

► BY JOSEPH L. HAZELTON, SENIOR EDITOR

Precision ON THE TABLE

Parts manufacturers must consider more than just standard product specifications when selecting and using rotary tables for tight-tolerance machining.

Adding a rotary table to a 3-axis CNC machine tool expands the range of parts a machine shop can manufacture in a single setup. Having 4th-axis capability or 4th- and 5th-axis capability for contour machining can allow parts manufacturers to quote and obtain jobs they had to pass on in the past.

They may also be able to reduce setups and workpiece handling because a cutting tool can access

more than three sides of a workpiece when the machine tool includes a rotary table. Fewer setups and less handling reduces the possibility of stack-up error, the inaccuracy that can appear and grow if a workpiece is mounted and remounted several times during machining.

However, expanded abilities mean additional possible problems. No parts manufacturer wants to gain capabilities if it results in diminished part accuracy, for example. Consequently, machine shops must be careful when evaluating rotary tables to ensure that the new equipment doesn't take away from machining accuracy.

What are you grinding?

**Tool Steel, Carbide, Inconel, Ceramic,
Cermets, Glass?**

**Advanced Superabrasives Inc.
Mans Hill, NC 28754
Phone: 828-689-3200
Fax: 828-689-9338**

- Manufacturers of precision superabrasive grinding wheels
- Grinding Consultation
- Experts on grinding cermets & new hybrid materials
- Filtration Systems

For your Superabrasive needs call 800-559-8252
Or visit our website: www.asfwheels.com



G-Mills

- Diamond coated G-Mills are designed with specific applications in mind
- Faster Hertz for better material evacuation
- Amorphous Diamond coating for longer tool life and smoother piece part finishes
- Available in:
 - Long flute/long reach
 - Long reach and extra long reach square end and ball nose
 - Long reach and stub flute for deep pocket milling



Cutting Edge Technologies • 290 Gerry Street • Plymouth, MA 02360
P: 800-259-8868 • F: 508-747-4338 • www.cutdirect.com

precision on the table

The Spec Sheet and Beyond

Before acquiring a rotary table, a parts manufacturer should review its part tolerances and figure what specifications its table will need to achieve those tolerances. Consequently, the company must consider the table's indexing accuracy and repeatability.

It also needs to determine the greatest cutting forces to which its table will be exposed. The forces have to be considered whether the table is used to position a workpiece as an indexer or to provide smooth, continuous motion for contour machining. If used only to index, a table must have enough clamping torque to hold a part steady under the greatest cutting forces the part experiences. "If the clamp isn't holding that [workpiece] in place, then your accuracy is going to suffer," said Bill Meo, president of rotary table supplier Koma Precision Inc., East Windsor, Conn.

The greater the gear drive's backlash, the less positioning accuracy a rotary table has.

A clamping system may consist of hydraulic or pneumatic clamps or of calipers that clamp on a disc. "The key is that it maintains its position while the customer is machining," said Preben Hansen, vice president and sales manager of rotary table supplier Lyn-dex-Nikken Inc., Mundelein, Ill.

Otherwise, the part would be inaccurate, perhaps out of tolerance, which would create scrap parts and lost time and money.

Besides spec sheet data, though, the company should learn about the accuracy of a table's construction, such as whether the table's surfaces and features have sufficient squareness, parallelism and perpendicularity.

Meo said parts manufacturers should also be aware of a table's rise and fall as it indexes and of runout in the center hole to minimize wobble in it, as examples. "Acceptable runout for rise and fall would be 0.0004" or better," he



A gear set, such as a worm gear set, that's free of backlash contributes to a rotary table's positioning accuracy. But backlash can appear and accumulate with use, so parts manufacturers need to ask about other gear system aspects designed to minimize the growth of backlash.

said. "You have to take all the accuracies into consideration."

Besides exterior aspects, companies should concern themselves with the internal assemblies of tables. "They all look the same on the outside, but they're very different on the inside," Hansen said.

Location, Location, Location

For example, if a table is gear driven, its gear system and bearings play a strong role in its performance.

"You want to have a system that's as backlash free as possible," Hansen said. "You want something that will maintain minimal backlash over a long period of time."

The greater the backlash, the less positioning accuracy a table has. However, even when new gear drives have no backlash, they will later develop it through use, so shops and manufacturers have to ask about the wear resistance of a gear set's materials and other measures that slow backlash's development. They also have to consider other factors that affect wear, such as the amount of rotating the table performs, the weight of its workpieces and the cutting forces generated. After all, the longer the gear set has no backlash, the greater the table's long-term repeatability.

