Engineering Support Tool That Reduces Lead Time and Improves Quality, Accelerating DX

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ABSTRACT

Conventionally, engineering work involved in new construction, expansion, and renewal of plants and facilities required a considerable amount of manual work. This resulted in significant variations in lead time and quality. The engineering support tool "HEART" accelerates DX by supporting the innovation in engineering operations, work flows, and business processes through automation and the use of data and digital technologies. It contributes to reducing lead time and improving quality by efficiently creating function specifications and project completion documents and automating the generation of control programs, the visualization of changes in various specifications and drawings, and the recording of test results in the control function specifications.

1. Introduction

Work patterns are rapidly changing as a result of the acceleration of globalization and the recent rise in worker diversity, work style reform, improvements to working environments, remote work, and other changes. Under these circumstances, there is an increasing need for digital transformation (DX) to provide new value to customers and improve corporate profits.

The engineering lead time and quality of monitoring and control systems in the construction, expansion, and renewal of plants and facilities are highly dependent on the skills and experience of engineers.

Accelerated globalization has led to an increase in the diversity of engineers, and the retirement of experienced workers in Japan has led to an increase in the proportion of engineers without extensive experience or advanced skills, reducing the efficiency and quality of engineering operations. In the past, it was necessary to spend a lot of work hours on various types of manual work, such as creating customer requirements specifications into control function specifications, turning function specifications into software, comparing and clarifying changes, and reflecting internal and on-site test results in the specifications, which caused large fluctuations in lead time and quality.

To solve these problems, engineering operations must be transformed. Provided by Fuji Electric, the engineering support tool "HEART" uses digital technology to transform a series of engineering operations, including specification compilation, design, manufacturing, internal testing, on-site testing, and technical drawing follow-ups, as well as operation flows and operation processes.

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2. Problems in Previous Engineering Operations

From the confirmation of requirements to follow-ups on on-site test results, many people were involved in conventional engineering operations, resulting in the following problems:

(1) During creation of control function specifications

Engineers create control function specifications based on the requirements specifications created by the customers. This procedure required them to create new symbols used in figures, tables, and control function specifications and convert them into PDF or image files and paste them.

In many requirements specifications, control logic is omitted to the extent that the outlined functions can still be understood, or the same processes are expressed in table format. On the other hand, control function specifications contained detailed logic diagrams that accurately represent functions and actions. For this reason, even though the logic was correct, the control contents were difficult to understand when viewed by anyone other than the author.

(2) During the design of control programs

After creating control function specifications and having them verified by the customer, the control program design phase begins. For the creation of control programs, dedicated loaders that were different for each controller model were used. To design a control program from the contents of the control function specifications, it was necessary to have advanced skills and experience, such as knowledge of controller programming and dedicated loaders. Furthermore, the large amount of work involving human intervention gave

rise to discrepancies in how specifications were interpreted, as well as oversights.

(3) When changes are occured

Previously, when changes are occured in the addresses of the input and output signals of various devices used for control or monitoring, or in the tags treated as identifiers, it was necessary to manually locate the control function specifications and the places where the tags and addresses are used in the control program, and to manually change both. In addition, it is necessary to clearly indicate the changed portions of the control function specifications and the control program so that they can be noticed by those other than the author. In the past, modified pages were printed, and changes were indicated by hand using revision clouds or other markings so that they could be noticed. As such, it took time to extract the changed portions and write symbols indicating changes, and in addition, there were at times oversights in the indication of changes.

(4) During testing

To write test results in control function specifications and test reports, it was necessary to copy them by hand while looking at the test data, and mistakes in writing sometimes occurred.

(5) During reflecting results to project completion documents

Changes in specifications and in the circuits of control programs often occur when on-site tests and adjustments are conducted at customer plants and facilities. Upon completion of on-site testing and adjustments, the test results need to be reflected in the control function specifications. However, the field engineers often only modified the control programs and neglected to revise the control function specifications. For this reason, the control function specifications needed to be reverse-engineered from the control programs. The discrepancy between the control function specifications and the control programs was a factor that led to a deterioration of quality in the revisions and updates that followed.

