Servo System Technologies Creating Monozukuri Changes

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1. Introduction

In recent years, it has become necessary for the manufacturing industry to both improve productivity and increase flexibility toward market changes and fluctuation. As such, many manufacturers are undertaking major change by incorporating ICT technologies for robot automation, etc. and information technologies, such as IoT and AI, in an attempt to achieve advanced *monozukuri*.

This article will introduce technologies that support robot development, and servo system monitoring functions and ICT technologies as servo system technologies that create monozukuri change. This article will also provide examples of our production line initiatives which use these technologies.

2. Robot Development Support Technologies

An effective way to increase monozukuri productivity and flexibility is to use robots to automate processes that were conventionally done by humans. However, there are a number of issues involved in developing a production system that uses robots, such as training personnel to have robot expertise and prolonged development periods.

In order to solve such issues, SANYO DENKI's *SANMOTION C Controller*(1) features technologies and functions supporting robot development, and these are introduced below.

SANMOTION C features an abundance of technologies enabling the development of robot operation programs easily and quickly, namely, robot posture control, a teaching/program function, and a simulation function. Below are explanations about each technology.

2.1 Robot posture control

For *SANMOTION C*, we have prepared a mechanism setting tool, as per Fig. 1, which makes it possible to control robot posture with ease.

Robot posture can be controlled simply by setting the type of robot to be developed, arm length, and gear ratio. Posture control does not require complicated calculations, therefore the burden of program development placed on customers is reduced.

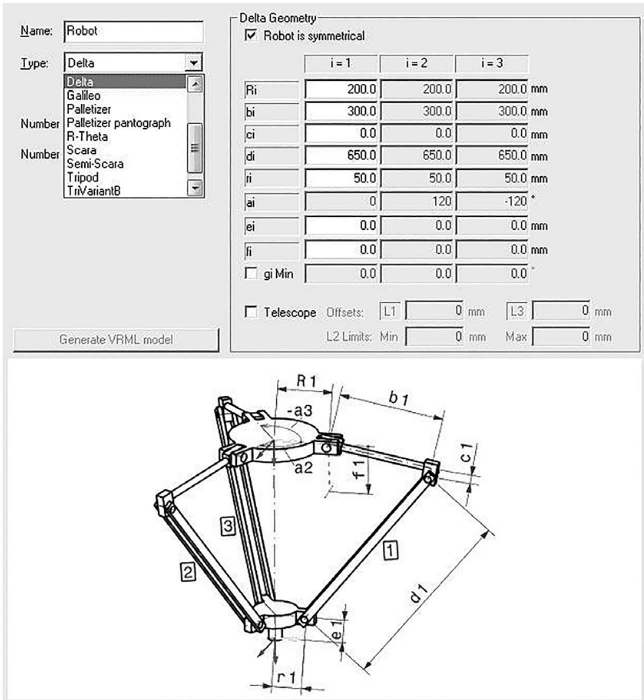

Fig. 1 Robot mechanism setting tool

2.2 Teaching/program function

As Figure 2 shows, *SANMOTION C* features a teaching pendant to easily program robot operations. Wizard-style screens such as that shown in Figure 3 simplify the process of setting complex robot hand positions. Moreover, the commands shown in Table 1 have been prepared to achieve robot operations with ease. These functions make it possible to program robot operations in a short period of time.

