New Technologies of CNC "M800/M80 Series"

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Mitsubishi Electric's computerized numerical controller (CNC) M800/M80 series released in 2014 offers high machining performance and ease of use through the application of CNC-dedicated CPUs. Meanwhile, manufacturing sites are facing a decreasing number of skilled workers and frequent worker turnover. Under these circumstances, there is a high demand for functions that make it easier for inexperienced workers to perform high-productivity machining. To meet this demand, Mitsubishi Electric has expanded the usability and productivity of the functions listed below.

(1) Program edit function

Two functions have been developed to make it easier to design the processing programs: (1) interactive cycle insertion function and (2) finish shape view programming function.

(2) Simulation function

To reduce the number of test runs prior to actual production, a 3D solid program check function has been developed so that users can check the programs in the preparation process.

(3) Five-axis control function

The spline interpolation function has been improved to enhance the speed and precision of the machining processes.

(4) Network function

In response to the need for factory automation and higher production efficiency through active use of the Internet of Things (IoT), the following four functions have been developed: (1) Manufacturing execution system (MES) interface, (2) Seamless Message Protocol (SLMP) server, (3) remote desktop, and (4) field network.

1. Introduction

Economic growth in Asian countries, increased demand for machine tools for the aeronautics industry, and active investment in factories and equipment by electronics manufacturing services (EMS) companies have steadily boosted the demand for machine tools. Against this background, CNCs for machine tools must deliver higher machining performance and also be safe and reliable. Meanwhile, given the decreasing number of skilled workers and frequent worker turnover, machining operations need to be more user friendly while still maintaining high productivity. Achieving this requires ease of use for inexperienced workers, establishment of factory automation systems, and enhanced compatibility with production management systems.

Mitsubishi Electric released the latest CNC model, the M800/M80 series, in 2014[(1)] and users have highly evaluated its machining performance and ease of use. Still, we have been expanding the functions to meet the growing need for higher productivity.

This paper describes the new technologies in the M800/M80 series developed for the program edit, simulation, five-axis control, and network functions that greatly contribute to productivity among the various functions.

2. Strong Points of the M800/M80 Series

2. 1 CNC-dedicated CPUs for revolutionary high-speed processing performance

The M800/M80 series incorporates our CNC-dedicated CPUs for high-speed processing performance and high productivity. These CPUs have also realized programmable logic controller (PLC) performance that can process large-scale ladder programs at high speed.

2. 2 Wide product lineup supporting diverse needs

Figure 1 shows the M800/M80 series lineup. The new M80W series was added to the standard model lineup in 2016. The human-machine interfaces are separated from the controllers in the configuration, which enables flexible installation. The number of expansion card slots was increased to more than that of the M80 to enhance its expandability as the standard model.

3. Expansion of Support Functions

Recent years have seen increasing demand for ease of use. Therefore, the M800/M80 series' functions for supporting tasks in each manufacturing process have been expanded (Fig. 2). In the design process, the interactive cycle insertion function and finish shape view programming function were added to make it easier to create processing programs. For the preparation process, the 3D solid program check function was developed to allow users to check programs in the preparation process, thus reducing the number of test runs prior to actual production. For the machining process, the five-axis control function was expanded and enhanced to achieve high-speed and high-precision five-

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axis machining. In addition, we are working to expand the network function in response to the need for factory automation and higher productivity using IoT, which has been attracting attention in recent years.

3. 1 Expansion of the program edit function

As the M800/M80 series' program edit function, two functions have been added: (1) Interactive cycle insertion function that allows users to insert cycles that support machining and preparation in processing programs being edited in dialogue form and (2) finish shape view programming function that immediately displays the 3D cutting results from the processing programs. These functions allow users to intuitively create processing programs and they immediately display user input errors in 3D, which can reduce the time required to create programs.

