

FH1250SW Horizontal Spindle Machining Center

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The FH1250SW horizontal spindle machining center possesses a quill spindle and a boring function with an additional W-axis. This newly developed large machine covers a wide range of machining types and superior cutting capability, and enables the further integration of machining processes.

Key Words: horizontal spindle machining center, complex machine, quill spindle, heavy machinery, roller guide

1. Introduction

In recent years, in the transportation equipment and energy-related industries where demand for large-sized components is favorable, the trend toward larger components has been accelerated by requirements such as cost reduction through component integration and improved capability. In the field of wind turbine power generation, for instance, while the market was dominated by 2.5 MW class wind turbine units up until around 2005, in recent years, 5 MW or higher class units which provide higher power generation efficiency and less output fluctuation have gradually started to become mainstream.

Even with the current worldwide economic slowdown, the demand for processing machines capable of manufacturing large components at a high efficiency is increasing.

2. Development Aims

To respond to the demand for high-productivity large-scale machining centers, in 2007, JTEKT developed and released on the market a high-speed, high-rigidity horizontal machining center, FH1250SX, which has been received favorably in the market¹⁾.

In 2009 we developed another version, the FH1250SW (pallet size 1 250mm × 1 250mm), incorporating a quill spindle and adding a W-axis for boring to the FH1250SX. This machine has enabled large-diameter-deep-hole processing and boring as well as machining of deep-inside sections surrounded by high walls on large components, which were difficult to perform on ordinary machining centers. It can also process workpieces at a high efficiency in one-chuck, which used to be processed on two separate processes, namely a machining center and boring machine. Maintaining the high speed performance of the FH1250SX and reducing set-up, which is cumbersome for large components, have enabled the overall processing time to be significantly reduced.



Fig. 1 FH1250SW horizontal spindle machining center

3. Features of FH1250SW

Specifications of the FH1250SW (hereinafter referred to as this machine) are shown in **Table 1**, and its overall layout is shown in **Fig. 2**.

3.1 Newly Developed 3 000 min⁻¹ Quill Spindle

This machine is equipped with a newly developed gear-driven quill spindle featuring maximum torque of 1 305 N·m and maximum rotational speed of 3 000 min⁻¹, suitable for cutting iron and casting components (**Fig. 3**).

The newly developed 3 000 min⁻¹ quill spindle is supported by a front bearing comprised of a $\phi 180$ mm large diameter four-row angular contact bearing. This bearing is controlled by a constant pressure preloading

Table 1 Main specifications

Item		Unit	FH1250SW
Stroke	X-axis	mm	2 200
	Y-axis	mm	1 500
	Z-axis	mm	1 850
	W-axis	mm	550
	Distance from pallet top surface to spindle center	mm	200–1 700
	Distance from table center to spindle nose	mm	260–2 110
	Height from floor to pallet top surface	mm	1 500
Table & pallet	Size of pallet working surface		mm 1 250 × 1 250 (1 250 × 1 600)
	Work size limit	Maximum workpiece swing	mm $\phi 2\,400$
		Maximum workpiece height	mm 1 800
		Maximum load on pallet	kg 5 000
Feed rate	Rapid feed rate	X-axis	m/min 32
		Y-axis	m/min 32
		Z-axis	m/min 42
		W-axis	m/min 5
	Cutting feed rate (X, Y, Z-axis)		m/min 30
Spindle	Spindle nose shape		ISO R297/No. 50
	Spindle output (15 min/continuous)		kW 45/37 (Gear driven)
	Spindle maximum rotational speed		min ⁻¹ 3 000
	Spindle maximum torque		N·m 1 305
	Quill diameter		mm $\phi 130$
Tool	Maximum tool length		mm 800
	Maximum tool diameter		mm 350
	Maximum tool mass		kg 35

system whereby a constant hydraulic pressure is imposed on the bearing. The incorporated spindle motor boasts a maximum output of 45 kW and continuous rated output of 37 kW, with torque that is transmitted through a gear arrangement that allows two-step speed change. Thus, by changing the speed reduction ratios between 1 000 min⁻¹ or slower where high torque is required and higher rotational speeds through shifting the gear meshing, a torque as high as 1 305 N·m can be generated, so that high-load processing can be performed at a high efficiency. **Figure 4** shows the output/torque diagram for this spindle.

