Development of In-Line Type "TOP Center F4X (F5X)" Machining Center

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The F3 and F4 series for light aluminum cutting were previously developed as machines highly suitable for customers' processes, products and production systems, but now the F4X and F5X series, which are capable of heavy cast-iron cutting, have been created by adding modules capable of high-load cutting and through a combination of these modules.

***Key Words**: In-line type machining center, module, top-center, standardization, compact*

1. Introduction

In the field of high volume manufacturing of products such as automotive components, it is desirable to select machines that are optimal for each product to be processed. At the same time, it is also demanded that the manufacturing equipment and the method should be suitable in terms of the customer's process costing.

To meet such demands, JTEKT has developed the new TOP Center F Series of machines featuring "modularized" components that allow an optimal combination of machine components. This new series is augmented with the new F4X and F5X Series which include modules capable of performing heavier cutting.

2. Modularization

In addition to the modules developed for the F3 Series (hereinafter referred to as F3), new modules (spindle, column, etc.) have been developed to form machines which can handle heavy cutting tasks equivalent to those previously taken care of by machine #50 of the conventional G Series. **Figure 1** shows an example of such a combination.

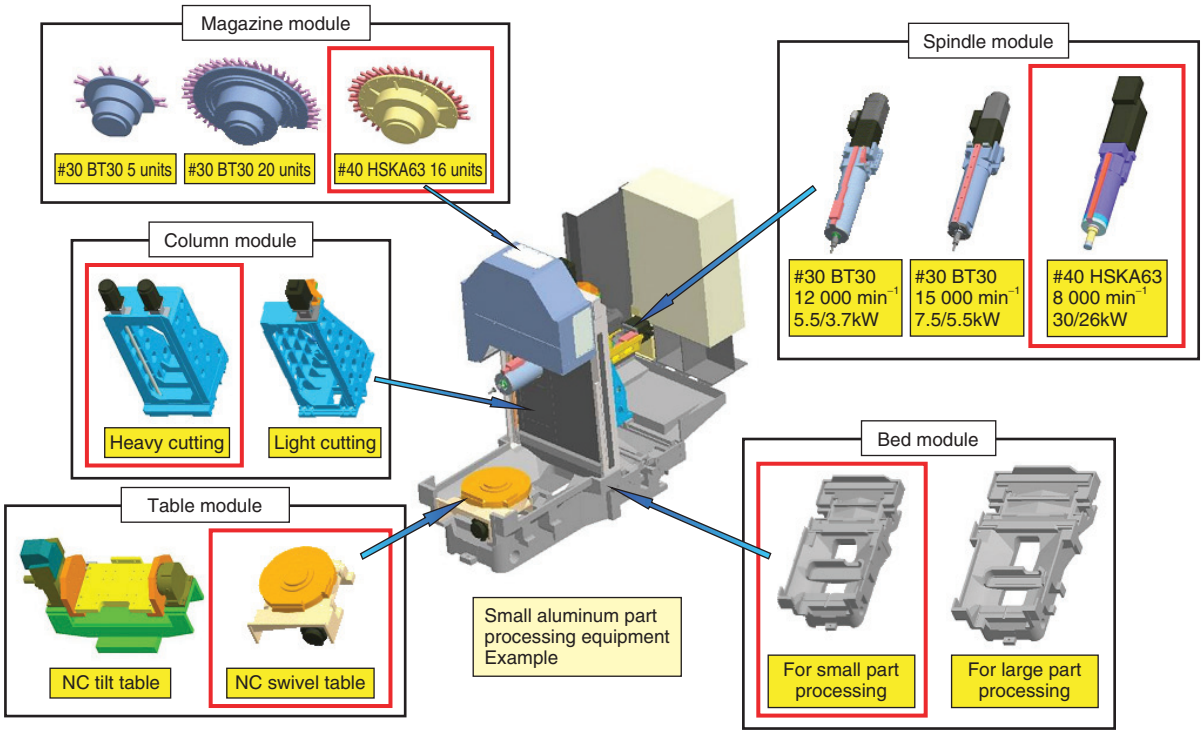

Fig. 1 Examples of combinations

3. Machine Features

These series of machines, with their varieties of standard modules, are instrumental in creating the optimal equipment configuration for a particular customer's process, products and production modes. Furthermore, they facilitate the construction of machines that are suited to the sizes of works through the sizing down of each element of the machine.

In addition, by using modules developed for the F3, it is possible to adjust to the widely diversified needs of our customers through cost reduction, improved reliability and reduction of development work load.

