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HIGH PRECISION, HIGH EFFICIENCY INTEGRATED MILL TURN CENTERS NT SERIES

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Abstract: *For many of these complexes, precise and advanced work pieces, many different kinds of machining must be applied. Some work pieces need to be machined by a lathe, then a machining center. The customer’s demand increases for one single machine that can perform all these tasks. The solution is integrated mill turn centers. The latest forms of integrated machines have a total of 9 axes, 2 spindles and 2 turrets.*

Key words: *CNC machining centers and CNC lathes.*

1. INTRODUCTION

What customers want from an integrated mill turn centers is to increase productivity from basic cutting processes. By combining cutting edge technologies developed by Mori Seiki, such as the milling abilities in NH Series horizontal machine centers and turning abilities by the NL series CNC Lathe, the NT series, the ultimate integrated milling turn centers, becomes a reality. With high productivity above that of all other machine tools, the NT series is leading the industry to a new era for integrated mill turn centers.

2. INFORMATION

The NT series supports a wide range of machining capabilities, from high speed machining to heavy duty cutting. With the tool spindle used in this horizontal series, in addition to DCG™ technology, there is high efficiency and high quality machining of all types of material, dramatically improving productivity.

With the outstanding rigidity offered by the tool spindle, from NL series, offers heavy duty cutting without vibration in both headstock 1 spindle and turret 2. Also, thanks to a new body construction that strengthens heavy duty cutting ability, wide cutting with no vibration is also possible.

2.1. Structure

The box in box construction supports the saddle and both ends, guiding the axes at the center of gravity, creating a balanced environment for unprecedented high-speed acceleration (Fig. 1).

The high speed rotating headstock 1 spindle is aligned with the rotary tool spindle, dissipating heat in all directions. While retaining its original rigidity within cast iron construction, thermal displacement has been reduced to a minimum, maintaining a high precision cutting.

A flat bed design evenly disperses and absorbs resistance during machining, without any distortion. With this benefit, the rigidity of the headstock 1 spindle has been greatly improved. DCG™ quickly eliminates vibration after a sudden stop.

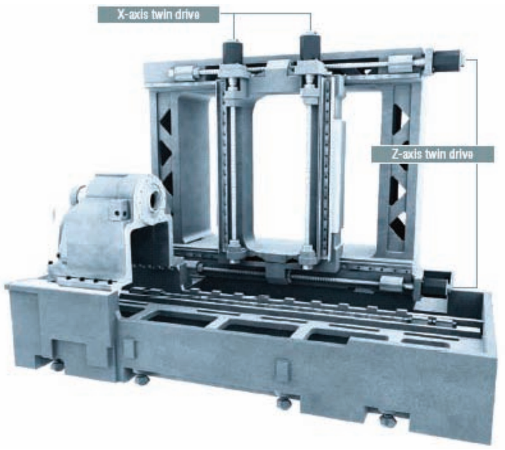

Fig. 1. Machine structure.

2.2. Turret with a built-in milling motor™

A “built-in” milling motor structure has been used, with the motor located in the turret, reducing heat generation and vibration to a minimum level and improving transmission efficiency. Cutting ability, speed, surface quality and precision have all been greatly improved.

The motor is located inside the turret (Fig. 2), doing away with heat transmitting structures that cause generation of heat. A decrease in sources of heat generation, together with the jacket cooling used with the turret built-in milling motor, effectively eliminates thermal effects.

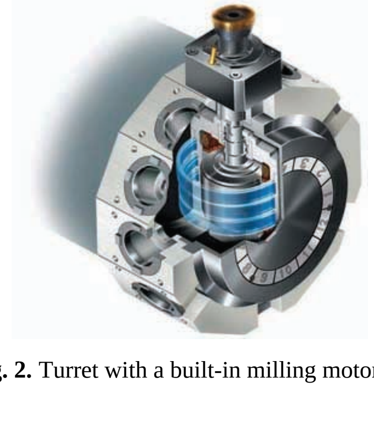

Fig. 2. Turret with a built-in milling motor™.

