Technology Introduction

Development of Quality Data Control System

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1 Introduction

The Casting Center of KYB-YS Co., Ltd. manufactures casted materials for valve housings (Photo 1) for control valves used in hydraulic excavators. Since a valve housing controls various actuators, such as hydraulic cylinders and hydraulic motors, it houses complex hydraulic circuits (Photo 2). In addition, casted materials are manufactured by setting the core in a mold and pouring in molten metal. However, sophisticated manufacturing technologies and quality control systems are required for production, due to the fact that we cannot manufacture stable products if there is the slightest deterioration in any of the manufacturing conditions.

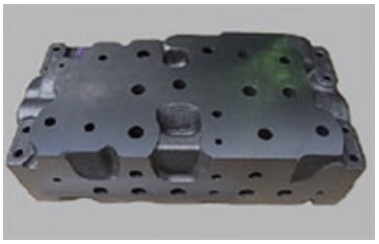

Photo 1 Valve housing

Photo 2 Product cut sample

However, our quality control had depended on the experience and intuition of expert engineers in conventional production. We did not used to be able to perform sufficient quality control utilizing quality data from manufacturing. Since quality data was actually only collected from processes that were deemed important, it sometimes required a lot of time to identify the cause in the case of a product failure or prevented us from identifying the true cause because we could not trace the problem sufficiently.

Therefore, we have developed a system to collect the manufacturing quality data from all processes on all products that can be traced back at a later stage. I would like to introduce this system.

2 Objective of System Introduction

While the ultimate objective for this system introduction was to reduce the defect rate, we developed the system by following the below steps incrementally.

① Collection/visualization of quality data
② Identification of failure cause
③ Prevention of failures

In this review, I would like to introduce the contents of the above ①.

3 Overview of Production Lines

Fig. 1 shows the flow of all production lines in the Casting Center of KYB-YS Co., Ltd.

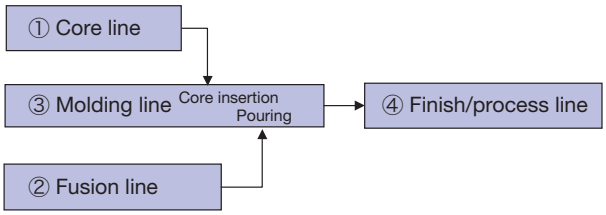

Fig. 1 Flow of all production lines

Main contents of production for each line are as follows:

① Core line
A cast is filled with sand and fired. Following this, the core is produced after assembly and finishing work (Photo 3).

② Fusion line
Metal and various materials are melted at high temperature to produce molten metal.

③ Molding line
Sand is packed in the cast and cured to produce the mold. After this, we set the core, which was produced in process ①, in the core-setting process. In the pouring process, the molten metal, which was produced in process ②, is poured into the mold. It is then cooled down, and the casted product is removed by dissembling the mold.
④ Finish/process line
Shot/inspection/machine processes are performed on the casted product, which has been taken out of the mold, and the product is finished.

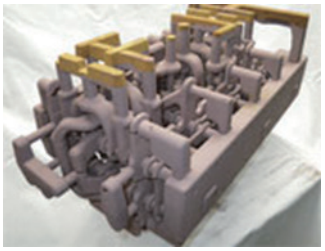

Photo 3 Completed core

This system targets collection of all data from all production lines. Especially with the core, mold, and molten metal, we ultimately do not have the actual objects in the end due to the nature of the casting method. Therefore, it is difficult to trace them back at a later stage even if we collect quality data. The key to this technology development is to enable us to trace them back.

4 System Configuration

Fig. 2 shows the system configuration. The basic flow of the system is to collect the quality data on a real-time basis from the touch panels, which are installed in facilities or in manufacturing sites, and to enter the data in the database (hereinafter referred to as "DB") server. We have also established a system to instruct the production part numbers and sequence by registering the production plans (plans for the molding line and fusion line) on a PC beforehand and forwarding the plans to touch panels and facilities (details are explained in Section 6).
Overview of each piece of equipment is as follows:
① DB server
Used to integrally manage various types of master data related to this system as well as collected quality data.
② PC
Used to browse collected quality data and register production plans and various types of master data by using the software for PCs used in this system.
③ Touch panel
Used to input items that require decisions by people that cannot be collected from facilities (notice information Note 1), failure location, evaluation result, etc.) and display production plans, work standards, etc.
④ Facility
Used to collect quality data measured by sensors and measuring equipment at the time of production.

