System Recorder for Post-Maintenance of Production Equipment

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In recent years, there has been growing demand for higher output from production equipment at plants while the devices constituting the equipment have become more diverse. This has increased both the functionality and complexity of the equipment. To boost the operating rates under such circumstances, maintenance is needed that can identify the causes of equipment irregularities more quickly and reduce the downtime.

Mitsubishi Electric Corporation has proposed a total maintenance solution that supports maintenance operations from all aspects and has developed a system recorder under the MELSEC iQ-R Series, Mitsubishi Electric's programmable controller, as a solution to support corrective maintenance among the maintenance operations.

The system recorder consists of various control devices, such as programmable and motion controllers, and different types of engineering tools that are related to such devices. Functions are provided for analyzing the causes of irregularities in the production equipment including various devices at the entire equipment level. When an irregularity occurs, the system recorder logs the system-wide control data on each control device and uses the data to reproduce the equipment conditions when the irregularity occurred. This enables a simplified analysis and quick identification of the cause of the irregularity, which reduces the downtime and increases the productivity.

FA devices and engineering tools that are compatible with the system recorder

By combining various control devices, such as programmable and motion controllers, displays, and engineering tools (GX Works3, GX LogViewer, GX VideoViewer, and GT Designer3) for the devices, the system recorder supports identification of the causes of equipment irregularities, helping to reduce the downtime of the production equipment.

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1. Introduction

In the manufacturing industry, continuous production without interruption has become increasingly important for boosting productivity.

The production equipment at plants consists of numerous devices that have increased the functionality and complexity of the equipment in recent years. If production stops due to an equipment irregularity, it takes time to identify the cause, prolonging the downtime. Accordingly, maintenance has become critical to reduce the downtime.

Maintenance can be divided into three types: Predictive, preventive, and corrective. In addition to corrective maintenance, which is performed to identify and eliminate the cause of an irregularity, predictive and preventive maintenance have attracted growing interest in recent years. In predictive maintenance, various statistical techniques are used to detect the signs of an irregularity before it occurs, and in preventive maintenance, periodic maintenance is performed based on previous experience in order to avoid unexpected production interruptions.

In order to reduce the downtime of production equipment, Mitsubishi Electric Corporation has proposed a total maintenance solution (Fig. 1). Maintenance functions for the aforementioned three maintenance types are provided at three levels: devices, equipment, and lines, which form a plant, and the maintenance operations are supported from all aspects.

In addition, Mitsubishi Electric has developed a system recorder under Mitsubishi Electric's programmable controller MELSEC iQ Series as a solution specifically for improving the corrective maintenance function of the total maintenance solution.[1]

This paper describes the characteristics of the system recorder and the technologies applied to the FA devices and engineering tools that form the recorder.

2. System Recorder

The system recorder is a corrective maintenance solution. When an irregularity occurs in the production equipment, the system recorder logs the system-wide operating conditions and provides supports through the simplified analysis function to enable the cause of the irregularity to be quickly identified. It is a combination of various FA devices, such as programmable and motion controllers, and different types of engineering tools related to the FA devices.

