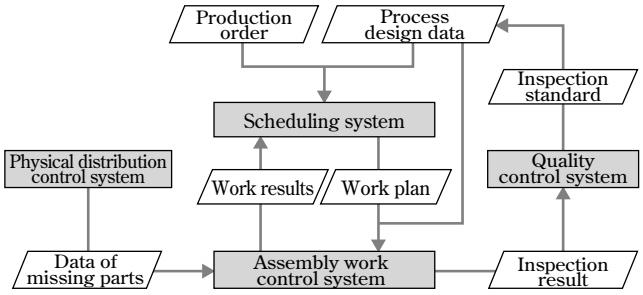

Fig. 2 Rough system configuration

(1) Scheduling system

If production order (date of production, production order, models, serial number, and specification information) and process design data (models, specification information, processes, man-hours, and worker information) are input, this system outputs the model, workers, working time, etc. for each process, considering the conditions of the workers.

(2) Assembly work control system

This system gives detailed work directions and collects work results according to the work plan and process design data (models, specification information, processes, work order, contents of work, standard working hours, images, etc.)

Each worker works according to the given directions and inputs the start and completion of each job. The work results are reflected in the scheduling system.

(3) Quality control system I/F

By cooperating with the quality control system which controls the inspection information on the parts and machine bodies, the assembly work control system can control the quality data at one place to realize perfect quality assurance.

The inspection standard received from the quality control system controlled by the inspection section is registered as the contents of the work directions in the process design data. The inspection results collected by the workers are transferred through this system.

(4) Physical distribution control system I/F

By cooperating with the physical distribution system which controls the information on delivery and transportation of the parts, the assembly work control system can display missing parts for each process. (Since the physical distribution control system is under modification, it is not yet connected.)

Fig. 3 shows a typical flow of data in the system and **Fig. 4** shows a typical system hardware configuration.

