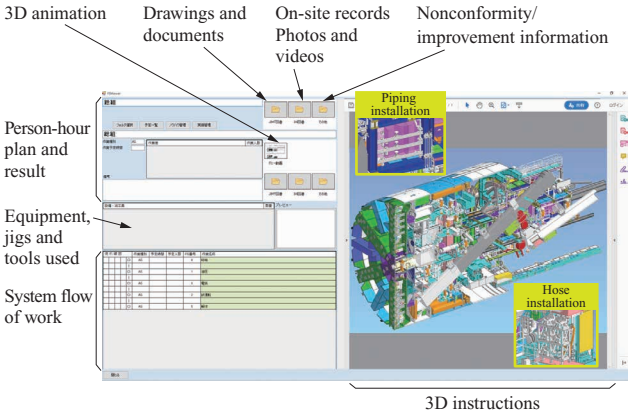
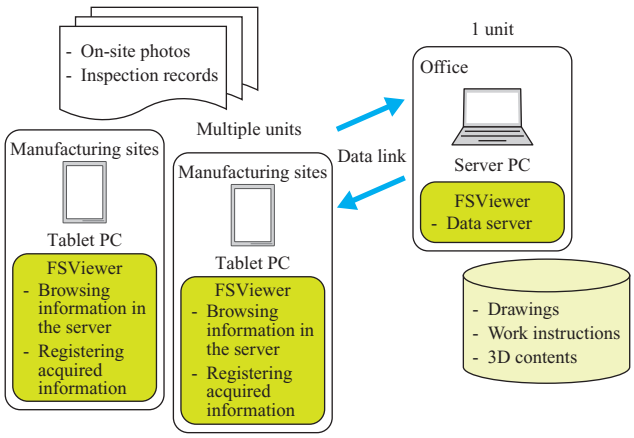
Efforts toward DX on Manufacturing Sites with Digital Work Instruction System

Realizing data sharing on manufacturing sites

It is unexpectedly difficult to realize digital transformation (DX) at manufacturing sites. It takes a lot of labor to arrange the necessary equipment and digital information. This time, we worked on the realization of DX at our manufacturing site with the slogan "Let's begin with what we can do." This article introduces the activities and results of the efforts using a digital work instruction system and data that we have digitalized on our own.



Digital work instruction system



(Note) A network or stand-alone system may be selected for the data link according to manufacturing site conditions.

Configuration of FSViewer

DX on manufacturing sites

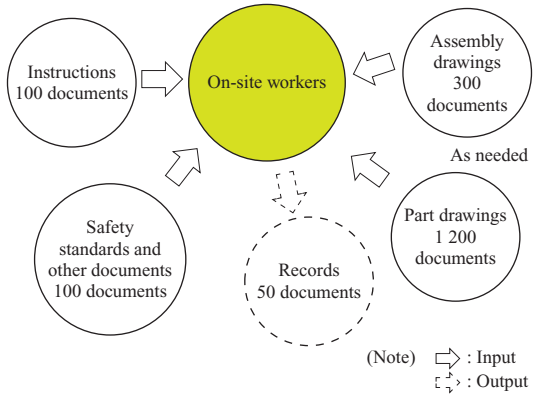
The IHI Group is working to realize DX from the perspective of enhancing on-site manufacturing efficiency.

Using Internet of Things (IoT) technology to shorten the turn-around time (TAT) in the on-site manufacturing is an essential theme in offering customers new value and enhancing product competitiveness. However, since IoT systems for large equipment are generally produced by the engineering-to-order (ETO) approach, developing, maintaining, and managing these systems may result in technical debt due to a prolonged rise in running costs or other reasons. Therefore, the decision to introduce these systems must be made carefully. As a solution to lower the barriers for introducing the systems, IHI's Nuclear Energy Business Unit has developed a digital work instruction system (FSViewer) in-house, which can operate on commercially available tablet PCs. FS is the abbreviation for fabrication sequence.

