Construction of a platform for supporting promotion of manufacturing workplace data digitization and improvement of overall equipment effectiveness

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Summary

Improving Overall Equipment Effectiveness (OEE) in manufacturing workplaces will be essential for overcoming the severe cost and quality competition in the years ahead due to vehicle electrification. To accomplish that, it necessary to use Internet of Things (IoT) tools to digitize, visualize, analyze and effectively utilize factory floor data. This article presents a platform that has been constructed to consistently support the collection, transfer, storage and visualization of such data for improving OEE.

1. JATCO's aimed for Smart Factory

JATCO is promoting efforts to improve Overall Equipment Efficiency (OEE) by digitizing GENBA data. These efforts are called Smart Factory activities and involve the three steps defined below and shown in Fig. 1.

Step 1: Factory that minimizes defects and equipment downtime

Step 2: Factory that does not pass on defects and does not stop production lines

Step 3: Factory that maintains maximum efficiency

As of 2022, the state of progress of the activities was between Step 1 and Step 2, and the target is to transition to Step 3 in the 2030s.

In order to achieve a factory that maintains maximum efficiency, efforts must be made to substantially improve OEE from the current level. JATCO's current OEE level is around 80%. We must aim to attain a level of 90% in Step 2 and 100% in Step 3.

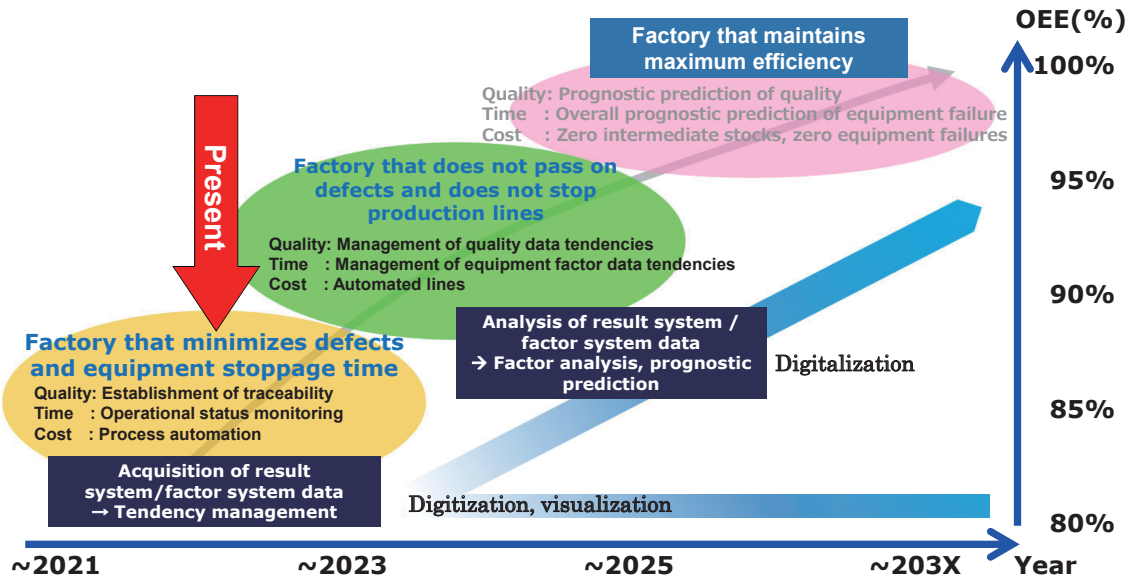

Fig. 1 Roadmap to JATCO's Smart Factory

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2. Ascertaining the current situation

2.1 Six large OEE losses in manufacturing workplaces

The question of how to minimize losses is a key factor for improving OEE. The following six large equipment losses can be cited as loss factors that lower OEE.

- Breakdown loss
- Setup and adjustment loss
- Idle time and short stop loss
- Speed reduction loss
- Defect and reworking loss
- Start-up and yield loss

In order to eliminate these losses, they must be discovered early and dealt with quickly. It is also necessary to take advance preventive measures.

2.2 Issues and measures concerning workplace data collection

Eliminating losses requires quick collection of manufacturing workplace data, identifying losses indicated by the data, and implementing countermeasures. However, the following factors in the current situation are delaying the elimination of losses.

- Employees do not realize the line has stopped and neglect losses.
- Checking the equipment takes time, so dealing with line issues is delayed.
- Long lead time is needed for investigation when a problem occurs, thus prolonging losses.

An analysis of these three factors revealed the issues shown in Table 1.

