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Reference Information Batch Application Model for Improving the Efficiency of MES

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MES 효율 향상을 위한 참조정보 일괄 적용 모델

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Abstract In the manufacturing industry, there is a transition to multi-item production for reinforcement of competitiveness. Therefore, the hybrid manufacturing technology is increasing. Especially, many efforts in production quality improvement are made through the adoption of the manufacturing execution system and ERP, so it is necessary to operate MES for prompt and effective management. MES should improve ineffective parts in production activities while managing all stages related to production of products. If there is change in the process, the changed items should be reflected to the system. However, most manufacturing execution systems are operated passively and repetitively by system administrators. This study presents a model that system administrators can comprehensively apply reference information about production related requirements on specific line's equipment to the same equipment of other lines. The flexible response for application to production lines is possible thanks to the division of blanket application and selective application of reference information through proposed model.

Key Words : Manufacturing Execution System, MES, WPF, .NET, IT Convergence

요 약 제조업 분야에서는 경쟁력 강화를 위하여 다품종 생산으로의 전환이 이루어지고 있으며, 하이브리드 제조 기술이 증가하고 있다. 특히 제조실행시스템과 ERP 등의 도입을 통하여 생산 품질 향상에 많은 노력을 기울이고 있기에, 신속하고 효과적인 관리를 위한 MES 운영이 필요하다. MES는 제품 생산과 관련된 모든 단계를 관리하면서, 생산 활동에 비효율적인 부분은 개선하고, 공정 변경의 경우에 시스템에 변경 사항을 반영해야 한다. 그러나 대부분의 MES는 시스템 관리자를 통하여 수동적이고, 반복적으로 비효율적인 작업을 계속 하고 있는 상황이다. 본 논문에서는 생산과 관련된 요구사항을 시스템 관리자가 특정 라인의 장비에 대한 참조 정보를, 다른 라인의 동일한 장비에도 일괄 적용할 수 있는 모델을 제안한다. 제안 모델을 통하여 참조 정보의 일괄 적용과 선택 적용의 구분으로 생산 라인에 대한 유연한 대처가 가능할 것으로 기대된다.

주제어 : 제조실행시스템, MES, WPF, .NET, IT 융합

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1. Introduction

There are various changes in all industries due to the fourth industrial revolution, and the manufacturing field is dominated by multi-item production due to the expansion of globalization, also in mass production, it is changing rapidly, centered on customers[1]. In addition, the generalization of internet and online transactions has brought about the production of various products that can meet customers' demands, and accordingly, the hybrid manufacturing technologies tend to increase[2,3]. Customers want high-quality products, so manufacturing companies should produce high-level products based on the optimum speed through the automation of equipment[4]. In order to produce high-level products, it is necessary to reduce the shutdown time of production machines, to optimize production speed, to improve delivery time, and to manage tools the administrator uses[5,6]. For this, the information system and automation were adopted to the production process from the design of products in order to improve quality of products and the efficiency of manufacturing process, and Manufacturing Execution System(MES) can be considered as the most representative information system.

MES performs its functions by connecting data extracted from the equipment of production field such as ERP(Enterprise Resource Planning) and SCM(Supply Chain Management), which are host systems, mutually. In case of the semiconductor industry, the procedures related to semiconductor manufacturing are fractionized, and manufacturing companies adopt MES for establishment of field-optimized system to reduce cost, thoroughly managing the manufacturing operation and production activities[7]. In addition, MES is adopted to reflect requirements of quality management, equipment, production history tracking and procedures[8].

The establishment of MES needs the equipment to transmit and collect data automatically, so using ineffective or unnecessary functions is the loss of company. It is critical to preferentially adopt necessary functions for the characteristics of company's manufacturing procedures among various functions of MES such as production plan, quality management and process control, and to improve the system for production optimization. Therefore, MES can be regarded as service-oriented interface that can connect production and business operation[9]. MES provides essential information for production activities throughout the supply chain via bi-direction communication[10]. Currently, most manufacturers are experiencing many difficulties in operating MES, mainly due to lack of basic infrastructure for data collection and analysis, data integration and utilization of MES functions[11,12]. Meanwhile, some functions used in MES require manual, repetitive and inefficient work of system administrator, but most of these functions can be conveniently used as a bundle of common functions. However, if reference information set on the equipment is needed to be comprehensively applied to numerous types of same equipment, the system administrator should register one by one, causing tardy and inefficient performance.