2.3. Octagonal Ram

To retain the ram's maximum rigidity in the restricted amount of space, an Octagonal Ram™ has been developed (Fig. 3). The opposing side length of 400 mm surpasses bridge type machining centers. This means that even when using the maximum Y-axis travel, the center of gravity does not protrude over the supported section, avoiding deflection and enabling high-precision machining. In addition, by making the ram a perfect octagonal shape, a V-shaped guide way produces superior straightness.

The saddle supporting the huge ram is a one-piece structure made using a special type of machining, allowing high rigidity possible.

2.4. High flexibility B-axis™

A Direct Drive (DD) motor has been adopted for arbitrary indexing specifications, making high precision and smoothness of movement possible due to the high speed it produces and the elimination of backlash (Fig. 4). In addition, B-axis indexing time has been reduced by half in comparison with conventional machines, from 2.6 seconds to 1.3 seconds (90°). It is possible to significantly reduce actual machining time, especially when conducting complex shape machining by simultaneous 5-axis machining, B-axis rotation range ±120°.

2.5. Tool Spindle

Direct Drive Spindle (DDS) motors rotate the spindle directly without the need for gears or belts.

By placing the spindle motor in the headstock (Fig. 5), the size and weight of the entire spindle is reduced,

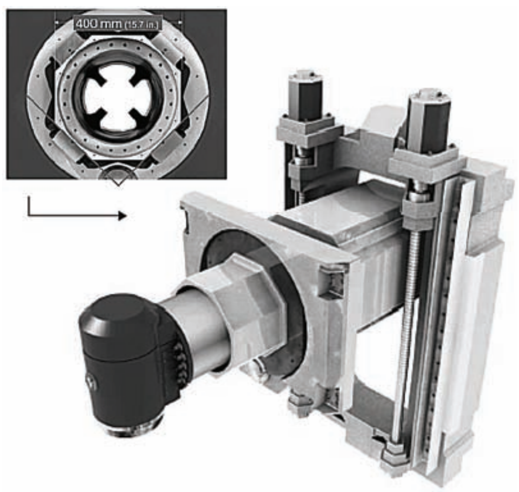

Fig. 3. One piece construction.

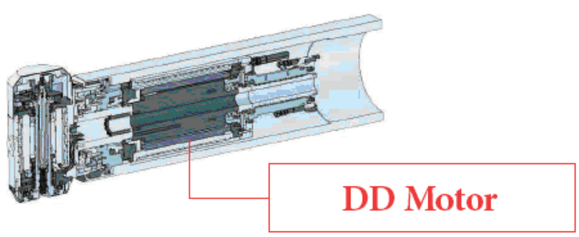

Fig. 4. B axis specifications

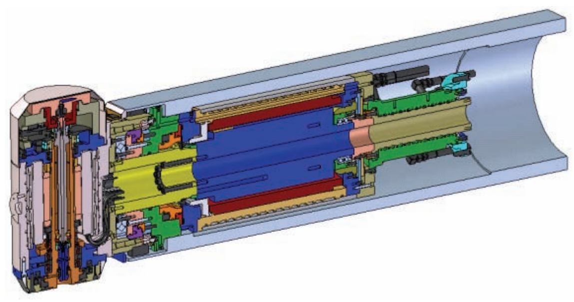

Fig. 5. The spindle.limiting vibration and achieving high output.

In addition, spindle speeds are significantly higher than those of conventional models, reaching up to 12,000 min^{-1}.

2.6. Restricting vibration

By pushing the structure at its center of gravity using twin drive, vibration occurring during movements is limited, and high speed machining and high quality is made possible (Fig. 6).

Vibration accompanying changes in travel direction in conventional models is minimized by DCG™. This significantly improves roundness in circle cutting.

While vibration in the machining using DCG™ does not occur at positioning, vibration in the machine not

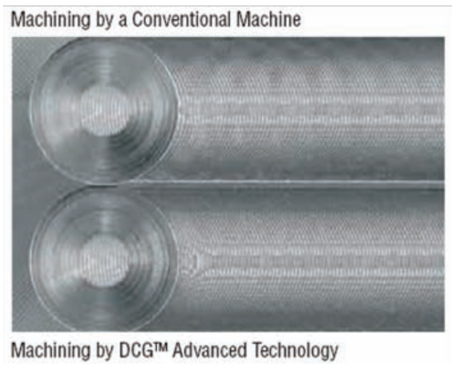

Fig. 6. Restricting vibration

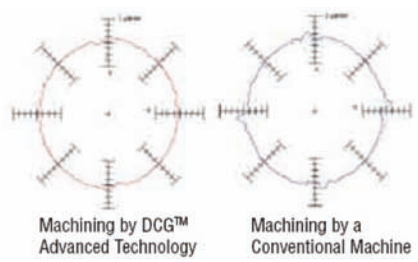

Fig. 7. Restricting vibration.

