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Technical Reports

One-Touch Servo MR-JN Series

Authors: *Shigeo Jimbo*, Toshikazu Satone** and *Shigehisa Kato**

1. Introduction

There is a growing trend in the AC servo market for semiconductors, LCDs and other high-end applications as well as for simple applications such as replacing stepping motors and cylinders.

While AC servo systems are equipped with a high-efficiency servo motor and high-resolution encoder to provide a precision drive mechanism for optimum speed and torque, they have a reputation of being difficult to use because of the professional knowledge, techniques and experience required for system selection, adjustment and maintenance.

To allow more users to fully enjoy the performance of servos, we have pursued the concept of ease of use in developing the new MR-JN series.

Fig. 1 One-touch servo MR-JN and servo motor HF-KN

2. Overall Easy-to-Use System

2.1 Simplified initial start-up by one-touch adjustment

In-house and external surveys have revealed that the adjustment during initial start-up is the highest hurdle for users in introducing a servo system.

Key elements of servo adjustment include (1) resonance frequency, (2) applied load, and (3) operation speed and stroke. In setting up the conventional servo system, it is necessary to manually adjust the response characteristics and the notch filter that suppresses the resonance. A personal computer (PC) connected to a servo amplifier and peripheral switches for adjustment are used to check the oscillation conditions and repeatedly increase/decrease the response parameters while considering the amplifier's allowable maximum load and speed (Fig. 2a). Therefore, it can take 30 to 60 minutes to adjust one axis, and each operator is responsible for judging whether or not the setting is good.

The One-Touch Adjustment function has organized the oscillation detection function and adjustment processes, thus enabling automatic execution of the oscillation level assessment, filter setting, gain (response) adjustment, and safety margin securement (Fig. 2b). The oscillation detection function enables optimum filter setting by detecting the oscillations in real time and analyzing their frequencies.

Since the amount of over- and undershoot during positioning is also evaluated, the response characteristics are adjusted to the optimum level. In addition, all functions involved in the adjustment sequence are integrated in the amplifier's main body, so a PC no longer needs to be connected for adjustment.

With this function, start-up adjustment is completed within a couple of minutes, just 1/30 of the previous level.

2.2 Stabilized operation by torque ripple improvement

The newly developed HF-KN motor has the same-phase coils arranged in a distributed manner to displace the phases of harmonics in the magnetic flux and thus reduce the harmonic components. As a result, torque ripples have been reduced by about 85% from the conventional level, thus achieving stabilized torque generation. Also, optimization of the number of poles and slots enabled a new structural design that avoids excessive load on the bearing.

Torque stabilization has not only realized stable operation by suppressing machine vibration but has also achieved a high-speed and high-precision drive by taking advantage of a high gain.

2.3 Improved maintainability by drive recorder

When the machine triggers an alarm, it is important but difficult to identify the occurrence factor, especially in a case of low reproducibility.

The drive recorder function, in the same manner as the drive recorder mounted on a vehicle, automatically records the data from just before the trouble. After the power is restarted, the logged data can be read out in a graph format and used for promptly determining the occurrence factor.

In addition, by analyzing past alarm records, the optimum setting is automatically made for the analog waveform, sampling rate and other data to be recorded for the analysis of occurrence factors in the future,

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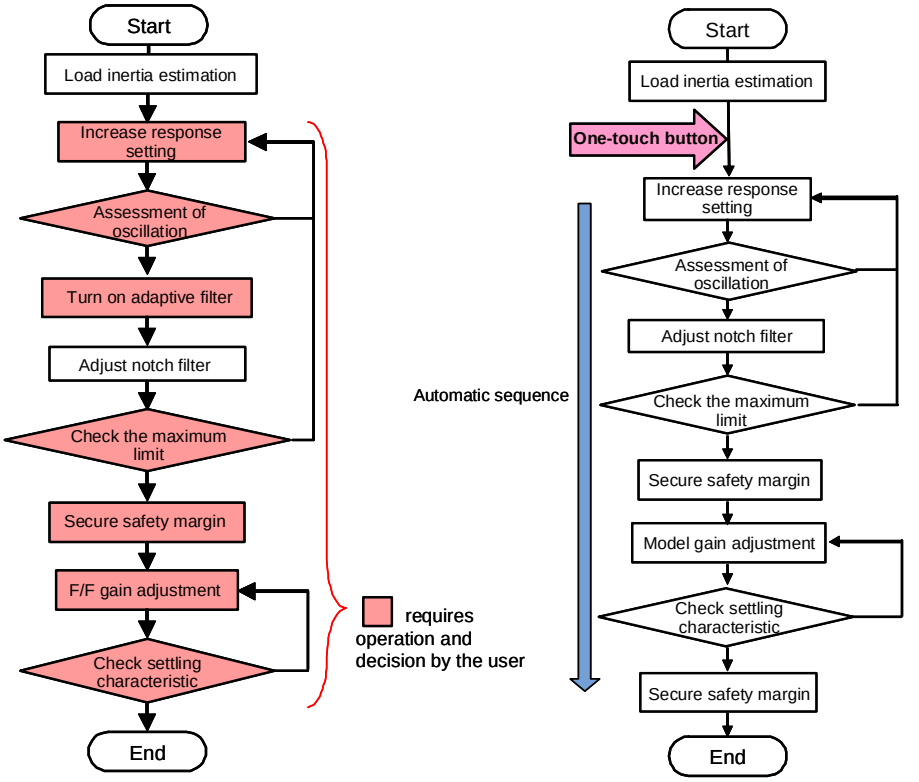

(a) Previous adjustment (b) One-touch adjustment of MR-JN

Fig. 2 Comparison of adjustment sequence during initial start-up

without troubling the user.

For the MR-JN series, a detailed analysis code is added to each alarm number shown on the 7-segment LED display. This feature, together with the drive recorder, assists quick troubleshooting of the system.

3. Conclusion

In developing the MR-JN series, priority was placed on ease of use not only to ensure high functionality and performance, but also to provide unique high performance of a servo system that can be effectively utilized on the user's equipment.

We will continue to work on product development from the customers' viewpoint, striving to provide product satisfaction for a wider range of users.

Development of Small Robot RV-2SQ for Assembling Application in Electronics Field

Author: *Takafumi Ishikawa**

1. Introduction

This paper describes the key features of RV-2SQ, a new six-axis vertically articulated small industrial robot, which is ideal for robot cell production systems required on the manufacturing floor (Fig. 1).