3. Transforming Engineering Process with the Engineering Support Tool "HEART"

3.1 Streamlined creation of control function specifications

(1) Creation of control function specification from requirements specifications

The requirements specifications that compile the needs of end users are usually prepared with general OA software[1], such as Microsoft Office*1, Excel*2 and Visio*3. Engineers need to take detailed and concrete control specifications that meet the needs indicated in the requirements and create them into control function specification documents. Here, based on the electronic files of the requirements specifications provided by the customer, the engineer can efficiently create control function specifications by adding control circuits using the many symbols provided by HEART. Because it utilizes familiar OA software, it is very easy for engineers to adopt.

(2) Clarification of control function specifications

HEART provides functions to express complex processes in control function specifications in a simplified manner using symbols, as well as to express the same processes compiled in the form of a table. Figure 1 shows the clarification of control function specifications. These functions make it possible to create simple, no wasted, and to-the-point control function specifications and to make the documents easier to understand.

3.2 Automatic generation of control programs

HEART provides a function to automatically generate control programs[1], which eliminates the need to manually create control programs from control function specifications. It enhances the reliability of control programs by eliminating omissions and errors in creation, which are inevitable in manual work, as well as through the constant logical alignment of control function specifications with the control programs. In addition, it supports many types of controllers, eliminating the need to program using a dedicated loader according to the type of controller, enabling engineering with familiar OA software.

Figure 2 shows a comparison of ways of engineering to create control function specifications into control programs.

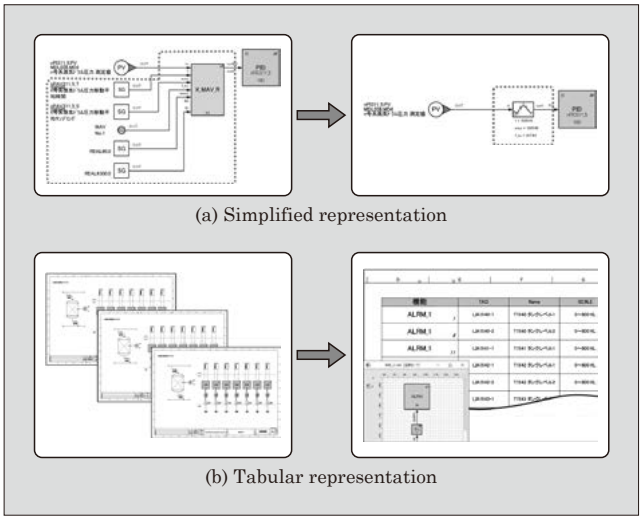

Fig.1 Clarification of control function specifications

*1 Office is a trademark or registered trademark of Microsoft Corporation

*2 Excel is a trademark or registered trademark of Microsoft Corporation

*3 Visio is a trademark or registered trademark of Microsoft Corporation

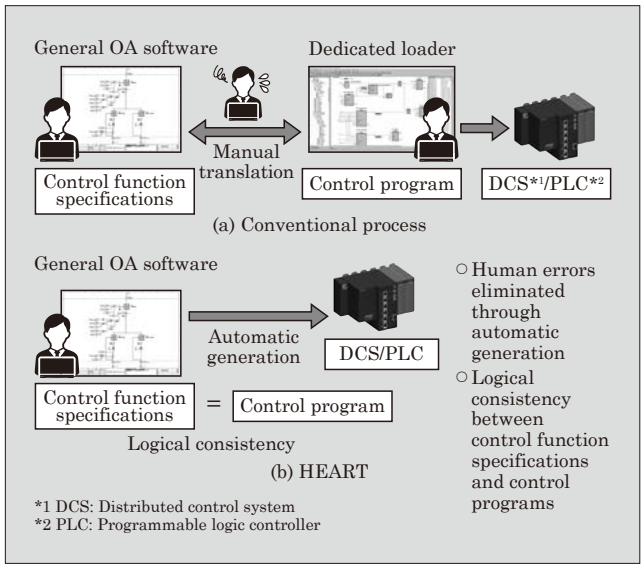

Fig.2 Comparison of ways of engineering to create control function specifications into control programs

