

TOYOPUC-MC70: Development of a CNC Device for Cutting Machines

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Our company has developed the TOYOPUC-MC70 drastically improving the performance of the MC50, the current CNC device for cutting machines. The features of the developed product are 1) the highest level high speed performance in any cutting machine CNC, 2) improvement of cutting performance through original CNC control technology, 3) visualization of NC programs and improved maintainability and safety, and 4) a small size control system compatible with compact equipment. Machining cycle time is shortened considerably with a CNC system maximizing the performance of the new CNC device hardware, and operability has been improved so that there is no need to be aware of NC programs. The maintainability and safety functions have been enhanced to support recording of machine operation history. Our new development contributes to process integration for the machining of gears by the e500H4 machining center through the development of a skiving method utilizing our original control technology.

Key Words: CNC, controller, cycle time, NC program, operativity, machining, gear cutting

1. Introduction

CNC (Computer Numerical Control) devices serve an extremely important role in determining machining accuracy of workpieces, machine performance such as machining cycle time, as well as the serviceability and maintainability and operability of machine tools.

JTEKT has developed CNC devices for our TOYODA brand grinders since the 1960s and we have maintained our competitive edge as a top manufacturer of grinders thanks to this CNC device. In 2010, we utilized this technology to develop the MC50, a CNC for cutting machines. However, there was still a desire to further shorten machining cycle time, as well as improve operability and maintainability.

This report will introduce the TOYOPUC-MC70 which was developed by fully revising both the hardware and software aspects of the CNC device and has successfully achieved high speed processing and high functionality.

2. Background and Aim of TOYOPUC-MC70 Development

Machine tools equipped with MC50, the current CNC device, have poorer processing speed, maintainability, overall servo performance and cost performance compared with the products of other companies. It was imperative to develop a CNC device as a successor to the MC50 which overcame these issues. There was also a strong need from customers to shorten machining cycle time, which greatly contributes to productivity

improvement.

In the development of TOYOPUC-MC70, JTEKT not only aimed to overcome the issues faced by MC50, but also positioned the improvement of processing speed, which directly links to shorten machining cycle time, as our greatest aim in order to develop a CNC device with a performance unrivaled by the CNC devices of our competitors.

3. Details of the TOYOPUC-MC70 Development

3.1 Development concept and targets

3.1.1 Development concept

TOYOPUC-MC70 was developed based on the below three concepts.

- (1) Highest level high speed performance in any cutting machine CNC
Build a CNC system which maximizes the latest CPU computing ability and improves NC program processing speed and CNC-PLC communication speed.
- (2) Improvement of cutting performance through original CNC technology
Characterize JTEKT machine tools with our original cutting technology utilizing CNC control technology which has a proven track record on grinders.
- (3) Visualization of NC programs and improved serviceability and maintainability
Through adoption of NCSFC, make it possible to achieve operability of an NC program without the user's awareness. In the event of alarms, shorten time to analyze causes for the alarm as well as shorten

equipment recovery time. (Refer to 3.2 (2), Fig. 4, and Fig. 5 for explanations of NCSFC).

3. 1. 2 Development targets

Table 1 shows the targets of TOYOPUC-MC70 development. There are many target values for the development items so we have only shown the representative values and functions. In regards to high speed performance, a target was established to shorten the machining cycle time of model parts on the MC50 (160.5 seconds) to 148 seconds through the adoption of TOYOPUC-MC70. This 12.5 second difference was calculated by considering the effects (theoretical values) of a faster CNC internal processing speed and by performing a pre-evaluation using a CNC device evaluation simulator. Regarding cutting performance, the target was to develop a simplified command function cultivated on CNC devices for grinders, a function which applied the virtual axis function and gear machining control. Through these functions, it would become possible to perform gear machining on a single machine tool, whereas up until now this had to be performed on multiple machine tools.

Table 1 TOYOPUC-MC70 development targets

Development item		MC50	TOYOPUC-MC70
		Current	Target
①	High speed (Machining cycle time example)	160.5 sec	148 sec
②	New cutting function	-	Skiving cycle (process integration of gear machining)
③	Improved serviceability and maintainability	Servo sampling function	Operation history record function Improved servo sampling function

3. 2 Development results

(1) Highest level high speed performance in any cutting machine CNC

By adopting the latest CPU and reconfiguring CNC internal processing, we achieved high speed NC program processing and high speed CNC-PLC communication. As a result of increasing CNC-PLC communication speed, we achieved a higher M code processing time than the CNC devices of our competitors (Fig. 1).

