Realization of a smart factory from the perspective of production performance processing using NFC

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Abstract— **There are various types of manufacturing industries. The characteristic of the process industry is the production of products that have a continuous process and are difficult to shape. The need to build a smart factory is increasing in factories in the process industry. Due to the nature of continuous and atypical products, it is difficult to process production data. To solve this, we presented a methodology that utilizes an NFC sensor rather than handwriting data. To this end, the environment construction and design process, implementation of an analysis method through the pivot function of the EXCEL program, and information and intelligence methods for problem solving using data were presented. As a result, quantitative effects such as reduction of data duplication work and reduction of data processing time were obtained, and a method that can help to establish a smart factory in the process industry was derived.**

Keywords—Smart Factory, Process Industry, Extrusion, NFC, Data, Excel

I. Introduction

Recently, research on smart factories has been actively conducted in the manufacturing industry. Smart Factory is a customer-customized and future model that automates and intelligently processes all processes, including planning, design, production, distribution, and sales, based on ICT (Information &Communication Technology) to produce products at minimum cost and time. It is a factory.[1] Manufacturers want to realize profits through smart factory construction, improve safety, and make systematic and rational decision making, and seek to compensate for increased manufacturing costs such as labor and material costs through smart factory construction.[1] In the process industry, the necessity of building a smart factory is increasing. The process industry refers to an industrial group in which a large amount of processed products are continuously produced by installing manufacturing facilities and continuously operating the manufacturing facilities. Typical industries include cement, mining, pulp and paper, steel, waste and recycling, oil and gas, power industry, and extruded plastic steel. The characteristic of the process industry group is that it has a large-scale, non-standardized production process, and has a structure in which the handling method for product handling is difficult to standardize.[2]

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It can be seen from the current status of the construction of a smart factory in a global company that the product is centered on a product line with an assembly process.[3] The purpose of this study is to solve the problem of processing data on production performance of atypical products. (1) it is difficult to analyze and utilize data by manually recording data input that occurs during production on paper documents. (2) it is difficult to paste barcodes due to atypical processes and product characteristics. Therefore, there is a need for a new methodology that can input and store data more easily and efficiently. (3) it was necessary to prevent multiple people from entering the same data twice and to enter data quickly. This study intends to present a case study using NFC as a data input method. It proposes an environment construction and design process for building a smart factory, implementation of production performance data input method through NFC, and implementation of an Excel program analysis method using external server data. We briefly introduce an analysis algorithm for analyzing and utilizing the data that has been input, and we intend to use it to advance to an intelligent factory.

II. Main subject

A. Review of previous research

The number of smart factories in the world is spreading. Germany is the leading country. Germany, a manufacturing powerhouse, presented Industry 4.0 in 2011 and formulated the introduction of a smart factory. In particular, the Siemens "Amberg" factory presented a roadmap to improve production efficiency as a sample of a smart factory, and is believed to have played an important role in increasing the willingness of companies to adopt in the future.[4]. Looking at the introduction of global companies, about 76% are currently preparing for adoption, and 18% are undecided.[4][5]. In addition, it can be said that companies belonging to the United States and Europe led the construction of smart factories.[3] In the case of Korea, LS Industrial Systems and POSCO have devised a differentiated smart factory strategy that matches the characteristics of the company, and have achieved relatively successful results.[6]. However, this is a large company-oriented introduction, and it is difficult to expect a high-level smart factory construction in most small and medium-sized enterprises in the world, including Korea, and a standard construction plan for each manufacturing type is required.[3] NFC is actively used in many industries, but it has been confirmed that there has been little research on production performance processing using it.