Note 1) Refers to information that workers notice or were concerned about in the course of performing tasks.

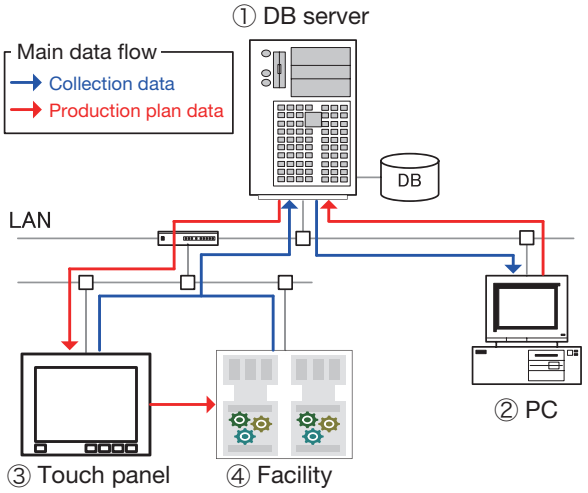

Fig. 2 System configuration

5 Systems to Identify Individual Items and Link Data

5.1 Overview of serial number generation and linking

In order to trace quality data, which is collected in each process, from produced products, we need to link quality data with information that enables us to identify the product. Therefore, we decided to generate a serial number Note 2) for each product and intermediate product Note 3) produced in each line and link it with quality data to collect data. Fig. 3 shows the flow of serial number generation and linking flow.

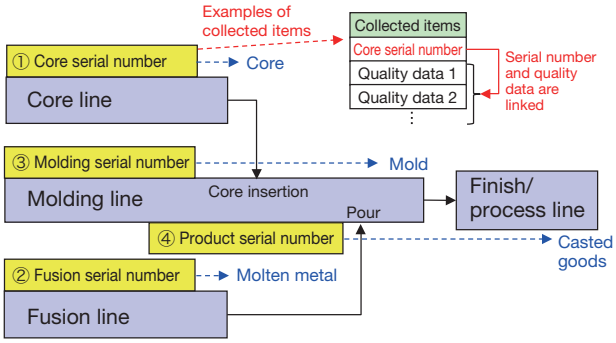

Fig. 3 Flow of serial number generation and linking

Serial numbers are generated for each of the cores, molds, molten metal, and casted goods (products). When a product and each intermediate product are combined, each serial number is linked. The linking process applies to the core insertion process in the molding line and the

pouring process. Linking information for each serial number is saved on the DB server so that relevant serial numbers can be searched among serial numbers as necessary. Through this process, the system enables quality data tracing (trace back) in each process from casted products as well as casted products tracing (trace forward) from intermediate products, such as molten metal.

Note 2) Refers to unique numbers that are not redundant with others. In this system, they are generated in the format of "manufacturing symbol-production date-additional number".

Note 3) Refers to products, such as cores, molds, and molten metal, that are produced in the middle of production processes, rather than final products.

5.2 How to link serial numbers to actual products

The generated serial numbers must always be linked with the target products/intermediate products. The common method is to directly print serial numbers on actual products, and we actually use this method to link serial numbers to casted products. However, it was technically and physically difficult to directly print numbers on other intermediate products due to the fact that the actual products were sand and molten metal. Therefore, we used another method to link serial numbers.

Fig. 4 shows how serial numbers are linked with cores.

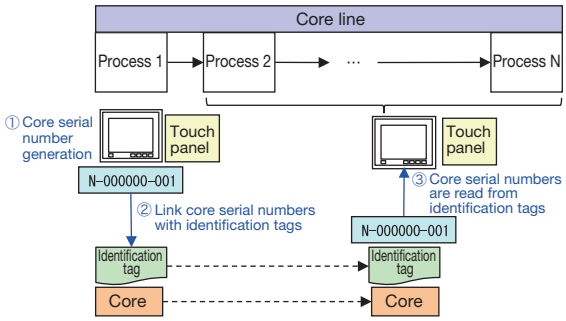

Fig. 4 How serial numbers are linked with cores

At the core line, we attach identification tags to each core so that we can identify the core at one glance. The identification tags include information, such as the part number and identification number to identify the identification tag, as well as the QR code that contains such information (Fig. 5). In this development, we have linked a serial number with each core by using this identification tag. Below is the flow of linking.

① The core serial number is generated by using the touch panel, which is installed in the first process, when the production of the process is completed.