This system is characterized by the following two points: (1) it enables to utilize digital information regardless of its original form by processing and storing various forms of information, from printed one to digital one of different file types, and (2) it is configured so that it can handle 3D-CAD data and 3D contents processed according to the purpose or intended use, including 3D animation created based on the 3D-CAD data. Accordingly, a wide range of information, such as input information and output information, can be handled with the system; the input information includes

traditional fabrication drawings, instructions, work procedures and other information necessary for manufacturing and the output information includes feedback from design. On our manufacturing sites, fostering successors and building up systems are important to make continuous use of rapidly advancing digital technologies. Therefore, this system has been devised so that anyone that has gone through quick training can create data necessary to build up the system except creating 3D contents, which requires specialized skills.

Fabricating large equipment involves a large amount of information from printed documents, including drawings and instructions. Therefore, necessary information cannot be retrieved efficiently on manufacturing sites merely by organizing digitalized information in automatic manner. FSViewer enables the users themselves to arrange the information appropriate for daily work planning into a systematic data structure with easy operations.

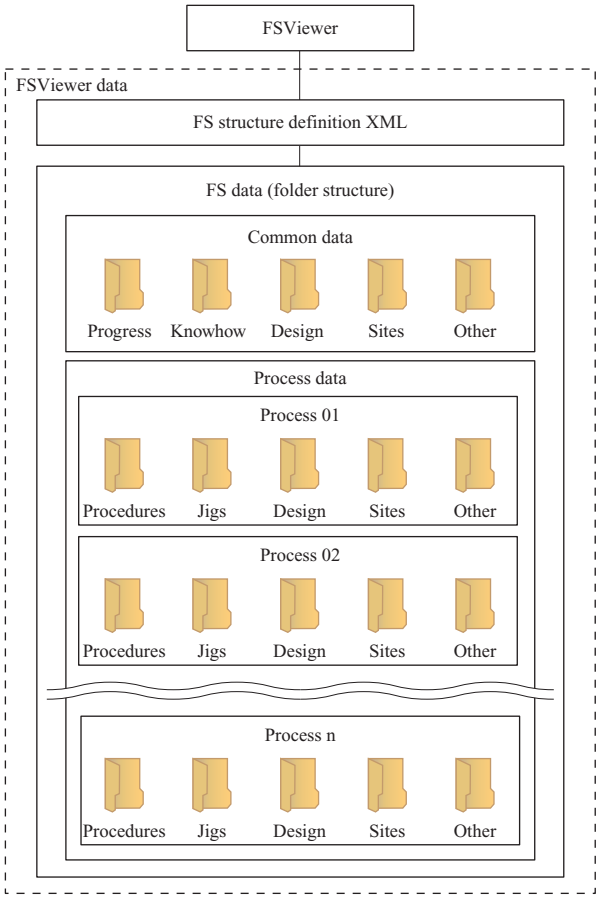


Documents relating to the large shield machine assembly work

Development objective and basic specifications of FSViewer

FSViewer was originally developed to use iDMU™ (IHI's Digital Mock-Up), a DMU system based on IHI's manufacturing knowhow (refer to "Video Creator Using Digital Manufacturing Technology," IHI Engineering Review, Vol. 50, No. 2, 2017). In an early stage of development, FSViewer was developed on the premise that information would be displayed on a large display panel, assuming the situation where information cannot be shared in print, for example, in areas into which we are not allowed to bring documents. At that time, the system was used with the product lifecycle management (PLM) database used for top-down DX and was useful as a viewer application for managing information associated with each process in an integrated manner. However, the system had a restriction in that it required the development of a network environment meeting the information security requirements.

Since the latest system has an additional function to work



Data structure of FSViewer

even in the local environment for bottom-up DX, it is not affected by DX environment at manufacturing sites, especially the network environment. With this system, it is possible to import information from printed document necessary for work, store 2D- and 3D-CAD data, and 3D contents compiling detailed procedures and work safety points, and use these data and contents by starting necessary application programs. These data can be associated with process information, which enables easy access to the desired information in the same process. This system uses the Windows folder format to save data, which makes it possible to share data with systems other than FSViewer. In addition, this system has no restrictions on the use of external application programs and the locations of shortcuts and therefore, supports various data formats flexibly.

Challenges with communication on our manufacturing site and measures for them

Two major types of documents are used on our manufacturing site. One is documents that contain input information necessary for fabrication, and the other is documents that contain output information prepared in each stage of work, including inspection records.

