Development of e640V3 Vertical Machining Center

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The e640V3 vertical machining center is a machine with a cutting ability and productivity derived from know-how acquired through experience on production lines and processing. It was developed as a model suitable for line production, offering the minimum floor space in its class.

Key Words: *inline-type machining center, high speed*

1. Introduction

For the past 10 years, the number of machining centers being imported by emerging countries, particularly China, has remained firm, and there is an indication of this further increasing in the future. Vertical machining centers account for around 49% of these imports and small machines account for 38% of these (**Fig. 1**).

In addition, automakers in Japan are experiencing a moderate recovery in production after the slump that had been continuing since 2008. However, capital investment is still restrained and potential equipment buyers are seeking even higher cost performance than ever before.

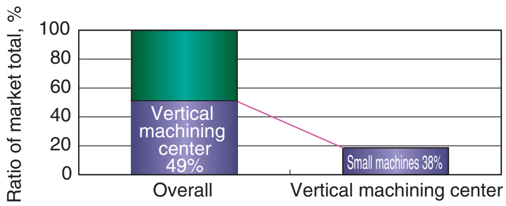

Fig. 1 Vertical machining center market (China)

2. Development Aims

JTEKT has delivered a large number of horizontal machining centers for machining lines of automotive parts, in particular, engine components, which have been highly regarded by customers.

The e640V3 introduced in this paper was developed as a base machine for simpler cell production vertical machining centers with high cost performance, inheriting the fixed-jig type unit configuration from the PV series which allows for easy jig setup and transportation (**Fig. 2**).

The e640V3, through a minimum width and overall length design that aims for minimization of machine installation space and the concentration of daily maintenance tasks in the forward and backward direction which eliminates space between machines, has reduced operator walking distance and is operator-friendly.

Fig. 2 e640V3 Vertical Machining Center

3. Features of Developed Machine

Table 1 shows the e640V3 specifications and **Fig. 3** shows the overall view.

With "uncompromising" and "focused approach" as keywords, basic configuration and necessary functions were carefully selected from the specification finalization stage (**Table 2**).

3. 1 Low-Cost Technologies

As a cost-reduction activity, casting weight was reduced through exhaustive machine downsizing. In the meantime, rigidity analysis was performed using CAE in order to ensure rigidity sufficient for machining was obtained, and rib arrangement and casting profiles were determined to achieve the target rigidity value. As a result, casting weight was able to be reduced by 51% of that of a conventional machine (**Fig. 4**).

Table 1 Machine specifications

Specifications		unit	e640V3
Feed unit	X-axis stroke	mm	600
	Y-axis stroke	mm	500
	Z-axis stroke	mm	400
	Rapid feed rate	m/min	48
Table	Workpiece swing (with tilt table)	mm	ϕ600
	Workpiece allowable weight	kg	250
Spindle	Spindle taper	–	BT No. 30
	Spindle rotating speed	min^{-1}	8 000
	Spindle motor output	kW	3.7/5.5
ATC	Tool capacity	Tools	14
	Tool change time	s	2.2 (C－C)
	Max. tool diameter	mm	ϕ80
	Max. tool length	mm	250
	Max. tool weight	kg	3
Control	CNC	–	MC50 (JTEKT) +TOYOPUC
Floor space		m^2	2.52

Table 2 Evaluation of functions

"Uncompromising"

Machining	An X-stroke of 600mm, Y-stroke of 500mm, and Z-stroke of 400mm adopted for machining aluminum die cast blocks and cylinder heads for inline-four cylinder engines.
Low cost/energy-saving	Changed to grease lubrication for spindle bearings and feed bearings (both manufactured in-house)
Space-saving	Machine width and total length for minimizing machine floor space.
Reliability	Improved chip discharge capabilities
Operability	Defining the way an operation panel should be on volume production lines, a CNC unit offering operability and space-saving features has been developed in-house.

