Hard Turning Large-Diameter Parts

FUJI'S VTP-1000 IS DESIGNED FOR HIGHLY ACCURATE FINE FINISHING OF CYLINDRICAL COMPONENTS UP TO ONE METER IN DIAMETER

William R. Stott, Managing Editor

Introduction

In recent years, the demand for large-part machining has increased due to growth markets such as wind energy. As a result, new production lathes in the one-meter class have been introduced by many manufacturers. Several, especially those coming from China and Korea, are heavy-duty cutting machines.

But the VTP-1000 from Fuji Machine Mfg. Ltd. is no ordinary vertical turret lathe, says Seiji Suzuki, sales engineer for Fuji Machine America Corp.

"If it's just large parts, there are tons of machine tool builders who can supply them," Suzuki says. "But if they want the same quality for 10, 15, 20 years, they need a machine specifically designed for hard turning."

The VTP-1000 was designed from the ground up as a hard turning machine for large components. It's built with the rigidity to achieve ± 1 µm accuracy on one-meter parts over the lifetime of the machine.

"To be able to hold a ± 1 µm tolerance on a one-meter machine is pretty phenomenal," says Bert Richey, sales manager. Even more important, Richey says, the VTP-1000 can hold that tolerance on two axes, allowing the machine to perform contouring operations that other machines simply can't handle.

"Regular turning lathes can't handle tapered cuts to the same tolerances," Suzuki says.

Wind power generation requires highly accurate bearings and gears, often requiring these parts to be hard finished after heat treatment. Normally, a rough machining lathe is used to turn the parts before heat treatment. After heat treatment, the parts require finishing with accurate contouring and profiling, as well as extremely accurate dimensional control. Previously, these hard finishing processes were accomplished with grinding. However, grinding usually requires some additional setup for part changeover, including grinding wheel dressing, workholding changes, etc.

But the Fuji VTP-1000 is designed to replace grinding in this process, and it does so with increased flexibility, reduced cost and shortened machining time, according to Fuji executives.

High-Accuracy Technology

Roller slides. One of the features of the VTP-1000 that contribute to its long-term accuracy and rigidity are its roller slides (RS). Typically the rigidity of hard turning requires a machine with box slideways. However, because of the long travel of these large ways, the stick-slip action from friction exerts a negative influence on fine position control. One way to overcome stick-slip is to use linear guideways. However, they lack the rigidity required for hard turning. So Fuji engineers incorporated a roller slide mechanism in its slideways.

The RS slideway incorporates both

continued

roller box and box ways to provide the best of both technologies. Stick-slip is avoided, but rigidity is maintained (Fig. 1). Pressure adjustment of the roller unit minimizes the contact space on the sliding surface and has improved the damping effect.

"You get the benefits of rollers without the penalty of stick-slip movement common with regular box-type slides," Suzuki says. "This is especially important with contoured movements."

Figure 2 shows data from the measurement of the tool tip with a displacement sensor. The tool was sent a 0.2 mm move command at intervals of four seconds. Even with the z axis lowered in the direction of gravity—which is considered to be the most difficult condition—stick-slip control was maintained.

Vibration reduction. One of the important elements of vibration reduction is in the power transmission of the spindle. Transmission systems using gears are effective for heavy-duty cutting; however, microvibrations from these gears travel not only to the work, but also to the tools through the bed and column, which affects tool life and surface finish. The VTP-1000 is equipped with a synchronous belt drive system (Fig. 3), and spindle bearings are arranged to provide maximum rotational accuracy.

Controlling the heat. By placing the heat generating sources (spindle, motor, control box, hydraulic unit and coolant pump) outside the machine, and also insulating the rear side of the column, thermal growth of the machine is minimized. Also, large parts of the machine structure, such as the bed, column and slide, were engineered symmetrically, to minimize heat displacement with respect to the center of the spindle (Fig. 4).

In addition, a pre-machining tank is provided to bring the workpiece up to the same temperature as the coolant in the machine. This minimizes growth or shrinkage of the part itself.

Multi-purpose and rigid tooling. The VTP-1000 is capable of mounting two six-tool automatic tool changers (ATC) on the tip of the ram. Figure 5 shows examples of various ram and ID processing. The machine is designed for the ram tip to hold two tools next to each other, one dedicated for ID and the other for OD. This design enhances the rigidity of the tool tip and reduces the overhang of the ram, as shown in Figure 6.

The standard ATC holds 12 tools, and any tool on either the left or right can be exchanged from one ATC. This ATC type provides flexibility and

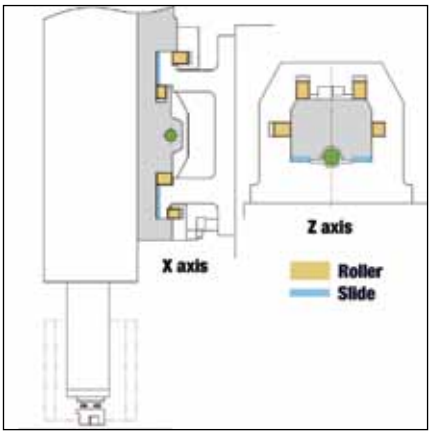

Figure 1—Roller slide mechanism.

