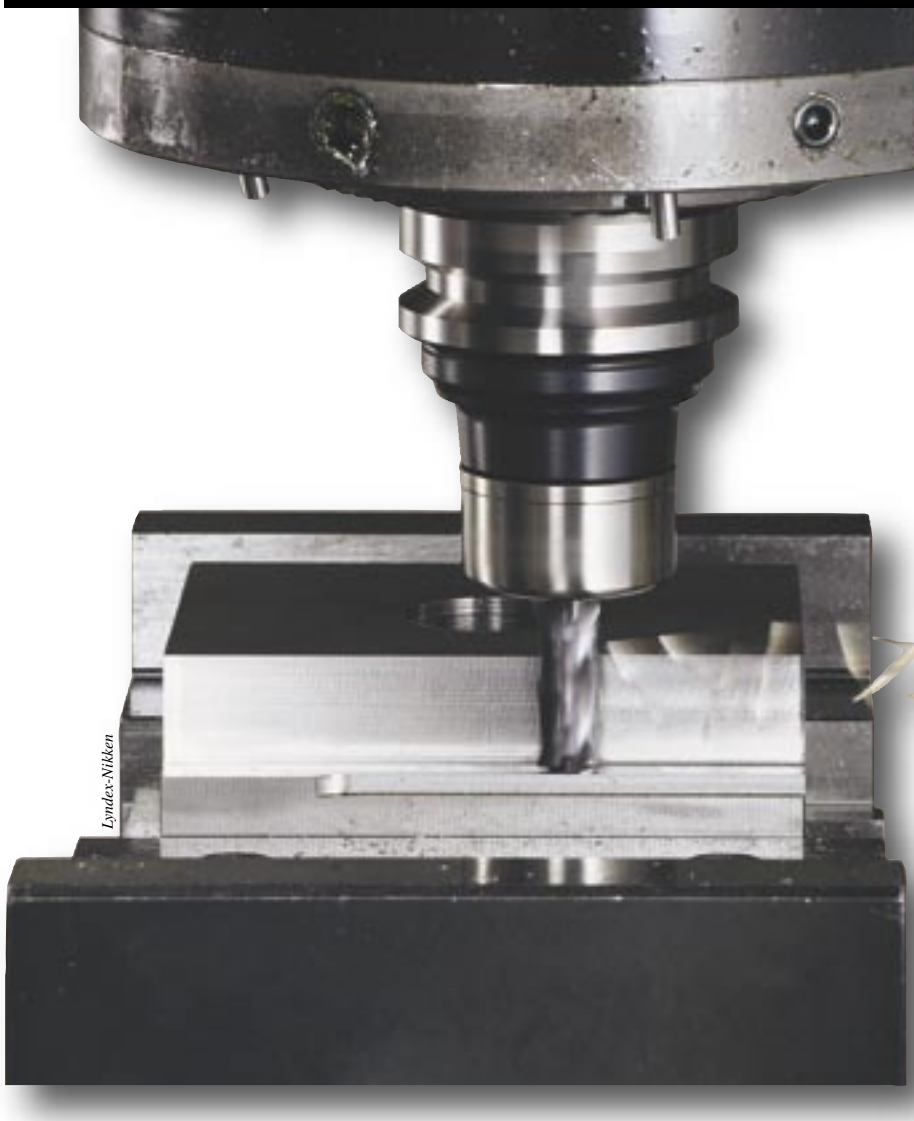
➤BY BILL KENNEDY, CONTRIBUTING EDITOR



Lyndex-Nikken

The Major Dream toolholder was designed to control vibration during jobs performed on lighter-duty machine tools, with setups featuring less-rigid fixturing and long-reach applications.

Holding Patterns

Demand grows for application-specific toolholders.

Maintaining manufacturing competitiveness requires continual improvement in productivity and part quality. As a result, shops seek to fine-tune every aspect of each operation.

Preben Hansen, national sales manager for toolholding systems supplier Lyndex-Nikken Inc., Mundelein, Ill., said the focus on improving individual operations is driving demand for toolholders that solve specific problems and fill certain performance niches. The constantly growing number of toolholding choices illustrates this trend.