Furthermore, using high speed CPU, we newly added a function to minimize the synchronous error displacement which occurs when both the spindle and the cutting axis operate during the tapping (thread cutting) process. By adding this function, it was possible to shorten the time

taken for spindle acceleration/deceleration at the time of tapping by half thereby shortening tap cycle time. Through the shift to high speed, we achieved the target value for cycle time of the overall operation, including the tapping process (Fig. 2).

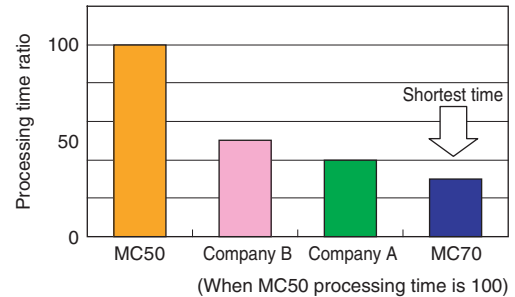


Fig. 1 Shortening of M code processing time

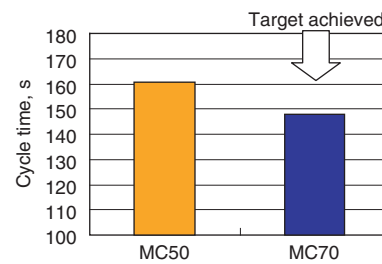


Fig. 2 Shortening of machining cycle time

(2) Improved cutting performance

Towards the realization of a skiving cycle, we developed a gear processing machine which possesses a function which applies both a simplified command function and a virtual axis function, which is a technology used in CNC devices for grinders. With a simplified command function to output the command sent to the master axis also to the slave axis, as well as a command virtual axis function which can specify the rotational speed ratio of the gear-cutting tool axis and workpiece axis and output multiple travel commands to a single axis,

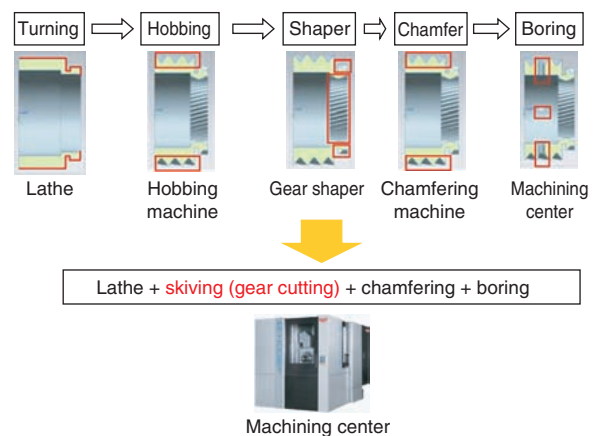


Fig. 3 Process integration through a machining center

the workpiece offset angle can be additionally calculated and incorporated in the workpiece axis rotation command. This technology enables the machining of not only spur gears, but also helical gears, to be integrated into the one e500H4 machining center, and all machining processes from turning to boring to be completed in a single chuck operation (Fig. 3).

The NCSFC developed at MC50 is also adopted on TOYOPUC-MC70. NCSFC (NC Sequential Function Chart) is a function which displays the NC program written in G code in machining process operation sequence in a chart as shown in Fig. 4. The NCSFC is displayed in blocks by individual machining processes and it is possible to assess progress intuitively as there is an automatic scroll to match the machining progress.

Even if customers do not possess specialist knowledge of G code, they can easily program the skiving cycle by observing the image of the machining portion displayed on the machining cycle setting screen shown in Fig. 5 while setting the gear element data and machining conditions, as well as the tool data in a short period of time.