Fig. 2 External appearance of the teaching pendant

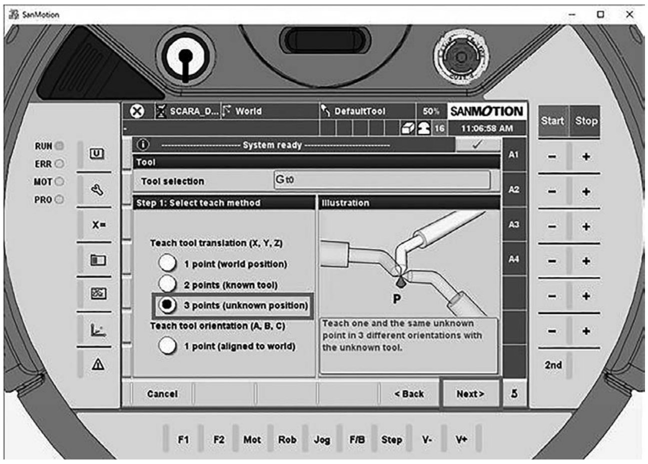

Fig. 3 Robot hand setting screen

Table 1 Examples of main robot language commands

Command name	Description
PTP	Point-to-point movement
LIN	Linear interpolation movement
CIRC	Circular interpolation movement
PTPRel	Distance-specified PTP operation
LINRel	Distance-specified linear interpolation operation
StopRobot	Robot stop
WaitFinished	Wait for robot command to process
RefRobotAxis	Homing operation
TOOL	Tool coordinates setting
Ovl	Overlap setting (Path)
Ramp	Acceleration/deceleration curve setting
WaitTime	Wait time (timer)
DIN.Wait	Wait for digital input
Dout. Set	Digital output setting (BOOL)
WHILE ... DO	Iterative control
IF ... THEN	Branch instruction

2.3 Operation simulation

SANMOTION C offers software that can simulate robot operations.

This software makes it possible to confirm whether the robot is operating efficiently and safely without using the actual robot.

As Figure 4 shows, it is possible to visually analyze each axis' operation (position, speed, acceleration) while confirming robot operations in 3D.

Even after the actual robot is installed, operations can be confirmed using simulation. Moreover, video footage can be recorded while logging motor speed, acceleration, and torque data, and this information can be utilized to analyze frequent robot stops or to improve cycle time.

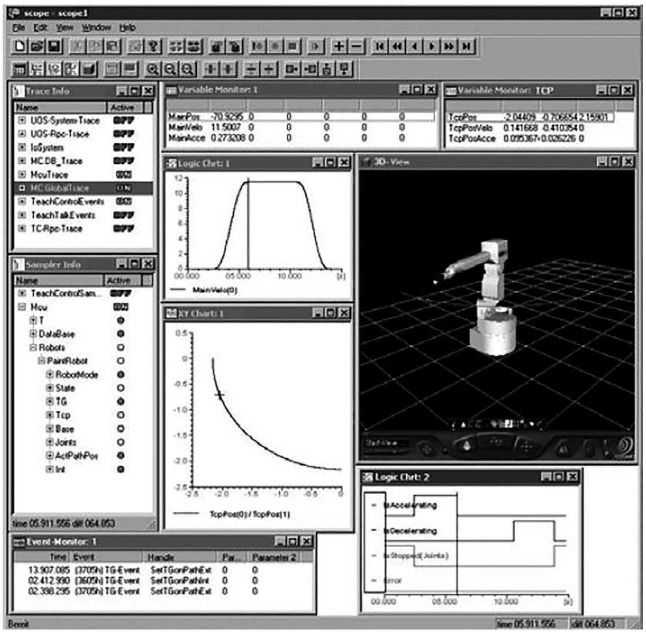

Fig. 4 Screen of 3D simulation software

In this way, even users without robot expertise can use the technologies in *SANMOTION C* to support the development of robot operation programs in a short period of time.

3. Monitoring function

With the aim of improving productivity and quality, servo systems are also required to have functions for monitoring part life, equipment operational status, operating environment, and so forth.

This section explains the monitoring functions of the *SANMOTION R 3E Model* servo amplifier.

3.1 Service life prediction function

Servo equipment such as servo motors and servo amplifiers are service life-limited components which wear and deteriorate over time. In order to use products for an extended period of time, regular part replacement is necessary. However, part life differs depending on the operating conditions and operating environment, therefore it is difficult to ascertain the appropriate replacement timing. As such, SANYO DENKI has included a function to monitor the remaining life of the motor holding brake and relays, etc. used in inrush current prevention circuits. The remaining life of these parts can be monitored through a motion network from the host controller. Moreover, as shown in Figure 5, motor setup software can be used for monitoring.