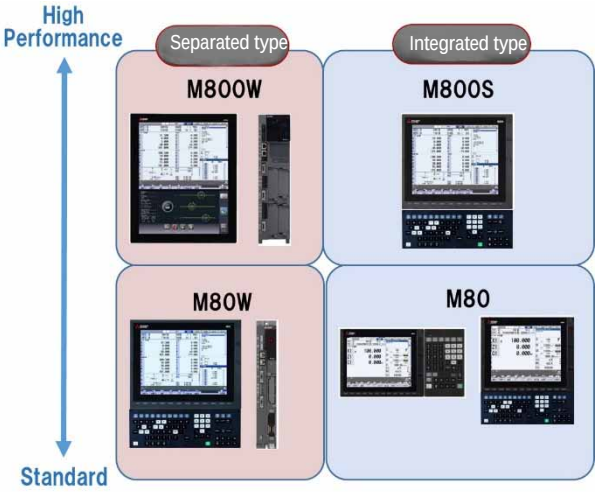

Fig. 1 Lineup of M800/M80 Series

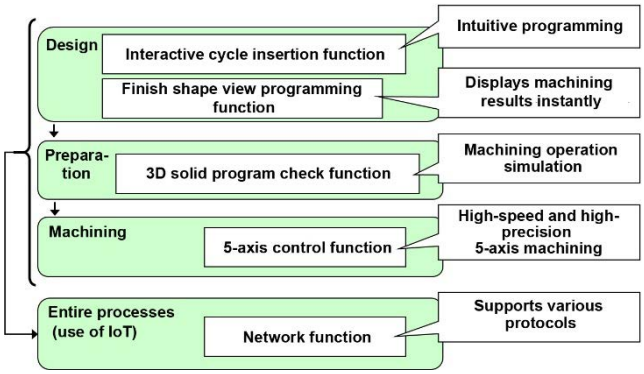

Fig. 2 Functions for assisting with tasks in manufacturing processes

When issuing instructions for machine tool movement to the CNC, users need to enter the tool paths in 3D space and the tool movement patterns into the processing programs. The interactive cycle insertion function creates processing programs automatically once the users specify the type of shape and its dimensions, so users can create programs intuitively (Fig. 3). In addition, the function can create processing programs for any shape specified by the users or based on drawing data. Particularly in Europe, where multiple models are manufactured in smaller lots, users like the function for creating processing programs interactively on the CNC.

In addition, the finish shape view programming function displays the 3D cutting results from the processing program being created whenever the program is revised. This allows users to immediately see any input errors (Fig. 4).

Usually, in a processing program, the material is gradually shaved to obtain the final shape. However, if all these processes are simulated, the geometric calculation for displaying the shape may take time and the screen display response may become slow. Therefore, the finish shape view programming function extracts only the movement related to the final shape from the processing program created with the interactive cycle insertion function and displays the shape. This allows users to see the input results immediately.

3. 2 Expansion of simulation functions

The M800/M80 series now has the new 3D solid program check function and other simulation functions to eliminate mistakes in creating processing programs and making preparations.

The 3D solid program check function allows users to see the behavior of processing programs in 3D graphic images without activating actual machine tools

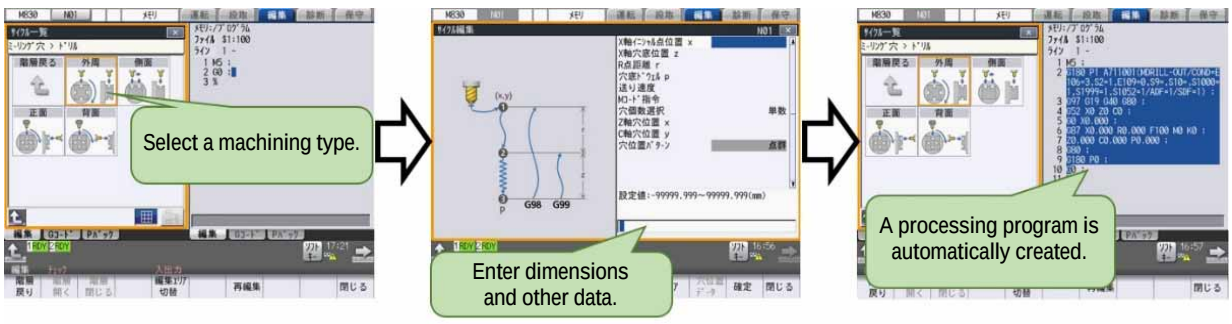

Fig. 3 Interactive cycle insertion

(Fig. 5). This function can reduce the number of test runs prior to actual production.

For equipment requiring immediate response, a pre-assigned memory area is often used for calculation, but this memory may not be sufficient for simulating complex shapes. Therefore, the 3D solid program check function shares a memory area with other functions: The memory area is not assigned in advance but is dynamically assigned. This newly developed technology has enabled the simulation of complex shapes without adding more memory.

3. 3 Expansion of the five-axis control function

The M800/M80 series' spline interpolation function has been improved to remove noise, for example, unnecessary level differences, included in fine segment programs created with computer aided manufacturing (CAM) to achieve smooth machining.