"When I came out of a machine shop 25 years ago," Hansen said, "there were two or three different types of toolholders, in a couple of different tapers. That was it. Now we have 50 different types of holders in 25 different kinds of tapers."

A Smoother Ride

Using a different toolholder can cure a persistent machining problem—excessive vibration.

"Vibration is a big issue," Hansen said. "If you can make a toolholder that will cut down on vibration, you can help cutters last longer and impart finer surface finishes."

Vibration begins when the cutting

Command Tooling Systems

Because a shrink-fit holder has a relatively small body diameter and gripping the tool requires no moving parts, setscrews, collets or nosepieces, the effect of centrifugal force is minimized in high-speed operations.

tool touches the workpiece. "No getting around that; it's part of the nature of machining," Hansen said. "But you don't want the vibration to transfer up to the spindle, because it will carry back down to the cutting tool, which can actually start to bounce."

Vibration-prone applications include milling thin-walled parts, situations where fixturing is insufficiently rigid and when lighter-duty machine tools are used to make heavy cuts.

Identifying a need in the market, Lyndex-Nikken has developed a toolholder system designed to help control vibration. It incorporates an internal dampening mechanism.

The holder, which will be shown at IMTS 2006 under the trade name Major Dream, features a two-piece construction consisting of a taper with inner and outer cones. The outer cone features a diagonal split that widens as the drawbar pulls the holder back into the spindle. In the connection between the cones, Hansen said, is a flat Belleville-spring mechanism that dampens vibration before it enters the spindle.

"A holder like this can help [users] mill effectively on smaller-spindle machines," he said, citing an application where the toolholder was applied on a 30-taper drill/tap machine in a fairly aggressive milling operation. A ⅜"-dia., 2-flute carbide endmill was employed at a 4,200-rpm spindle speed, a 49.6-ipm feed rate, a 0.78" DOC and a 0.118" WOC on a 1045 steel workpiece. No vibration problems arose.

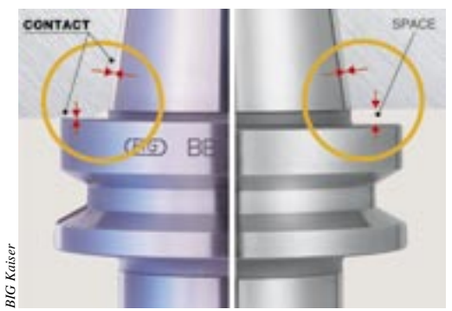
The toolholder's vibration-control technology is based on experience Lyndex-Nikken gained in developing its 3Lock holder—a multicomponent steep-taper system—and its NC5 short-taper system. "From these tooling systems, we learned what the two-piece construction does for dampening vibration," Hansen said.

A Fine Balance

Dennis King, director of engineering at Command Tooling Systems LLC, Ramsey, Minn., also sees a need for application-specific toolholders, saying, "There's really no 'one size fits all.' "

For example, he noted, a key contributor to vibration reduction in high-speed applications is a combination of tool and holder concentricity and balance.

Concentricity of the tool and holder unit is extremely important, he said, because the unbalanced forces resulting from eccentricity are greater than the unbalanced forces generated by unsymmetrical mass. "If you've got a 0.0005" eccentricity, and you are taking a cut of 0.001" per tooth, you've got one tooth that is taking twice the load of the other one," he said. "So the effect of the tool not being concentric is extreme."



BIG Kaiser

The simultaneous-fit tooling system from BIG Kaiser consists of a toolholder and spindle. It promotes simultaneous, dual contact at all times between the holder and spindle (left). With conventional steep-taper tool, the flange and spindle face are not always in contact.

The following companies contributed to this report:

BIG Kaiser Precision Tooling Inc.
(888) 866-5776
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Bilz Tool Co Inc.
(800) 227-5460
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Command Tooling Systems LLC
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Lyndex-Nikken Inc.
(800) 543-6237
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For many high-speed applications, King recommends shrink-fit toolholders. With shrink-fit toolholders, like those in Command's Thermolock line, King said, "you get 'dead nuts' concentricity."