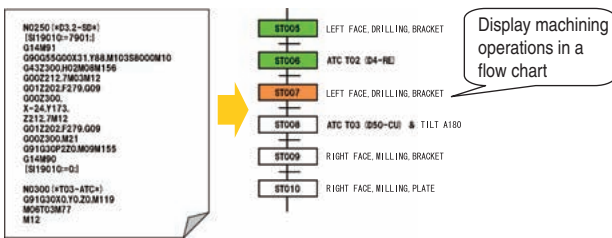


Fig. 4 NCSFC display screen

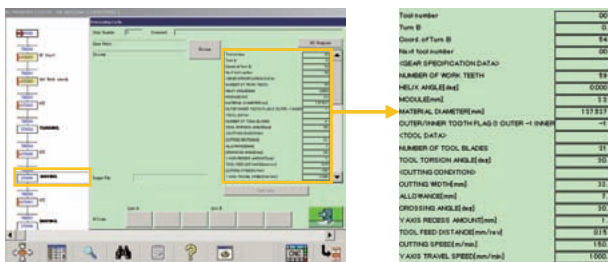


Fig. 5 NCSFC machining cycle settings screen

(3) Improved serviceability and maintainability

In regards to serviceability and maintainability, we newly added an operation history record function and improved the servo sampling function. With the operation history record function (Fig. 6) it is possible to record approximately 1 weeks' worth of operations performed by the operator and confirm operation history on the CNC screen. Moreover, operation history data can be stored on external memory. By using this function together with the existing alarm history record function (Fig. 7), the operations before and after alarm occurrence and the lead up to alarm occurrence are clearer, so this is valid in the cause analysis at the time of alarm occurrence.

The servo sampling function has been improved to allow twice as much data to be saved and a more detailed analysis (Fig. 8). Moreover, by establishing a servo sampling start trigger function, operability at the time of servo sampling data acquisition has been improved (Fig. 9).

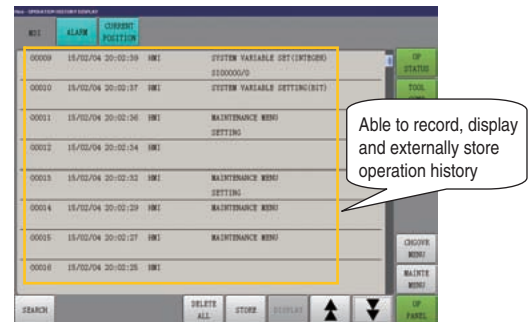


Fig. 6 Operation history record function

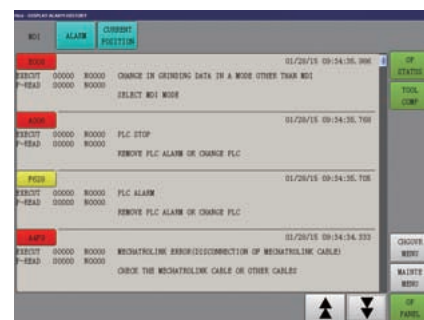


Fig. 7 Alarm history record function

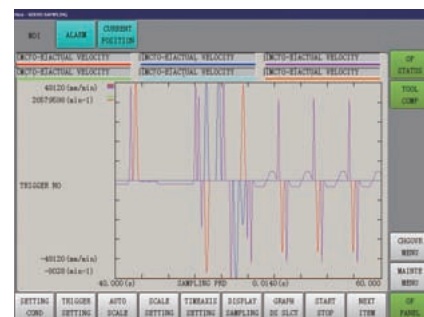


Fig. 8 Servo sampling function

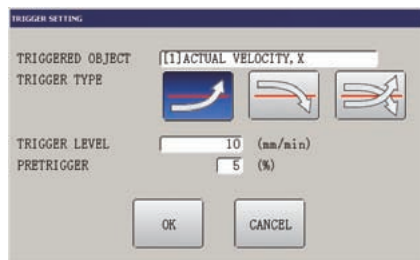


Fig. 9 Trigger function to start servo sampling

4. Conclusion

This time, we were able to develop TOYOPUC-MC70 as a CNC device for cutting machines which meets the original development targets. We will continue to develop functions which lead to higher accuracy and expand the applicable workpiece and machining ranges of the CNC device for cutting machines. Furthermore, we will use the advantage of a CNC device made by a machine tool manufacturer, challenge ourselves to find innovative machining methods and be a leader in the market.

*1 TOYOPUC is a registered trademark of JTEKT CORPORATION.

References

- 1) H. Takahara: JTEKT ENGINEERING JOURNAL, No. 1009 (2011) 91.



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