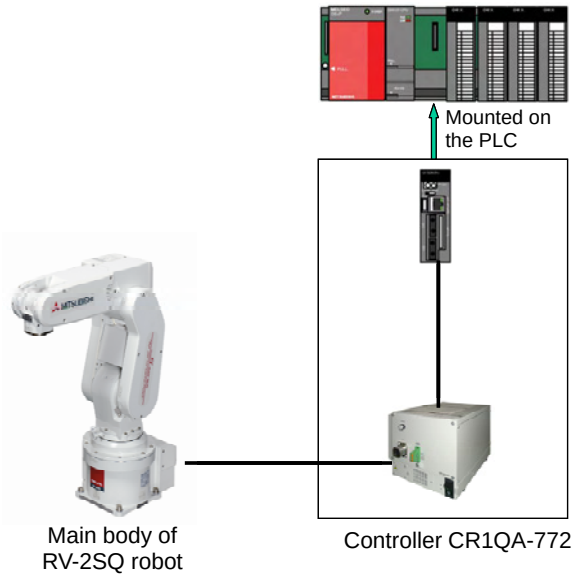

Fig. 1 Configuration of RV-2SQ

2. Features of RV-2SQ

2.1 Compact size and wide operating range

Industrial robots should have a small footprint to achieve a compact cell size. It is especially important to slim down the arms and secure a wide operating range close to the robot body.

2.1.1 Slim arm

The design target of arm No. 2 was set to 100 mm (16 and 14 mm shorter than the previous and competitor's model, respectively).

As the arm becomes slimmer, the chance of interference with the adjacent area is reduced and the user has greater flexibility of system design. However, if the motor were integrated with the brake as in the conventional model, the target size of RV-2SQ, 100 mm, could not be achieved. Therefore, the motor and brake were arranged as separate parts to allow the arm to be slimmer (Fig. 2).

2.1.2 Expanded operating range cose to the robot body

Arm No. 1 is designed in a "<" shaped flap type. With this design, interference between arms No. 1 and

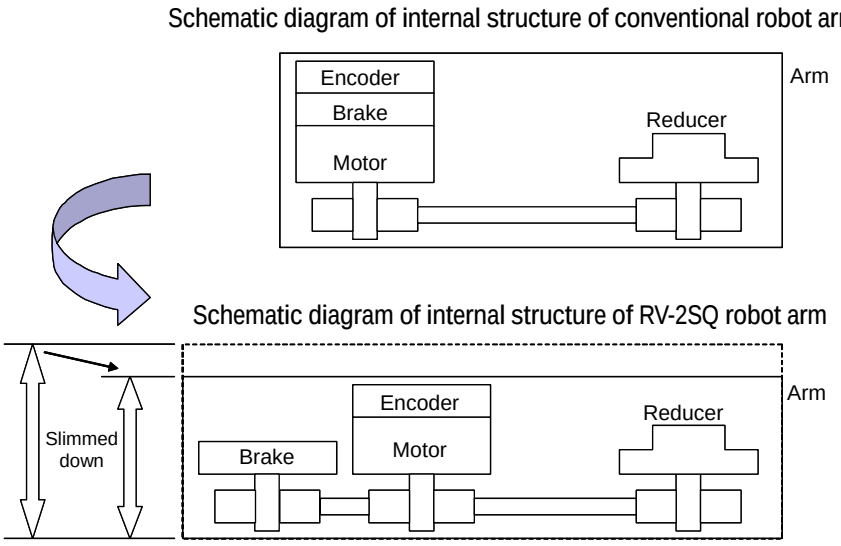

Fig. 2 Schematic diagram of internal structure of RV-2SQ arm

**Nagoya Works*

No. 2 is avoided and the operating range is expanded closer to the robot body compared to the conventional model, thus allowing users to design a compact machine layout (Fig. 3).

2.1.3 Wide operating range

The J1 and J4 axes of the RV-2SQ have an operating range greater than 360°. Generally, a wide operating range reduces the blind area and allows the working space to be arranged around the robot, thus resulting in a compact machine layout. Meanwhile, for the J1 axis that has the widest operating range, a mechanical stopper must be installed as required by safety standards. A typical fixed-type mechanical stopper is installed at the position just before where the operating range exceeds 180° in one direction, and the operating range cannot be extended beyond that position.

In response, the stopper position was made movable by installing a movable rail inside the arm so that the limit of the operating range can be overcome, ensuring a total operating range greater than 360°.

2.2 Low-cost robot arm

The top-cost elements of the robot arm are:

(1) Motor and encoder: 20% plus
(2) Reducer and bearing: 20% plus
(3) Man-hours for assembly and inspection: 20% plus
(4) Arm, cables, etc.: 15% plus

Items (1) and (2) are mostly fixed once the specifications are determined. In developing RV-2SQ, special emphasis was given to item (3) to reduce the cost.

We tried to simplify the wiring work, which accounts for a high proportion of the assembling man-hours. When assembling the main model of the previous series, wires must be threaded through narrow holes inside the arm having complicated shapes. For the new model, although there are slightly more parts, a cover is attached after the completion of wiring, thus dramatically shortening the working man-hours.

As an additional measure, we have procured the arm parts and materials from overseas, and thus reduced the cost by 67% compared with the conventional model. Prior to procurement, local suppliers were audited to ensure the quality. In addition, procurement risk was reduced by asking the manufacturers to maintain an appropriate inventory level.

3. Improved Compatibility with PLC and GOT

The previously released SQ series products used a robot controller that is compatible with the Mitsubishi iQ Platform. In addition to the conventional functions compatible with the iQ Platform, three main new functions have been developed for the RV-2SQ to improve compatibility with the PLC and graphic operation terminal (GOT).

3.1 Enhanced shared memory function

The shared memory is a storage space commonly used by multiple CPUs for high-speed data exchange (Fig. 4).

Until now, the shared memory in the robot controller has been used only for the communication of I/O data with the PLC CPU, and its memory function was not utilized. Based on market research, we have newly developed the following attractive functions for users:

(1) Display the status of variables in the robot program code
(2) Display the servo conditions and maintenance information of the robot

The newly added functions allow the above items to be stored in the shared memory so that they can be read out from the PLC and GOT, and, for example, the robot data can be manipulated by the PLC program and

