Features of High-precision Double-column MVR-Eχ Machining Center and Cutting Example

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Large die molds are necessary for the production of large parts used for automobiles, electric appliances, etc., and are increasingly produced overseas. With an increased need for stable, high-quality die mold manufacturing, however, there is also a move toward return production to Japan. In addition, for today's machine tools for molds, higher precision in terms of machined surface quality, such as that at the level that needs no polishing and reduces the stepping caused by thermal displacement, etc., is required.

Against this backdrop, Mitsubishi Heavy Industries, Ltd. released the MVR-Eχ large double column machining center, which is equipped with the high-precision technology adopted for the recently released LH250 high-precision machining center (**Table 1**). This paper presents the technological features of the MVR-Eχ, which realizes high-precision machining, and also details a cutting example.

Table 1 Main specifications of MVR-Eχ series (standard specification machine)

Item/Model type			MVR25Eχ	MVR30Eχ	MVR35Eχ	MVR40Eχ	MVR45Eχ
Table	Work area	Width (mm)	1,500	2,000	2,500	3,000	3,500
		Length (mm)	3,000	3,000	4,000		6,000
	Loading mass (t/m)		12/3.0	20/3.0	25/4.0		35/6.0
Distance between columns (mm)			2,050	2,550	3,250	3,750	4,250
Distance between spindle end and workpiece mounting surface (mm)			1,650		1,850		
Spindle head	Ram size (mm)		350 x 350				
	Spindle speed (r/min)		20 to 8,000				
	Spindle motor output (kW)		22/30 (continuous/30 minutes)				
Number of ATC tools			50				
Machine weight (tons/work area length: mm)			33.5/3,000	33.5/3,000	51.6/4,000	59.6/4,000	98.2/6,000

1. Features of MVR-Eχ series

Because the manufacturing of large die molds can take up to several dozen hours, the thermal elongation of the spindle caused by heat generation from its rotation and the heat deflection of the machine peripherals due to temperature changes result in the stepping of the machined surface. This hinders the elimination of manual finishing. Although a thermally symmetrical structure or heat deflection correction technology is typically adopted for large machine tools, no correction technology can correct the inclination of the machine or the tool. As a result, technology improvement that does not overly depend on heat deflection correction is required in order to eliminate manual finishing. To address this, the MVR-Eχ series uses internal spindle cooling technology and lubrication optimizing technology that have been cultivated with the LH250 high-precision double column machining center to suppress the thermal elongation of the spindle in high-speed rotation and the heat generation of the bearings to establish a structure that allows high-precision cutting without heat deflection correction. In addition, it uses efficient spindle cooling technology to increase the preload of the spindle bearing in low-speed rotation for the establishment of a structure that withstands rough cutting. In this way, the high-precision spindle achieves both low-speed heavy cutting and high-speed, high-precision finish cutting.

Also with regard to the machine body, the MVR-Eχ series is equipped with a thermally stabilized column as standard equipment for high-precision cutting without the need for heat deflection correction. The column suppresses the heat deflection due to changes in the outside temperature, and even reduces heat deflection such as the inclination and shrinkage of the column that cannot be corrected by thermal correction. For example, changes in perpendicularity between the x axis and the z axis against a change in the ambient temperature of 7°C are suppressed to the maximum limit of 6 μm per 500 mm to attain a structure that is not subject to environmental temperature changes in the machine installation location. Meanwhile, the rigidity of the main structural components such as the saddle and the cross rail is enhanced to realize high-power and stable cutting even with the ram fed at 800 mm (**Figure 1**).