Specifically, the information input to the manufacturing site includes assembly drawings, instructions, and applicable

standards. In addition to these documents, recently there have been increasing opportunities to use 3D-CAD data for fabrication studies and past work records. However, since such documents and work records were generally distributed in print, the workers organized the handouts individually and took them out when necessary for their work. Moreover, when comparing 3D-CAD data with the actual product in progress, in general, they printed out the 3D-CAD data in their office, and then used them on their manufacturing site. In other words, despite digitalization, information was still eventually communicated in print.

The information output from the manufacturing site includes mainly inspection records and fabrication records. It took some time and effort to prepare inspection records. The on-site workers completed forms by hand and the office staff rewrote clean copies with a PC when submitting them to the customers. Photographs for recording fabrication were also sorted by the workers and stored in the PC after necessary information was added.

As just described, 3D-CAD data and other digital data were already used on the manufacturing site, but were not used effectively. Information was still communicated in print, and data were sorted manually. Reducing the time that on-site workers and process control staff spent on managing paper documents can be said to be an improvement in work efficiency. We identified such wasted tasks as issues with communication and took measures for these issues as follows:

(1) Realizing real-time information sharing
Sharing information by a server system
(2) Introducing means of going paperless
Browsing electronic data with tablet PCs
(3) Utilizing digital data
Promoting the use of digital data on the manufacturing site

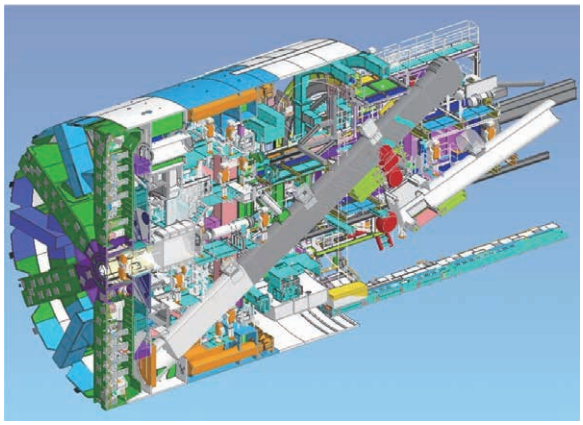
We conducted this verification in the assembly process of a large shield machine fabricated in a factory of IHI Yokohama Works. The verification was aimed at minimizing paper-based communication and sharing and utilizing digitalized information for efficient manufacturing. At this time, the master data used in FSViewer were developed by the process control staff. The master data were used simultaneously by the on-site workers via multiple tablet PCs. We verified the possibility of contribution to enhancing manufacturing efficiency on the site.

Application to the manufacturing site and effectiveness

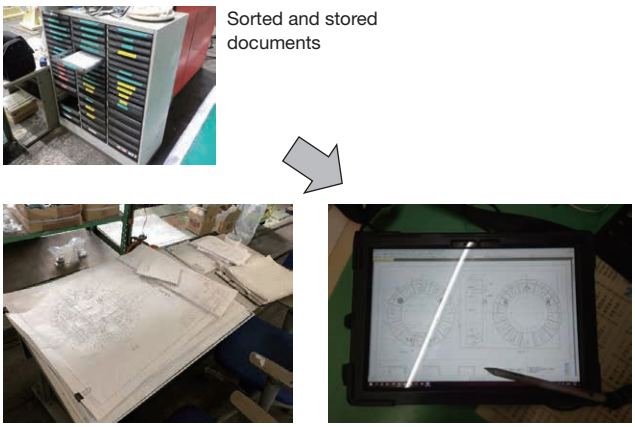
Compared with the plate working and machining processes, the shield machine assembly process, which we conducted the verification with, uses many more documents, and therefore is suitable for effectiveness verification. Until that time, some arrangements were required to use the necessary documents. For example, documents were sorted and stored in document drawers, or were filed in binders and stored in book shelves. CAD data and other digital information were stored in the PCs at the office, and the application program was started to retrieve them when necessary.