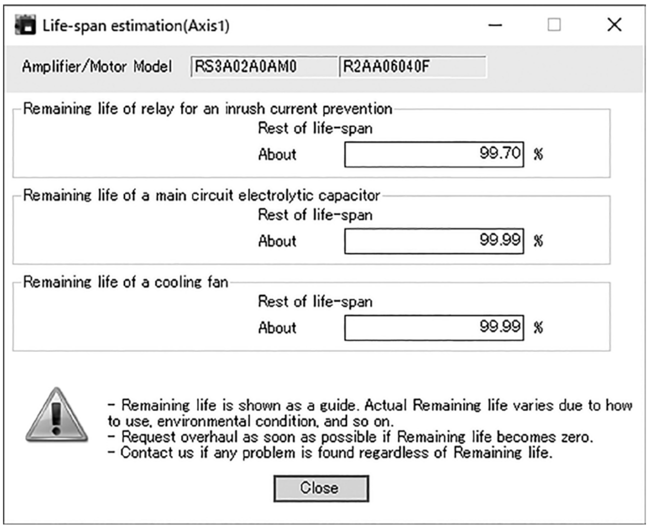

Fig. 5 Service life prediction screen in the motor setup software

Knowing a part's remaining life makes it possible to schedule maintenance before breakdowns on servo equipment and machinery actually occur.

For details on the service life prediction function, please refer to "New Product Introduction: *SANMOTION R 3E Model* 400 VAC Input Servo Amplifier (150 A, 300 A)"(2) of this Technical Report.

3.2 Operational status monitoring function

The *SANMOTION R 3E Model* servo amplifier is equipped with numerous functions to monitor the equipment operational status.

For example, it is possible to easily monitor motor and amplifier power consumption with a power consumption monitoring function that calculates the power consumption based on the rotational speed and electric current of the servo motor. By monitoring power consumption, it is possible to ascertain the energy usage status of machinery and production equipment. This helps to reduce the factory's overall energy costs and promote energy-saving.

The *SANMOTION R 3E Model* servo amplifier is also equipped with a communication error monitoring function which monitors communication quality. By quantitatively monitoring communication quality, it is possible to prevent communication trouble caused by changes in equipment over time and operating environment changes. Moreover, when a problem does arise, it is possible to swiftly perform troubleshooting.

4. Information and Communication Technology

As mentioned above, a lot of information can be obtained from the servo system, such as remaining part life and machine operating status. As shown in Figure 6, this information can be collected and accumulated in host production management systems, data servers, etc. via devices on each level and a network.

In order to effectively utilize this information, there is a need for ICT technology to easily transfer data from the servo equipment to the host device or data server. This section explains the ICT technologies SANYO DENKI is working on for servo systems.

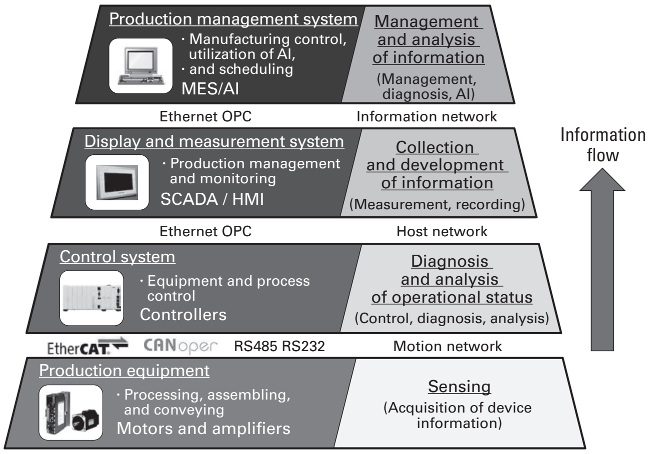

Fig. 6 Flow of production equipment information

4.1 Motion network communication technology

In order to acquire a high volume of information from a servo system, there is a need for a high-speed, large-capacity motion network.