As countermeasures, the operational status of the line must be ascertained in real time and advance preventive measures must be taken based on the implementation of tendency management. To accomplish these tasks, an Internet of Things (IoT) tool was used to promote digitization of manufacturing workplace data in this project.

2.3 Benefits of using IoT tools

The following benefits are gained by using IoT tools.

- Because data are treated digitally, not like paper-based analog data, data searches, processing and visualization can be done flexibly.
- IoT tools can replace human employees for processing data on equipment and quality without relying on people.
- Large improvements in cost effectiveness can be obtained because many inexpensive IoT tools have been put on the market in recent years.

Table 1 Issues delaying elimination of losses and countermeasures

Present situation	Issues	Countermeasures
Employees do not realize the line has stopped and neglect losses.	Employees have no means of confirmation except looking at the line directly.	Automatically collect and visualize data on the operational status of the line.
Checking the equipment takes time, so dealing with line issues is delayed.	Checking equipment is time consuming because many items have to be written on paper by hand.	Digitize hand-written tasks to shorten employee man-hours and increase their line monitoring time.
Long lead time is needed for investigation when a problem occurs, thus prolonging losses.	It takes a long time to find the true cause of a problem after it occurs because of investigations.	Predict problems in advance or take immediate action based on management of equipment and quality tendencies

2.4 Necessity of constructing a data platform

Implementation of the countermeasures in Table 1 makes it possible to obtain and utilize data from different inputs such as from equipment and PCs connected to measuring instruments. However, if the collected data are in different formats, it can be troublesome to visualize and analyze the data later, so it is necessary to convert data to a unified format.

In addition, the scope of data utilization is limited if the collected data are stored in independent storage devices such as the separate PCs of individual employees. It is necessary to have a unified data storage location so that data can be shared, analyzed and utilized with other departments. A platform needs to be constructed that enables company-wide visualization of data.

3. Platform development concept and construction

3.1 Platform concept

The following concept was formulated for the platform described here.

- It must allow importation of different types of inputs.
- It must be possible to visualize different types of data in the same format.

To achieve these capabilities, the processing flow of the platform was defined as follows.

- Different types of inputs are digitized.
- Digitized data are converted to the same format.
- Converted data are stored in same location.
- Data can be visualized in an identical format.

This processing flow is illustrated in Fig. 2.

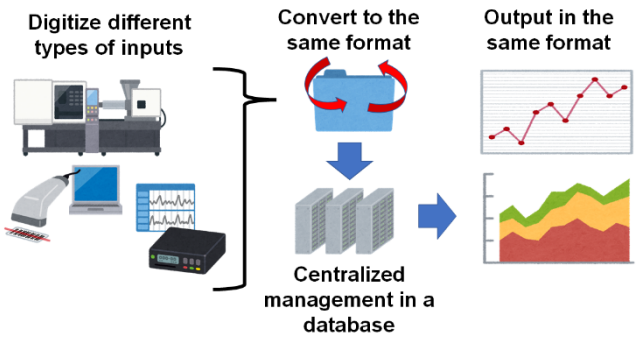

Fig. 2 Platform development concept

3.2 Examples of digitization of different types of inputs

This section explains specific examples of the different types of inputs mentioned in the previous section.

1) Data on equipment operational status

The signals of the programmable logic controller (PLC)[*1] that is used to control each piece of equipment are collected.

The internal signals of the PLC are monitored and suitably output in real time to ascertain the operational status of equipment. This method can be adopted on any line if it is possible to monitor PLC signals.

2) Check sheet data

The hand-written check sheets of employees are collected.

The input format is imported to a PC, and employees' hand-written elements up to that point are converted to PC inputs, and the input data are summarized.

This method can be adopted on any job line if the input format of check sheets can be imported to a PC.

3) Measured quality data

The data measured with 3D measuring instruments or other devices and accumulated on PCs connected to the instruments or in storage devices are collected.

PCs and storage devices are connected to JATCO's in-house network. The data they accumulate internally are saved on an in-house data server.

This method can be adopted for any measurement instrument if the measured results are saved as digital data.

3.3 Platform construction

This section explains how the platform was constructed based on the development concept. The overall configuration of the platform is shown in Fig. 3.

The platform constructed in these activities is called EQ_Connect, a name coined from the words “easy, quick, equipment and connect.” The name is now applied as a unified in-house standard.

