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Multi Mod


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Multistation, modular tooling for mill/turn machines speeds the cut-to-cut tool-change time while reducing tooling costs.

Mill/turn, or multitask, machines make up an increasing portion of the equipment found in metalcutting plants. The machines' versatility is well-suited to today's workpiece mix and batch size. The use of multistation, modular tooling in mill/turn machines can greatly enhance the capability of these machines and broaden their application area.

Mill/turn machines have a primary tooling connection that allows different types and styles of cutting tools to be changed to suit the required operations. Examples of these connections include KM, HSK and steep taper, such as BT, CV and DV. The machines usually have one or two positions, with one or both capable of acting as a static turning tool or as a rotating spindle.

Tool changes are accomplished similar to how they are done on a machining center. A cutting tool is replaced in the clamping receptacle by another that's retrieved from a disk- or chain-type tool magazine. A typical magazine may have between 20 and 40 storage positions. The cut-to-cut tool-change time is longer than on a dedicated turning machine, where tools are accessed by indexing a turret or moving to another position on the tool slide. This negative aspect of the mill/turn machine is readily overlooked because of its flexibility and other capabilities.

A modular tool designed for a mill/turn machine consists of two or more secondary tooling connections located on a tooling base, which includes the primary tooling connection. Each secondary connection is capable of receiving various styles of cutting tools. The cutting tools themselves should be compact, accurate, sufficiently rigid and easily changeable from one style to another.

Some modular tooling designs have as many as six secondary connections. These designs allow multiple cutting tools to be used in a single station, which decreases the cut-to-cut time significantly.

The time decrease is accomplished by indexing the spindle to a new tool and, in some cases, repositioning the machine slides. The modular concept also increases the magazine's tool capacity without adding additional receptacles.

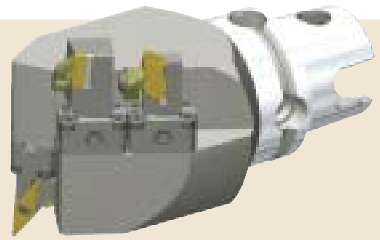
Tooling Dilemma

Some mill/turn machine builders and tooling suppliers offer multiple cutting tools on a single primary tooling connection. Some of these multistation tools have fixed pockets with four insert styles.

These tools have several basic problems. One is their lack of flexibility. Each mix of insert styles must be machined into the tool body. Any change in insert style requires a whole new tool.

Another problem is the cost of the tool. A tool with fixed pockets can easily cost more than $1,000. Equipping a mill/turn machine with a variety of these tools can push tooling costs up dramatically. If one insert pocket is damaged, the whole tool is no longer useable.

Other machine tool builders and tooling suppliers offer adapters that accept multiple square-shank cutting tools. This allows various insert styles to be applied and eliminates the need to have a dedicated toolholder. It also addresses the damage issue.



A 2-slot, angular side-mount tool creates clearance for the tool spindle housing with the workholder. This can allow for shorter overall tool lengths.

However, the design of a standard square-shank cutting tool limits the cutting tool to an axial orientation, one that has the square-shanks roughly parallel to the primary toolholder connection axis. The square-shank adapter is not well-suited to the more advanced applications of mill/turn modular tooling, such as the Y-axis capabilities.

Modular Benefits

Modular tooling can bring many benefits to users of mill/turn machines. The most obvious, as previously stated, is the increase in tool capacity without the additional cost of magazine expansion.

Using a total of seven modular tools with four cutting units on a machine with a 20-tool magazine capacity would double the tool capacity. The same seven tools on a machine with a 40-tool magazine capacity would increase tool capacity by 50 percent.

The fact that the cut-to-cut time decreases dramatically when using modular tools makes it practical to make smaller parts on mill/turn machines. The machines' cycle times are competitive with those of dedicated lathes.

It also allows families of parts to be more efficiently manufactured on mill/turn machines. The tooling requirements for a particular size of a family of parts can be housed on one or two multistation, modular toolholders.

Considering Cost

Reducing costs is another advantage to using multistation, modular toolholders instead of their fixed-pocket counterparts. For example, the cost of a fixed-pocket, multistation tool with four inserts is between $1,000 and $1,200. Equipping a machine with 10 of these tools would cost between $10,000 and $12,000. A backup tool, which ensures that production can continue uninterrupted in the event of a crash, is required for each of these tools, which doubles the cost.

The equivalent modular tooling is available in two styles. The first style incorporates the individual receptacles for cutting units machined directly into the primary toolholder body. This style is less expensive, costing $400 for a four-receptacle toolholder. A total of 10 would cost $4,000. Two backup toolholders would add another $800, and 40 cutting units at $80 apiece would add $3,200. If backup cutting units for each of the stations are desired, another $3,200 is required.

Some of the cutting units would probably be duplicated. Threading and grooving toolholders are often duplicated but are used with different-size threading and grooving inserts. Despite this, a total of 40 backup cutting units would be needed. The total for the modular tooling package is $11,200, or about half the cost of the fixed-pocket package.

The second style of modular tooling uses bolt-on flanges. The advantage of this style is that if a cutting unit receptacle is damaged in a crash, it can be replaced without having to replace the entire primary toolholder. Because the cost of a flange is $120, this can be a cost-effective solution.

The bolt-on flange style also allows the machine builder or the end user to machine the primary tool body from a blank. The flanges are then mounted to the tool body. A primary toolholder equipped with four flanges costs $700, so 10 would cost $7,000. Only one backup toolholder would be required, which would add $700.