The *SANMOTION R 3E Model* EtherCAT servo amplifier(3), which is compatible with high-speed motion networks, is the optimal product for utilizing ICT technology on the production line.

This servo amplifier achieves a minimal communication cycle of 62.5 μs, meaning that the maximum data transfer amount in one communication cycle is approximately 1.6 times greater than the conventional model. It is possible to send information to the host controller in real-time, including not only commands and feedback information required for servo motor control, but also monitoring information such as remaining part life and equipment operating environment.

By utilizing these features, naturally the performance of machinery is improved, but so too is the reliability of failure detection, preventive maintenance, etc.

4.2 Network connection technology

SANYO DENKI's *SANMOTION C* motion controller can easily establish communication between devices through an OPC server and network library. Figure 7 shows an example of network connection between devices.

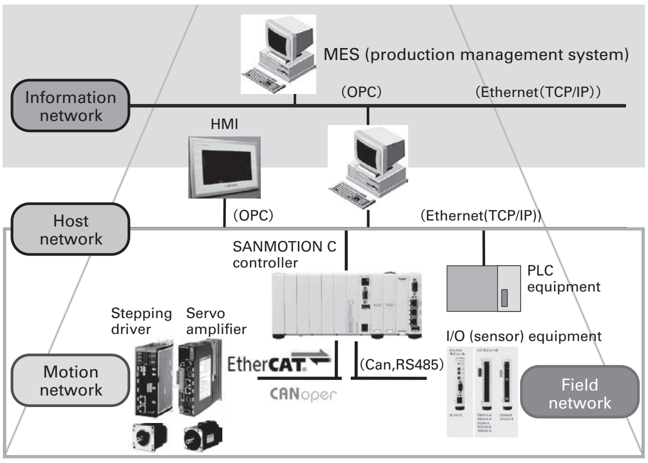

Fig. 7 Network connection between devices

Users who develop communication programs only need to set parameters through GUI for the controller to automatically establish communication between devices, thus enabling a network to be built in a short period of time.

5. Examples of use on SANYO DENKI's production line

This section introduces examples of how we have applied technologies that support the development of robots, servo system monitoring functions, and ICT technologies to SANYO DENKI's monozukuri.

5.1 Example of use for robot development support technologies

Previously, the part insertion process for servo amplifier's printed circuit board heavily depended on manual work and was known as a bottleneck process of the production line. To alleviate this bottleneck, we built a production system utilizing robots. Figure 8 shows the external appearance of a dual-arm robot developed in-house by SANYO DENKI.

This in-house robot loads and unloads printed circuit boards to and from the in-circuit tester then transfers PCBs to the downstream process.

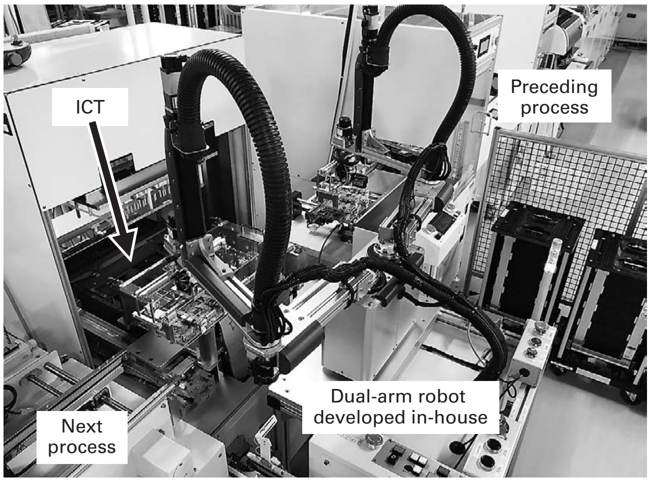

Fig. 8 External appearance of an in-house developed dual-arm robot

By using the robot development support technologies of *SANMOTION C*, we were able to develop this robot in one-third of the time typically required, and minimize installation costs. The newly built part insertion process achieves four times greater productivity and two-thirds shorter lead time compared to the conventional process. Moreover, it is possible to produce several different varieties of PCBs on the same production line, therefore productivity and flexibility have been dramatically improved.