3. 1 Spindle Modules

As each spindle module has a specific spindle cartridge, the tool size and the maximum spindle speed can be readily changed by simply replacing only the spindle cartridge. Also, with three different spindle cartridges made available, they can satisfy a wide range of needs.

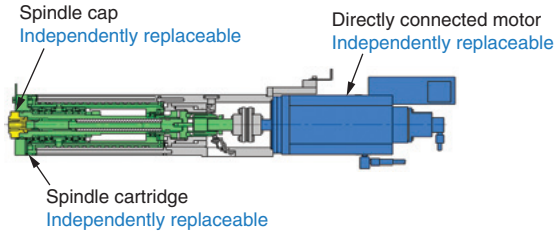

Fig. 2 Spindle section

Table 1 Spindle specifications

		F4X		F5X
Bearing	Diameter	ϕ100	ϕ80	ϕ100
	Type	NN	AN	NN
Housing diameter		ϕ240	ϕ240	ϕ240
Motor size		30/26	22/18.5	30/26
Tools	Size	#40	#40	#50
Rotational speed	min^{-1}	8 000	12 000	8 000
Lubrication		Oil mist	Oil mist	Oil mist
Process		Casting Heavy cutting ϕ160	Casting High speed cutting	Casting Heavy cutting Large diameter tools ϕ160~200

3. 2 Column Module

The new column module has been optimally designed in terms of the wall thickness and the rib location based on an analysis of displacement under loads from different directions. The result was the successful development of a small-sized, light-weight, yet highly stiff column module that can handle heavy cutting of iron or casting works.

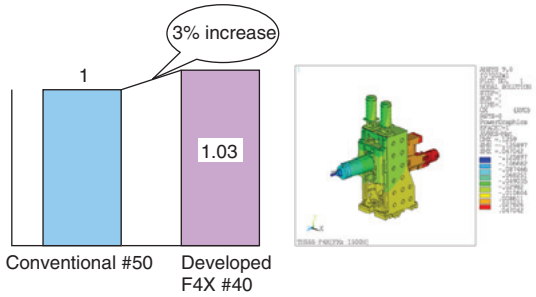

Fig. 3 Comparison of column module stiffness

3. 3 Bed Module

Utilizing simulations based on topology analysis (**Fig. 4**), the machine bed, which is the structural component of the machine, has been successfully innovated into a light-weight bed with limited height and high stiffness. The bed is commonized throughout all F and FX Series machines, with sufficient stiffness required in combination with F4X and F5X modules.

In addition, the three point support has made it possible to reduce the time required for leveling adjustment during installation as well as to stabilize the machine accuracy for a long period of time.