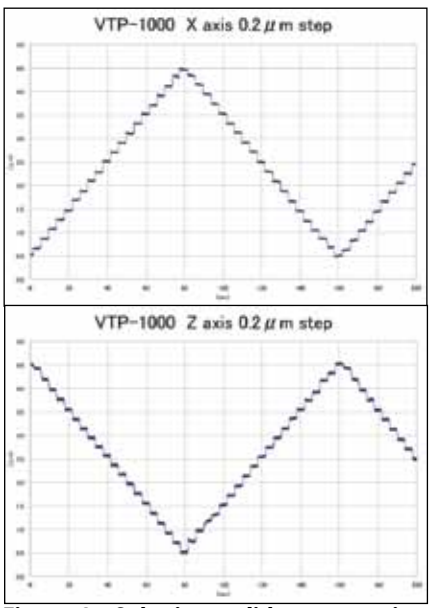

Figure 2—Submicron slide-step motion accuracy.

Figure 3—The VTP-1000's spindle structure uses a synchronous belt transmission instead of gears.

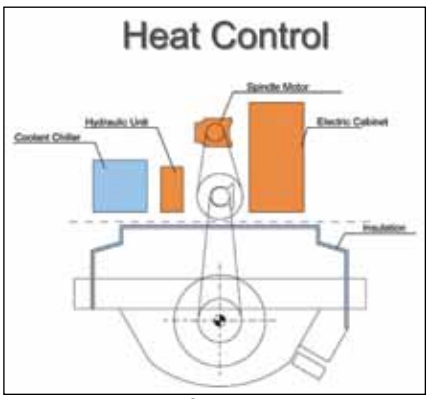

Figure 4—Most of the heat-generating components are placed outside the machining area to minimize machine and part distortion.

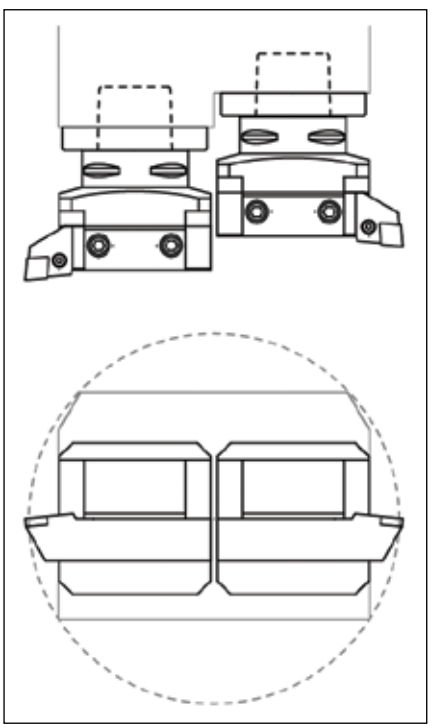

Figure 5—Tooling options with the VTP-1000.

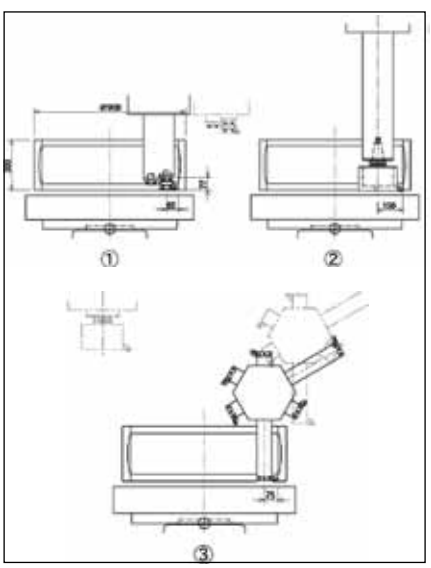

Figure 6—The VTP-1000's tool holder on the Z-axis tip accommodates two tools.

room for expansion.

High Accuracy Machining Example

Figure 7 shows an example of a hard turn finishing process. This test was performed without using coolant. The feed rate was 0.1 mm/rev to reduce the influence of tool tip heat abrasion. Even under this condition, machining surface roughness was 0.1–0.3 mm Ra.

In this example, the surface finish achieved with single-point hard turning compares favorably with grinding. The total cycle time is much lower than with grinding due to the elimination of dressing or changeover of the grinding wheel.

In addition, using a magnetic chuck allows processing of ID, OD and face all in a single clamping. Because there is no need to change from one workholding device to another, the resulting accuracy is improved.

Options

On-board measurement. Measuring the dimensions of a large workpiece is not easy, especially measuring a one-meter-sized part. Normally, a large CMM is used, which is costly. The work handling time for this process consumes a large amount of the total processing time. In order to reduce this time, the VTP-1000 can be equipped with an on-board measurement system.

Twin slides. To make the production process even more efficient, the VTP-1000 is also available in a 4-axis version. This allows the reduction of machining cycle time by half.

Work material	SUJ 2
Work hardness	HRC 60
Feed rate	0.1 (mm/rev)
Stock removal	0.1 (mm)
Speed	200 (m/min)
Condition	Dry
Tool material	BNX10

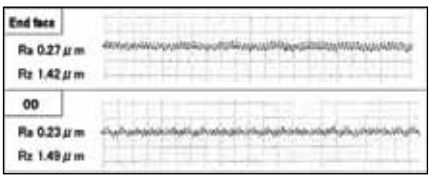

Figure 7—Example of a hard turning machining process.

Conclusion

The VTP-1000 is designed to replace grinding for fine finishing of large-diameter components. It's especially effective for manufacturers who require tight tolerances, contours, lower volumes and frequent changeovers. In those cases, the machine can be much more productive than grinding.

Because of that, several gear manufacturers specializing in wind turbine gears are already exploring investing in this new technology, Suzuki says.

And because the machine would typically cost two to three times less than a large-diameter grinding machine, the investment could pay for itself rather quickly for the right manufacturer.

For more information:

Fuji Machine America Corp.
171 Corporate Woods Parkway
Vernon Hills, IL 60061
Phone: (847) 821-7137
Fax: (847) 821-7815
www.fujimachine.com