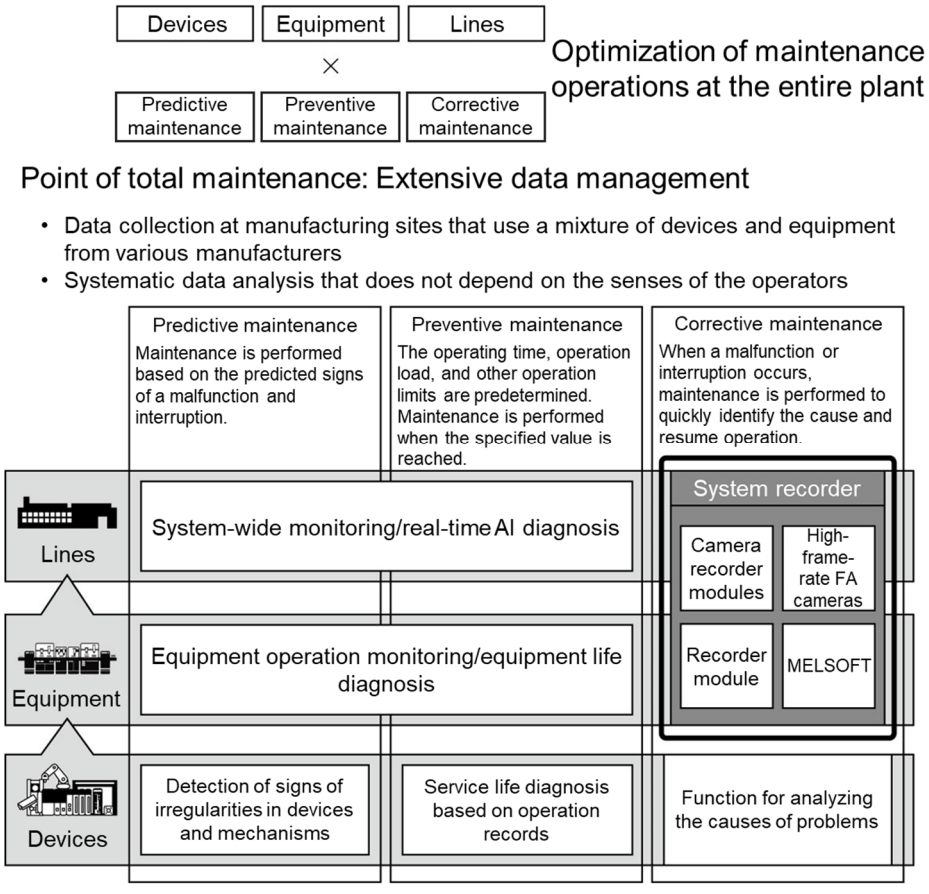

Fig. 1 Total Maintenance Solution

If an irregularity occurs in production equipment that is a complex combination of many devices, it is necessary to understand the facts (what happened in which section and when) before and after the irregularity in order to recover the equipment. For conventional FA devices, data must be collected and analyzed for each device. Therefore, if multiple devices are related to the cause of the irregularity, it is difficult to check the data of one device with that of the other devices for analysis; it takes time to identify the cause and resume operation. In addition, if the data was not retained during the irregularity, it takes more time to resume operation.

The system recorder collects event histories and the histories of operations on displays in addition to the control data of programmable controller CPUs and the data on the servo axes of motion units, which enables the analysis of operations by operators at the actual manufacturing sites in addition to the operating conditions of the equipment. Therefore, an irregularity originating from a human error can also be analyzed besides equipment irregularities. The recorder can also collect videos from the network cameras, which makes it possible to analyze the movement of the equipment, work, and operators when an irregularity occurs.

In analysis, the various collected data items can be linked to reproduce the conditions. Therefore, even if multiple devices are related to an irregularity, the cause can be easily identified.

3. Characteristics of the System Recorder

3.1 System-wide recording

3.1.1 Collection of all device and label data

To allow the programmable controller CPUs to collect data on all the devices and labels (Fig. 2), Mitsubishi Electric has developed recorder modules under the MELSEC iQ-R Series.

The recorder modules can collect whole data on all the devices and labels used for a sequence program created by a user on the control cycle (scan time) of the programmable controller CPU. This makes it possible to reproduce the operating conditions of the equipment when an irregularity occurred.

In addition, the recorder unit is separated from the programmable controller CPU; the programmable controller CPU collects the device and label data in synchronization with the sequence scan and the recorder unit accumulates and stores the collected device and label data. Thus, the loads in the collection processing are distributed, which reduces the increase in the scan time and minimizes the influence on the equipment performance.

The engineering tools automatically extract the target devices and labels for which the data is to be collected using the collection function for all device and label data, eliminating the need for users to manually select the target devices and labels. To record the equipment conditions, users only need to set triggers that determine the collection timing and the storage locations for the data.

In the case of a large-scale sequence program and large number of devices and labels in use, it takes a longer time to collect and scan the data. To solve this problem, in addition to the function for collecting whole data on all the devices and labels, another function is provided to make it easy for users to select the target devices and labels. The engineering tools extract and display all the devices and labels used for a sequence program and users can easily select target devices and labels from the displayed list. Selecting the minimum necessary targets can reduce the extended scan time.

3.1.2 Camera video collection

Mitsubishi Electric has developed camera recorder modules under the MELSEC iQ-R series that makes it possible to directly connect network cameras to programmable controller systems (Fig. 3). The camera recorder module has a video collection function in addition to the aforementioned collection function for all device and label data of the recorder module.