In the reference information applied to equipment, production line, production process area, equipment type, equipment information such as equipment ID, and event information are used. The existing MES doesn't have function to apply reference information to comprehensively apply to the equipment of all lines in order for standardized reference information value set on specific equipment to set up in the same equipment of different line,

so the improvement on this part is needed.

This study suggests a model that can apply reference information comprehensively to improve the repetitive and inefficient parts that system administrator individually applied reference information of equipment in the existing MES. The suggested model is expected to enable system administrator to manage MES more promptly and efficiently, so that production process can be controlled effectively.

2. Related Researches

2.1 Manufacturing Execution System

The MES(Manufacturing Execution System) is a system used in manufacturing to control all stages of production from initiating production by product order to quality inspection of finished goods. It is an integrated management system that collects various types of information of production field such as operation of equipment, activities of workers, product quality information and production output in real time and controls total, analysis, monitoring and production process for the establishment of quality and profit-oriented production system. The MES reflects the characteristics of the field according to customer companies' demands for products while improving productivity by accurately managing the execution state of production plan in real time. It sometimes links with ERP(Enterprise Resource Planning) to manage warehousing/releasing of raw materials and to clarify receipts and disbursements of raw/subsidiary materials.

This MES is a tool used in many manufacturing companies, enables information exchange between administration organization and production field's control system with the linkage with ERP, and is composed of high level software[13]. In the beginning, it was mostly used by chemical and pharmaceutical corporations, and large corporations, but since early 2000s, it has been used by small companies for their production.

2.2 WPF

WPF (Windows Presentation Foundation) is a user interface framework based on Microsoft .NET Framework to establish Windows client application program, and it offers intuitive and immersive user environment[14]. The user interface design is an essential element for all products and services[15], and WPF combines document, 2D/3D graphic, multimedia and application program user interface into sole framework and provides developers with more software application program experiences, so that they can make conversation type application programs. In addition, WPF was focused on providing necessary tools to realize better quality user interface while repeating more quickly in shorter time at UI, and satisfying developers' expectations on feasibility of application programs. Fig. 1 is the workflow of the WPF application.

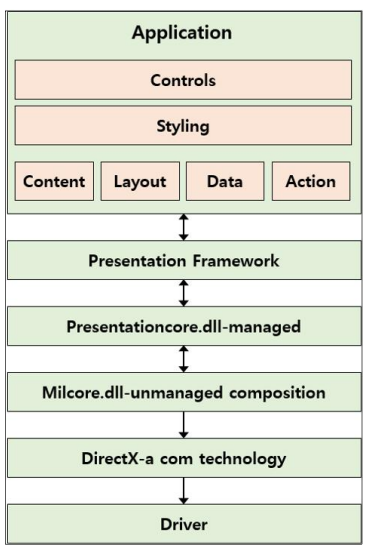


Fig. 1. Workflow of the WPF Application

3. Proposed Model

Fig. 2 is the concept map of WPF application program. The system administrator receives files needed for WPF client application program, registers through execution screen and transmits the revised data to the server. The WPF application program server communicates with database server providing services with files needed for client application program execution and communication. The database server stores the data that client registered and revised and provides inquired data. This study suggests a method to apply comprehensively at once what had to be registered individually one by one when the administrator of the existing MES registers the reference information registered to equipment to the same equipment in the same line and different lines.

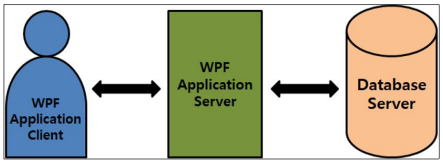


Fig. 2. WPF Application Program Diagram

Fig. 3 is the MES equipment reference information batch application and selective application process of the suggested model, and it broadly consists of seven stages.