3.3 Detection and automatic application to affected areas during design and modification

When changes to tags are made in control function specifications, HEART is able to automatically detect the affected areas and list the points that need to be modified. By double-clicking a point on the list detected by HEART, you can jump to the corresponding page of the control function specifications and apply the tag change with a single action. The list will continue to be displayed until the user decides whether to implement or reject the changes, allowing them to avoid omitting changes or entering the wrong tags. It also automatically detects discrepancies in placement, such as overlapping tags or missing control instructions to the output signal, and displays them in the list. Figure 3 illustrates the ease with which specification changes can be made with HEART.

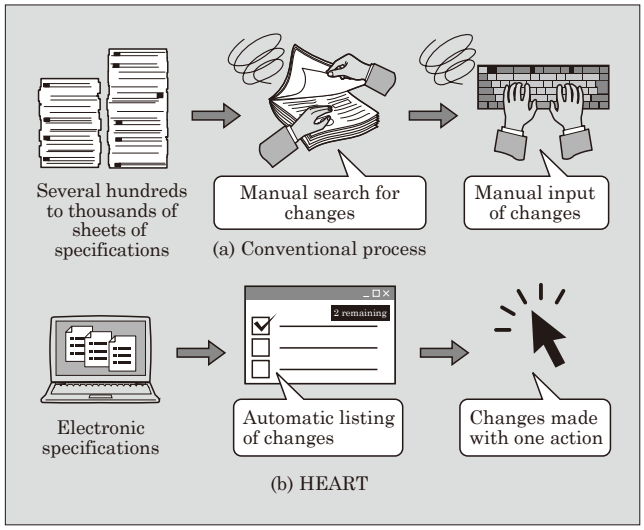

Fig.3 Ease of making changes to specifications using "HEART"

3.4 Automatic visualization of changed portions in various specifications and drawings

There are hundreds to thousands of specification documents per project. Revisions are made as needed through specification meetings and design reviews, then shared with customers and those in charge of the next process. Engineers need to determine the extent of direct and indirect impacts on the plant from changes made as a result of the revisions. As such, an accurate representation of the changed portions is required.

HEART provides a function to digitize handwritten changed portion marks to visualize the affected areas[2]. Figure 4 shows an overview of the automatic changed portions visualization process.

The main features are as follows:

(1) Extraction of page layout-independent changes

Figure 5 illustrates how changes are extracted independently of the layout within the page. When revising specification documents, specifications are added or deleted. These changes often cause the positions of subsequent specifications to change. If an