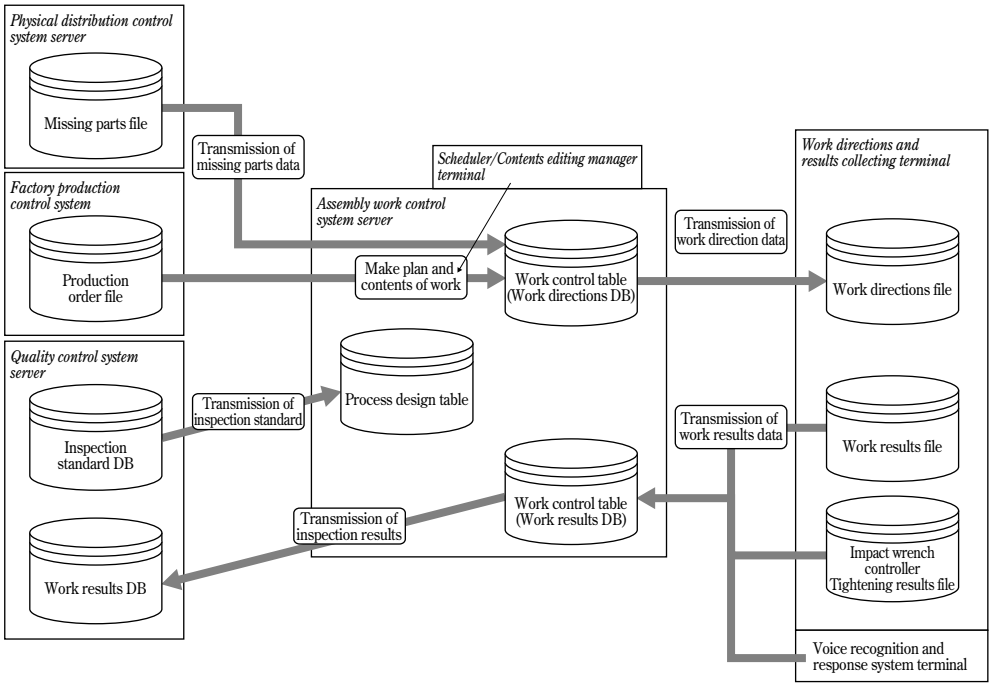

Fig. 3 Flow of system data

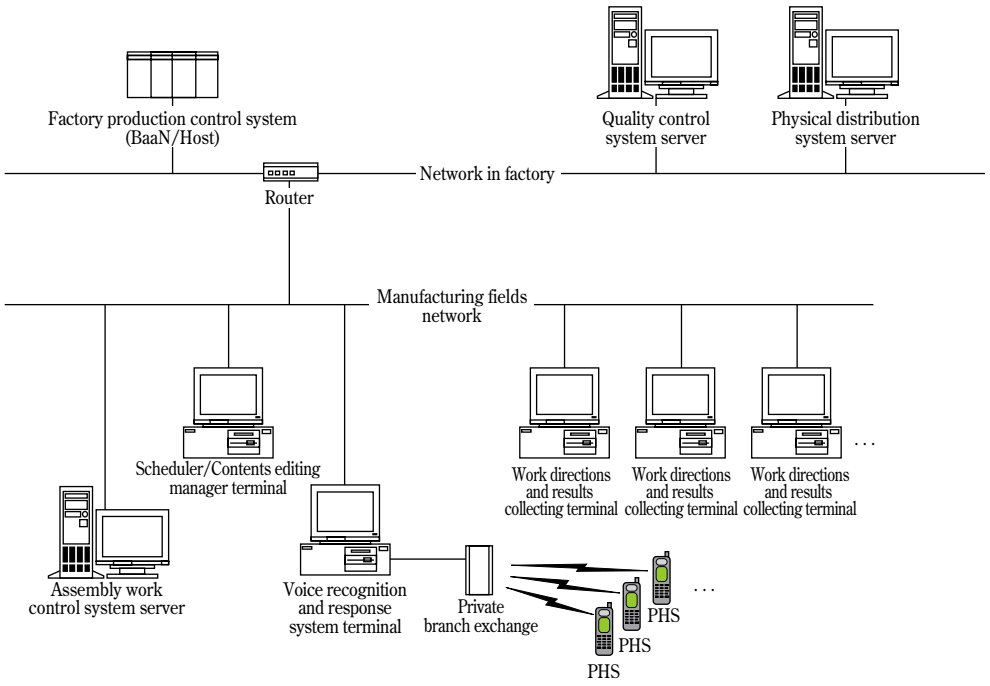

Fig. 4 Hardware configuration of system

4. Functions of assembly work control system

We will describe the main functions and features of the assembly work control system below.

(1) Work directions and results collecting terminal

(a) Main functions of giving work directions

Work directions are made on the basis of the production order and process design data, then detailed work directions are given by voice and images.

The contents of the work directions (models, specification information, processes, work order, contents of work, standard working hours, images, wording, etc.) are registered as process design data by model and specification of the products. Information on past trouble is fed back to the work directions quickly to improve quality.

The image data, which are a part of the contents of the work directions, must contain the information on each part number and important points of the quality and must be made so easy to understand that even an unskilled worker can work by himself (herself) if he (she) sees them. Accordingly, those data are used as tools to increase the number of workers who have multiple skills.

Much of the image data used currently are based on the photos taken with digital cameras. If a model is developed by means of 3-dimensional CAD, however, we will use the 3-dimensional data effectively instead of the photos.

Fig. 5 shows an example of the main screen of the work directions.

This example is the work directions screen displayed 4 seconds after the worker "Hamamura" started the job *2 "Permanent tightening of both mounting bolts of P/L" in the major work division of *1 "Assistance in mounting P/L" in the "5th process" of the products of "D155A-3", the standard working time of which is "2 minutes 10 seconds". At the same time when the worker starts the above job, the voice work direction for "Permanent tightening of both mounting bolts of P/L" is given, too.

Voice output from the work directions and results collecting terminal and the display connected to that terminal are prepared as means to give work directions.

If a wireless voice transmitter-receiver or a PHS is used, the voice directions can be received by wireless at a place remote from the work directions and results collecting terminal.

In addition to a desktop personal computer used as the normal terminal, a PDA, notebook personal computer, wireless display personal computer, large-sized display, etc. can be combined and used according to the requirements in each workplace.

Photo 1 shows examples of the work directions and results collecting terminal and the voice work directions and result collecting device.

Photo 1 Large-sized display (left), headset and PHS (right)