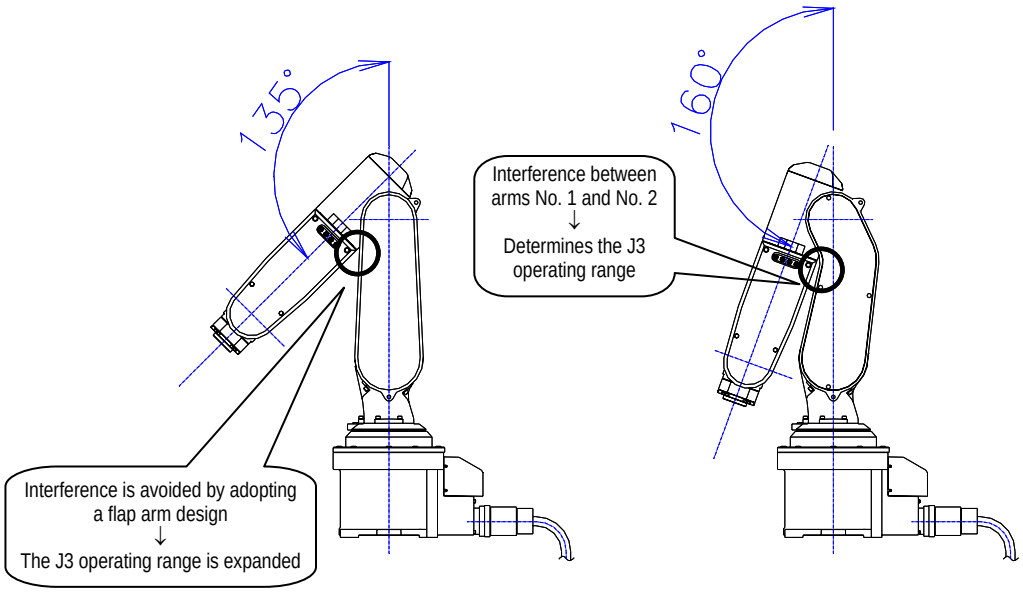

Fig. 3 Comparison of RV-2SQ and RV-3S structures

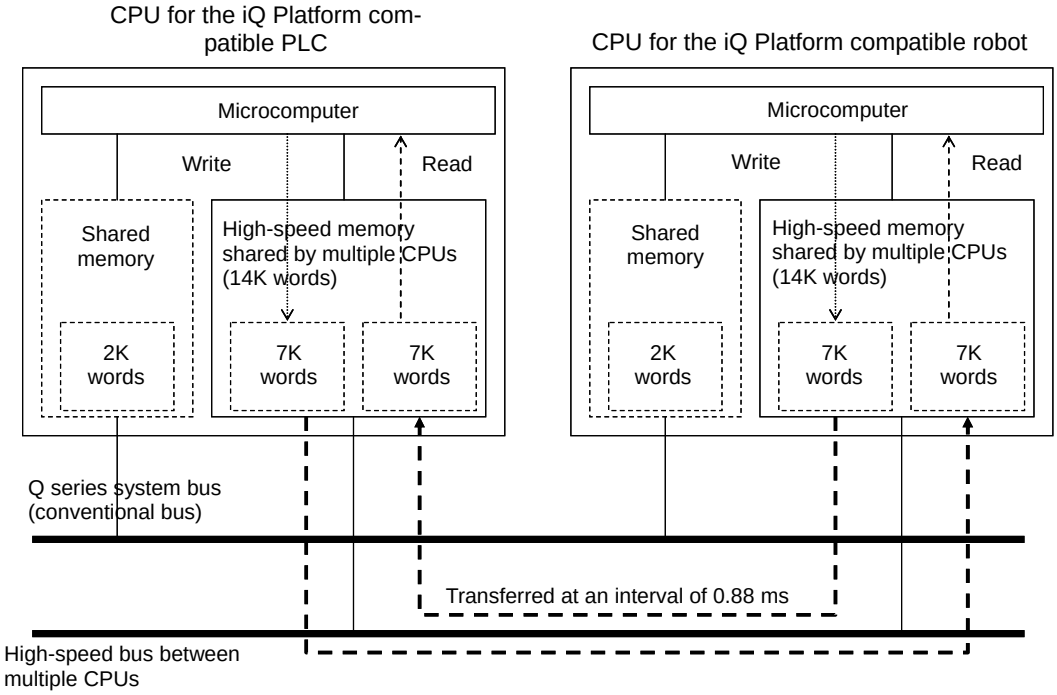

Fig. 4 Schematic diagram of high-speed communications between multiple CPUs

displayed on the GOT screen. While the same contents can also be displayed on a personal computer, the new functions enable them to be displayed on the GOT screen and so a PC is not required.

(1) Display the status of variables in the robot program code
- Numerical variables (Variables used for computation in the program code)
- Position variables (Variables that describe the robot posture in the orthogonal coordinate system)

(2) Display the servo conditions and maintenance information of the robot
- Current and target position of the robot
- Electric current and load factor of each axis
- Time remaining until the next maintenance check of the belt, battery and grease (Fig. 5)

Fig. 5 Sample screen of GOT

3.2 GOT Backup and restore function

The collective data backup and restore function for the robot controller can be operated from the GOT. It is no longer necessary to bring a PC to the manufacturing floor, thus improving user operability.

3.3 PLC direct function

Software assets are a hurdle for users switching from a competitor's robot to the Mitsubishi robot. To remove this hurdle, we decided to control the robot by using only the PLC language. The PLC provides the robot with specific numerical data, which the robot converts to operation commands to control the robot arms.

We have also developed a function that allows the user to control the robot without writing any programming language code. That is, certain command data is predetermined and written into the PLC device table via the shared memory. For each step of this operation, a user interface is provided on the GOT screen; the user is able to control the robot motion simply by operating the GOT screen according to the sequence of robot movements, without having to consider the programming language.

4. Conclusion

This paper has presented the newly developed RV-2SQ and its extended functions available only from Mitsubishi Electric. The features facilitate system design and differentiate our products from those of our competitors.

New Standard Type CNC M70V Series

Author: *Shunro Ono**

1. Introduction

The M70 series, which is in high demand in Asian and other industrially developing countries, has been improved to create the M70V Series, Mitsubishi Electric's new standard-type computerized numerical control (CNC). The main features are: (1) high-accuracy control at increments of 1 nm, (2) machining program capacity of 500 KB, and (3) compared with the M70, 1.7 times higher performance of the built-in programmable logic controller (PLC) for processing basic instructions.

2. Enhanced Basic Performance by the Adoption of the Latest ASIC

The M70V series has adopted the latest application-specific integrated circuits (ASIC), the same as those of the M700V series (higher grade model), to improve the PLC processing performance. In addition, the CPU/bus clock speed and bus utilization factor have also been increased to improve the data processing performance. As a result, the M70V series offers higher basic performance over the M70 series including: capability of nano interpolation control, increased maximum number of part systems, and improved execution speed of 10 ns/step for the basic instructions of the built-in PLC (1.7 times faster than the M70 series). In addition, the program capacity has been nearly doubled from the previous level to cope with the increasing size of machining programs.

Table 1 Main performance improvement items

	M70 Series	M70V Series
Maximum number of part systems (for machining center)	1	2
Minimum control increment	10 nm	1 nm
Processing speed of PLC basic instructions	17 ns/step	10 ns/step
Built-in machining program capacity	230 KB	500 KB

3. Additional Interfaces and Expandability

As a standard feature, the M70V unit has interfaces for Ethernet and a front-side Compact Flash (CF) card, and thus large amounts of data, e.g., machining program code and display screen data, can be easily input and output. It is also possible to directly run a machining program stored in the front CF card. With these features, even though the M70V series is a standard model, it can perform machining operation using a large program.

Two extension card slots are provided on the back panel (Fig. 1). By connecting a CC-link extension unit to the extension card slot, the M70V unit is able to operate as a master/local/intelligent device station. An optional expansion unit of large-capacity memory is also available. By installing this expansion unit, the size of available custom data can be expanded to twice that of the conventional M70 model.