② The QR code on the identification tag, which is attached to the core, is read by the barcode reader connected to the touch panel. This work links the core serial number with the identification tag.

③ In processes following the next process, the core serial number is called by scanning the QR code on the identification tag with the barcode reader.

In addition, this method has also enabled us to thoroughly collect data (link quality data and serial number) within a short period of time.

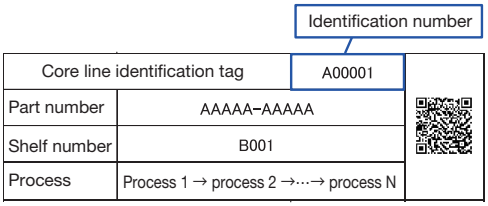

Fig. 5 Identification tag image

Fig. 6 shows how serial numbers are linked with molds.

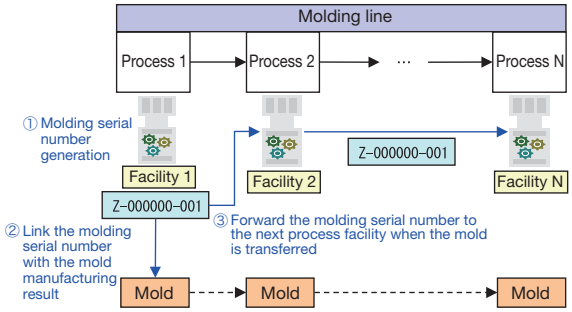

Fig. 6 How serial numbers are liked with molds

In this development, we link serial numbers to molds by using facilities in each process. Below is the flow of linking.

① Facility in the first process automatically generates the mold serial number when the production of the process is completed.

② The generated mold serial number is linked with the mold manufacturing result (quality data), which is held in the facility.

③ When the mold moves to the next process, the mold serial number is forwarded to the facility in the next process. When the production in the next process ends, the mold serial number is linked with the manufacturing result. The same flow is repeated until the last process.

The main characteristic is that the serial numbers are linked with manufacturing results rather than actual goods. With this method, we can link them by simply controlling facilities. Therefore, we have the advantages that workers are not given extra work and linking errors are also prevented. In addition, serial numbers are also linked in the fusion line with the same method as the molding line. The reason that the linking method differs for the core line is because the core line involves many manual processes and processes without facilities.

6 Production Instruction Structure

In this development, we established a system that issues production instructions to facilities and workers by forwarding the production plans, which were prepared beforehand, for the modeling line and fusion line to the facility and touch panel of each line as part of quality data control. Fig. 7 shows the flow of production instructions.

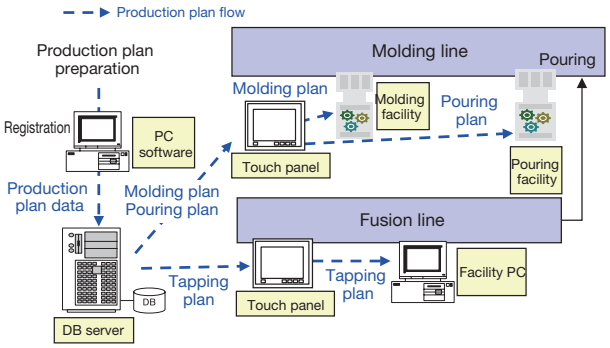

Fig. 7 Flow of production instructions

Molding plans and pouring plans are forwarded to the molding line. Molding plans include part numbers to be molded, production sequence, etc. Pouring plans include part numbers to be produced, production sequence, pouring pattern number Note 4), etc. In addition, the reason that molding plans and pouring plans are divided is because the molding sequence and pouring sequence sometimes differ due to the nature of the molten metal. Facilities perform controls so that they automatically transfer molds and pour molten metal based on these plans. In addition, Tapping plans are forwarded to the fusion line. Tapping plans include the material and weight of molten metal, which is to be tapped, target part number to be poured, etc. Facilities perform controls so that they automatically calculate the materials to add as well as their volume and inject them into the furnace based on the tapping plans. As you can see, automatic control of facilities through production instructions has reduced the number of workers and contributed to the prevention of human errors. Furthermore, we have also been generating fusion serial numbers for the fusion line based on these production plans and also linking part number information with quality data. They play major roles in quality data control.

Note 4) Numbers used to identify facility conditions when pouring. Different numbers represent different pouring volume, pouring speed, etc.

7 Features of Developed Software

In this development, we have developed software for touch panels and PCs as screen software to be operated by users. The main features are as explained below.