"Focused approach"

Cutting capabilities	Cutting capabilities optimized for drilling, tapping, and milling (light cutting) of aluminum material
Specifications	Minimum number of tools tailored for the specific machining process composition
Functions	CNC unit with only the necessary functions

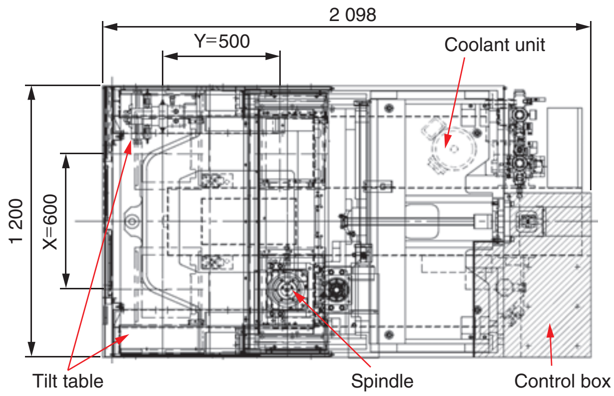

Fig. 3 Machine layout

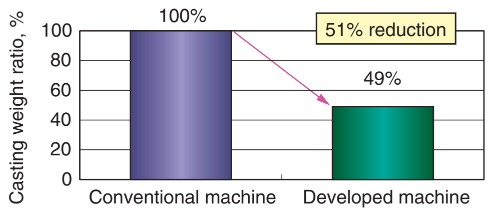

Fig. 4 Reduction of casting weight

In addition, the functions necessary for each specific machine part were investigated, reducing the number of parts through integration. Integration of the bed and the base reduced the machining area by 60%. Also, the addition of a shutter function reduced the number of magazine unit parts by 59% (**Fig. 5**).

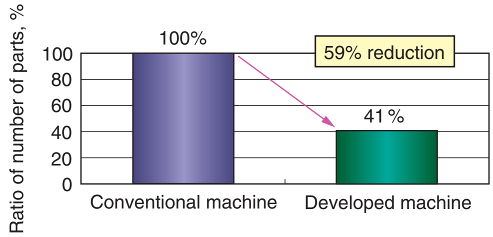

Fig. 5 Reduction of number of parts

Taking an uncompromising stance towards energy-saving also, spindle and feed unit bearings were changed to the grease-lubrication type, eliminating the lubrication unit. Moreover, by mechanically installing and removing spindle tools, cylinders and hence the use of hydraulic pressure were eliminated. Furthermore, motor size was reduced by making the movable body smaller and lighter and, as a result, power consumption was reduced, in turn, contributing to the reduction of running costs.

3. 2 Space-Saving Technologies

With respect to the machining stroke, the stroke and machining position of target workpieces were investigated and ATC stroke range was minimized. This shortened the Y-axis ball screw by 30%.

In addition, the feed motor size was reduced from 4.5 kW to 1.8 kW by making the movable body smaller and lighter, shortening the overall machine length.

On the spindle itself, motor fan layout was changed and spindle length was shortened. These changes shortened the total spindle length by 15%, achieving a total height of 2 400mm (**Fig. 6**).

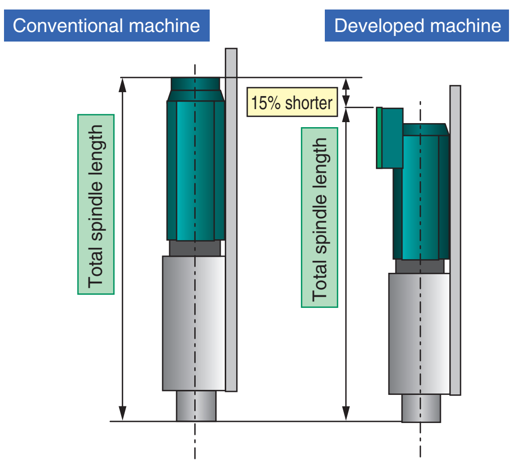

Fig. 6 Overall spindle length comparison

3. 3 Uncompromising Quality

(1) Shortening overall spindle length and optimally arranging bearings improved rigidity at the loading point by 11% (**Fig. 7**). In addition, an increased natural frequency allows the spindle to satisfactorily exhibit machining performance, thus contributing more to the stabilization of machining accuracy.

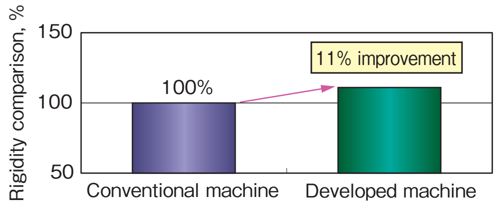

Fig. 7 Comparison of rigidity at loading point

(2) Shortening the stress path to the spindle head increased cutting area rigidity by 20% (**Figs. 8** and **9**). In addition, by optimizing the slider profile and the guide position, overall rigidity was increased.