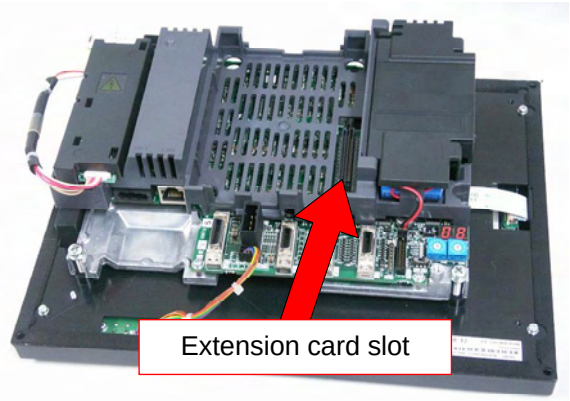

Fig. 1 Back panel of M70V unit

4. Extended Functionality of M70V Series

We have adopted the nano interpolation control method, which was originally used in the higher grade M700V model. While the minimum control increment was 10 nm with the M70 series, an increment of 1 nm in the CNC system would reduce errors in the control data to one-tenth.

The CNC performs its control function by periodically sending out a command specifying the next position after a certain time. Therefore, even if the machining program issues a command that specifies the axis to travel at a constant speed, a minute calculation error is always generated within the CNC, resulting in a speed fluctuation that sometimes affects the accuracy of the machined surface.

By reducing the minimum control increment to 1/10 of that in the conventional M70 series, the effect on the mechanical movement such as speed fluctuation due to errors in the control data can be suppressed and thus machining accuracy is improved (Fig. 2).

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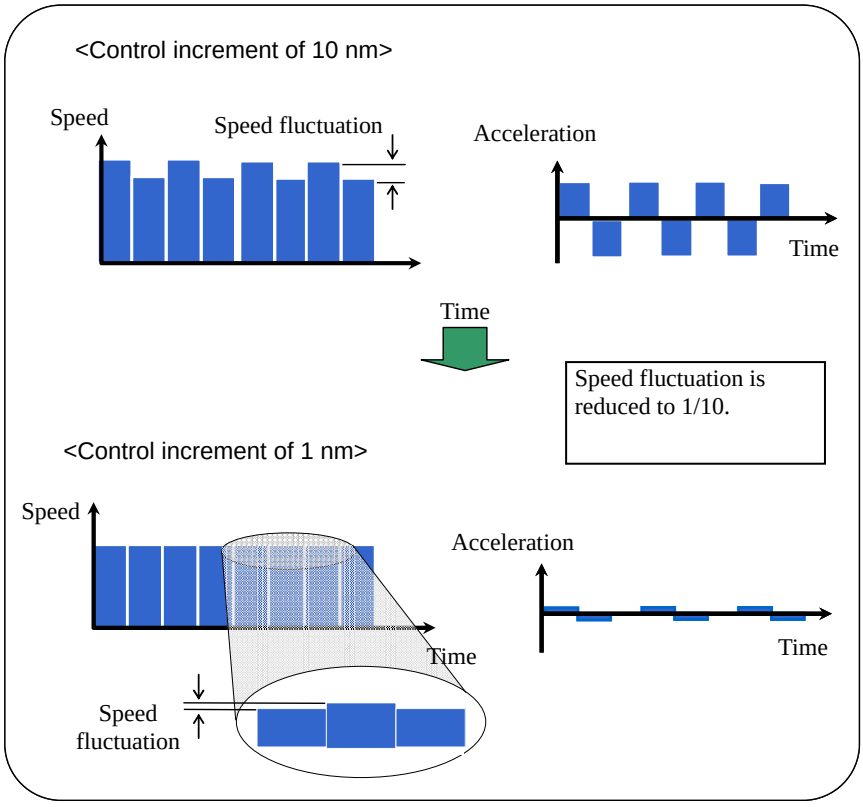

Fig. 2 Speed fluctuation due to interpolation

5. Extended Service Life and Improved Environmental Resistance of Hardware

Generally, machine tools are used for a long time and so it is important for the integrated CNC unit to have a long service life as well as to provide good maintainability.

Among the parts having a finite service life, electrolytic capacitors are mounted on a circuit board and cannot be replaced. Therefore, long-service-life types are selected and used only where they are definitely needed. Thus, even if their capacitance weakens due to operation beyond the design life of the CNC equipment, the power supply circuit is configured to operate without interruption as long as the external power supply is maintained within the normal range.

Considering the estimated battery capacity, the expected service life was designed to be a minimum of five years (at an ambient temperature of 40°C) by minimizing the number of battery backup devices and selecting low power consumption types.

While cooling fans also have a finite service life, the M70V series do not need them thanks to the reduced power consumption and using part of the enclosure as a heat radiator.

6. Conclusion

The requirements for higher-performance and price-competitive CNC systems are expected to intensify. We will continue to offer quality products appreciated by many users, striving to make a positive contribution to the world.

Development of CC-Link IE Field Network

Author: *Hisafumi Koumoto**

1. Introduction

CC-Link has established a large market share in Asian and other countries. On top of CC-Link/LT and CC-Link Safety, the addition of CC-Link IE, an Ethernet-based integrated network, is expanding the application range of the CC-Link family.

CC-Link IE has been developed based on general-purpose Ethernet technology, in pursuit of the following goals:

(1) Use of the Ethernet-based network technologies for control applications

(2) Optimization of the entire system by realizing seamless data transmission from the information system to the manufacturing floor.

CC-Link IE is divided into two categories depending on its application layer and purpose: the controller network that acts as the backbone network for factory automation (FA), and the field network. The newly developed CC-Link IE Field Network is an advanced application intended for increasingly intelligent manufacturing systems, not simply for controlling devices and equipment.

2. Features of CC-Link IE Field Network

In addition to good communication performance such as high speed and large capacity, users require a field network with features that allow easy and various system configurations, and realize seamless communication linkage from the upper-level information system to the field level.

(1) High-Speed Communication

The CC-Link IE Field Network enables remote I/O control with little transmission delay by utilizing ultra-high-speed gigabit transmission and real-time protocol.

The CC-Link IE Field Network provides two types of data communications: real-time cyclic communication and non-real-time transient communication. For each type, individual bandwidth is provided to ensure that cyclic communication is deterministic. With this scheme, stable high-speed control is maintained without being affected by upper-level communications for supervisory control and data acquisition (SCADA) or connection of programming tools, resulting in stable performance of the manufacturing system and equipment.

(2) Seamless Networking Environment

The CC-Link IE Field Network enables 1:1 message communication (transient communication) between devices and equipment connected to the network.

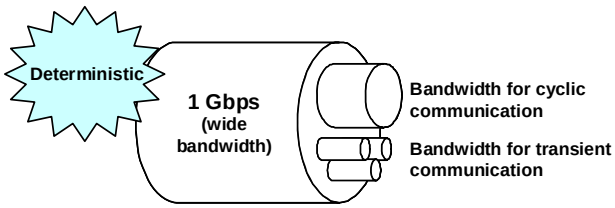

Fig. 1 Conceptual diagram of the bandwidth

As a result, users can monitor or set up devices or equipment without having to consider the network layer.