The operating principle behind shrink-fit systems is fairly straightforward. The ID of the holder is smaller than the OD of the tool it will grip. When the holder is heated in a special unit, the ID expands sufficiently to accept the tool. When the holder cools, it contracts and grips the tool uniformly.

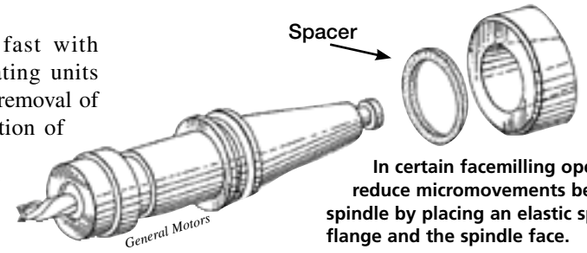
The symmetrical grip of a shrink-fit holder is preferable to that of a conventional endmill holder, which, by design, generates eccentricity. Because the OD of the endmill must be smaller than the ID of the holder, the endmill is pushed off center when the conventional holder's setscrew pushes on the tool's Weldon flat.

Because a shrink-fit holder has minimal body diameter and gripping the tool requires no moving parts, setscrews, collets or nosepieces, the effect of centrifugal force is minimized in high-speed operations. The lack of mechanical clamping devices also permits use of shorter tool projections, another path to higher tool/machine rigidity.

Tool changes can be fast with shrink-fit systems, as heating units are designed to enable the removal of one cutting tool and insertion of another one quickly.

King cited the efficacy of shrink-fit holders in applications where rigidity is crucial. "Go to Windsor, Ontario, the die/mold capital of the world," he said. "Every shop that you go into has a heat-shrink machine, because they use heat-shrink tools down inside the molds."

King said balancing the mass of the toolholder is also a critical element of vibration control. "All of our shrink-fit holders and collet chucks are balanced," he said. "It's really a combination of two things. Balance without concentricity doesn't work, and concentricity without balance doesn't work very well either."



General Motors

In certain facemilling operations, GM found it could reduce micromovements between the toolholder and spindle by placing an elastic spacer between the toolholder flange and the spindle face.

Add Some Space

Seeking a low-cost, application-specific method to reduce micromovements between the toolholder and spindle in certain milling applications, General Motors engineering personnel experimented with placing an elastic spacer between the toolholder flange and the spindle face. The aim was to improve the flatness of the workpiece surface and reduce chatter (see illustration on p. 45).

The thinking was that placing a flexible donut spacer at the toolholder/spindle interface would improve vibration dampening and dynamic bending stiffness. A manufacturing engineer involved in the effort, John Agapiou, pointed out that, in some cases, a tool can be too rigid.

"If everything is very stiff, you tend to get more vibration," he said. "When you add flexibility to the toolholder/spindle interface, static stiffness goes down but dynamic stiffness goes up. Dynamic stiffness is the product of the static stiffness multiplied by the dampening ratio. At the end of the day, dynamic stiffness is what is important when you work at higher speeds."

The donut spacers, which are made of rubber or a flexible polymer, reduced the static stiffness of the tools and holders tested but increased dynamic stiffness. Frequency-response-function testing of CAT 40 tools with and without a 3mm-thick elastic rubber spacer at the toolholder/spindle interface showed that the dampening ratio and dynamic stiffness of a tool with the spacer was higher than that of a tool without it.

GM conducted milling tests on the face of a transmission valve body. Without a spacer, the deviation in height from surface-profile flatness ranged from 0.03mm to 0.06mm. With a spacer positioned at the toolholder/

Rigid thinking

When tapping on a CNC machine, the feed rate and cutting speed can be programmed to match the pitch of the tap, enabling the production of threads without the need for a compensating chuck. In rigid-tapping applications, however, the tap can be subjected to high axial forces when small manufacturing variances in the tap pitch make it differ somewhat from the tightly programmed feed rate.