Quill spindle diameter was made $\phi 130$ mm, taking into account deep-hole processing and boring of holes $\phi 150$ mm or over as well as quill spindle rigidity. The extension stroke of the quill spindle (W-axis travel) is set at 550mm which is suitable for large components, allowing the reference surface of the spindle nose to reach 290mm or more from the table center.

Machining reaction force in excess of 10 kN imposed on the W-axis when conducting large-diameter-deep-hole processing is sustained by $\phi 50$ mm ball screws installed in tandem on the quill spindle through which deep thrust is transmitted. The maximum permissible thrust is set at 20 kN assuming a $\phi 170$ mm large diameter deep hole shear-off machining.

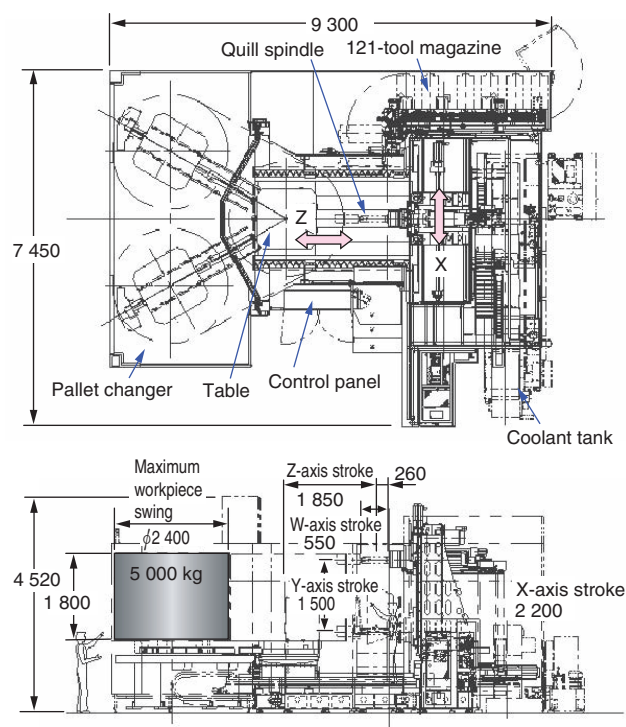


Fig. 2 Machine layout

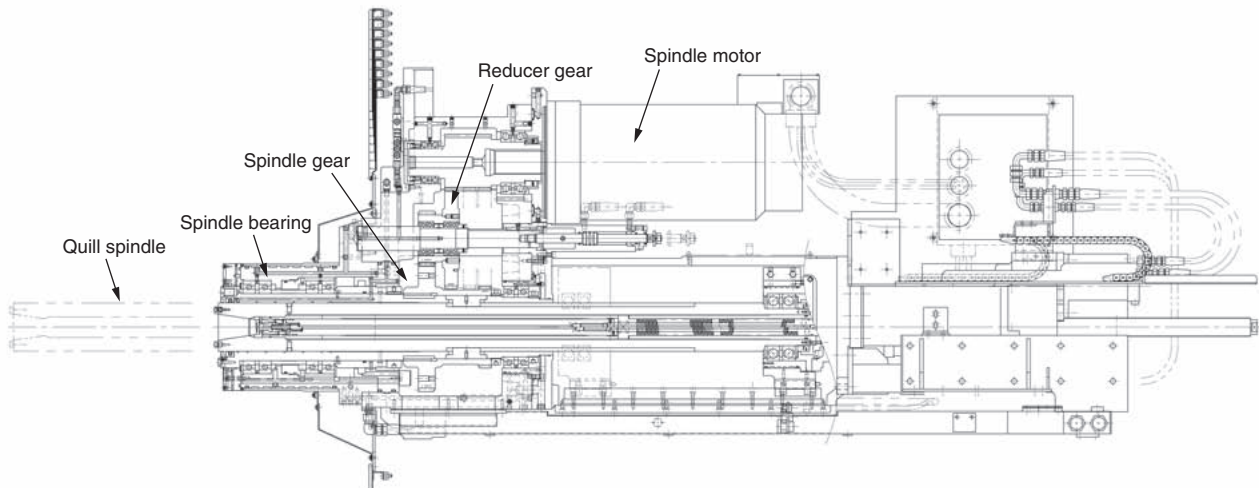


Fig. 3 New quill spindle structure

For the quills W-axis guidance, optimum design is used for the clearance on the sliding surfaces so as to ensure adequate stiffness when the quill is extended. Since the quill is structured in such a way that the bearing, i.e. the heat source, is located over the periphery of the quill housing, an imbalance in thermal distribution is created between the bearing part and other parts when the spindle is rotated for a short time. In order to avoid sticking when the W-axis is driven, believed to be due to the partial difference in thermal expansion between the housing and the quill, it is important to use appropriate fitting dimensions. For this machine, the optimum clearance on the sliding surface of the quill spindle is selected through a thermal transmission analysis based on CAE.

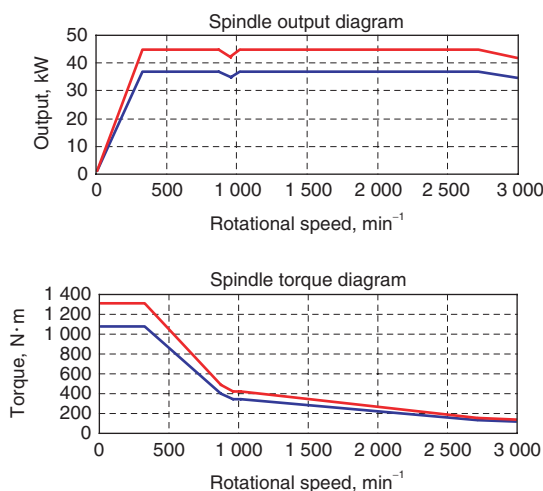