(3) All-round Network (Distributed Controller, I/O Control and Motion Control)

Taking advantage of the high-speed and large-capacity communication bandwidth, which has been realized by the industry's fastest gigabit transmission capability and real-time protocol, the CC-Link IE Field Network enables configuration of the distributed controller, I/O control and motion control on a single network (motion control is to be added in the future). Also, by using an Ethernet adapter, the CC-Link IE Field Network can be connected to a vision sensor, RFID reader/writer and other general-purpose Ethernet devices, thus broadening the range of system configurations. In addition, the CC-Link IE Field Network allows flexible network setup by supporting various topologies including star, line and their combination.

(4) Advanced Network Diagnostics

The CC-Link IE Field Network also has enhanced network diagnostic functions to help troubleshoot problems with a device and transmission line (cable).

For example, when a problem occurs on a conventional network, it is difficult to locate the problem and it takes a long time to restore the network. In contrast, the CC-Link IE Field Network employs, in addition to the Ethernet-compliant frame check sequence (FCS), a header check sequence (HCS) embedded in the frame header and a data check sequence (DCS) attached to the data, to identify the station that has received a damaged data frame. This function enables quick troubleshooting of cable problems.

With failure detection and other advanced network diagnostic functions, the man-hours for initial start-up and network restoration can be reduced.

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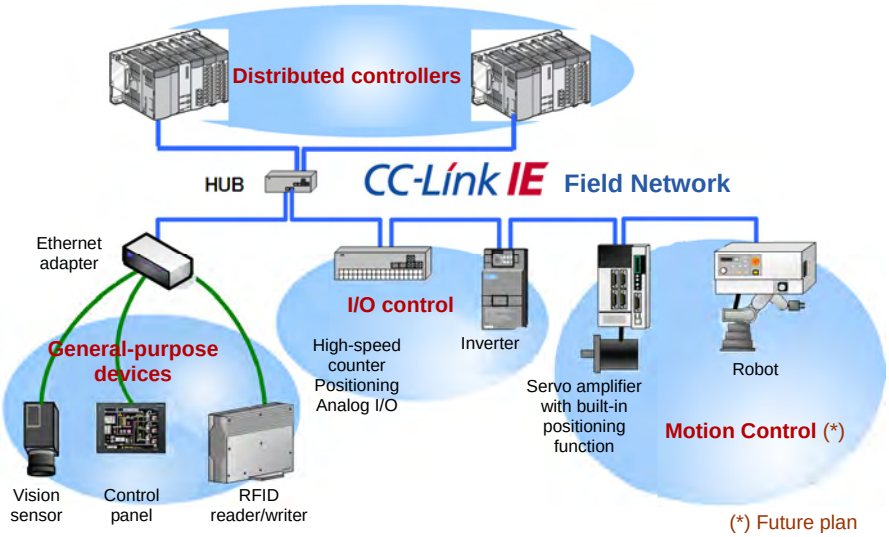

Fig. 2 Mixed configuration combining various network schemes

3. Conclusion

Mitsubishi Electric has developed the new CC-Link IE Field Network. Based on general-purpose Ethernet technology, the CC-Link IE Field Network provides high-speed communications while simultaneously supporting real-time data communication required for control purposes as well as transient data communication used for exchanging non-control-purpose data such as administrative data for traceability. We will continue to develop motion control and safety-related functions to broaden the application range and enhance the system performance.

New Functions of GOT1000 Series GT16 Model

Author: *Shinya Hashimoto**

1. Introduction

In August 2008, Mitsubishi Electric released the GOT1000 Series GT16 model (Fig. 1). The GOT1000 series employs the one-touch ladder jump, backup/restore and other industry leading functions, which have improved the efficiency of maintenance work on the factory automation (FA)-oriented manufacturing floor. Consequently, the GOT1000 series is regarded by customers as a display device that provides superior solutions for reducing machine downtime.

Since its release, the GT16 model has continued to provide enhanced functionality based on the users' viewpoints, focusing on compatibility with Mitsubishi's FA devices and equipment. In particular, the GT16 has provided various solutions for improving transparency and efficiency for the office (high-level system), remote site and manufacturing floor and thus improved the efficiency of maintenance work.

This paper describes the new functions and features of the GT16 model.

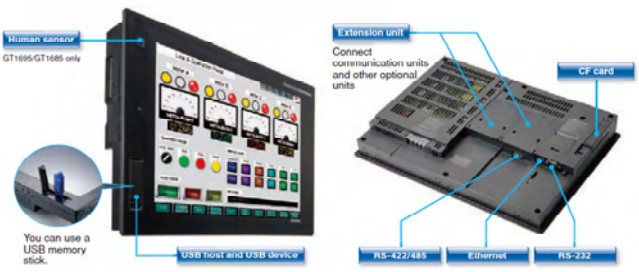

Fig. 1 External appearance of GT16 model

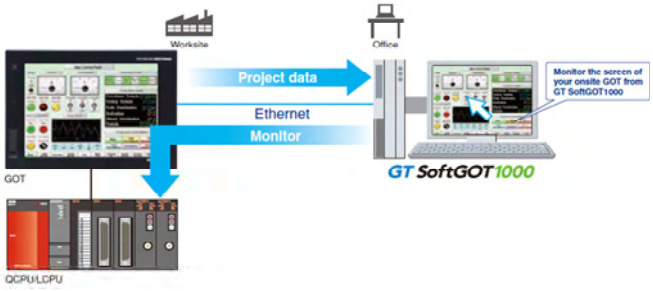

Fig. 2 SoftGOT-GOT Link function

2. Enhanced Linkage between Office PC and Manufacturing Floor GOT

For quick troubleshooting, users prefer to use a personal computer (PC) in the office to monitor the graphic operation terminal (GOT) on the manufacturing floor. Therefore, we have developed the SoftGOT-GOT Link function for enhanced bidirectional linkage between the office PC and the floor GOT (Fig. 2).

The SoftGOT-GOT Link function establishes a connection between the GT SoftGOT1000 and the GOT via Ethernet, so the GT SoftGOT1000 can utilize the project data on the GOT to monitor the device connected to the GOT.

Meanwhile, to prevent simultaneous operation from GT SoftGOT1000 and GOT when manipulating an input object (touch switch, numerical input, etc.), an interlock function has been implemented using an operating authority method.

3. Ladder Editor Function

Recent factors such as strengthened security and the introduction of clean rooms make it difficult to bring a PC onto the manufacturing floor, so it is necessary to determine the cause of an anomaly and take corrective actions without using a PC. We have therefore developed the Ladder Editor Function, which allows the operator to use the GOT for editing simple ladder programs of sequencers on the manufacturing floor (Fig. 3).