The backup toolholder could be used to supply backup flanges to replace any that become damaged. However, two backup flanges, at a cost of $240, would be added to the total. The cost for cutting units and their backups adds $6,400. The total cost of this system would be $14,340, which still offers a significant savings compared to a fixed pocket.

Let's now consider the implications of a series of workpieces that would best be machined with six multistation toolholders. The fixed-pocket style would need an investment of between $12,000 and $14,000 for primary and backup tooling.

Both of the modular systems would require a total of $5,760 for 24 primary and 24 backup cutting units. It is likely that several of the existing cutting units could be taken from the previous tooling package, thus reducing the required investment. In most cases, only standard cutting units would be required, resulting in shorter delivery times.

Any further configurations would only require the purchase of the specific cutting units needed. The primary toolholders and flanges, if used, almost become part of the capital expense.

This illustrates not only the cost-effectiveness of a modular system but also its flexibility. Custom tooling can be created in minutes with standard components, damaged tools can be replaced quickly and efficiently, and the productivity of mill/turn machines can increase dramatically.

Internal Tooling

All of the configurations previously discussed concern tooling designed to cut on the exterior of the workpiece. The modular tooling concept can also be applied to internal tooling, but its application is limited by the bore size of the workpiece. If the workpiece bore diameters are large enough, it is possible to use up to four modular receptacles and cutting tools. The orientation of the tools should be such that the spindle does not have to be reversed to use all of the tooling.

The primary tool body takes the form of a boring bar, with the receptacles for the modular tooling machined directly into tool body. In rare cases, if the bore is large enough, it may be possible to use flanges. If the machine has a Y-axis capability, all four tools can be utilized by using the machine axes instead of indexing the primary tool body with the spindle. Internal modular tools can be designed using standard boring cartridges available from many tooling suppliers. The use of boring cartridges allows a single primary tool body to be customized for different tooling packages. They provide the added benefit of making it easy to replace damaged cutting tools.

If the bore dimensions of the workpiece are large enough, it is possible to use more than four tools on an internal modular tool. If this is the case, the tools will have to be accessed by indexing the spindle and using axis motion.

Machine Design Considerations

Several design parameters, when taken into account during the design of a mill/turn machine, can be extremely beneficial to the application of modular tooling. One of the most important parameters is the amount of Y-axis stroke. The amount of stroke determines the maximum part diameter that can be produced with the side-mount modular turning tools.

For example, a machine with a Y-axis stroke of ±100mm, when combined with a side-mount toolholder with an "F" dimension of 50mm, would be capable of turning a diameter of just under 100mm. It is important to keep the Y-axis stroke in mind during the machine design process so that the machine's functions will not be limited.

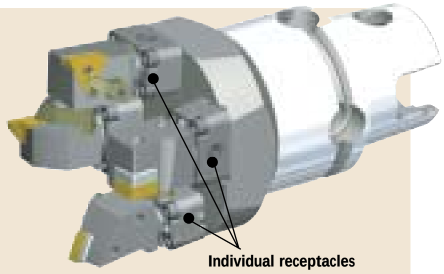
Some software packages on mill/turn machines limit the rotation of the tool spindle housing so as not to exceed the perpendicular position in the area of the workholder. This limits the use of a canted end-mount modular turning tool, which typically works at 5° to 10° beyond the perpendicular position. It is extremely helpful to be able to use these tools on a mill/turn machine.

The radial position capability of the spindle is an important design consideration in the ability to apply modular tooling for turning. If the spindle is only capable of being oriented in 180° positions, tooling options are limited. The ability to orient the tooling spindle in increments of 30° allows the use of all of the designs discussed in this article. The ability of the spindle to be oriented in increments of 5°, 10° or 15° increases the possibilities for tooling designs.

The number of machine offsets and their type is also important. Ideally, offsets should be available for each individual cutting tool as well as a general offset for the primary spindle toolholder. This offset would change the position of the whole modular tool by a specific amount.

The individual tool offsets would work within the layout of the tool to provide exact positioning of each cutting insert, if required. In this manner, a modular tool could be measured offline in a presetting pot and individual tools could be assigned an offset relative to a reference tool, such as the finishing tool. These offsets could be downloaded to the machine or entered in before the production run.

When the tool is clamped into position, the reference cutting unit can be probed and the general offset changed to place the reference cutting unit in its ideal position. When the other tools are indexed individually into position to cut, the individual offsets for each of the tools are applied. This modifies the position established by the reference tool or general offset and allows proper workpiece dimensions to be produced. The other individual offsets will work with the general offset to provide the proper part dimensions. Depending on workpiece tolerances, premeasurement of the insert positions may not be necessary.



For this end-mount tool, the axes of each of the cutting unit receptacles are inclined at an angle, usually between 5° and 10°, from the primary connection axis. The primary connection axis is then inclined at the same angle from the perpendicular position toward the workholder, if the cut is to take place toward the chuck. This presents the insert its proper lead angle and creates clearance between the workpiece and the nonactive tool 180° from the tool that is cutting.

Modular tooling on mill/turn machines offers many advantages. It provides a low-cost method for increasing tool capacity, and the reduction in the cut-to-cut time makes it feasible to manufacture smaller parts. By keeping individual modular tools set up for specific workpieces, small lots sizes can be manufactured more economically.

It also increases the machines' productivity, flexibility and range of applications, and provides a natural extension of the inherent capabilities of the mill/turn machine.

About the Author

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