The improved function smoothly moves the tool on a curved line that passes within the specified tolerance. Therefore, even when a fine segment program contains unnecessary level differences and other noise, the quality of the obtained machined surfaces is high, without flaws. This function also supports simultaneous five-axis control, so it can smoothly move both the tool center point and tool orientation within the tolerance during the tool center point control. Therefore, in simultaneous five-axis machining in which complicated changes occur in the tool position and orientation, flawless and smooth machined surfaces can be obtained without the user having to correct the processing program, thanks to the spline interpolation function (Fig. 6).

When a curved line is simply created such that it remains within the tolerance, the outward path is different from the return path, which may cause a flaw. To solve this problem, a new algorithm was developed for this function. The algorithm creates a curved line such that the return path will be the same as the outward path, while evaluating the characteristics of the shape (e.g., corners), achieving flawless and smooth machined surfaces.

3. 4 Expansion of network functions

IoT is attracting increasing attention. At manufacturing sites involving machine tools, the need for network functionality is also increasing. To meet this need, network functions for the M800/M80 series have been developed and are being gradually expanded.

This section describes four of these functions.

3. 4. 1 MES interface

The newly developed manufacturing execution system (MES) interface function sends machines' operation status data from the CNC to databases automatically when an event occurs, for example, when the machining is completed or an alarm is issued. This function makes it easy to visualize the machines' operation conditions and makes it possible to quickly

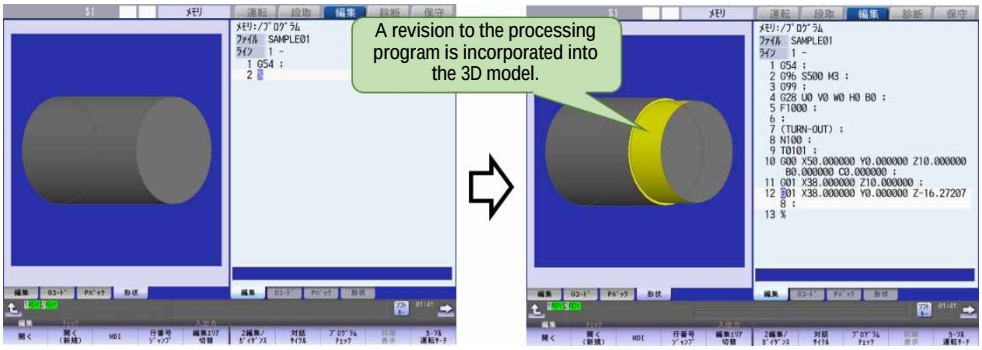

Fig. 4 Finish shape view programming function

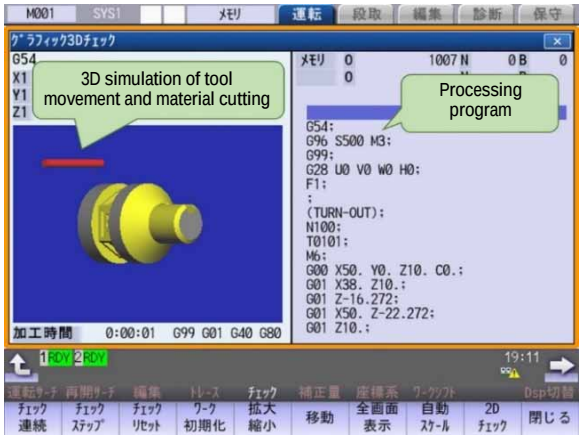

Fig. 5 3D solid program check

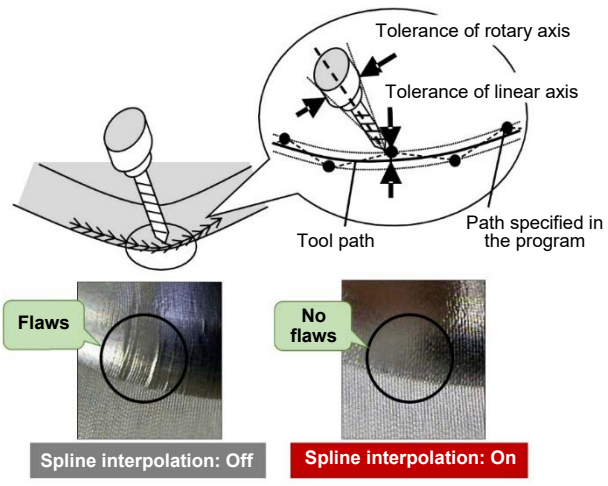

Fig. 6 Five-axis spline interpolation

recover from machine problems, prevent problems, and thoroughly manage the quality in each manufacturing process, thus improving productivity (Fig. 7).