B. Introduction of NFC and establishment of basic environment.

NFC is a 3.56MHz band contactless short-range wireless communication technology. It is a two-way wireless tag technology that can send and receive various wireless data within a short distance of less than 10cm, providing not only short-range data communication between mobile terminals such as a smart phone, but also contactless smart card technology and interoperability with RFID.[7] The main applications of NFC are commonly used in subways, payment transportation cards, and credit cards. It is also widely used from mobile payments to access control, ticketing, data sharing, and advertising.[8]

In order to enable NFC input in the production plant, a wireless internet network capable of communication and an information acquisition platform using mobiles and tags were established. The upper application is the Manufacturing Execution System(Below MES)

C. Workflow analysis

A database was built to store and utilize production performance data. For the database design, the entire business process was analyzed and the process was designed as shown in Figure 1 below.
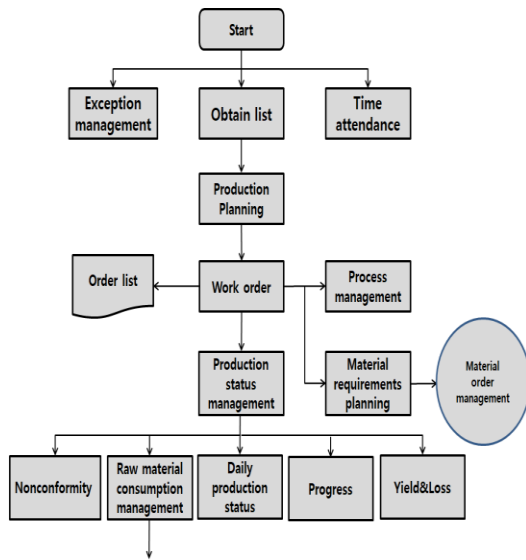

Figure 1. Total Work Flowchart of Product management

Figure 1 receives orders from customers and proceeds with production planning and work orders. After that, it leads to the process management plan and the material demand plan. After receiving the work order, the production status is managed. Production status management leads to tasks such as usage management of raw materials, daily production status, progress, daily production yield, and loss status, and then leads to inventory management.

D. Workflow analysis Smart Factory Implementation

1) DB design

DB was designed to input production performance. By locating the information elements of the analyzed task and grouping the elements related to the task name, an entity was constructed by giving the set of elements a name as a DB table. Primary key and foreign key were assigned, and the type of data for each column and whether null was applied were defined.[9]

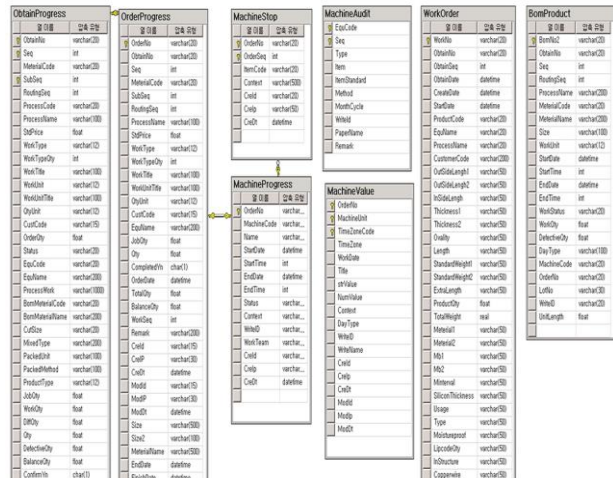Figure 2 shows the overall E-R diagram.

Figure 2. Production Performance Input DB ERD

It was designed as a relational data model by connecting the generated DB table.[9] .Linked each relevant table[6] After that, we created and linked the order confirmation DB table, work order table, production performance input table, and production facility information input table.

2) NFC System design

The communication mode of NFC utilized in this study used a contactless reader mode that reads tags.[7]

The system in which NFC, mobile app, and DB server are connected is designed as shown in Figure 3 below.

The main components are NFC code generation and management programs. When tagging the NFC tag with a mobile, the production performance input program is executed on the mobile, and the production plan data is automatically called in the executed app and can be input with Key In. The entered data is stored in the form of DB tables on the server. The mobile app and the MES program app are designed to be synchronized with each other.
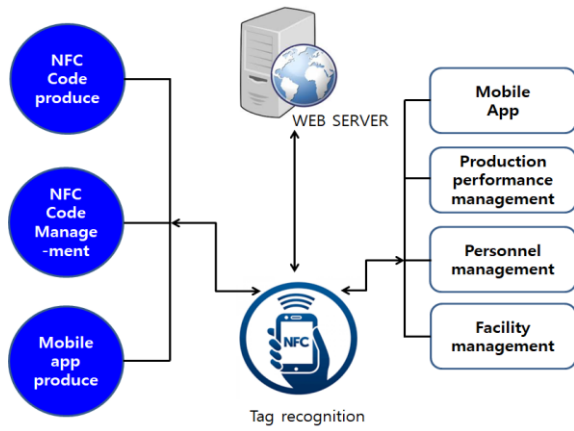
Figure 3. NFC system