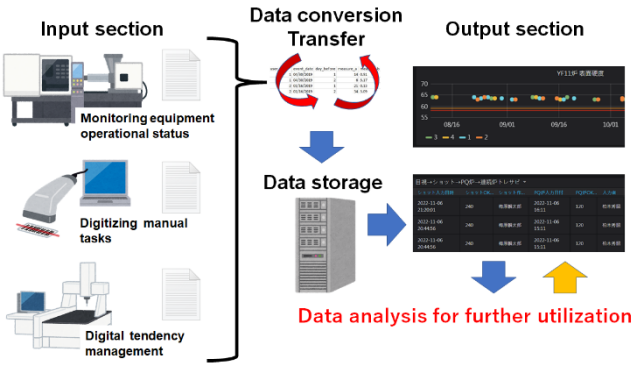

Fig. 3 Platform configuration

1) Input section

An IoT tool has been adopted for importing into the platform the various types of input data mentioned in the preceding section.

Discussions were held with the users[*2] of the platform for each matter in order to identify the necessary data items, and a data specification was developed.

2) Data conversion section

Input data are converted to a common list format composed of rows and columns using a programming language that is well-suited to character string processing.

At the time of conversion, there are instances when unexpected data may be input such as abnormal values output by the equipment or data input errors by the employees. Platform robustness has been enhanced by creating a program that envisions various types of error countermeasures so as to ensure that the conversion program does not stop when such instances occur.

3) Data transfer section

The converted list data mentioned above are transferred from each terminal to a storage server. Data are transferred in batch files[*3] that are executed at specified time intervals by the task scheduler.

This operation is a standard Windows function that enables data to be transferred reliably.

4) Data storage section

The storage server is one that has been installed in-house and is connected to the in-house network.

A relational database[*4] (RDB) has been created on the storage server.

Whenever data are transferred to the server, a program developed in-house writes the lists contained in the data into tables.

The specifications of the in-house program allow the imported lists to be modified easily, which facilitates easy horizontal deployment to other departments or plants.

5) Output section

A commercially available business intelligence (BI) app[*5] called WebAccess was adopted for visualizing data. This software reads data from the RDB for representation in tables and graphs.

4. Results obtained with EQ_Connect

4.1 Effect on OEE

As of December 2022, EQ_Connect has been implemented on approximately 40% of JATCO's main production lines. The following benefits have been revealed by visualizing and analyzing data from lines equipped with EQ_Connect.

- Data visualized by WebAccess are displayed on monitors installed in plants and offices, enabling the line operational status to be ascertained in real time. This now makes it possible to take corrective action immediately whenever a loss occurs.
- The collection of equipment data reduces the time employees have to spend checking equipment, thereby increasing the time they have for tending to the line.
- Highly accurate data that have already been collected and accumulated can be analyzed and utilized whenever a problem occurs, enabling a loss countermeasure to be

implemented in a short lead time..

- It is not necessary for employees to prepare data, so they can spend more time on analyzing and correcting problems that occur..

The measures mentioned above have improved OEE by approximately 5% on the lines where EQ_Connect has been implemented.

4.2 Secondary benefits of the activities

The activities described here have made it possible to visualize and utilize data effectively, enabling users to realize for the first time the value and importance of data. Users who now know the importance of data have requested that various types of data be visualized by EQ-Connect. More users are seeking advice about data analysis, and the number of users who are conscious of using data has been increasing.

In the course of proceeding with efforts to deploy EQ_Connect, it was found that many departments simply store data they have already visualized. Importing such data into EQ_Connect for visualization now enables the data to be deployed horizontally for use by other departments.

5. Future prospects

The platform constructed in this project is designed to be easy to operate, but a certain educational period is needed to gain consistent operational proficiency. It is desired to develop a certain number of employees capable of operating the platform to ensure continuous use going forward.

Activities for implementing the platform quickly are also needed to establish EQ_Connect throughout the company. Patterns can be created for each matter based on the types of inputs involved. It is desired to quicken horizontal deployment by preparing packages that can be varied for connecting to EQ_Connect according to the matter concerned.

Footnotes

*1: PLC

This is an acronym for programmable logic controller. It has an embedded microprocessor and is used to control production equipment by means of programs that users can modify.

*2: Users

The target users of this platform are manufacturing employees, manufacturing managers, engineers and others who require data.

*3: Batch files

These are files in which a series of commands are described, such as for connecting to a server, copying data or other tasks; they are executed automatically in serial order.

*4: RDB

A relational database is a collection of data consisting of interrelated rows and columns.

*5: BI app

This software is used for visualizing and analyzing various types of data possessed by a company in order to assist management in making decisions about business and operations.

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