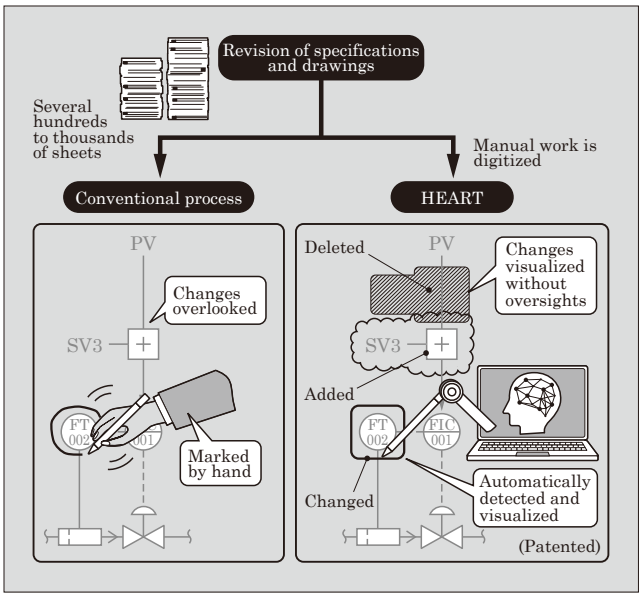

Fig.4 Overview of automatic visualization of changed portions

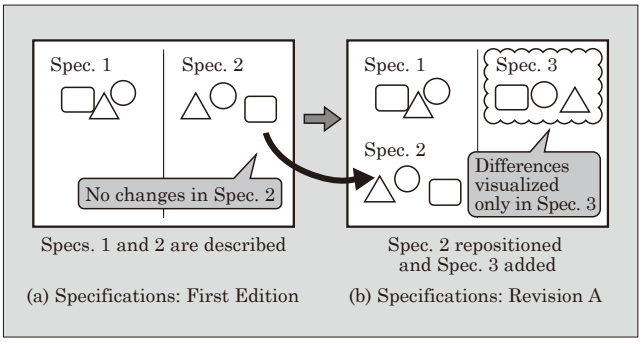

Fig.5 Extraction of page layout-independent changes

image recognition technique is used according to the layout within the page when extracting changes, unchanged specifications are also extracted. To solve this problem, this tool turns the characters, graphic elements, and software elements that comprise the specifications into a database and applies an original algorithm that is independent of the layout within the page to accurately identify changes such as additions, modifications and deletions. For example, even if "Spec. 3" is added to Fig. 5(a) by repositioning "Spec. 2" as shown in Fig. 5 (b), only "Spec 3" will be displayed as a change.

(2) Easy-to-see marking of changes

Figure 6 shows the easy-to-see marking of changes. As shown in Fig. 6(a), when changes are displayed in a detailed manner on the specifications, they may not be easy to see, causing a reduction in readability. To solve this problem, an algorithm for classifying changes and determining visual overlap is applied, resulting in easy-to-see views. As shown in Fig. 6 (b), when multiple changes of the same classification overlap, the markings can be automatically combined. This function eliminates the need for manual entry of revision clouds, ensures that there are no oversights, and enables accurate communication of changes to other people. Greater accuracy in the visualization of changes provides useful information to ensure that design verification in engineering work and testing of subsequent processes are carried out reliably.