As a result, main body, feeder and spindle parts were lightened and, at the same time, the necessary rigidity was secured, resulting in increased productivity.

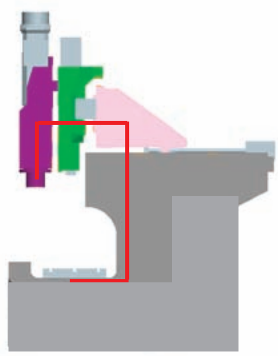

Fig. 8 Stress path

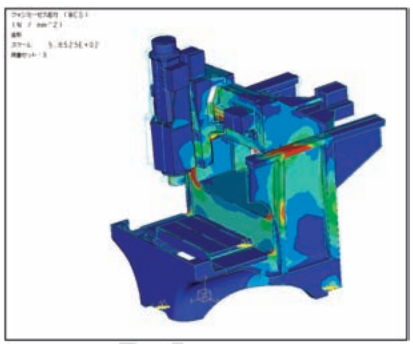

Fig. 9 Rigidity analysis

(3) In order to improve chip discharge capability, the chip chute opening area of the bed was expanded to suit the chip scattering area, and the opening ratio of the chute was increased by 8 points compared to the conventional opening ratio. These measures resulted in increased reliability (**Fig. 10**).

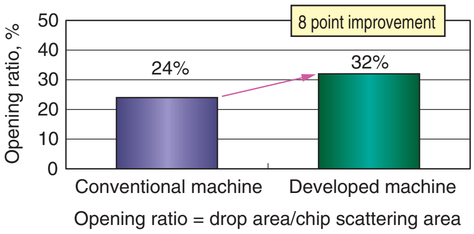

Fig. 10 Ratio of chip chute opening

4. Features of MC50 CNC Unit

The e640V3 is mounted with a CNC unit developed independently by JTEKT for cutting machines, the MC50, and TOYOPUC®, which is highly reputed as a PLC that makes visualization easy. The MC50 is a personal computer-based CNC unit with refined NC functions for cutting, and it places particular emphasis on simple and easy operability and high-speed technologies. The MC50 is accompanied by a HMI (human-machine interface), into which the extensive know-how acquired by JTEKT on production lines has been condensed, resulting in an easy-to-follow menu configuration broken down into operation levels such as daily tasks, setup work and maintenance work, and a maintenance screen that makes abnormal conditions and recovery methods clear even without knowledge on electrical sequence circuits or the experience of skilled maintenance personnel (**Fig. 11**).

5. Conclusion

Major Japanese automakers are also shifting their production systems from conventional volume production lines to small-scale cell lines. We are confident that the e640V3 we have developed, with its high cost performance achieved by utilizing our line equipment know-how, will contribute significantly to the reduction of product unit price, which is an issue in cell lines. We will continue to make efforts to develop even better user-friendly machines fitting for our customers' line configurations.

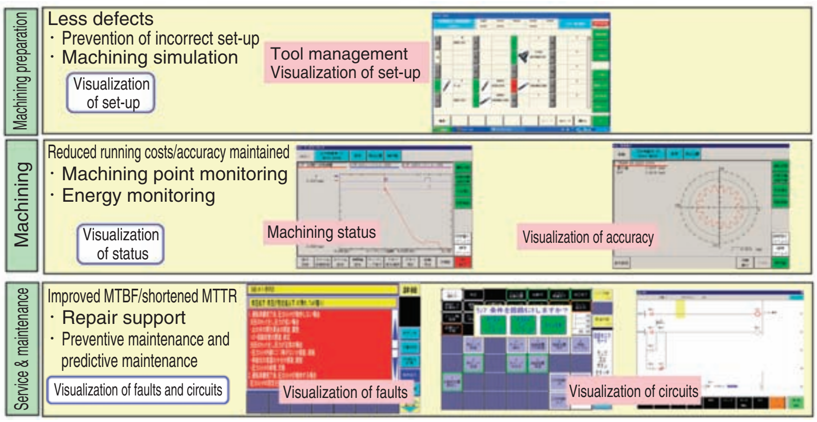

Fig. 11 MC50 system structure (in-line-type)


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