3. 4. 2 SLMP server

The newly developed Seamless Message Protocol (SLMP) server function can transmit data from peripheral equipment to the CNC via Ethernet.*1 This function makes it easy to connect machine tools and peripheral equipment supporting the SLMP to networks with only LAN cables. In addition, the SLMP can be used with the Transmission Control Protocol/Internet Protocol (TCP/IP). Therefore, the CNC, peripheral equipment, and higher-level systems can be connected using a single type interface and data can be seamlessly linked between the higher-level systems and peripheral equipment.

For example, when a barcode reader supporting the SLMP is connected to a CNC and a higher-level system with LAN cables, the ID of the workpieces being machined can be sent not only to the CNC but also to the production management system. This makes it possible to visualize information on workpieces on the production management system, thus boosting productivity at the factory (Fig. 7).

3. 4. 3 Remote desktop

The new remote desktop function makes it possible to display and operate CNC screens remotely on another computer via a network. A PC or tablet installed in an office or factory can be used to view and operate the screens of a machine tool installed at a manufacturing site, thus reducing the labor-hours for testing machine tools (Fig. 8).

3. 4. 4 Field network expansion cards

In recent years, the need to connect machine tools to peripheral equipment, such as robots and sensors, has been increasing as a part of factory automation. The field network required for connection varies depending on the use environment of peripheral equipment, so we have been gradually increasing the number of supported field network types for the M800/M80 series. This time, a new type of expansion card was developed to support field networks with an RS-485 serial interface (PROFIBUS-DP*2 and CC-Link).

In addition, recently developed field networks that can transmit signals at high speed using Ethernet (CC-Link IE Field and EtherNet/IP) have been spreading, so conventional serial interfaces may be replaced with Ethernet interfaces. Therefore, we are planning to support various Ethernet field networks in turn in the future (Fig. 9).

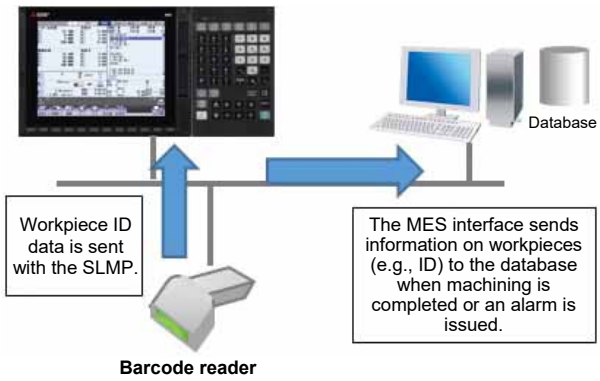

Fig. 7 Usage example of MES Interface and SLMP

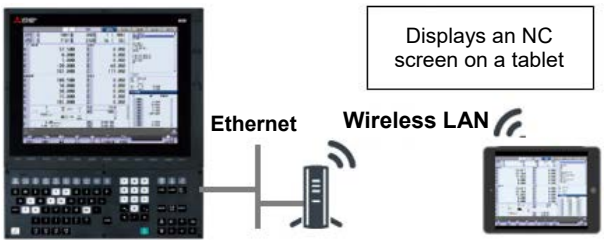

Fig. 8 Usage example of remote desktop

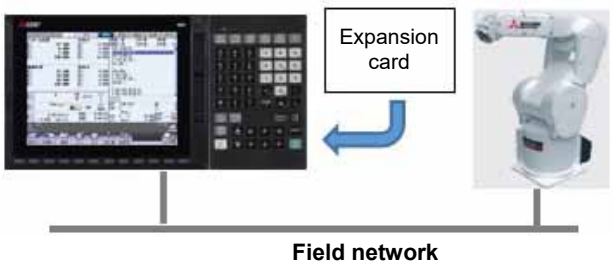

Fig. 9 Connectivity to field networks through expansion cards

4. Conclusion

This paper described the latest CNC model, the M800/M80 series. This series will contribute to upgrading machine tools that support the fundamentals of manufacturing. We will continue working to develop products that meet the changing market needs.

5. Reference

(1) Nakamura N., et al.: Brand-new Model of CNC "M800/M80 Series", Mitsubishi Denki Giho, 89, No. 4, 247–250 (2015)

[1] Ethernet is a registered trademark of Fuji Xerox Co., Ltd.

[2] PROFIBUS is a registered trademark of PROFIBUS User Organization.