Fig. 4 New quill spindle output/torque diagram

3. 2 Wide Range of Machining

This machine has basic components such as the bed, column and table that are common with the FH1250SX, and has a maximum load capacity of 5 000 kg and a maximum workpiece swing of $\phi 2\ 400\text{mm}$, making it

capable of carrying the largest workpiece in its class and adequately providing the necessary mechanical travel distance.

The extension stroke of the quill spindle (W-axis travel distance) is 550mm, so short tools in length can be used to machine workpieces. In addition, the Z-axis stroke is set as 1 850mm. This achieves few limitations on shape or swing diameter of the workpiece even with a long tool installed on the spindle, thereby offering more freedom when selecting tooling and jigs.

Tools can be a maximum of $\phi 350\text{mm}$ in diameter by 800mm in length, with an allowable tool mass of 35 kg. The allowable tool moment is 29 N·m for pot type magazines (60, 121 tools) or 50 N·m for matrix type magazines (180, 240, 330 tools) (**Fig. 5**).

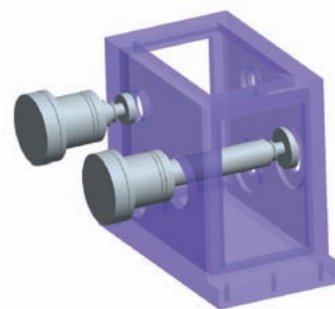


Fig. 5 New quill spindle machining example

3. 3 High-speed/High-rigidity

In order to attain both high-speed and high rigidity features, the feeding mechanism of this machine employs roller-type linear guides, which allows rapid feed of 32 m/min for the X and Y axis and 42 m/min for the Z-axis.

The Y-axis and the Z-axis, which are subject to substantial machining load, are provided with a dual drive composed of two ball screws, while the main components, like the bed, column and table, that support

them have been given optimum rib distribution by the CAE to provide adequate rigidity.