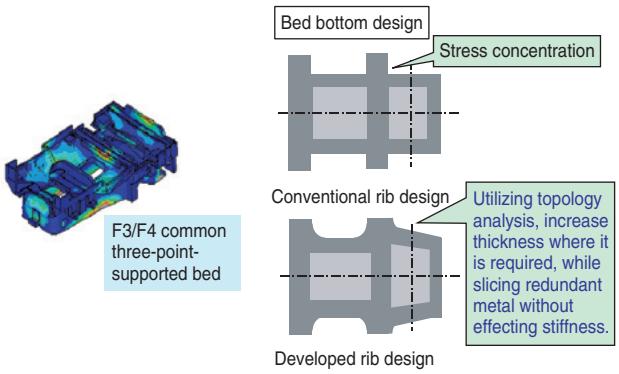

Fig. 4 Cross section of bed

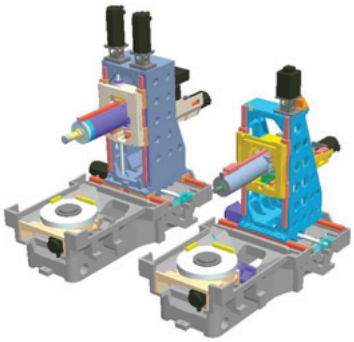

Fig. 5 Comparison of column modules

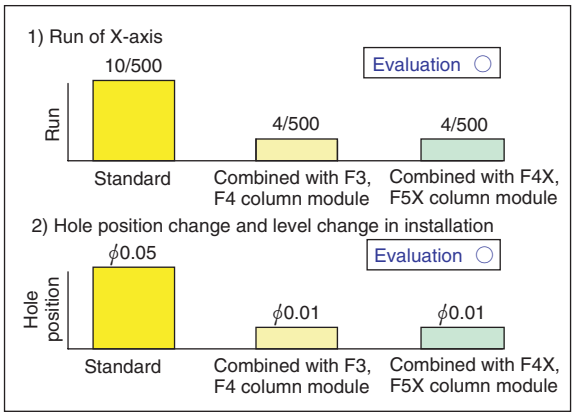

Fig. 6 Comparison of stiffness

3. 4 Table Module

With this table module we have accomplished faster indexing speed and a smaller size compared to the conventional turntable of G Series machines. In addition, in order to construct the machine in a simplified manner using only the minimum number of components, the manifold is integrated into the main body, which drastically reduced the overall number of parts. Also, the adoption of the face clamping method ensures stiffness that allows for heavy cutting. This has been confirmed through practical boring process testing on a casting.

【Main Changes】

· Higher rotational speed: from 18 min^{-1} to 40 min^{-1}

· Reduction of the number of parts: 35% reduction

4. Main Specifications

The main specifications of the machine are listed in **Table 2**.

Table 2 Machine specifications

Item		TH355F4X	TH555F4X	TH355F5X	TH555F5X
Stroke	X-axis, mm	300	500	300	500
	Y-axis, mm	550		550	
	Z-axis, mm	530		530	
Feed	Rapid travel, m/min	60		60	
	Cutting feed, m/min	0.001～30		0.001～30	
Spindle	Spindle rotational speed, min^{-1}	8 000		8 000	
	Spindle end configuration	HSK-A63		HSK-A100	
	Axial load on spindle, kN	5		10	
Magazine	Number of tools	5		5	
	Mass of tools, kg	15		20	
Electric motor	30 min. rating for spindle/ continuous, kW	30/26		30/26	
Performance/ capability	Positioning accuracy, mm	±0.003/total length		±0.003/total length	
	Repeated position accuracy, mm	±0.002		±0.002	
Machine dimensions	Width, mm	990	1 190	990	1 190
	Depth (including tank), mm	4 000		4 000	
Mass, kg		6 000	6 500	6 000	6 500

5. Machine Layout

5. 1 F4X Machine Layout TH355F4X

The machine layout of the F4X is shown in **Fig. 7**.

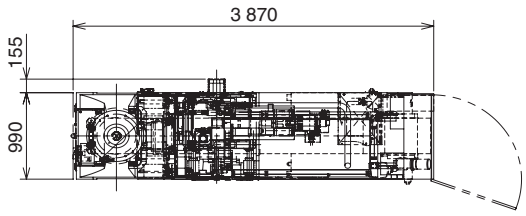

Fig. 7 Machine layout

5. 2 Comparison between the G5 and the FX4

The layouts and spaces of the conventional G5 and the FX4 are compared in **Figs. 8** and **9**.

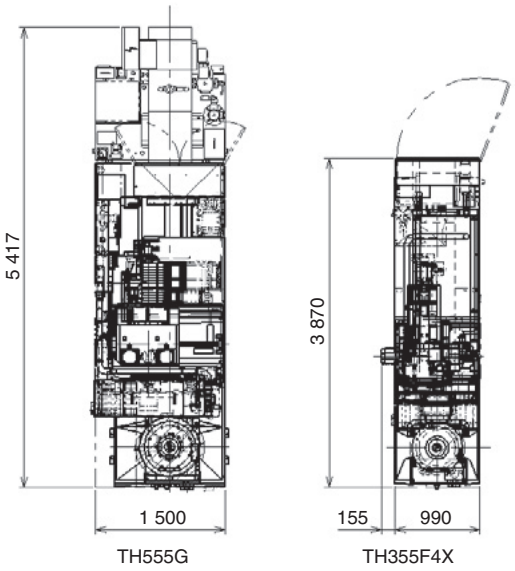

Fig. 8 Comparison of machines

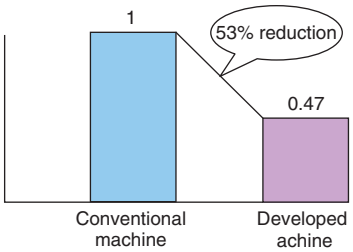

Fig. 9 Comparison of spaces

6. Conclusion

Through the development of compact, simple and standardized modules, the development of the F Series of machines, which consist of the minimal functions required, began with the F3 and continued on through the F4X and F5X. We would like to continue this development and expand the application of these modules into small sized machining centers so that we may further strengthen our competitiveness.

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