Excessive tap wear and diminished thread quality can result. Small synchronization errors can also occur, especially when the spindle is reversed at the end of the thread.

The Synchro Chuck tapholder from Bilz Tool Co. Inc., Elk Grove Village, Ill., was designed specifically for rigid tapping. The company's vice president, Tom Gibbings, said the holder compensates for manufacturing variances in tap pitch.

"The chuck provides tension and compression movement of 0.08mm to compensate for the manufacturing tolerance of the thread on the tap itself," he said. The ability to move relieves pressure on the flanks of the tap threads and enables the tap to cut freely and accurately.

In addition, Gibbings said, the Synchro Chuck tapholder is unique in that it is engineered to absorb a specific kind of shock. "There is an oil-repellent polymer wrapped around the cross post, which acts as a cushion so that the tap doesn't tear the thread at the bottom of the stroke," he said. "Without that polymer, there can be a banging, or a metal-to-metal contact, when reversing."

Although the polymer insert is not designed primarily for vibration control, Gibbings said that "anytime you have a softer substance, you are going to have some vibration dampening."

—B. Kennedy

Bilz Tool

Synchro Chuck tapholders feature an oil-repellent polymer wrapped around the cross post, which prevents the tap from tearing the thread at the bottom of the stroke.

spindle interface, flatness ranged from 0.02mm to 0.045mm—a significant improvement.

Agapiou said machining tests indicated that the spacer could be beneficial in facemilling applications in which the toolholder and spindle tapers do not match exactly. Besides acting as a dampening medium, the spacer closes the gap between the holder flange and spindle face. This would reduce the micromovement of the holder relative to the spindle when taper tolerances are poor, when large-diameter facemills are applied and when roughing with an endmill.

Agapiou emphasized that the spacer is application-oriented. "You cannot generalize everything," he said. "We tried using the spacer in some endmilling applications with 0.5"- to 1"-dia. cutters [and saw no] significant improvement."

He added that if using the spacer is being considered to reduce vibration, its efficiency should be compared against several other techniques. They include process corrections, such as changing the spindle speed, number of teeth or DOC, or making changes such as adding heavy metal within the tool body or using a shorter tool.

The added-flexibility approach usually can improve performance, according to Agapiou, as long as the cutting force is not great enough to generate instability in the cut.

"When we do heavy milling, such as deck facemilling, we use big milling cutters," he said. "If the taper is damaged or manufactured out of tolerance, the tool can wobble. In that case, use of holders that create rigid contact between the tool flange face and the spindle face makes sense."

Simul-fit

Such "simultaneous fit" toolholder designs employ tool shanks or spindles that deflect when subjected to the force of the machine tool's drawbar.

Examples of simultaneous-fit toolholding systems include those designed to the German-developed HSK standard, in which the shank of the holder conforms to the interior of the spindle, and the BIG Plus system from BIG Kaiser Precision Tooling Inc., Elk Grove Village, Ill.

The latter consists of spindles and holders that en-sure simultaneous, dual contact at all times between the spindle face and toolholder flange face, as well as the spindle taper and the long-taper shank of the tool. BIG Plus achieves this by eliminating the gap, or space, that generally exists between the machine spindle face and the toolholder flange face.

The high rigidity provided by face-contact tooling offers clear advantages in applications that put heavy side loading on the tool, toolholder and spindle, according to Alan Miller, engineering manager at BIG Kaiser. The rigidity of the workpiece, fixturing and contact between the spindle and toolholder come into play in achieving maximum metal-removal rates when facemilling with large arbors and tools.

"The increased mass of a larger tool, along with the larger contact area, provide more inertia and stability, which naturally dampens the harmonic frequencies," Miller said.

He also noted that BIG Plus spindles accept conventional steep-taper tools and can run them without any accessories.

Matching Up

Lyndex-Nikken's Hansen said that shops are "pushing things to the extreme these days. We need to be more efficient in this country, because we have the world as our competition. We have to find ways to be competitive, and that means being at the forefront of technology."

Developing and applying toolholding technology that matches the job at hand is a step in that direction. △