Keywords

backlash:

Reaction in dynamic motion systems where potential energy created while an object was in motion is released when the object stops. Release of this energy or inertia causes the device to quickly snap backward relative to the last direction of motion. Can cause a system's final stopped position to be different from what was intended.

rotary table:

An assembly that's installed in 3-axis CNC machine tools to allow them to machine workpieces in the 4th or 4th and 5th axes. May be used to position and hold a workpiece in those axes or provide continuous motion through them for contour machining. Can reduce the number of setups for a workpiece by allowing a machine tool to access more than three sides of the workpiece and can improve the position of part features relative to each other.

—CTE Metalworking Glossary

ROTO COPE

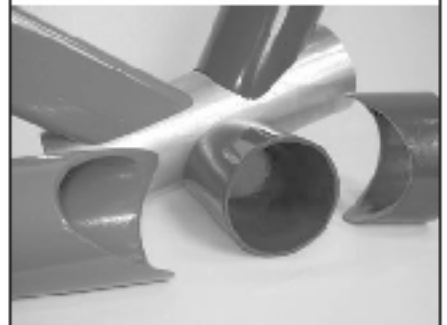
SECRET FINISH



The Ultimate High-Volume COPING TOOLS

- Unique Design (Patent-Pending)
- Premium Carbide Teeth
- Fast - Under 1 Minute
- Highly Accurate
- Very Low Cost Per Cope
- Copes Hollows & Solids
- Copes Most Materials Incl. Stainless, Plastics & Composites
- Cuts Multiple Angles
- Easy To Use
- Long Tool Life, And It Can Be Re-Sharpened!
- Mass Production Tool
- Environmentally Clean Process

**Attractive, Weld-Ready
Copies!**



(807) 626-8131

www.rotocope.com
Dealer Inquiries Welcome

precision on the table

Besides the gear system, a manufacturer should ask about the quality and location of the bearings that support the table. Bearing location is important because it affects the table's rigidity and therefore its ability to permit accurate machining of workpieces.

"If it's just back of the face plate, you get maximum rigidity," Hansen said. If the bearings are further down the spindle, the table wouldn't be as rigid.

Rigidity is also affected by how the face plate is attached to the spindle. According to Hansen, rigidity is greater when the spindle is an integral part of the face plate assembly as opposed to being bolted to the assembly. "If it's one integral piece, you're going to have a more solid, rigid setup," he said.

Size Affects Accuracy

Also, a table's accuracy is affected by its face plate's size. The position-

ing accuracy that's sufficient on one table may not be sufficient on another table with a large face plate. The difference results from the magnifying effect of the second table's larger diameter.

The difference involves backlash. If the tables are gear driven, for example,

expect to be machining.

Also, that distance should be within the face plate's diameter. Workpieces shouldn't hang over the face plate's edges so machining is done on a surface without the plate directly underneath it, supporting it. This guideline should be followed even if the

For contour machining, a rotary table needs to be rigid enough to withstand the greatest cutting forces to which it's exposed and yet move accurately.

and if the two gear sets have the same backlash, say, 0.0005", the two tables would have the same positioning accuracy at the same distance from the face plate's center. Beyond that distance, though, the larger table's positioning error would be greater. Consequently, manufacturers must determine the required face plate size and a table's positioning accuracy at the greatest distance from the center at which they

workpiece is within the table's weight capacity. A massive, but light workpiece can be positioned accurately on a smaller table, and an operator may even be able to apply light cutting forces to the workpiece's overhanging surfaces. With heavier cutting loads, though, the tool might push too hard on the workpiece, causing the table to move out of position and resulting in a loss of part accuracy.