3) Implementation and utilization of production performance information NFC System design

The application analysis program was constructed for the purpose of effective implementation and utilization. In this study, only the method of utilizing external server data through the Excel program is introduced

4) Design and implementation of input method through NFC

The information is read by tagging through the NFC chipset built into the smartphone. Place the web page information on the tag sticker and execute the input screen app when tagging. That is, it leads to the corresponding URL.
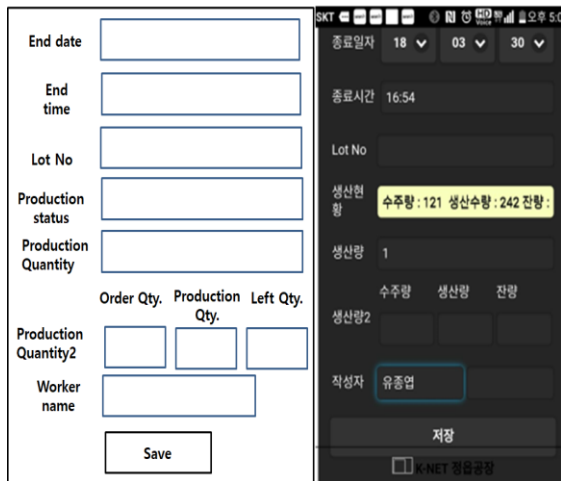
Figure 4. production quantity input mobile screen

As shown in Figure 4, when the input form is displayed on the screen and the production order number and product name match, if the production quantity is entered and saved, it can be checked in the mobile and MES programs after being input to an external server.

In this way, the input form is designed for the inspection

information input form, the quantity of non-conformance, and the content of the non-conformity.

The following is an explanation of the sticker type NFC tag and tag method. Figure 5 below shows the NFC sticker and the screen at the time of tagging. The tag list includes equipment start, stop, and end inputs, production performance registration inputs, non-conformance management inputs, process management inputs, and inspection management inputs.

Figure 5. NFC stickers and tagging

The following Figure 6 is a screen to check whether the input data is correctly entered into the MES program.

Figure 6. NFC Input Result Confirmation

E. Analysis and utilization

In this study, it was implemented by importing external data, which is a function of Excel program, and analysis and utilization using pivot table[10].

Figure 7 below shows how the data entered on the server is converted to a PivotTable after being converted into a table using a personal PC.

Figure 7. Pivot Table Transform [10]

Analyze the visualized information by using the pivot table in various ways. Furthermore, I would like to present a basic algorithm to go to artificial intelligence, the final stage of the smart factory.

The following Figure 8 introduces the algorithm for analyzing the cause of production failure.
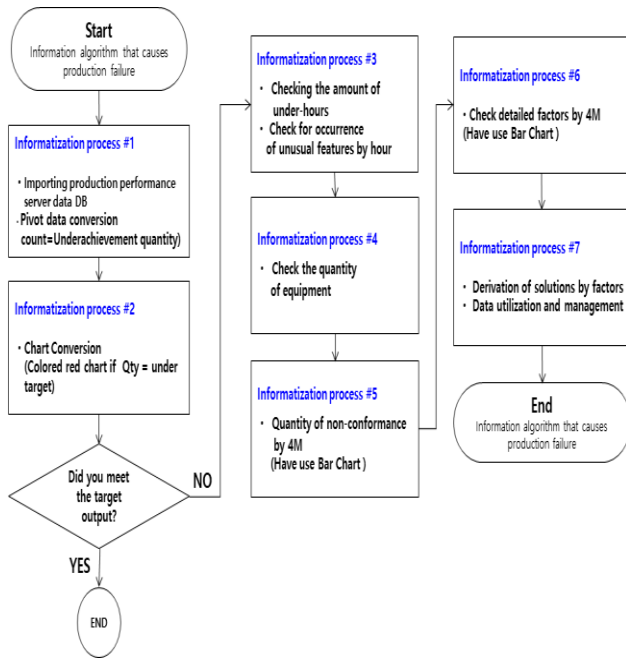