First, the demands of MES administrators are defined. The system administrators require improvements in the parts that they have to execute one by one manually, repetitively and efficiently in order to register the reference information set in the equipment to the same equipment in other lines. Second, the screen of presently operated system is analyzed. The functions and data that have common features in the screen the equipment reference information is individually applied are classified in the existing system. The applicable reference information objects such as production line, production process area, equipment information like equipment ID and equipment type, and event information are classified. Third, the screen to comprehensively/selectively apply the reference information to the targeted line and equipment is designed. Fourth, the screen to comprehensively/selectively apply equipment reference information is implemented. Fifth, whether to apply the reference information comprehensively or selectively through the suggested model is decided, and application is executed. Sixth, in case of reference information batch application, the reference information is registered to the same equipment in all the lines, and in case of selective application, the reference information is registered to the equipment in the selected lines. Seventh, the production equipment is operated as the reference information the administrator set up.

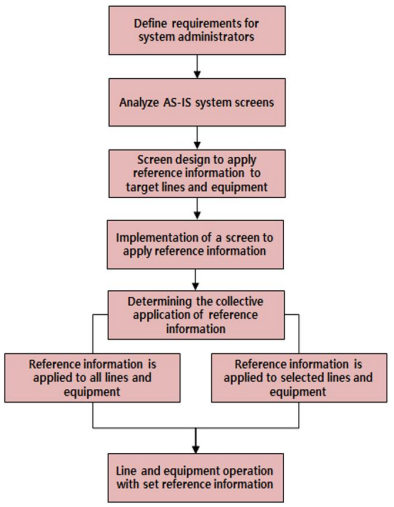


Fig. 3. MES Equipment Reference Information Application Process

Fig. 4 is the algorithm of the suggested model's equipment reference information lookup and execution.

The data for registration of reference

information is looked up with the search conditions of line, process and equipment information, and if the data exists, the lines that are designated as source and destination of the reference information are selected in the result list. If the destination line that is the same as the source line and primary key column value exists, revision or deletion is executed. Otherwise, the destination line with the reference information registered is registered anew.

```
IF Lookup Data > 0

  FOR i FROM 0 TO Whole Lookup Condition Number – 1 DO
        After ith lookup condition is executed, the result value
        binding

    IF ith lookup condition execution result data number= 0
              BREAK FOR LOOP
    END IF
END FOR

    Reference information source/destination choice

    Check if there is the same line as the value of IF Primary
    Key column
       Correct/delete reference information
    ELSE
       Adding the destination line and register new reference
       information
    END IF
END IF
```

Fig. 4. Algorithm of reference information lookup and execution

Fig. 5 is a multi-combo box control implemented with UserControl for batch application of reference information on the equipment of whole lines. The UI Component used for sole line, process and equipment information lookup conditions in the existing system is switched to the availability of multi-line, process and equipment information lookup, so that the system administrator can check the equipment information data of all lines comprehensively.

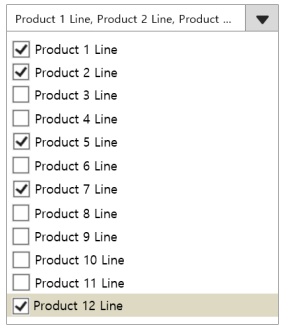


Fig. 5. Multi-combo Box Control

Fig. 6 is the screen that the data that reference information will be applied to with the use of multi-combo box. Many lines and equipment information can be selectively looked up. The selected line in the data looked up become the standard of the reference information, and the rest lines are the objects that reference information will be applied to. With Process and Eqpt. Type in the red background columns as the mapping keys, whether lines with the same keys exist is checked, and if one exists, the information of Unit Type and Unit ID in the green background columns can be revised. In case Command Type at the bottom of the screen is Copy, the reference information is corrected if line with the same mapping key exists, and new line is added to the reference information of selected line if one doesn't exist. If Command Type is Delete, the relevant line can be deleted if a line that has the same mapping key as the selected line exists.