A much expected improvement effect brought about by the introduction of FSViewer is saving the time wasted on handling paper-based documents. Using portable tablet PCs provides real-time access to information necessary for fabrication on the manufacturing site, which has saved the time spent going back to the office to retrieve that information. It often took more than 10 minutes to go back and forth between the office and manufacturing site to check paper-based documents or drawings in the PC. The total amount of time saved cannot be easily ignored from the perspective of enhancing work efficiency.

We confirmed that as described above, information digitalization is effective in saving not only the labor spent on searching for necessary information and the time spent, for example, on filing documents but also the fabrication work time. Also, we have reduced the use of paper-based documents by 95%, concluding that almost all paper-based documents are unnecessary except for some special cases. The latest tablet PCs have functionality that enables practical use of 2D- and 3D-CAD software. For example, by using



Overall view of the large shield machine (3D model)



Paper-based drawings of the shield machine and tablet PC

them at the manufacturing site, it is now possible to find the numerical values not included in paper-based drawings from CAD data and quickly verify them with the actual products. This is effective in preventing the need to undo work and enhancing work efficiency. Through this verification, we have confirmed the following effects:

(1) Improving work efficiency through real-time information sharing
The person-hours have been reduced by 5%

(2) Drastically reducing paper-based documents
Paper-based documents have been reduced by 95%

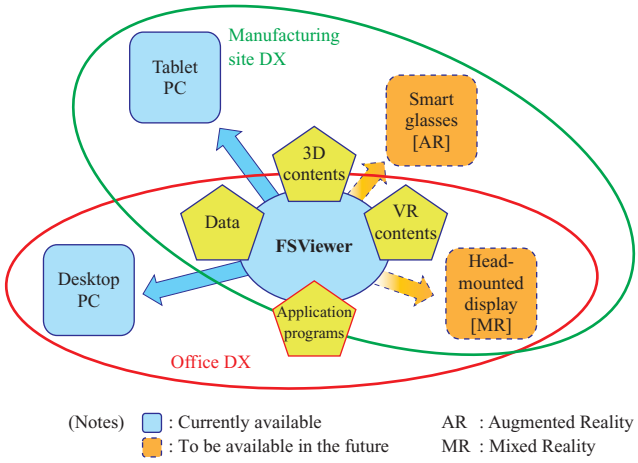
(3) Utilizing digital data
Visualization by 3D models and other information has brought about better understanding and reduced the non-conformity rate

For better usability and wider applications

As mentioned at the beginning of this article, DX on manufacturing sites is aimed at enhancing product competitiveness. The important things to achieve it are to lower the hurdle to introducing DX systems so that even those unfamiliar with PCs can use these systems in a sustainable way and to allow these systems to respond flexibly to advances in DX technology. With these points in mind, FSViewer has a simple configuration and serves as a "box" to put digital data and application programs in. Therefore, there is large room for the user to obtain different effects by devising ways of developing master data. For example, at another manufacturing site, the progress of work is recorded sequentially as time-series work process records with the aim of using these records as a fabrication database in the future.

A key challenge we, who are promoting DX, must tackle to use 3D data more actively on manufacturing sites is to establish a method reasonably in any situation. IHI's Nuclear Energy Business Unit is promoting engineering activities using iDMU as previously mentioned and at the same time exploring new technologies, including virtual-space fabrication simulations and safety simulations using virtual reality (VR) technology. We will aim to establish FSViewer as a system that enables easy importing and utilization of such 3D contents and at the same time expand its applications so that it can be used for DX on many other manufacturing sites.

Utilization on our manufacturing site



Future development of FSViewer

INFORMATION

Thank you very much for reading the article of IHI ENGINEERING REVIEW.
We hope you will take a look at other articles.

Webpages of our journals on technology are as follows:

Journal of IHI technologies (in Japanese)

IHI ENGINEERING REVIEW (in English)

Vol. 56 No. 1

Contents page of Vol.56 No.1

Our corporate website introduces our technology categorized according to social issues: “IHI Challenges with Society”. The articles of IHI ENGINEERING REVIEW are also provided there. We would appreciate it if you would visit our website.

IHI Challenges with Society

Technologies supporting IHI

Inquiries:
Editorial office of IHI ENGINEERING REVIEW
ihi-ty9776@ihi-g.com