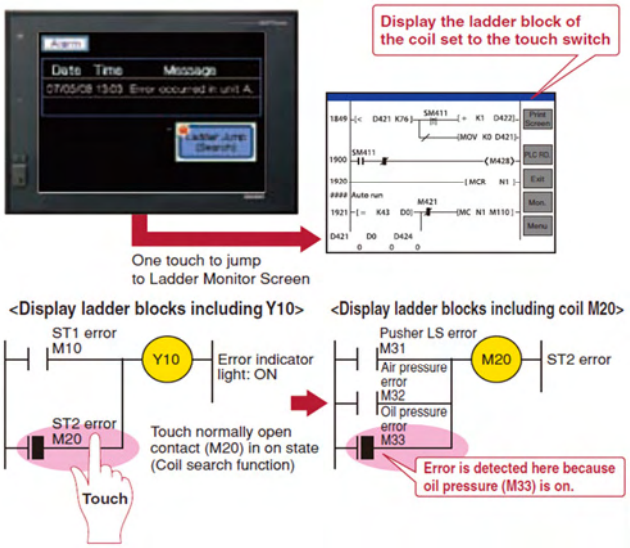

Fig. 3 Ladder editor function

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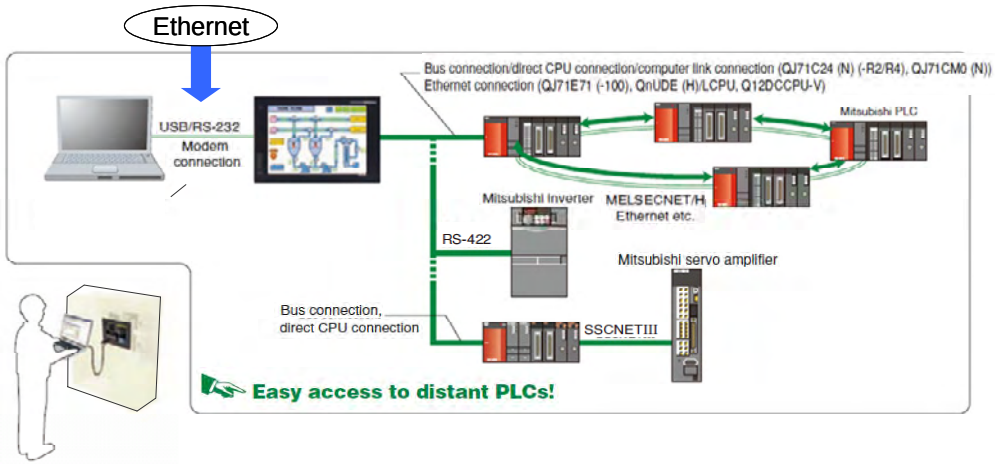

Fig. 4 FA transparent function

4. Oher Enhanced Functions

(1) Enhanced Monitoring Functions for Maintenance Purposes

The monitoring functions for maintenance purposes have been enhanced. The newly incorporated Motion Sequential Function Chart (Motion SFC) monitoring function and Log Viewer function make it possible to visualize the motion and data of devices and equipment, thus reducing the initial start-up time and machine downtime.

(2) Enhanced FA Transparent Function (Additional Connection via Ethernet)

The GOT and PC can now be connected via Ethernet, allowing the PC to handle programming, start up, and adjustment of Mitsubishi FA devices and equipment via the GOT.

5. Conclusion

The GT16 model has further evolved to provide users with additional functions that facilitate trouble-shooting, reduce downtime, and enhance compatibility with Mitsubishi FA products.

In response to market needs, we will continue to enhance the performance, pursue ease of use, and propose effective solutions.

Preventive Maintenance Service for EDM, Mitsubishi EDM Smart Service

Authors: *Kotaro Watanabe*, Yoshiko Katada** and *Rika Obata**

1. Introduction

Electrical discharge machines (EDMs) are widely used throughout the world, and customers continue to want to minimize or prevent machine downtime due to failures. Therefore, Mitsubishi Electric has launched a new Internet-based maintenance service, the Mitsubishi EDM Smart Service. By collecting precise data on the machine conditions and detecting a sign of failure, this service allows users to perform preemptive maintenance and drastically reduce the time for troubleshooting.

2. Structure of Mitsubishi EDM Smart Service

This service consists of three functions: EDM data collection, website service and data accumulation, and data analysis performed at the service company (Fig. 1).

The data collection function holds the chronological data on when, how long and how the EDM machine has been used, and what alarms were generated. Additional information is also collected, as needed, on various setting switches of the machine, processing conditions, and applied software programs. There is yet another approach provided to assess the aging deterioration by prompting the EDM to perform certain operations in order to gather data. All data collected is saved in a single file via the machine's controller screen and can be read out via USB memory or LAN.

On the website DIAX-NET.COM (http://www.diax-net.com/), an ID and password are issued to each Mitsubishi EDM customer for service support. On this site, we have created a web page to receive the data file obtained from the machine. Member customers are asked to upload machine data via this page every few months. Once the data is uploaded, the customer can immediately see the results of data analysis and find out which general area of the machine needs maintenance.

Using this system and uploaded data, the service engineers of Mitsubishi Electric and the maintenance company can perform a detailed analysis and prepare a diagnostic report.

3. Three Services

With this approach, the Mitsubishi EDM Smart Service provides customers with the following three types of services.

3.1 Data analysis and display service

With this free service, once the customer uploads the data file on machine operating conditions to the Mitsubishi EDM support site, DIAX-NET.COM, the data is immediately processed and the analyzed results are displayed for the EDM conditions, alarm occurrences, automatic wire threader (AT) conditions, ambient temperatures, etc. The displayed analysis results are a useful guide for basic machine maintenance that can be performed by the customer. Figure 2 shows an example of the analysis results, and Fig. 3 shows the flow of the service.