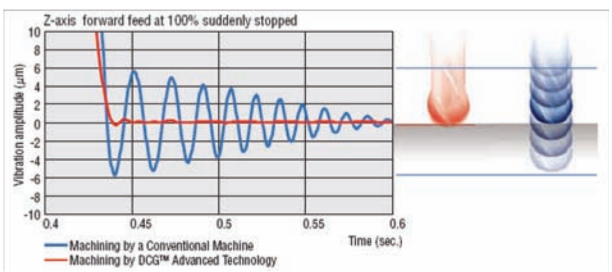

Fig. 8. Residual vibration.

using DCG™ persist for a long period. Rotational vibration, occurring at all acceleration start points, is reduced to an amount commensurate with the distance between the drive point at the center of gravity, preventing deterioration (Fig. 8) in machined surface quality (Fig. 7).

2.7. Acceleration and deceleration

The machine with DCG™ generates little vibration at the beginning of acceleration, and is able to accelerate from the very start maximum power (Fig. 9).

2.8. ATC

With the cam-operated ATC, a tool-to-tool time of 1.0 seconds has been made possible. Chip-to-chip time, 14 seconds with conventional machines, has been reduced to 4.0 seconds. Time for each tool has been reduced by 10 seconds. Additionally, the size of the ATC shutter is the smallest possible required, and furthermore, the machine is designed to enable tool changes outside the machining room.

2.9. Heat shielding

The motor is located inside the turret, eliminating heat-transmitting structures.

With a decrease in sources of heat, together with the cooling jacket inside the built-in milling motor, thermal effects are practically eliminated (Fig. 10).

Through holes have been made in the core section of the ball screws, and a ball screw core cooling system using cooling oil to suppress thermal change has been adopted. While suppressing heat generation in the ball screws, it also circulates cooling oil around the entire support bearing, reducing generation of heat during high-speed rotation. Cooling oil is circulated in the motor base, preventing heat from the motor transmitting to the cast iron of the main body.

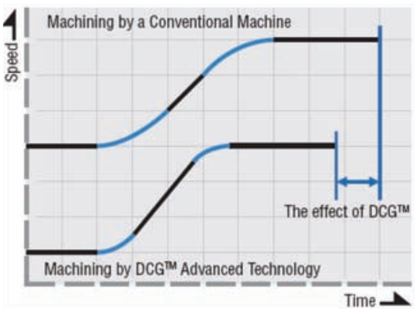

Fig. 9. Residual vibration.

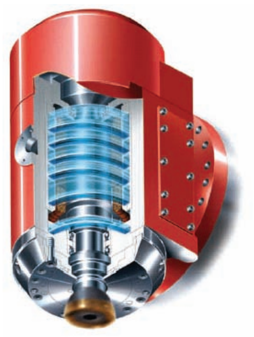

Fig. 10. Spindle cooling.

2.10. Spindle

The NT Series boasts maximum torque standard specifications of 358 N·m (rated for 20 min) and high output specifications of 456 N·m, and its maximum spindle speed of 5,000 min^{-1} significantly surpasses acceleration/deceleration rates for conventional models, meaning that the NT Series in fact possesses spindle motor capabilities similar to machines in the next highest class. It has been designed to be compatible with large diameter work pieces with spindle through-hole diameters of Φ73 mm, possessing unwavering stability for heavy-duty cutting. Milling and turning are possible through simultaneous operation (Fig. 11) of the headstock 1&2 spindles, enabling high-precision machining of long and thin work pieces.

2.11. Tool magazine

The most important benefit provided by integrated mill turn centers is the consolidation of processes, and when you are even one tool short of the number required for machining, this benefit is lost. The ATC arm rotation radius (Fig. 12) has been made smaller, and synchronization of the spindle tool clamp/unclamping operation with the ATC employs a software based encoder. The tool to tool time of 1.0 seconds is greatly shortened in comparison with conventional models.