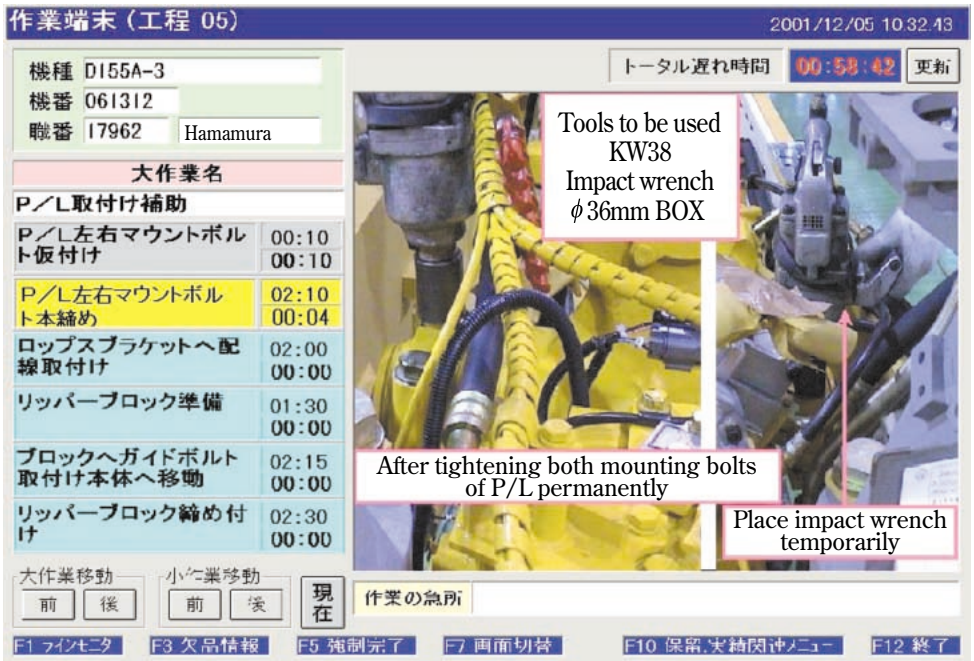

Fig. 5 Main screen of work directions

(b) Sub-functions of giving work directions

When a worker uses an impact wrench controller to tighten a bolt, the sub-screen shown in **Fig. 6** is displayed.

At the time for this work, the standard values for each model and part registered in the process design data (lower limit and upper limit of the tightening torque, number of impact, etc.) are set to the impact wrench controller connected to the work directions and results collecting terminal, and the controller judges the result of each tightening impact. If the result is judged bad, the worker must loosen the bolt and tighten it again similarly or must tighten it by hand (without using the impact wrench controller) to leave only the normal tightening result.

Fig. 6 Work direction sub-screen

Since the bolt to be tightened next is shown on the screen, the worker can tighten all bolts in the same order every time. Accordingly, the quality is kept consistent.

(c) Main functions of collecting work results

The worker can input the start and completion of each job with a remote controller, a voice device based on a voice recognition and response system, or the keyboard and mouse of the work directions and result collecting terminal.

If the worker uses a headset (Photo 1) to collect the results by voice with a PHS, he (she) can collect the results with his (her) hands free. The worker can select work plans and collect the basic work results by using several words such as “Finish”, “Interrupt”, etc. which are set in the voice recognition and response system and pressing the push buttons of the PHS.

Fig. 7 shows a rough flow of jobs of giving voice work directions and collecting work results through the PHS.

