

▶ BY ALAN RICHTER, MANAGING EDITOR

# The Right Angle

Selecting and making the most of an angle head when other tooling can't get the job done.

**'A** right-angle head is—and I hate to say it—almost like a Band-Aid,” said John Darling, chief application engineer for Royal Machine & Tool Corp., Berlin, Conn. “It’s an add-on fix to get that one extra hole so you don’t have to run another operation.”

With that in mind, when a Royal customer inquires about an angle head, “we ask if it is going to be a practical solution for them,” Darling said. “Is an angle head really going to save time or is it going to be cheaper to run another operation?”

He added that sometimes a part can be re-engineered to avoid having to use an angle head or performing a secondary operation. For example, a hole might be repositioned without reducing functionality. Darling explained: “We had one customer who did that. The hole he had to put in was a drain hole and he didn’t care if it was at 90° or not. He went back to the product engineer and moved the hole, and then he could do everything in one operation.”

Experience also plays a role in knowing if an angle head is right for the job. Takeshi Yoshimoto, engineering vice president for Tecnara Tooling Systems Inc., Santa Fe Springs, Calif., noted that Tecnara has a database of various metals to help users decide if an angle head is suitable for an application, “but I believe my eyes. I’ve got my instinct.”

If an angle head is the best route to go, a variety of styles are available. They include fixed angle and universal, with through- or side-coolant ports. These can be flange-mounted or operated by an automatic toolchanger (ATC), and mechanically driven, coolant-driven or air-driven.

Although a right-angle head is the most popular fixed-angle version, angle heads can be built with any fixed angle up to 90°. But programming the machine to cut at an angle other than 90° is “a little trickier,” Darling said.

Universal angle heads allow the angle the tool is positioned at to be adjusted. Darling explained that a universal head is appropriate for a short run where the part needs an odd-angled hole to be drilled, for example, but not for a long production run. “A universal head introduces another joint, which has to be locked, and you have to be able to set your angles accurately,” he said. “It just weakens the whole unit.”

An alternative to a mechanically driven angle head is a fluid-driven head. Instead of being powered by the machine tool’s spindle, the machine’s high-pressure



Pibomulti

coolant system drives the positive-displacement, ball-piston motor in the angle head. Shop air could also be used to drive such a motor for low-horsepower, dry machining, but a motor designed to be pneumatically driven functions more efficiently.

## Rigid Rules

Because angle head attachments are somewhat bulky and have a reduced level of support compared to tooling directly driven by the machine tool spindle, rigidity is an issue. "If you have a CAT 50 taper and the head hangs out of the spindle 10" and the cutting tool is off-axis another 4" or 5", you're putting a tremendous amount of strain on that taper," said Gregg Mitchell, vice president and general manager of Pibomulti North America, Auburn Hills, Mich. "You're asking that taper to support a hell of a lot of weight and a hell of a lot of force, so you're going to flex the head."

However, methods exist for enhancing the rigidity, or stability, of an angle head. The first option is a flange-mount unit, but for most that's not viable. "Usually, you're only going to see a flange mount on a dedicated operation or in a toolroom operation," said Mitchell.

For an ATC angle head, which always has a locating pin and stop block for providing radial orientation and stopping the head from turning with the spindle, he said rigidity can be enhanced by making the ring that holds the pin larger in diameter and adding vertical supports. These should be arranged as a three-point support system—like a tripod.

"When you pull the head up into the spindle, these supports come in contact with either pads or with the casting that holds the spindle," Mitchell explained. This allows the head to be supported outside of the taper. He added that because the supports can potentially interfere with the ATC's arms, "you [may] have to build a pickup station to where you come over and pick up the tool rather than swing it through the toolchanger."

Mitchell noted that because the taper is the point of support for the angle head, the end user has to pay close at-



**A universal angle head can be set at any angle up to 90°.**

tention to the aspect ratio of where the head is supported and where the cutting is being performed and decide if outboard support is needed.

Jack Burley, vice president of engineering at BIG Kaiser Precision Tooling Inc., Elk Grove Village, Ill., said that to increase rigidity, "you want the radial location of the positioning pin as far away from the centerline of the spindle as you can get it." The standard distance for the 50-taper BIG Daishowa angle heads the company distributes is 4½", with a shorter standard distance for its 40-taper heads. "If you only had a 3" radial offset, you would reduce the acceptable cutting parameters for the unit by half," he said.

He added another way to increase rigidity is to specify a main support beam, or housing, made of steel instead of aluminum. The housing connects the head's driven side to its output side.

Of course, not all machining processes are created equal—especially when performed using an angle head. Tecnara's Yoshimoto said drilling is relatively easy because the tool is only exerting thrust force, whereas both radial and thrust forces are present when endmilling. Therefore, more rigidity is required to control the forces when milling. "If you apply excessive force, vibration will be seen between the connection of the positioning pin and positioning block," he said.

Rigid tapping with an angle head

adds another level of complexity. "There is always some gear backlash whenever you reverse an angle head, so you always have some lost motion," said Mitchell, adding that you can't have that lost motion when rigid tapping.

To overcome backlash, tapholders with extension and compression adjustment are needed. "You've got to be able to put a tapping system into the end of the angle head that is going to give you the amount of play you need [to compensate] for the lost motion in the angle head when reversing it," Mitchell said. Although difficult, he noted that tapping with angle heads is common. "You just need the right tapping attachment, that's all."

Frank Cerrito, inside sales manager for Koma Precision Inc., Windsor, Conn., agreed. "You can do tapping with an axial compensating collet," he said. "It's a spring mechanism, so if the feed rate isn't quite right, the spring will stretch out to avoid stripping. The tap will follow the thread on the way and not strip."