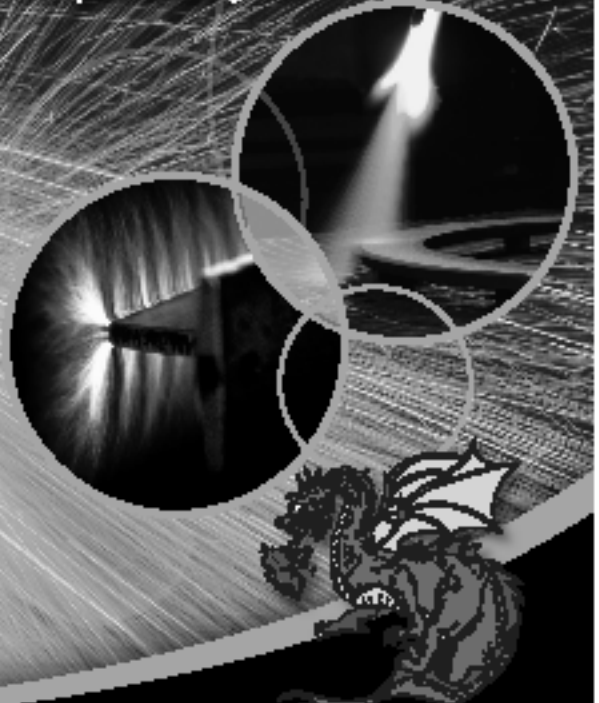
It's time to let go. Release no longer has to be a sticky subject.

Blemishes, build-up and tool failure are just a few of the issues resulting from poor material release. Plasma Coatings has your solution. Our effective mold-release coatings, when applied directly to your valuable molds and tools, provide superior product release. This one-time application will reduce waste, build up, and down time, increasing productivity and efficiency.

While costly chemical release agents transfer to the product and can build up on the tool, Plasma Coatings finishes provide a clean release that is virtually maintenance free and more cost effective. Plus, our release finishes allow for better mold fill and longer tool life. As much as 6 times longer than non-coated parts.

We have a solution to your sticky situation. Call us at 901-867-9511.

www.plasmacoatings.com



The Originators of Plasma-Sprayed Release Coatings, with over 30 Years of Experience.

Rollers • Coatings • Recovering • Refinishing • Results

Table Robustness

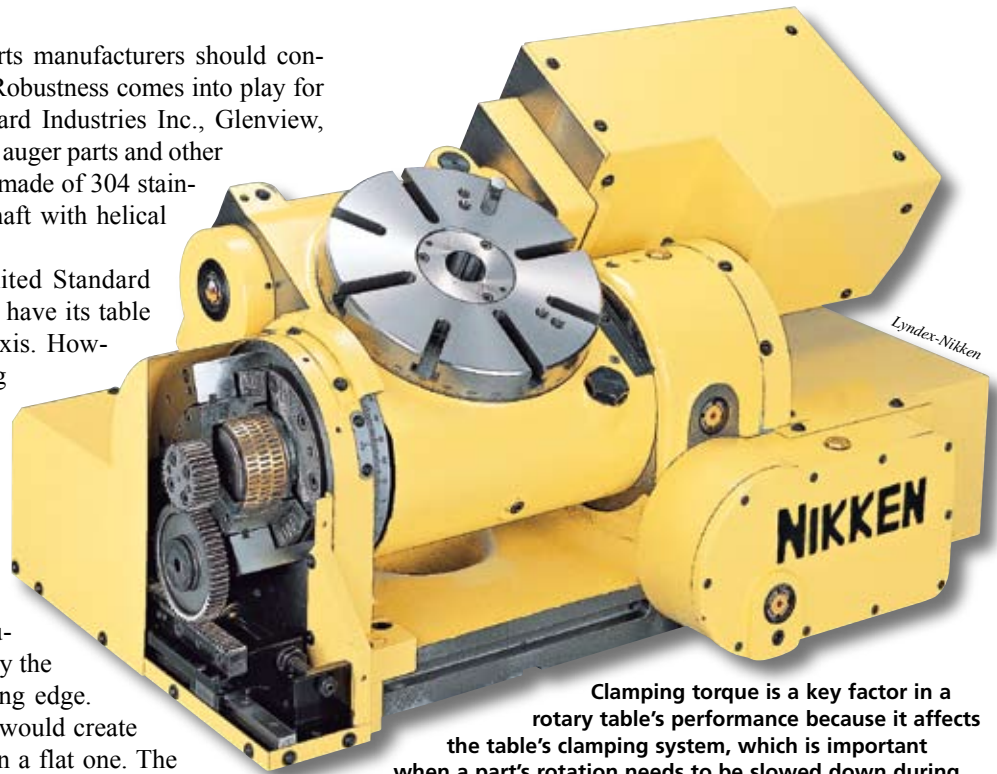
Besides a table's size, parts manufacturers should consider its overall robustness. Robustness comes into play for machine shop United Standard Industries Inc., Glenview, Ill., when it manufactures ice auger parts and other components. The augers are made of 304 stainless steel and consist of a shaft with helical ridges, or "flights."