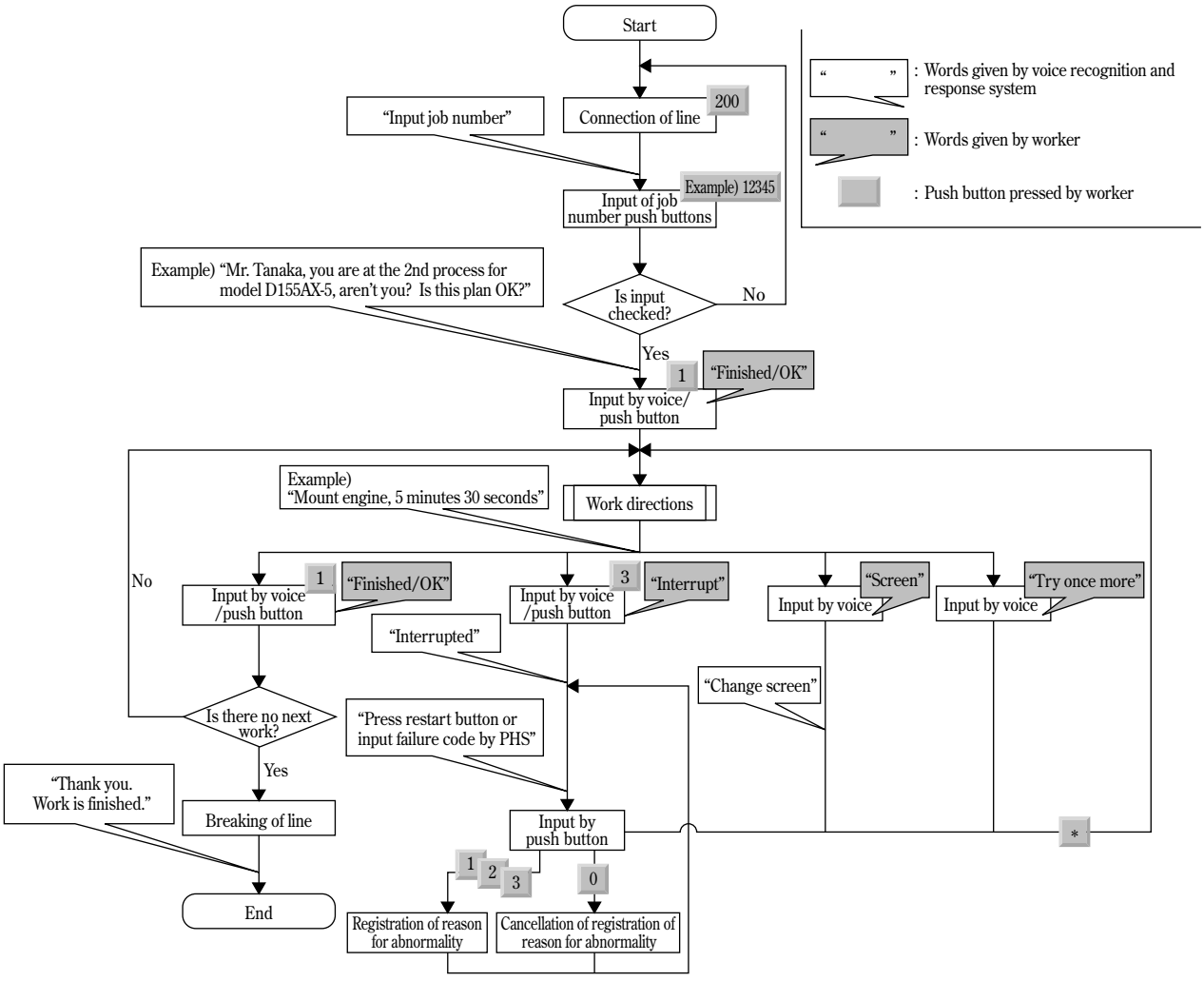

Fig. 7 Rough flow of jobs to give work directions and collect work results by voice

(d) Sub-functions of collecting work results

For jobs concerned with inspection in the work directions (input of visual inspection result, input of stamp number, and input and judgment of measured values), the sub-screen shown in **Fig. 8** is displayed to input the work results.

Fig. 8 Sub-screen for collecting work results

(2) Server

(a) Function of displaying operating condition table of line

The server displays the real-time operating condition table of the client connected to this system (processes, models, serial numbers, workers' names, and progress). The progress of each worker can be determined by coloring the delay and lead from the standard working time set for each work item.

The manager can grasp the progress in the field at a glance from the office.

Fig. 9 shows a sample screen of the line monitor.

Fig. 9 Screen of the line monitor

(b) Function of displaying work results

The Gantt chart of the work results by worker is displayed.

The manager analyzes the data, extracts and solves problems, and corrects the process design data repeatedly with this function to continue improvement.

Fig. 10 shows a sample of the work results screen.

Fig. 10 Work results screen.

5. Examples of application

The following are examples of application of the above system.

(1) Assembly line for bodies of large-sized construction machines

On this line where the above system was introduced for the first time, work directions are given by a large-sized display. In addition, the work directions are also given and the work results are collected through a voice recognition and response system and PHS. Workers can perform these operations with their hands free.

(2) Assembly line for parts of large-sized construction machines

On this line where the main work is to tighten bolts with impact wrench controllers, ordinary personal computers are used to give work directions and collect the results.

We are now introducing the above system to the sub-assembly line for the bodies of large-sized construction machines, assembly line for medium-sized engines, and assembly line for custom machines.

6. Conclusion

In this paper, we introduced the system used mainly for supporting the assembly work by giving detailed work directions by voice and images and collecting the work results by voice and remote control to improve the quality and productivity.

In the future, we will examine and develop tools to reflect frequent design changes in the work directions quickly and systems to efficiently use the 3-dimensional design data for the work directions in cooperation with the CAD/CAM systems.

Introduction of the writers

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[A few words from the writers]

If the functions of this system are improved and utilized fully, cooperating even more with other systems, the culture in the conventional manufacturing fields can be changed. We intend to develop production systems mainly for the manufacturing fields to make up flexible factories directly coupled with the market for build-to-order service.