5.2 Examples of use for monitoring functions and ICT technology

Robots and automation equipment using SANYO DENKI's SANMOTION products have also been introduced to the servo motor production line. We have begun initiatives to increase productivity and stabilize quality by utilizing the various types of information that can be obtained from the servo motors, encoders, and servo amplifiers using such equipment.

As one example, this article will introduce how we have used ICT technology on the rotor assembly line for compact servo motors.

This assembly line performs everything from attaching the magnet to the motor shaft to rotor inspection. As shown in Figure 9, the control system comprises of the *SANMOTION R 3E Model* EtherCAT servo amplifier and the *SANMOTION C* controller.

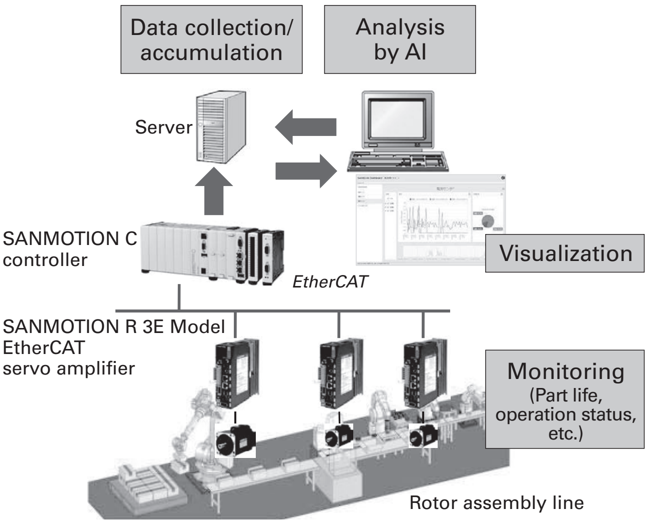

Fig. 9 Example use of ICT technology on a rotor assembly line

A large volume of information monitored by the servo system, such as part life and power consumption, is sent to the *SANMOTION C* controller in real-time by utilizing the high-speed performance and efficient data transfer of EtherCAT. Moreover, information acquired by the controller is accumulated in the data server.

By utilizing the data stored in the server, it is possible to achieve visualization of remaining part life, equipment operating status, amplifier operating status, and so on. As such, users can expect many benefits from the support functions that enable scheduled maintenance and enhanced productivity of servo equipment. Moreover, by utilizing machine learning such as AI, the large quantity of data that is collected can be analyzed and used to verify symptom detection for equipment failures and faults.

6. Conclusion

This article introduced robot development support technologies, and the monitoring functions and ICT technologies of servo systems as servo system technologies creating monozukuri change. This article also provided examples of SANYO DENKI's monozukuri using these technologies.

We will continue enhancing support technologies for the introduction and utilization of robots in order to further improve productivity and flexibility. Moreover, SANYO DENKI wishes to incorporate the know-how relating to ICT technology verified on our production lines into developing technologies and products creating new values for our customers, as well as creating change.

Reference

(1) Kodama, Tazaki and others: Development of the Motion Controller SANMOTION C
SANYO DENKI Technical Report No. 21 (2006-5)

(2) Chino, Koike and others: Development of the SANMOTION R 3E Model 400 VAC Input Servo Amplifier (150 A, 300 A)
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(3) Ito, Machida and others: Development of the SANMOTION R 3E Model EtherCAT Servo Amplifier
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