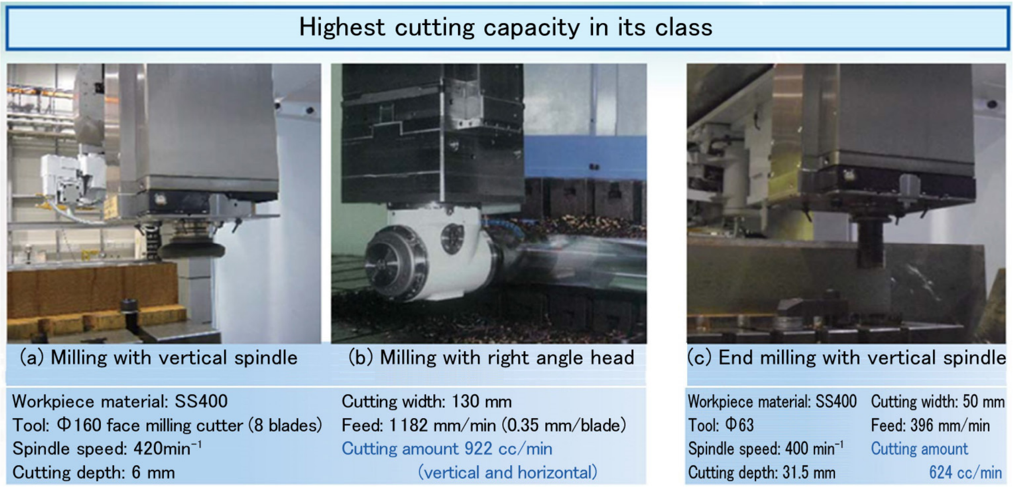

Figure 1 Example of heavy cutting

2. Cutting example

This chapter shows the result of the high-precision cutting (vertical shaft cutting) of an A5052 test piece (**Figure 2**). This test cutting was aimed at verifying the effects of the heat deflection suppression structure of the MVR-Eχ using the high-precision spindle and the thermally stabilized column. The test cutting was performed without any electrical correction of heat deflection such as spindle thermal elongation correction, while changing the spindle speed from 1000 min^{-1} to 8000 min^{-1} in order to intentionally generate spindle thermal elongation. To confirm the stabilization of spindle thermal elongation in a short time, the cutting was performed within 30 minutes of changing the spindle speed. Typically, a relative large heat deflection occurs in a change from low speed to high speed or from high speed to low speed, but the test resulted in a high-precision machined surface with a small amount of stepping up to 1 μm even under the conditions of the test environment where spindle thermal elongation tended to occur.

In addition, for the confirmation of the reduction in heat deflection (in particular the stepping of the machined surface caused by column inclination) resulting from changes in machine peripheral temperature, high-precision side face cutting (horizontal shaft cutting) of an aluminum test piece was performed with a right angle head (horizontal spindle) attached (**Figure 3**). This resulted in a small amount of stepping of 8 μm between two machined surfaces of machining passes that were performed with an interval of several hours even when the outside air temperature of the machine peripherals changed by 5.5°C over 18 hours. Accordingly, the structure of the machine with which heat deflection and stepping of the machined surface caused by changes in outside temperature are much less likely to occur was verified (Figure 3). In addition, the virtual lack of change in perpendicularity allows stable high-precision cutting, and even perpendicularity and accurate hole pitch in the five-face machining of a general workpiece cutting can be attained.

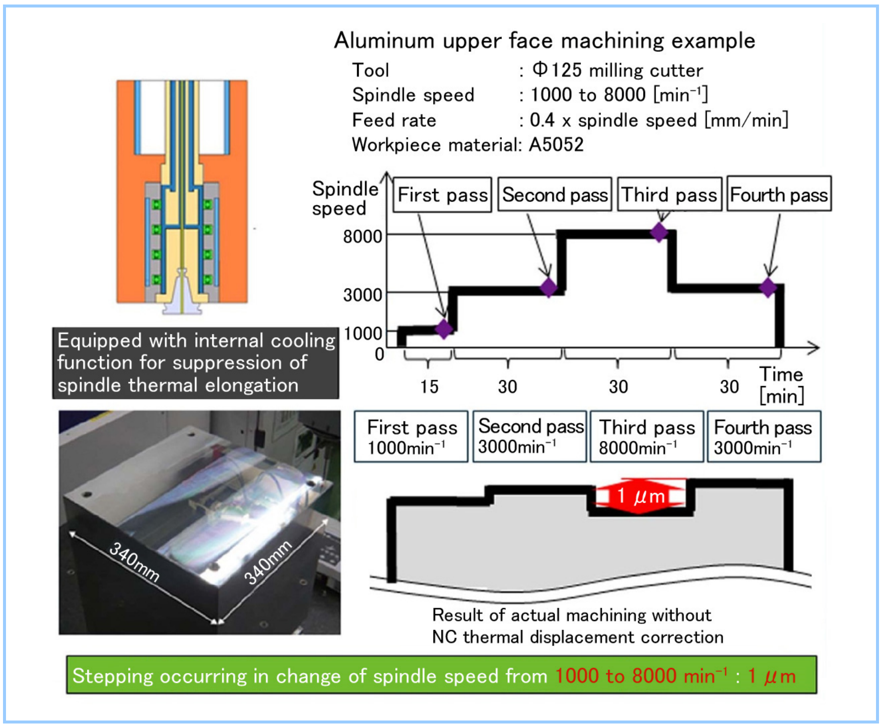

Figure 2　Example of high-precision cutting (vertical shaft cutting)