3.5 Automatic recording of test results in control function specifications

By adding input and output results of test data

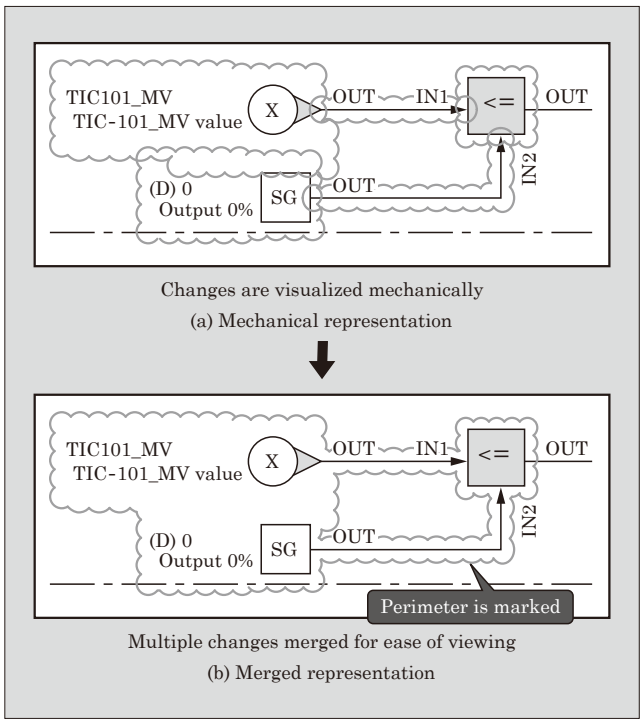

Fig.6 Easy-to-see marking of changes

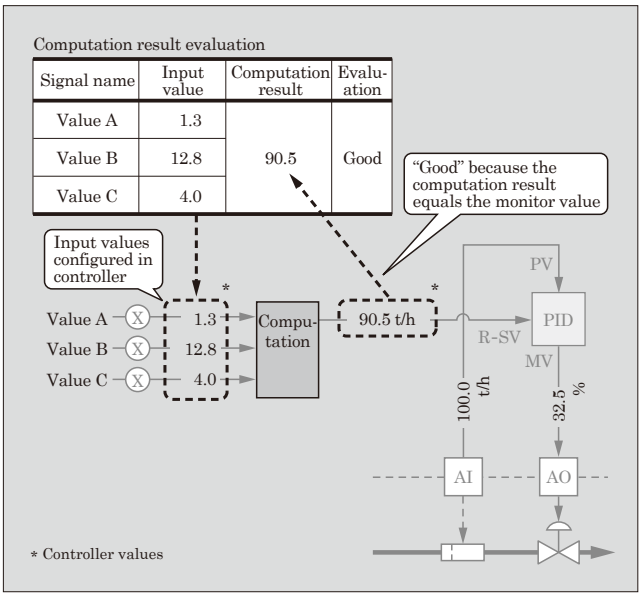

Fig.7 Test procedure and reports using monitor function

and evaluation fields, control function specifications prepared using HEART can also be used as test procedures and reports. Figure 7 shows the use of test procedures and reports for monitoring. During testing, values processed by the controller and setting values can be monitored on the specifications[1], and results can also be automatically evaluated. Through automatic recording, it is possible to prevent testing oversights and falsification of results, thereby ensuring reliability as evidence. In addition, this tool supports the automatic conversion of specification modifications and additions that occur during testing into control programs by modifying the control function specifications, allowing the user to efficiently retest and record results simply by monitoring the modified specifications again.

3.6 Labor saving in reflecting results to project completion documents

Figure 8 shows the reverse engineering process

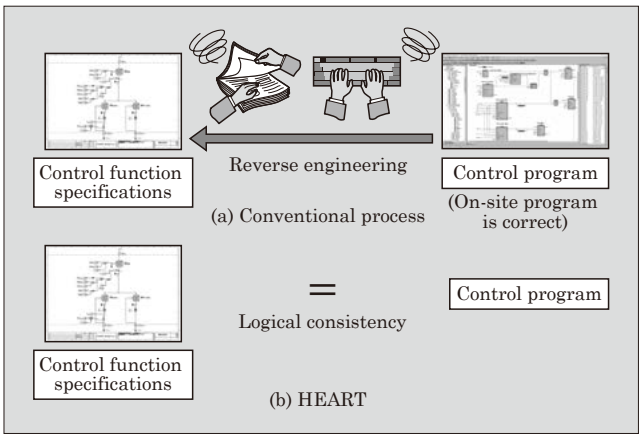

Fig.8 Reverse engineering for reflecting results to project completion documents

in reflecting results to project completion documents. HEART automatically generates control programs from control function specifications, eliminating the need for reverse engineering and reducing the amount of labor required for the preparation of project completion documents. When performing engineering work on HEART, changes made due to mechanical or external factors that could not be assumed before shipment are always reflected in the control function specifications. For example, even if the system is to be revised in a few years, problems such as inconsistency between the control function specifications and the control programs will not occur.

4. Postscript

This paper has described a support tool that reduces engineering lead time and improves quality, accelerating DX.

To further promote DX in engineering going forward, we intend to provide optimal value to our customers while responding quickly to the changing times and user requirements, such as by adding cloud and multi-engineering capabilities to engineering support tools.

References

(1) Kitamura, S. et al. "HEART" Engineering Support Tool for Shortening Design Periods and Improving the Quality of Monitoring and Control Systems. FUJI ELECTRIC REVIEW. 2020, vol.66, no.1, p.46-50.

(2) "HEART" Highly Efficiency Engineering Support Tool Automatically Visualizing Changes in Specifications and Diagrams. FUJI ELECTRIC REVIEW. 2022, vol.68, no.2, p.83.

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