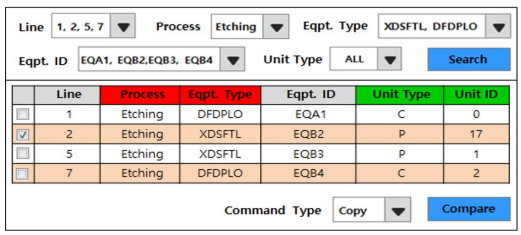
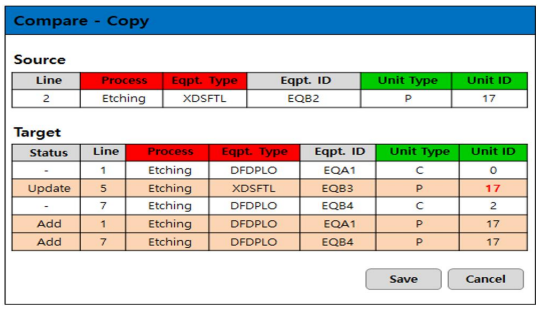


Fig. 6. Data lookup screen that reference information will be applied to

Fig. 7 is the result of comparison when Command Type at the bottom of Fig. 6 is Copy. The selected line is marked as Source, and the rest lines are marked at Target after Source lines and Mapping key are compared. Whether to store is decided after the changed items marked at Target are confirmed.


Compare - Copy

Source

Line	Process	Eqpt. Type	Eqpt. ID	Unit Type	Unit ID
2	Etching	XDSFTL	EQB2	P	17

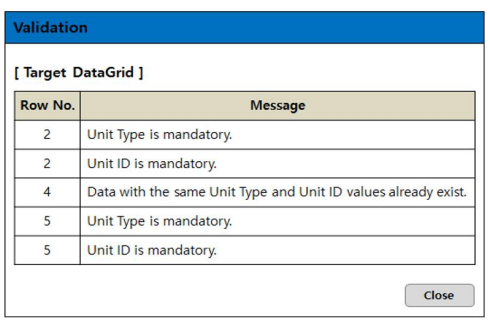
Target

Status	Line	Process	Eqpt. Type	Eqpt. ID	Unit Type	Unit ID
-	1	Etching	DFDPLO	EQA1	C	0
Update	5	Etching	XDSFTL	EQB3	P	17
-	7	Etching	DFDPLO	EQB4	C	2
Add	1	Etching	DFDPLO	EQA1	P	17
Add	7	Etching	DFDPLO	EQB4	P	17

Save Cancel

Fig. 7. The result of comparison when Command Type is Copy

Fig. 8 shows the screen of validation test whether the reference information marked in Target is correctly registered. If mandatory items are not input, or there is overlapped data, it tells the relevant spot and stops saving being executed.


Validation

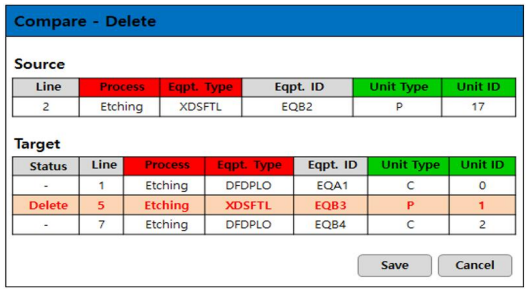
[Target DataGrid]

Row No.	Message
2	Unit Type is mandatory.
2	Unit ID is mandatory.
4	Data with the same Unit Type and Unit ID values already exist.
5	Unit Type is mandatory.
5	Unit ID is mandatory.

Close

Fig. 8. Reference information registration validation test

Fig. 9 is the result of comparison when Command Type is Delete at [Fig. 6]. If the line of Source having reference information of the equipment and the same line as the values of Process and Eqpt. Type columns, which are mapping keys, already exit in Target, it is displayed, and the relevant line is deleted.


Compare - Delete

Source

Line	Process	Eqpt. Type	Eqpt. ID	Unit Type	Unit ID
2	Etching	XDSFTL	EQB2	P	17

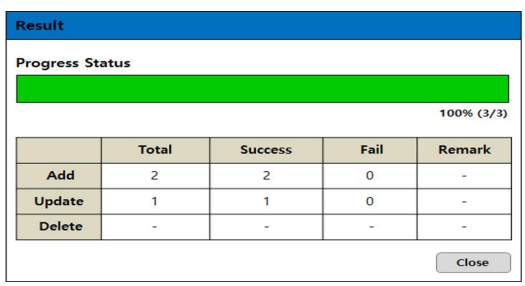
Target

Status	Line	Process	Eqpt. Type	Eqpt. ID	Unit Type	Unit ID
-	1	Etching	DFDPLO	EQA1	C	0
Delete	5	Etching	XDSFTL	EQB3	P	1
-	7	Etching	DFDPLO	EQB4	C	2

Save Cancel

Fig. 9. The result of comparison when Command Type is Delete

Fig. 10 shows the result of saving the reference information. The final results of Add, Update and Delete can be checked through Progress Bar and Table. If there is data with failure of saving, the information of the failed object is marked at the Remark column, so that the system administrator can comprehend the cause of failure.