3. CASE STUDY

In this study, the machining time calculations are based on the drawing for the work piece: gear shaft, material: 18MoCrNi17 and use of the NT4300DCG/1000SZ CNC Integrated Mill Turn Center made by Mori Seiki.

3.1. Work piece machining drawing

The machining drawing, for first machining area is shown below (Fig. 13).

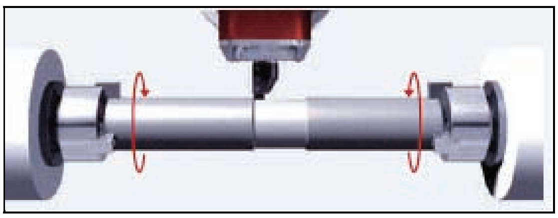

Fig. 11. Simultaneous operation.

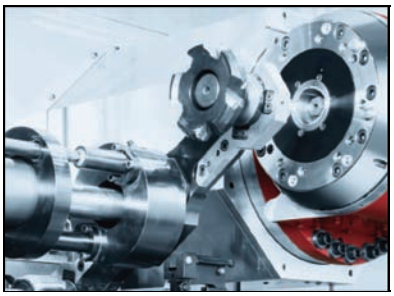

Fig. 12. ATC arm.

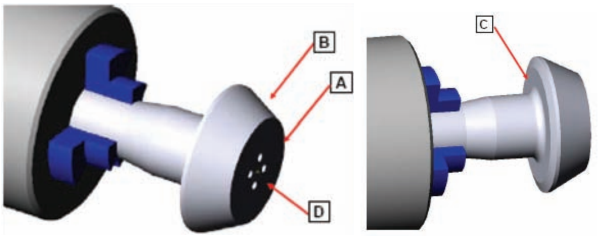

Fig. 13. Machining drawing.

Cutting conditions for machining OP1 are presented in Table 1.

Table 1

Machining OP 1

Machining Type	**Location**	**Diameter**	**Cutting speed**	**Machining time**
		[mm]	[m/min]	[s]
Face turning	A	70	240	39
O.D. turning	B	145	280	44.8
O.D. turning	C	115	260	44.7
Drill	D	10	65	8.6
Drill	D	9.8	65	8.6
Reamer	D	10	10	16.8
Transfer				15
TOTAL				**177.4**

The machining drawing, for second machining area is shown below (Fig. 14).

Cutting condition for machining OP2 are presented in Table 2.

Table 2

Machining OP 2

Machining Type	**Location**	**Diameter**	**Cutting speed**	**Machining time**
		[mm]	[m/min]	[s]
Face turning	A	45	200	22.8
Centre drill	A	8	60	4.7
Tailstock	A			8
O.D. turning	B	65	260	54.1
O.D. turning	B	65	285	68,7
Drill	E	6	55	28.9
O.D. grove	C	40	220	19.1
O.D. grove	D	75	220	22.7
Thread	E	40	70	34.9
Gear shape	B	70	66	257.3
TOTAL				**521.2**

The machining time for the work piece gear shaft is:

- Machining time for OP 1: 177,4 s/pc

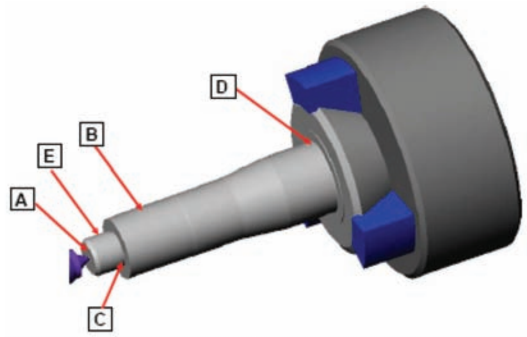

Fig. 14. Machining drawing.

- Machining time for OP 2: 521.2 s/pc
- Total machining time: 698.6 s/pc.

The machining time does not include the loading and unloading time.

4. CONCLUSION

Using CNC machines we can observe the increase of precision by using automated cycles and cutting tools with higher tool life.

If we compare the classical machining with CNC machining, for the same part, the time for machining is reduced up to 250%. Another advantage of this technology is that the prices for machining of this part are reduced up to 35 %.

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