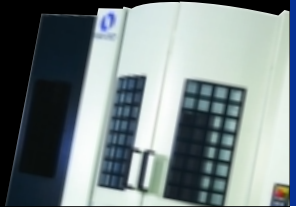


Makino

SPECIAL FOCUS: MACHINE TOOLS

No Regrets

Asking the right questions before purchasing a machine tool can help you avoid 'buyer's remorse.'

► BY BILL KENNEDY, CONTRIBUTING EDITOR

It may seem like the worst of times to be a manufacturer. But in at least one respect, it's the best of times.

Manufacturing and, consequently, machine tool sales have suffered the worst slump in at least 2 decades. According to AMT—The Association for Manufacturing Technology, McLean, Va., 2001 metalcutting machine sales lagged 2000 by 30 percent.

AMT Vice President of Technology Charlie Carter said that the "basic problem is that there's a lot more capacity out there than people wanting parts made."

However, pockets of manufacturing stability—if not strength—do exist. Among them are medical products, land-based turbines for power generation and defense-related equipment.

And, fortunately, the latest economic data indicates that the decline may have bottomed out. The timing and speed of the anticipated ascent is anyone's guess, though.

The current cyclical lull does have an up side. It's a good time to begin thinking about acquiring the machine tools and related technology necessary to profit most from the inevitable recovery.

"It is exactly the right time to evaluate your internal costs of manufacturing and examine proposals to change the way you do some of your work," said Mark Rentschler, marketing manager for machine builder Makino Inc., Mason, Ohio. "You can drive costs down and improve your overall operation and profitability."

Before ordering new equipment, however, you should carefully analyze your needs and answer the following questions.

Update or New?

The first thing you'll have to decide is whether to update existing equipment or buy new. Retooling or upgrading existing machines can be done quickly and relatively inexpensively. Plus, your operators are already familiar with the machines and should still be able to operate them once they're upgraded.

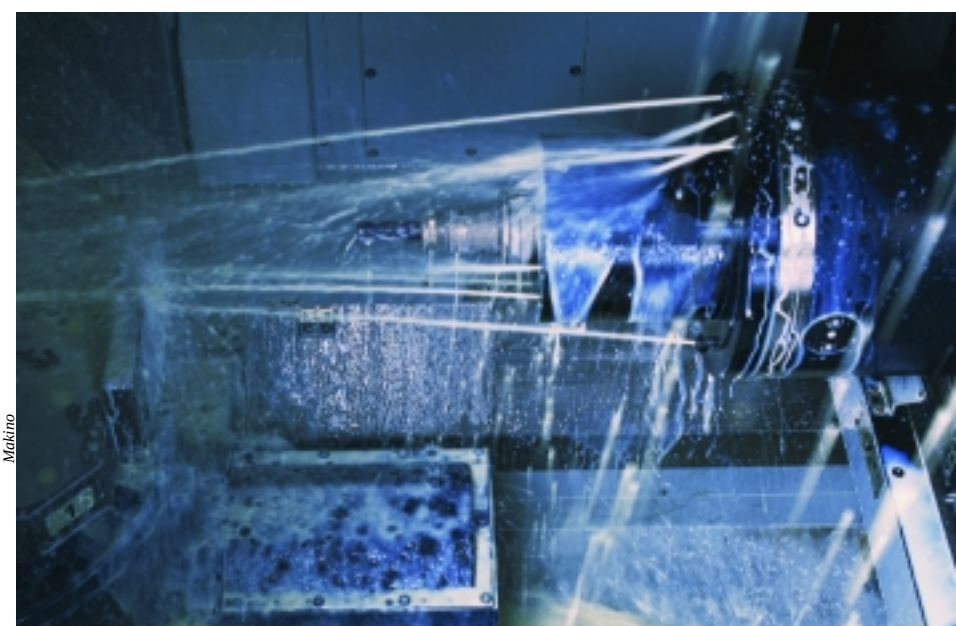
Conversely, sticking with existing technology limits your ability to optimize processes, and an old machine can bleed you dry with ongoing repairs.

Having said that, you need to be aware of *all* the costs associated with buying new equipment, including purchase price, shipping, installation, operator training and the production time lost while ramping up to full capacity. And some operating costs, such as utilities and tooling, may be higher for a new machine than an old one.

You may find, though, that your labor costs decrease, because much of today's equipment is designed to be run by less-skilled operators. You may realize other savings as well. New machines can eliminate operations and allow certain tasks to be combined, thereby reducing cycle times. They also reduce setup times and speed changeovers.

How Big?

If you opt to buy a new machine, it obviously should accommodate the



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parts you plan to produce on it. The cubic, or cylindrical, envelope formed by the X-, Y- and Z-axis travels is the initial criterion. But there are other considerations. The machine table must be able to bear the weight of the parts that will be loaded onto it. And there has to be clearance for movement of the machine axes as well as the tools applied.