7.1 Software for touch panels

7.1.1 Production plan display feature

Fig. 8 is a screen that displays production plans displayed at the molding line. The screen displays part numbers to be produced, sequence, and progress (● and ▲ in the image), enabling users to comprehend the current production progress at a glance. In addition, the charge number (CH) represents the unit of molten metal, which is produced in the fusion furnace of the fusion line per production, and users can confirm the production plan for the fusion line on this screen. Therefore, in case of a problem in a molding line, you can understand which charge in the fusion line is affected and take action on the fusion line beforehand.

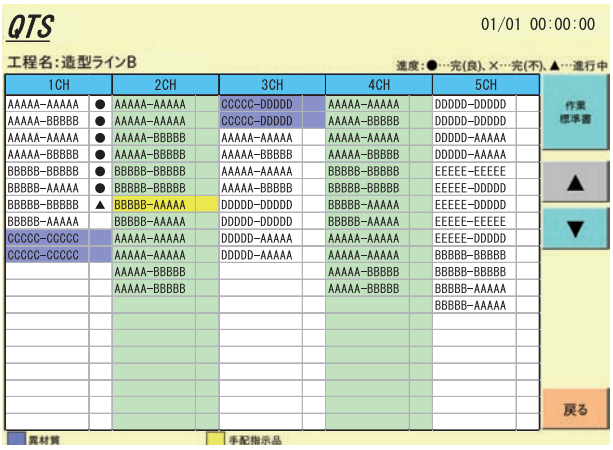

Fig. 8 Display screen for molding line production plans

Fig. 9 is the production plan screen displayed at the fusion line. The top of the screen shows charge number, process number that indicates the tapping unit per production, material, weight, etc. The tapped weight in the fusion line is different in each production, and added materials also differ depending on the nature of the material. Therefore, we must prepare by considering these aspects. You can understand the contents of preparation, which should be taken in the next step, on this screen.

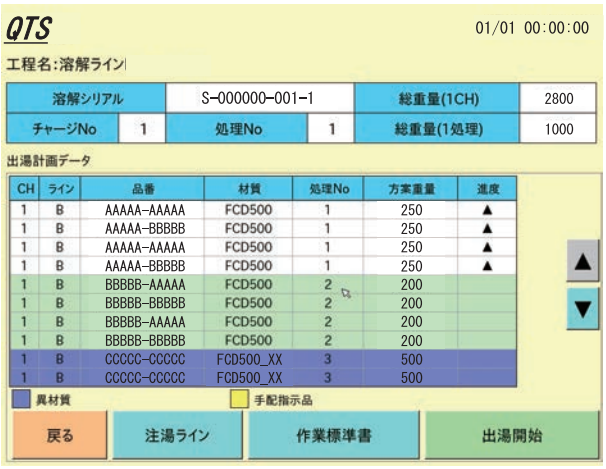

Fig. 9 Display screen for fusion line production plans

7.1.2 Notice information entry feature

Fig. 10 is the screen into which workers input information that they notice.

The screen displays a list of notice information registered for each process. Workers can input notice information by simply touching the arbitrary notice information from the list. In addition, due to the fact that notice information may be added at a later stage as necessary, you can collect information that is more accurate for the reality of the field as you operate.

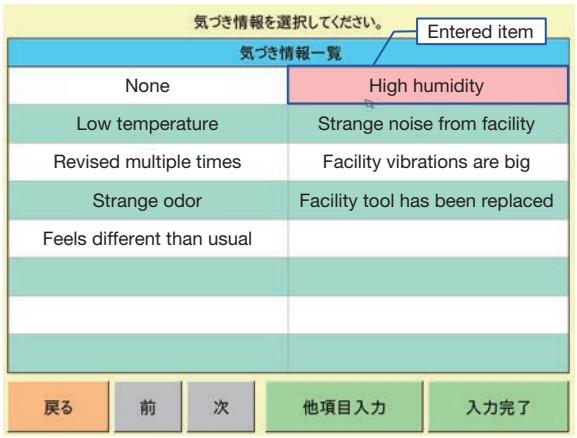

Fig. 10 Notice information entry screen

7.2 PC software

7.2.1 Collected data browsing feature

Fig. 11 is a screen that displays a list of quality data collected from facilities and touch panels. You can use this screen to confirm who produced each product, when, and under what conditions. In addition, you can not only search arbitrary processes and line results but also all of the processes. The all-process search displays a list of all quality data for cores, fusion, and molding related to casted products. You can confirm which data in what process is problematic for defective casted products. In addition, due to the fact that quality data is collected on a real-time basis, you can also understand the current production status.