Result

Progress Status

100% (3/3)

	Total	Success	Fail	Remark
Add	2	2	0	-
Update	1	1	0	-
Delete	-	-	-	-

Close

Fig. 10. The result of saving the reference information

4. Evaluation of Use of the Proposed Model

Table 1 shows the details of the test and survey done on system administrators and developers after the batch application function of equipment reference information, the suggested model of this study, is applied to the existing MES.

Table 1. Details of survey on the batch application function of equipment reference information

Classification	Details
Survey targets	40 system administrators, 60 developers
Date	May 1, 2021 ~ July 24, 2021
Date of survey	July 27, 2021 ~ July 31, 2021

Table 2 shows three times of equipment reference information batch application tests. Copy and Delete are the Command Type of [Fig. 6], and Copy includes new registration and correction functions. In the beginning of the test, it wasn't 100% successful due to the exceptional situation that the wrong existing data exist in the database. The validation test function for the original data that cause the exceptional situation is added, which was notified to the system administrator so that the system administrator could correct the wrong original data accurately. Then, the equipment reference information batch application was implemented again, and 100% data process accuracy was achieved.

Table 3 shows the results of the survey consisting of evaluation items for the equipment reference information batch application function, which was classified into 'Strongly Disagree(1 point)', 'Disagree(2 points)', 'Neutral(3 points)', 'Agree(4 points)' and 'Strongly Agree' with the use of five-point Likert scale. The average points of each evaluation item indicate both system administrators and developers are highly satisfied with the adoption of the equipment reference information batch application function to the existing MES, expressing very positive responses.

Table 2. Test for batch application function of equipment reference information

The number of lines	The number of equipment	1st success rate(%)		2nd success rate(%)		3rd success rate(%)	
		Copy	Delete	Copy	Delete	Copy	Delete
1	15	100	100	100	100	100	100
5	75	93	90	97	96	100	100
10	750	81	77	94	97	100	100

Table 3. The results of the survey on the batch application function of equipment reference information

Evaluation items	Contents	Average points (5-point scale)
Data processing speed	The blanket application of equipment reference information enables faster data processing than the individual application of the existing system.	5.0
Data compatibility	The blanket application of equipment reference information accurately reflects data the same as the individual application of the existing system.	5.0
Extendability	It seems that the blanket application function can be extended to other data in MES screen in addition to equipment reference information.	4.6
Work efficiency	Users could work more efficiently after the blanket application than the individual application of equipment reference information.	5.0
Convenience of maintenance	The blanket application of equipment reference information makes correction or maintenance of system more convenient than the existing individual application.	4.1
UX / CX	Users feel more convenient to use the screen with the blanket application than the individual application of equipment reference information.	4.2
Product productivity	The blanket application of equipment reference information increases the product productivity compared to the individual application of equipment reference information.	5.0

5. Conclusion

It is essential to improve work environment for optimized production activities in order to produce excellent quality products in quantity quickly in MES. It is also important to provide effective work environment where system administrators can set up equipment promptly without any errors and monitor the process. The batch application function of equipment reference information suggested in this study can improve work conditions effectively due to the availability to apply to all equipment of whole lines not being limited in sole line. And can reduce system administrators' inconvenience and time because they can finish work at once, which they had to register the same reference information repeatedly one by one in the existing system. In addition, the selective application function of reference information like the existing system is provided together, which enables flexible use of the system. In future studies, the collection of MES administrators' demands should extended in order to expand the batch application function of reference information, and there should be more studies on the improvement of the automation of manual work in the system MES administrators implement as well.

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