Figure 8. Cause Analysis Algorithm

The description of the algorithm follows the following step-by-step classification.

step 1 : The Excel program's external data import function loads data and converts it into a pivot table. Using the calculation field, the 'target quantity-actual quantity' value is generated as the 'undersupplied quantity' field.

step 2 : Check the amount of under-equipment for each facility.

step 3 : When the 'undersupplied quantity' in step 2 occurs, the time and date at that time are classified to check the peculiarities at the time.

step 4 : Check the amount of under-equipment for each facility.

step 5 : Check the amount of non-conformance by 4M.

step 6 : Check the detailed factors for each 4M.

step 7 : Derive solutions for each factor. Discover elements that can be managed using data.

The following is an introduction to the screen analyzed through EXCEL pivot and chart according to the algorithm. In Figure 9 below, the graph of the date of achieving the goal of the production plan is blue, but it was constructed so that it is displayed in red on the days when it is not achieved.
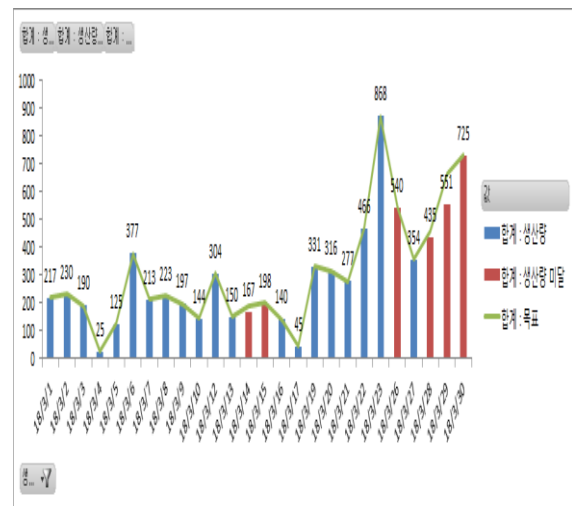

Figure 9. Chart Transformation Appearance
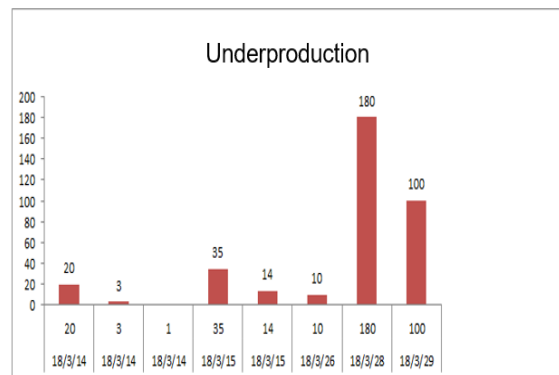
Consider Figure 10 below.

Figure 10. Performance Graphs for Targets in Unit 103

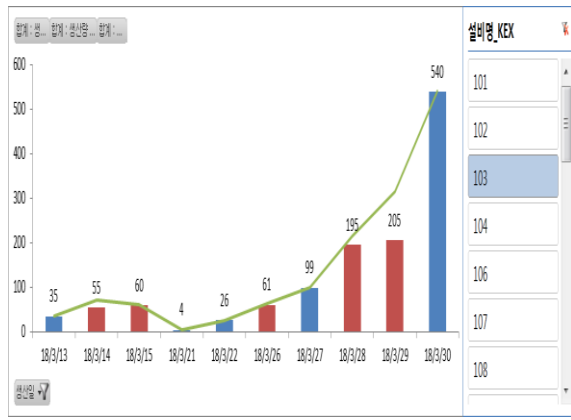In Figure 10 above, you can see a total of eight unfulfilled dates.

Figure 11. Performance Graphs for Targets in Unit 103

Figure 11 above shows the frequent occurrences in Unit 103 as a result of stratifying which facilities are underachieving.