Fig. 11 Collected data display screen

7.2.2 Data trend confirmation feature

Fig. 12 and Fig. 13 show screens that display collected arbitrary data shifts and dispersion in X-Rs control charts and histograms. By managing the trend of collected data every day on these screens, you can instantly detect abnormal data and study data characteristics in the case of a failure to lead to identification of the failure cause, etc.

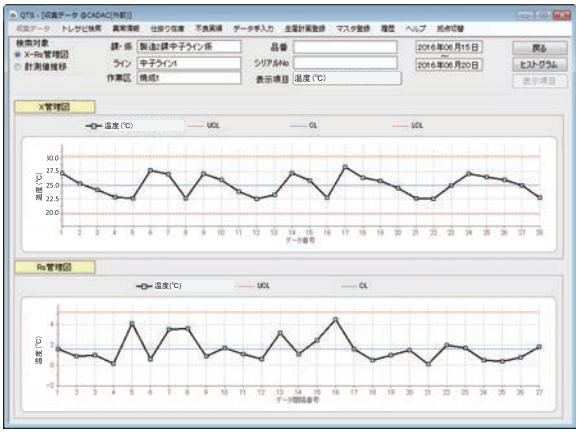

Fig. 12 X-Rs control chart display screen

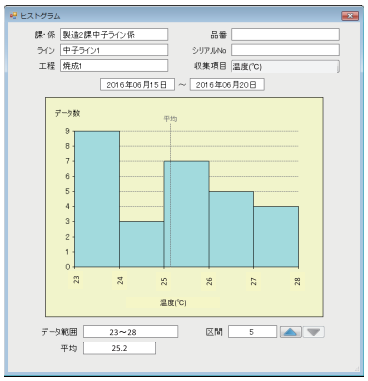

Fig. 13 Histogram display screen

7.2.3 Data tracing feature

Fig. 14 is the screen to trace product/quality data of each relevant line from serial numbers. You can select the search target product, core, molten metal, and mold serial numbers. You can trace (trace back) intermediate products prior to casted products and trace (trace forward) between intermediate products and casted products. Therefore, in case of product failure, the range of the effect can be immediately identified. This enables us to take swift and appropriate measures on products that require such measures.

Fig. 14 Data tracing screen

7.2.4 Production plan registration feature

Fig. 15 is the feature to register production plan data to be forwarded to molding line/fusion line facilities and touch panels. Production plan data is originally prepared as Excel files, but Excel file data is read in this screen, automatically converted to the format to be forwarded to facilities and touch panels, and registered in the DB server. In addition, the screen also shows results against the plan (molding line progress, fusion progress, and mold evaluation result), so we can also understand the current progress status on this screen.

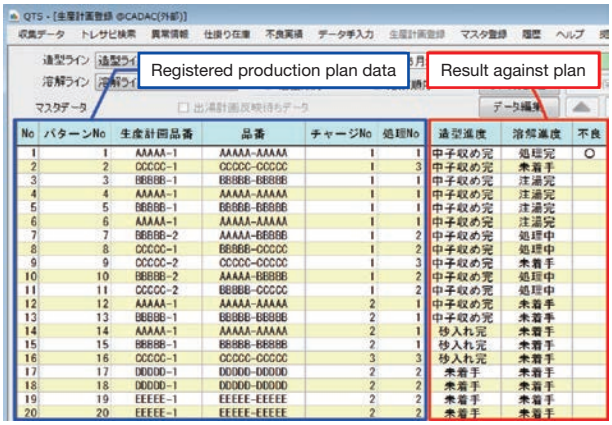

Fig. 15 Production plan registration screen

8 In Closing

The introduction of this system has enabled us to collect quality data of all products covering approximately 300 items, to visualize data, and to trace data in case of failures. In the future, we will utilize the collected data, perform failure analysis/failure prediction, and lead to failure reduction, which is the primary objective.

In addition, since this system collects not only quality data but also other basic manufacturing information, such as production time and number, we will consider applying the system to process control, inventory control, etc., in the future.

Finally, I would like to take this opportunity to express my sincere gratitude to everyone in the relevant divisions who has provided us with great support and cooperation in the course of the development and introduction of this system.

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Joined the company in 2005.
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