Some consider tapping nearly impossible with a mechanically geared angle head, but the process is impossible using a coolant-driven head. Because the machine's high-pressure coolant system drives the motor in one

### The following companies contributed to this report:

**BIG Kaiser Precision Tooling Inc.**  
(847) 228-7660  
[www.bigkaiser.com](http://www.bigkaiser.com)

**Eltool Corp.**  
(877) 4ELTOOL  
[www.eltool.com](http://www.eltool.com)

**Koma Precision Inc.**  
(860) 627-7059  
[www.komaprecision.com](http://www.komaprecision.com)

**Pibomulti North America**  
(248) 377-8170  
[www.pibomulti-na.com](http://www.pibomulti-na.com)

**Royal Machine & Tool Corp.**  
(860) 828-6555  
[www.royalworkholding.com](http://www.royalworkholding.com)

**Tecnara Tooling Systems Inc.**  
(562) 941-2000  
[www.tecnaratools.com](http://www.tecnaratools.com)

direction, and a tap cannot be reversed to exit the hole. “The coolant is coming through the spindle and there’s just no way to run it backwards the other way,” said John Young, president of Cincinnati-based Eltool Corp. However, thread-milling is possible.

### Fluid Power

Nonetheless, a coolant-driven head offers some advantages compared to a mechanical head. Because the machine tool spindle is not rotating while the head is being used, the spindle can be used as an indexer to provide another axis of motion. “Say you needed to drill three holes 120° apart,” Young said. “With a mechanical head, you would have to buy three different heads and set them at three different angles and run them through the toolchanger. With our coolant-driven head, you drill one hole, index 120°, drill another hole and index another 120° and drill the third hole and do the whole job with one head.”

In addition, speeds and feeds need to be reduced when machining with a mechanical head, whereas a coolant-driven head can run at a high rpm. “We have tested them to 20,000 rpm. We rate them at 14,500 rpm,” Young said. “Most mechanical heads have a maximum of 3,500 to 4,500 rpm.”

Cerrito said Koma’s standard mechanical head is rated at 4,000 rpm, but the company can provide heads that operate from 8,000 to 12,000 rpm with special seals that prevent too much heat buildup. “Most applications with an angle head don’t require that high of an rpm,” he added.

For those operations that do require high speed, a coolant-driven head’s rotating parts are bathed in the coolant that drives the motor so there’s no heat buildup. “It doesn’t have a duty cycle, where after 6 minutes of operation per

hour a mechanical head gets too hot and you have to put it away and let it cool off before using it again,” Young explained. “You can run a coolant-driven head 24/7.”

When using a coolant-driven head, the coolant pressure varies from 200 to 2,000 psi, with 1,000 psi being typical. Young noted that a coolant-driven head will develop 2.5 hp, when driven by a 10-gpm pump at 1,000 psi.

The equation for calculating theoretical horsepower is:

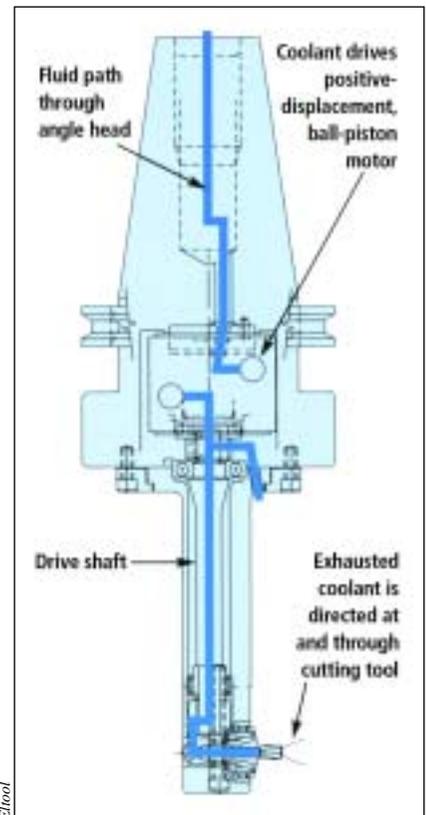
$$\frac{(\text{pressure in psi} \times 0.019) \times (\text{flow in gpm} \times 900)}{63,025}$$

This is speed times torque divided by 63,025 equals horsepower.

Because coolant runs through the angle head, all coolant needs to be removed from the fluid path if the head sees intermittent use. This can be done by blowing air through the path followed by a lubricating oil. Depending on the length of time the coolant remains in the unit and the coolant’s concentration and its mix of rust preventatives, it can cause corrosion or turn into a residue and gum up the internal mechanisms. “In either case, it’s going to have to be taken apart and cleaned,” Young said.

Similar to other machining operations, the most appropriate angle head for a job depends on the application. “Our heads are relatively small, so typically they’re not used for drilling large holes or doing heavy milling,” Young noted. “If someone needs a 5-, 6-, 7-hp head to drill a ¾” hole in steel, that’s where mechanicals are better. But if he’s trying to get into a small, tight area at a very high speed, is up against a wall or doing multiple angles, coolant-driven heads can do a lot of things mechanicals can’t do.”

Standard mechanical and coolant-



High-pressure fluid, from 200 to 2,000 psi, flows through a coolant-driven angle head to drive a positive-displacement, ball-piston motor, which rotates the drive shaft to turn the cutting tool at a rated speed of up to 14,500 rpm.

driven heads cost around \$5,000 to \$8,000, with complex mechanical specials going for \$50,000 or more.

Whatever angle head is selected for a job, it’s chosen out of necessity and not because there’s a desire to incorporate a fairly pricey piece of tooling into the machining operation. “It extends the capability of your machine,” Pibomulti’s Mitchell said. “Instead of having to refixture a part or move a part to a different machine, you are able to, for a relatively small investment, get the job done with an angle head.”