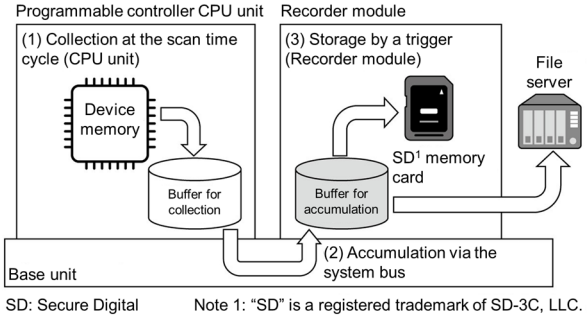

Fig. 2 Collection of data using the collection function for all device and label data

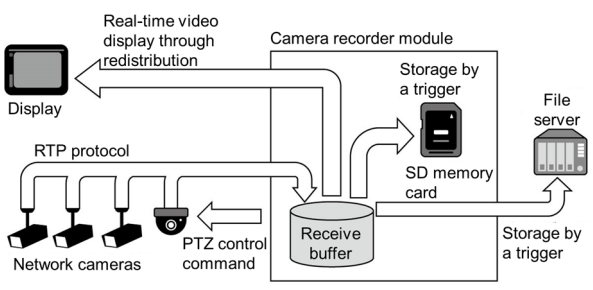

Fig. 3 Camera recorder module

The camera recorder module supporting the Real-time Transport Protocol (RTP) receives streaming video data from the network cameras and accumulates and stores the data along with the device and label data. The camera recorder module receives multiple RTP sessions at the same time and up to four network cameras can be connected to one camera recorder module. Since up to four camera recorder modules can be connected to a single CPU module, up to sixteen network cameras can be connected to a single CPU module. In addition, the installed recorder and camera recorder modules can share triggers, which means that when an irregularity occurs, the video from all the connected network cameras can be synchronized with the device and label data and stored.

Furthermore, the camera recorder module supports the Open Network Video Interface Forum (ONVIF), which is a standard network camera interface, enabling the connection of various types of general-purpose network cameras. This allows users to select the optimum network cameras suited to their application.

Moreover, the combination with PTZ network cameras for which the fields of view can be controlled makes it possible to control the PTZ of the cameras using commands from the sequence program, which enables flexible photographing based on the movement of the equipment and operators at the actual manufacturing sites. The term “PTZ” is the abbreviation for “pan” (horizontal oscillation), “tilt” (vertical oscillation), and “zoom” (zooming).

The camera recorder module also supports the function for redistributing received streaming RTP data to Mitsubishi Electric’s displays. This function makes it possible to check the video from the network cameras in real-time by simply setting the communications between the camera recorder module and the displays. Because the video from the network cameras can be checked at the actual manufacturing site in real-time, network cameras can be easily installed and adjusted when starting to use new equipment.

3.1.3 High-Frame-Rate FA Camera

The camera recorder module supports the “FAC-1020/1000”[(2)] high-frame-rate FA cameras made by Mitsubishi Electric, in addition to general-purpose ONVIF network cameras.

High-frame-rate FA cameras send out image data at up to 200 frames per second. The camera recorder module optimizes the reception processing of RTP packets, which realizes video storage at a high frame rate. This makes it possible to capture the movement of high-speed production equipment and work.

In addition, the parameters of the time synchronization function are adjusted between the camera recorder modules and the high-frame-rate FA cameras, which realizes high-accuracy time synchronization. This makes it possible to check the device and label data and the video data when an irregularity occurs on the same time line even for high-speed subjects, making the analysis easier.

3.2 Simplified analysis

The simplified analysis function makes it easy to analyze data obtained through system-wide recording using the engineering tools.

The simplified analysis function consists of video analysis, offline monitoring, and data flow analysis (Fig. 4).