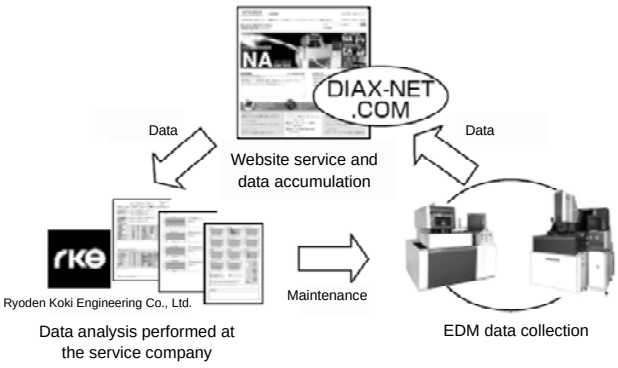

Fig. 1 Structure of Mitsubishi EDM Smart Service

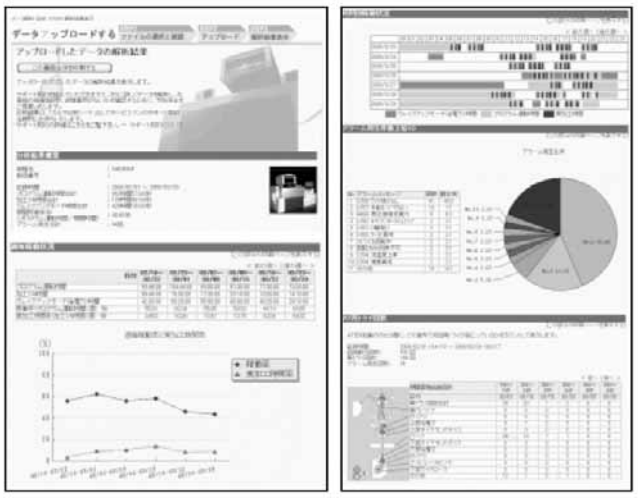

Fig. 2 Example of analysis results

*Nagoya Works

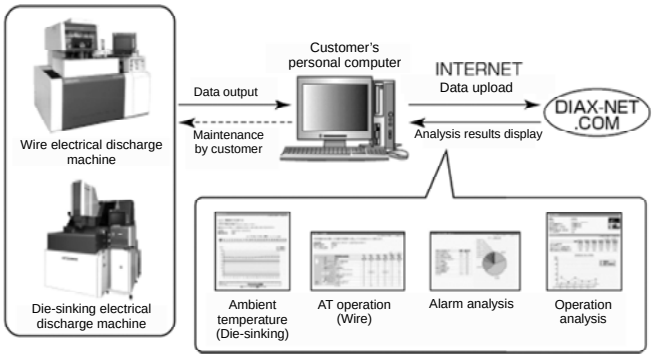

Fig. 3 Data analysis and display service

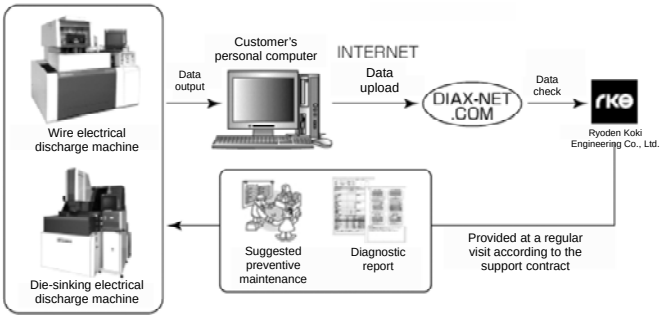

Fig. 4 Diagnostic report service

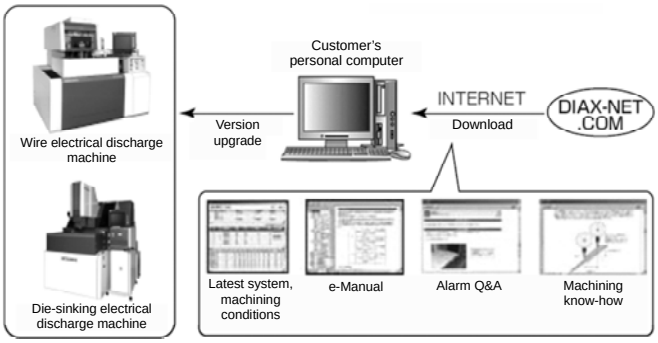

Fig. 5 System download service

3.2 Diagnostic report service

The Diagnostic Report Service is an optional service for customers who sign a support contract with the maintenance service company, Ryoden Koki Engineering Co., Ltd. The service engineer takes the previously mentioned diagnostic report at a regular visit, and provides the customer with advice derived from the data, explaining any problems with the machine and discussing parts replacement at the appropriate timing.

3.3 System download service

The free System Download Service is available on the DIAX-NET.COM website. The customer can download the latest EDM system software and upgrade the machine version. With this service, even after the EDM has been installed in the factory, the customer can continue to use the latest system software functions.

4. Conclusion

Currently, the Mitsubishi EDM Smart Service covers electrical discharge machines installed in Japan. We will work on improving the service system considering different EDM service conditions in various countries in order to expand the service area, including overseas.

New CO_2 2D Laser Processing System ML3015LVP-45CF-R

Authors: *Hitoshi Kidokoro** and *Junji Kano**

1. Introduction

In the sheet metal cutting industry, recent requirements for laser processing systems include: productivity improvement, applicability to high-mix low-volume production, low power consumption to reduce running cost, and enhanced reliability to ensure stable longtime operation. In response to these market needs, Mitsubishi Electric has released the new CO_2 2D laser processing system, ML3015LVP-45CF-R, which is presented in this paper.

2. Improved Processing Performance

By increasing the power output of the laser oscillator, improved laser processing is expected, such as higher cutting speeds for thin- to medium-thickness plates and a wider range of thicknesses for high-thickness plates. We have thus released the 45CF-R by improving the efficiency of the conventional 4-kW type laser oscillator to successfully achieve an output power of 4.5 kW. Higher performance has been realized by the combination of: a beam stabilizer that generates uniform beam intensity over the entire processing area; a beam optimizer that controls the beam characteristics and focus position to the best conditions for each material to be processed; and a capacitance sensor that achieves, during high-speed processing, high-precision control of the distance to the material surface. Compared with the previous model, up to 20% higher processing speed is achieved for a wide range of materials including medium-thickness mild steel plate (SS400), stainless steel (SUS304), and aluminum alloy (A5052) (Fig. 1).

When processing medium to thick mild steel plates, the piercing process accounts for a large percentage of the total processing time. Thus, for mild steel plates 9 mm thick or more, we have adopted a new piercing method (beat pierce), which controls the optimum peak output in a stepwise fashion by taking advantage of the Mitsubishi oscillator's unique output response characteristics. When processing a 12 mm-thick mild steel plate, the piercing time is reduced by up to 50% while mainitaining a pierced hole diameter of 1 mm or less. The reduction in piercing time together with the improvement in processing speed due to the increase in output power has reduced the processing time by about 30% compared to the previous model (Fig. 2).

In addition, the improved processing speed also improves the quality of the cut edge by reducing the contribution from the iron combustion reaction to the melting of the base metal. Compared with a 12 mm-thick mild steel plate processed by the previous model, the roughness of the cut edge is reduced by about 45% (Fig. 3).