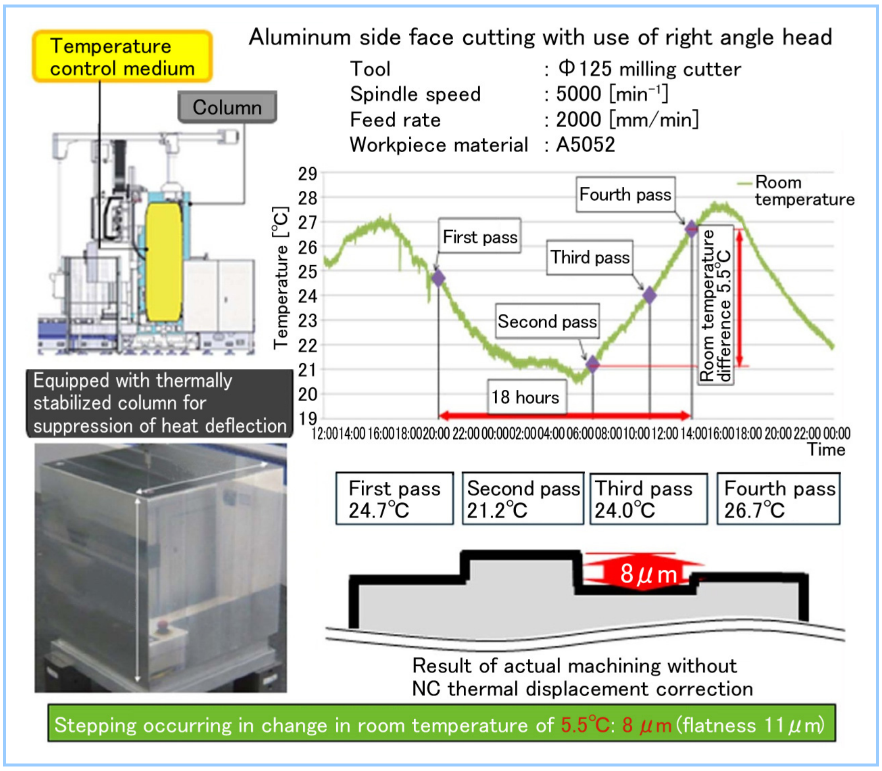

Figure 3　Example of high-precision cutting (horizontal shaft cutting)

In fact, the effects of the high-precision spindle and thermally stabilized column were verified in the cutting of a die mold model sample that lasted more than 40 hours (**Figure 4**). This die mold model sample cutting resulted in a small amount of stepping between finished surfaces machined with multiple tools having various diameters, suppressed the stepping of the connection between finished surfaces (where stepping tends to occur) to 1.5 μm at most and realized the elimination of manual finishing due to a high-quality machined surface that had no disorder of die mold dimensional accuracy and surface-machined shape.