The support bearings installed on both ends of the ball screws on all the axes use a double anchor system that restrain the ball screw in both axial directions, so that high rigidity can be ensured throughout the stroke while preventing vibration.

3. 4 Low Thermal Displacement Design and Compensation Function

The bed, column, and other main components of this machine are designed using thorough symmetrical geometry.

Furthermore, in order to build a machine structure which is immune to bending and warping caused by fluctuations in room temperature, CAE-based thermal capacity analysis was repeated until the geometry was one with good balance in terms of thermal capacity.

The ball screw of each axis is provided with a hollow through which cooling fluid is supplied to the shaft center with temperature constantly controlled in response to the bed temperature to minimize thermal displacement, which enables stable high precision machining. The support bearings restrained by double anchor method is kept free of excessive load caused by the thermal expansion of the ball screws to improve reliability.

In addition, the optional spindle thermal displacement compensation function (which directly measures the elongation of the spindle and executes real time compensation) can be added to ensure comprehensive protection against thermal displacement.

3. 5 Improved Accessibility and Operability

Because operation of a large machine requires the operator to conduct tasks such as centering of the workpiece and checking of the machined surface and tool edges inside the machine, it is important to design the layout so that these tasks can be performed easily and safely. To improve accessibility into the machine via the operator door, the coil conveyor inside the machine is located on each side and in the center of the table with the bed height lowered to minimize the stepping height from the operator door as well as to facilitate the discharge of chips (Fig. 6).

The main operation panel is located on the left side so that the operator can work while watching the workpiece. The panel selected is a tilted type to facilitate program input and other operations, able to swivel freely to allow the monitor to be checked from the inside of the machine.

Also, like inside the machine, the pallet changer area has a wide front opening and a step with a smooth surface laid down across a wide area so as to facilitate material handling by a crane or the like as well as set-up operation including loading and unloading on the pallet. Providing a sufficiently wide work area with high visibility allows operators to

safely work from any position around the pallet. Splash guns on both sides are also available (optional).



Fig. 6 Operator door vicinity

3. 6 Repair and Maintenance Functions

This machine incorporates a PC-based CNC device and pursues intuitive operability by using a visually easy-to-understand screen display and a touch panel. It also incorporates a diagnostic function making use of the rich technology and know-how JTEKT has acquired on our in-line NC special-purpose machines to date.

As shown in Fig. 7, the fault diagnostic function displays a graphic presentation, such as photographs and/or drawings of the location of the occurring failure on the NC screen. This display also gives a description of the alarm, cause of the fault and method of restoration in a visually easy-to-understand fashion so as to achieve quick recovery of the machine and reduction in overall maintenance time.

It goes without saying that the regular diagnostic function includes a display of routine inspection items. It also, however, displays information that promotes regular measurement of the machine installation level, pitch error, backlash etc., together with a display containing an explicit explanation of these procedures, in order to support maintenance work for the preservation of machining accuracy.



Fig. 7 Example of detailed alarm screen

3. 7 Global Design, Compliance to Safety Standards

JTEKT has always designed machine safely in compliance with international standards. As far as this machine is no exception, the operator door is designed big with ample of space up to the ceiling so that the operator can work comfortably. Also, when the door is open, power is isolated on those devices which can be accessed by a person to secure operator safety. Furthermore, measures such as interlocking doors which people access using limit switches with electromagnetic lock-type keys show safety and user-friendliness in this machine.

For communication of the control devices, a fieldbus method is used to achieve improved reliability through a reduction in wiring and adaptability to global applications.

4. Conclusion

This machine was developed based on the FH1250SX released on the market in 2007. With the addition of a boring function being strongly desired by our customers, this machine is now capable of machining large components across a broader range of industrial fields. Even though the machine tool market has been weak in the current stagnant economy, we still receive numerous inquiries for large-size machine tools from customers, particularly in the BRICs. We hope the FH1250SW developed and other large machine tools to trigger the entire industry's growth.

References

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