In Figure 12 below, it can be seen that Machine is the main problem as a result of each layer by 4M.As a result of layering this by detailed factors, it can be seen that the cutter, the extruder bearing, and the take-off shaft have to be repaired.
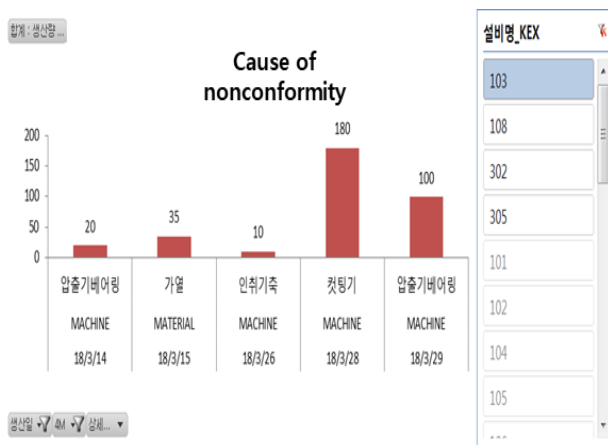

Figure 12. Underachieving Major Facility Name

Here, the mean time between failure (MTBF) of the extruder bearing is '15 days'. This can be used for equipment preventive maintenance.

F. *Verification*

From the viewpoint of convenience of work, it has been changed from manager-centered to field-worker-oriented systems through NFC input. In this study, the research results were verified from the viewpoint of reducing processing time. Before the introduction, the worker devoted about 23.4 minutes of input time each day, and the manager took about 53.1 minutes of work time to review and check the input data and prepare the daily report. As a result of the study, after introducing the NFC input system, the worker took 5.3 minutes and the manager took 15.7 minutes. To help you understand the research results, you can check the box beard picture in Figure 13 below.
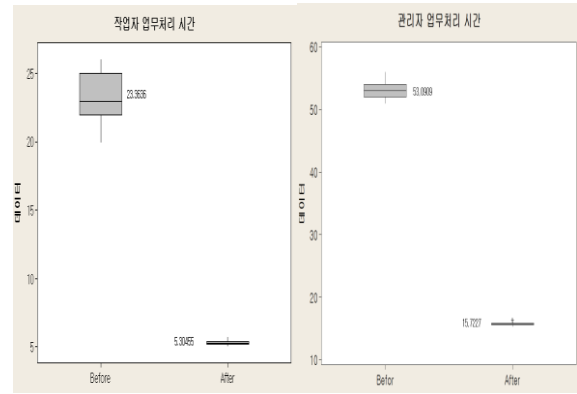
(a) (b)

Figure. 13 Pre- and Post-work time Boxplot [11]

(a) Worker's processing time (b) Manager's processing time

In Figure 13 above, it can be seen that the average value and standard deviation value of the business processing time before and after the introduction were significantly reduced.

Table 1 below is a basic statistical analysis table before and after the introduction of the smart factory.

TABLE 1. Statistic analysis of before and after work processing time

Object of Measurement		Mean Time (min)	Statistic
Processing Time	Worker	Before: 23.3 After :5.3	t : -479 p:0.000
	Manager	Before: 53.1 After: 15.7	t : -733.6 p: 0.000

The hypothesis test was conducted as shown in Table 1 above. The t-test was performed on the average processing time of workers and managers, and 'the null hypothesis (H0) is equal to or greater than the processing time'. We hypothesized that the 'alternative hypothesis (H1) has a small processing time' and tested it. As a result of the test, the statistics t and p-value are as shown in the table above, and H0 rejected and H1 were adopted as the judgment result. As a result, the test was completed as the processing time was reduced. In conclusion, it can be said that it has brought convenience to work.[12]

III. Conclusion

This study introduced a methodology that utilizes ICT economically and efficiently using NFC. It is considered that the conclusion of this study can be defined as follows.

1) Data input using NFC and the like is a new methodology, and is particularly useful in the process industry. As a result of the study, the double work of data processing was reduced and the effect of reducing the data processing time was effective.

2) It is an efficient methodology that utilizes an external data server and implements an easily accessible EXCEL program in the implementation of informatization, analysis, and intelligence of data.

3) We suggested a methodology to analyze and utilize production performance, and it is thought that it was helpful to advance to the intelligent stage by utilizing it in the future.

Based on this study, management items in the factory through NFC sensor include inventory management, product management, and quality management. Therefore, it is considered that more research will be needed to apply to manually managed tasks. Also, it is necessary to utilize various artificial intelligence techniques. It is thought that research will be needed to create new analytical models and create various values using the collected data.

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