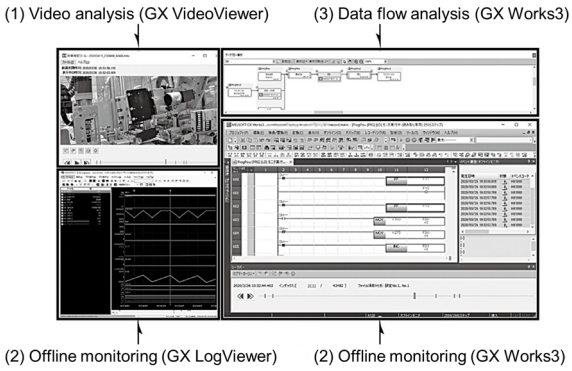

Fig. 4 Simplified analysis function configuration

Fig. 5 Video analysis function

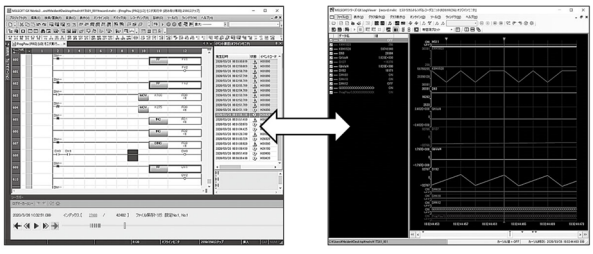

Fig. 6 Offline monitoring function

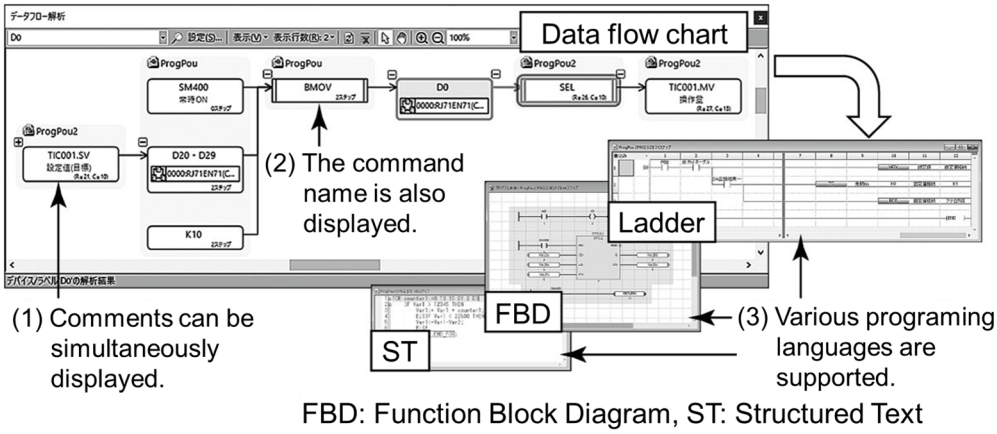

Fig. 7 Data flow analysis function

(1) Video analysis function

The video analysis function is provided by the GX VideoViewer tool for viewing and checking videos, and has the following characteristics (Fig. 5).

(i) The tool plays up to four videos while synchronizing the time, which makes it possible to check the equipment conditions from multiple angles when a problem occurs.

(ii) Maintenance engineers can share the analysis information with the designers by adding comments and colored marks (log markers) to a video in which the movement seems irregular.

(2) Offline monitoring function

The offline monitoring function provided by the GX Works3 tool that supports programming, configuration, and maintenance by programmable controllers and the GX LogViewer tool that displays and analyzes the device logging data. GX Works3 has characteristic (i) and GX LogViewer has characteristic (ii) listed below (Fig. 6).

(i) When a problem occurs, the tool can reproduce the program transition offline based on the logging data of all the devices (GX Works3).

(ii) The tool displays waveform data that was synchronized with the program transition to show the relationship between the program transition and the changes in the device values (GX LogViewer).

(3) Data flow analysis function

The data flow analysis function is provided by GX Works3 having the following characteristic (Fig. 7).

(i) The tool displays the relationship between the devices and the labels in a program along with comments and command names, which can clarify the relationship in a complex program.

These three functions bring the following two improvements, helping to reduce the downtime.

- The situations at actual manufacturing sites can be remotely understood based on the data obtained through system-wide recording without going to the sites.
- Log markers can be used to add information to the recorded data, which makes it easier to share information between the actual manufacturing sites and the design sections.

4. Conclusion

This paper described the background of the development of the system recorder that supports corrective maintenance in the total maintenance solution, along with its characteristics and the technologies applied to realize the system recorder.

The system recorder reduces the time required to identify the causes of equipment irregularities and improve the operating rate, contributing to higher productivity. Mitsubishi Electric will expand the application scope of the system recorder as well as improve and expand the total maintenance solution to help boost productivity in the manufacturing industry.

References

(1) Mitsubishi Electric Programmable Controller “MELSEC iQ–R Series” System Recorder, Mitsubishi Denki Giho, 95, No. 1, 16 (2021)

(2) High Frame Rate Network Camera “FAC – 1020/1000”, Mitsubishi Denki Giho, 95, No. 1, 77 (2021)