3. Running Cost Reduction

In order to further improve the oscillation efficiency of the CO_2 laser oscillator 40CF-R, which offers the high output required for high-speed processing and high beam quality for high-quality processing, we have

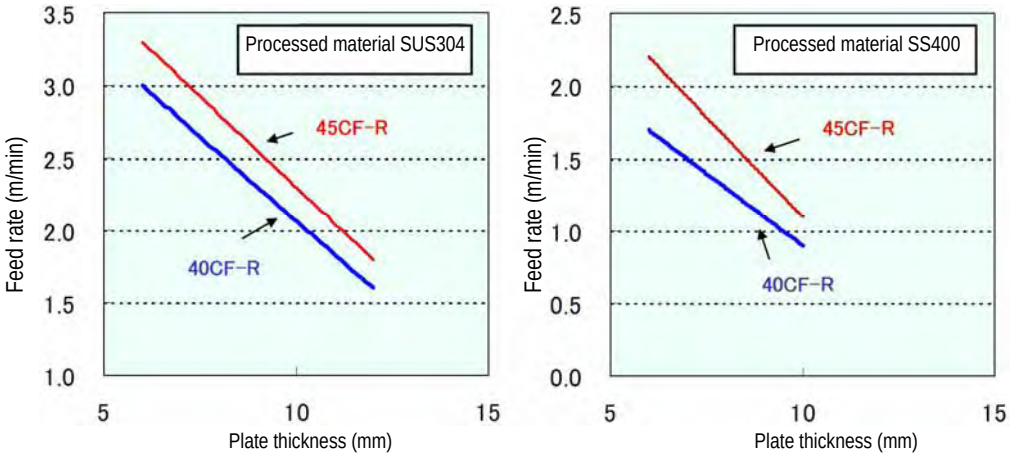

Fig. 1 Comparison of feed rate (Material: SS400 and SUS304)

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Piercing method	Conventional piercing	Beat pierce
Enlarged photo of pierced hole		
Pierced hole diameter	1mm	1mm
Piercing time	10 seconds	6 seconds

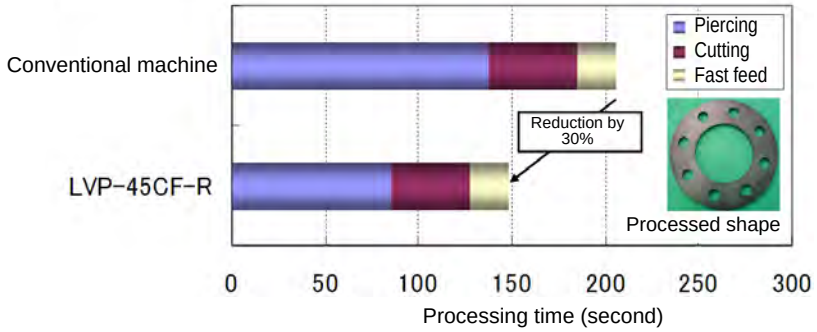


Fig. 2 Comparison of piercing process and comparison of processing time (Material: SS400, thickness: t12 mm)

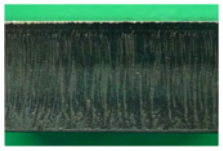
	Conventional machine	LVP-45CF-R
Output power (W)	4000	4500
Feed rate (m/min)	1.6	1.8
Appearance of cut surface		
Roughness of cut surface (Rz)	26.3	14.5

Fig. 3 Comparison of cutting edge (Material: SS400, thickness: 12 mm)

experimentally determined the optimum light-focusing characteristics for medium-thickness plates and applied quality engineering techniques to design a resonator that achieves the required focusing characteristics in a stable and efficient manner (Fig. 4).

The capacity of the high-frequency power supply unit, which generates a discharge current in the excitation space where the laser beam is generated, has been enhanced by modifying the cooling fin structure to improve the cooling efficiency and by applying the optimum frequency control method to reduce the heat generation from power devices. In addition, we have adopted the just-in-time discharge system that enables prompt laser beam generation at the time of operation while minimizing power consumption during standby mode, thus reducing total power consumption by 11%.

Meanwhile, the reduction in processing time has also reduced the use of assist gas. In combination with the reduction in power consumption, the running cost has been reduced by 20% (Fig. 5).

4. Improved Reliability

We have improved the quality of key components of the laser oscillator by using our achievements and engineering know-how acquired through 30 years of in-house development, manufacturing and maintenance of laser oscillators, thus dramatically improving reliability. Consequently, for the first time in the industry, we now offer a three-year warranty for the laser oscillator.

5. Conclusion

This paper has described the main features and processing performance of the LVP-45CF-R. As a comprehensive manufacturer of laser processing systems, we will continue to improve the performance and proactively respond to the shop-floor needs of the automobile, electronics and other manufacturing industries.

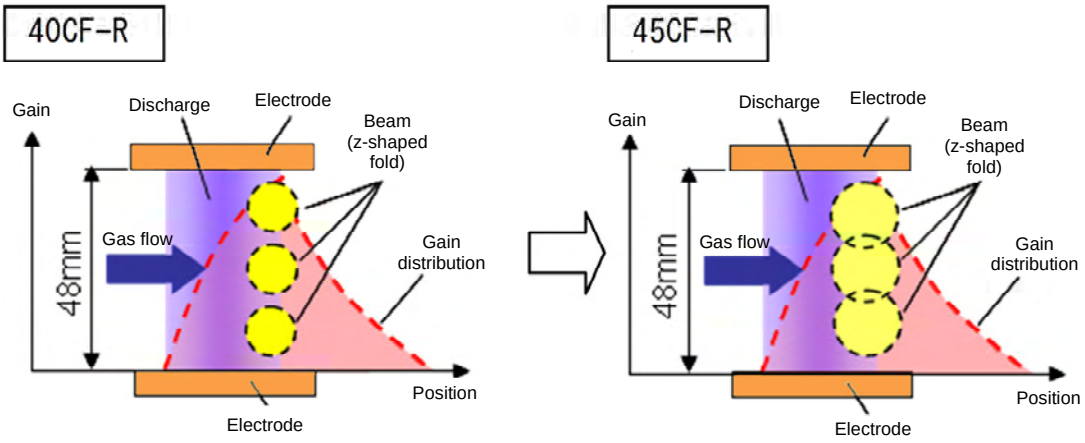


Fig. 4 Improvement of laser oscillation efficiency

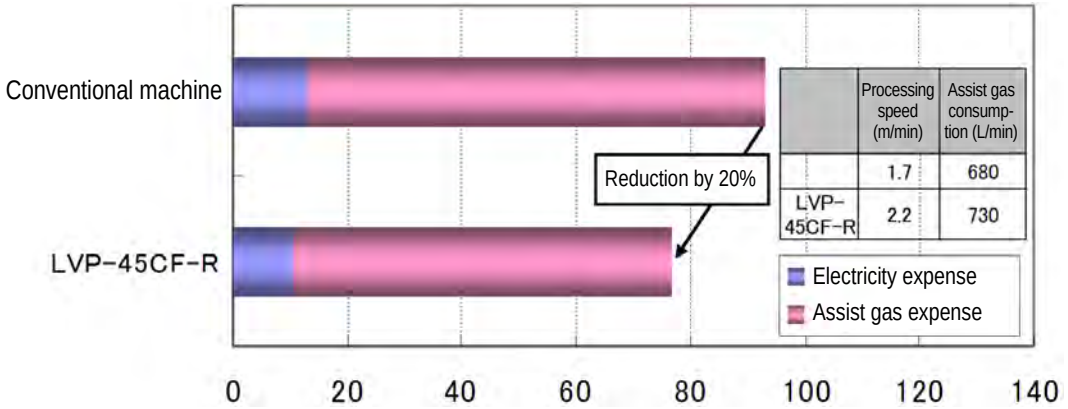


Fig. 5 Comparison of cost (Material: SUS304, thickness: t6 mm)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