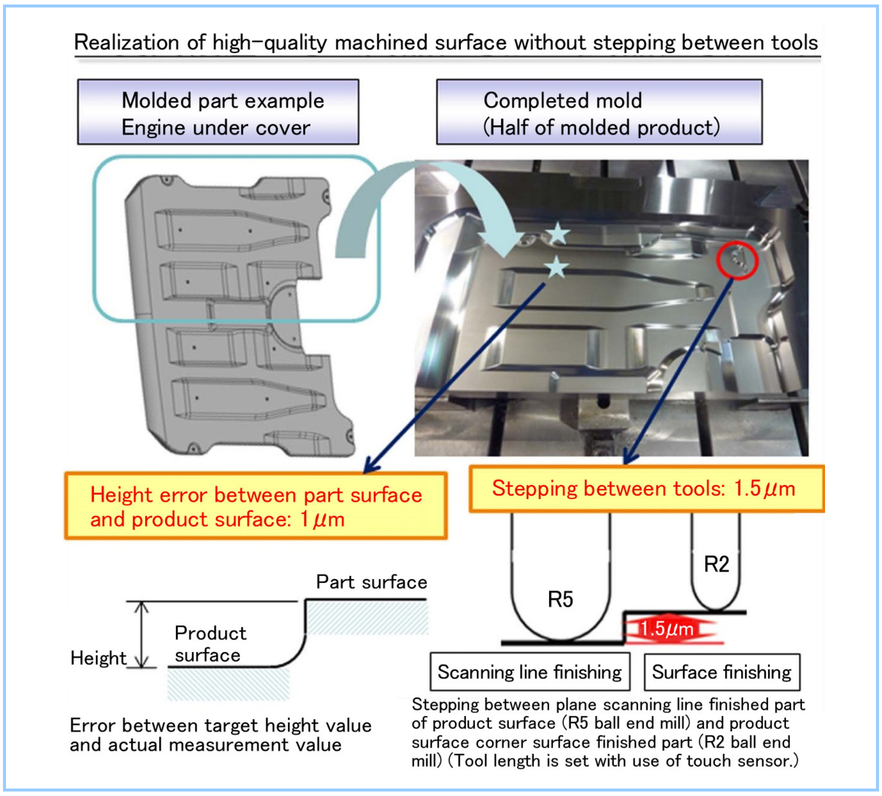

Figure 4 Effects of high-precision spindle and thermally stabilized column

3. Attachments for realization of various types of machining

For supporting the various types of cutting of customers, the MVR-Eχ can mount a wide variety of attachments (**Figure 5**). In addition to a right-angle attachment for double-column machining, an extension head for the improvement of accessibility to the workpiece and a universal head optimized for tilted surface machining are also available. In addition, the MVR-Eχ can satisfy the needs of various sites such as a reduction of the lead time, automation, high-precision machining, etc., by utilizing a high-speed universal head optimized for high-speed finishing of a die mold, a 5-axis head that enables curved shape machining of aircraft parts and railway parts and other attachments.

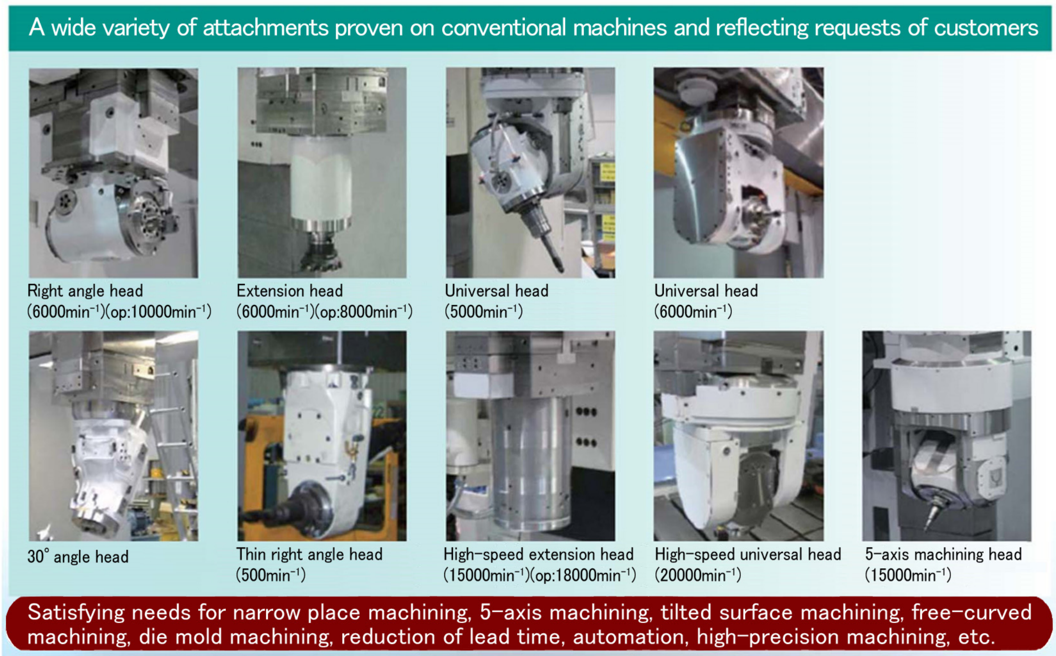

Figure 5 Lineup of various attachments