To create the flights, United Standard applies an endmill and must have its table always rotating in the 4th axis. However, the DOC for roughing the widths between the flights places the table under considerable strain. Each width is 1.5" and must be kept within a 0.004" total tolerance.

Also, the table's motion must be accurate so the auger's minor diameter is cut by the center of the endmill's cutting edge. If it cuts off center, the tool would create a concave surface rather than a flat one. The concave surface wouldn't allow United Standard to hold the widths' flatness tolerance, said Bill Richter, United Standard's CNC manager.

Consequently, for contour machining, the table needs to be rigid enough to withstand the cutting forces and yet move accurately. "That requires a lot of control," Richter said. "It's not a light-duty table. It's solid, solid as a rock."

If the turntable were light duty, he added, the machine



Clamping torque is a key factor in a rotary table's performance because it affects the table's clamping system, which is important when a part's rotation needs to be slowed down during an interval in contour machining or when a part needs to be held steady during machining, as examples.

Direct-drive offers gearless option

Among rotary tables, direct-drive ones are attractive to many parts manufacturers for some applications because of their speed and accuracy in positioning workpieces.

"You've got no gears," said Cal Macomber, director of sales and marketing, workholding for rotary table supplier Hardinge Inc., Elmira, N.Y., which sells a series of direct-drive tables. "You don't have the inherent issues of a gear train."

One key issue is gear backlash, the "wobble" between meshing gear teeth that can result in positioning inaccuracy. Without backlash, a direct-drive table can be extremely precise in its positioning accuracy and repeatability.

Hardinge said direct-drive tables require little maintenance, retain their accuracy over time and have fewer parts to wear than gear-driven tables. Hardinge added that its tables don't require cooling, except at higher torques. In that case, the tables are designed to accept an ordinary coolant hose for inner jacket cooling, according to the company. Also, a direct-drive table's price can range from \$15,000 to \$24,000.

—J. Hazelton

BEST OF BOTH WORLDS



MONSTER TOOL CO.
PHONE: 888-CARBIDE (227-2433)
FAX: 888-ENDMILL (363-6455)

The following companies contributed to this report:

CNC Engineering
(951) 674-7486

Haas Automation Inc.
(800) 331-6746
www.haascnc.com

Koma Precision Inc.
(800) 249-5662
www.komaprecision.com

Lyndex-Nikken Inc.
(800) 543-6237
www.lyndex-nikken.com

United Standard Industries Inc.
(847) 724-0350
www.unitedstandard.com

Vorzeigen Medical
(765) 827-1500
www.vorzeigen.com

precision on the table

tool wouldn't impart the required finish on the workpiece or create correctly sized part features.

Measuring More Closely

For greater accuracy, a rotary table should include a rotary scale. "That helps for accuracy," Hansen said. Also, the rotary scale should be mounted on the table's rotary spindle on the face plate's underside.

In a rotary table, an encoder is connected to the table's servomotor. The feedback device measures the motor's movement. But that motion may be transmitted through a gear set if the table is gear driven. As Hansen noted, "You're as good as your gear system is for accuracy."

If the gears have backlash, the table would rotate more or less than it should. The encoder mounted on a table's servomotor can't register this backlash.

However, the rotary scale on the face plate's underside can. From that location, the rotary scale detects gear

backlash and takes it into account. If the table has a tilting axis, gear backlash is likewise solved by an encoder located on the axis' main spindle. "The direct measurement system is reading right off the movement of the table," said Koma Precision's Meo.

In both instances, the table would thereby have greater positioning accuracy. How accurate could it be?

"Single-digit arc accuracy," said Jeff Law, product manager—rotary products and horizontal machining centers for table supplier Haas Automation Inc., Oxnard, Calif. Meo agreed, saying total accuracy could be as small as ± 2 arc seconds with repeatability of ± 1 arc second, depending on the rotary table and its drive system. (See sidebar on page 69.)

Table Attachments

Besides the table itself, there are attachments to consider to maintaining table motion accuracy.

Casey Heinrichs, vice president of machine shop CNC Engineering, Lake Elsinore, Calif., cited an attachment's weight as a factor in maintaining a

Competitive Edges

Get better edge life out of your PVD coated tools —
Call ICO Surface Coatings.

- Standard coatings: TiN, TiCN, TiCN-MP, AlTiN, SS1218, Phoenix™, ZrN
- Special and proprietary coatings
- Ultrasonic cleaning of tools
- Tool sorting and sizing for optimum coating results
- Large and small volume coating capability
- Part capability up to 100mm x 70mm dia.
- Local pick up and delivery

ICO Surface Coatings

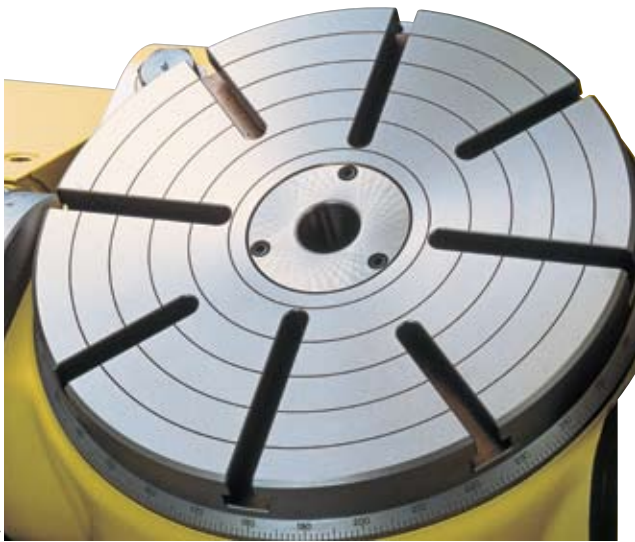
TEL: 256.226.5223
www.icosurfacecoatings.com



**fast
forward**

Don't miss the **DECEMBER ISSUE**
of CUTTING TOOL ENGINEERING!

- Threadmaking
- Maintenance Products
- Machining Centers
- Grinding
- Year-End Recap



Lynde-Nikken

The further that machining occurs from a face plate's center, the greater the table's positioning error will be, so a parts manufacturer looking for a larger table than it has will need one with greater positioning accuracy.

table's ability to permit accurate machining. If an attachment, like a subplate, is too heavy, a table wouldn't have the drive torque needed to accurately rotate the combined weight of the attachment and workpiece.

The attachments that concern Vorzeigen Medical, Connersville, Ind., are fixtures for 5C collets.

The part manufacturer's tables index workpieces for 4th-axis machining and actually have no face plates, or tables. Instead, each indexer features a 5C collet for holding workpieces. If a workpiece requires a fixture, Vorzeigen creates one on a CNC milling machine. An operator then places the fixture in the collet and the workpiece in the fixture and applies indicators to ensure accuracy among the components and workpiece, such as the fixture's or workpiece's centerline passing through the indexer's centerline. If the indicators show inaccuracies, the fixture can be corrected through remachining. Without accuracy among the components and workpiece, the resulting part won't be accurate, either.

Also, such attention is needed because even though the collet is in the spindle and is therefore not an attachment, a workpiece in a fixture is, in a sense, an attachment on an attachment, and that stack can add error to a setup. "Anytime you add anything extra to the setup, it takes away from the accuracy and repeatability of the process," said Tyler Mitchell, Vorzeigen project manager.

Consequently, parts manufacturers need to be mindful of many aspects of a rotary table to be certain that adding wanted 4th- and 5th-axis machining doesn't mean subtracting needed accuracy. △

CUTTING TOOL ENGINEERING Magazine is protected under U.S. and international copyright laws. Before reproducing anything from this Web site, call the Copyright Clearance Center Inc. at (978) 750-8400.



The Thread and Form Milling Specialists

SOLUTIONS FOR THE MEDICAL AND AEROSPACE INDUSTRIES

The Problem:

- Proprietary, one-of-a-kind thread form
- Steep taper on form
- Triple lead thread
- Full form right and left hand threads in same form
- None of your tooling vendors can get over "Why?", let alone "How?"

The Solution:



ADVENT TOOL & MANUFACTURING

- Blueprint specials in record time
- Complete design, engineering and manufacturing in-house
- Complete programming assistance, or code generation
- Thread & form milling tools are all we do
- Full lot traceability



Advent Tool. You'll like our form...

38 Baker Road • Lake Bluff, IL 60044
847-549-9737 • FAX 847-549-9714
info@advent-threadmill.com

1-800-THREAD 4
(1-800-847-8294)

www.Advent-Threadmill.com