Be aware, too, that certain areas within the work envelope will be "dead zones" in which machining won't be possible.

"When we help a customer choose a machine, we look at the part, the fixture, the tooling to be used and where the axes have to travel," said David Austin, engineering and information manager at Mori Seiki U.S.A. Inc., Irving, Texas. "Then we look for the smallest machine we can put around the part and fixture."

A machine that is bigger than necessary and costs more doesn't make sense, said Austin. "A large machine is overkill for small parts. Noncutting time goes up, regardless of the size of the part, simply because tools have to travel farther within the machine envelope to return to the tool-change position." Smaller machines offer faster rapid-traverse rates as well.

Besides part size, the operations you expect to perform will dictate the appropriate size of your new machine.

The marketing manager at Chatsworth, Calif.-based Fadal Machining Centers, Dan Gustafson, explained: "The length of the tooling and the height of the fixtures can drastically reduce the usable Z-axis travel of a machining center. So if you are milling relatively flat, shallow parts, Z-axis travel is not a crucial factor. But if you are drilling holes, double-check the potential machine's Z-axis travel before you make the purchase."

How Much Power, Speed?

The materials you intend to cut will determine the power and speed you need in a machine. In general, hard, tough metals require high torque at lower speeds, while softer, free-machining materials call for a machine with a higher-speed spindle. And, oftentimes, a single machine is asked to deliver both power and speed.

That's frequently the case with job shops. A shop typically requires high torque one day—to cut steel, for example—and high speed the next day, to machine aluminum. Depending on the level of efficiency you desire, though, one machine probably won't be able do it all.

Austin pointed out that a machine's speed capability depends on many factors, including its spindle bearings. "A high-speed spindle may have special ceramic bearings that are more efficient and generate less heat at high rpm. A lower-speed spindle may have hardened metal-alloy bearings. If you apply the ceramic bearing in a heavy, hard, interrupted cut, the bearing life may suffer. There are trade-offs everywhere."

One is between torque and horsepower. Traditional vector-drive motors maintain torque at lower speeds but have limited horsepower when run fast. A partial solution is to choose a spindle motor with two winding systems, one tailored for lower speeds and one for higher. One winding produces sufficient torque at low spindle speeds while the other produces the necessary horsepower at a higher rpm. Switching the windings effectively creates an electronic gearbox. Additional mechanical advantage is possible by combining dual winding systems with a mechanical gearbox.

How Strong?

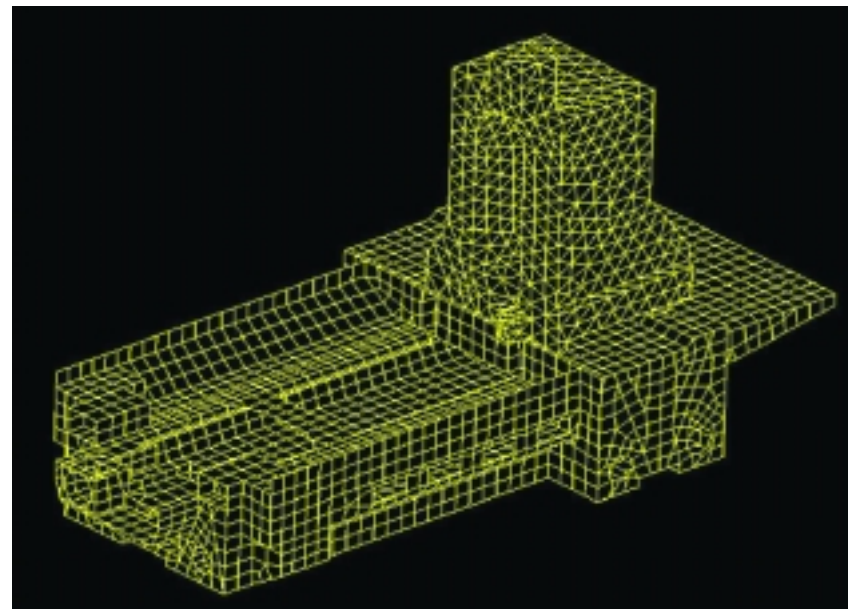
To be accurate, reliable and safe, a machine tool must be built to resist the forces generated during machining. A traditional indicator of a machine's robustness is its weight. It's true that a heavy machine dampens vibration better. But the design and construction of the structure is also crucial.

Machines built with castings are recognized for their rigidity, strength and ability to dampen vibration. Some machines, on the other hand, utilize steel weldments. They may be stiffer than castings, but not as good at controlling vibration. Higher speeds and heavier cuts require a strong machine structure.

Gustafson said: "Some people's applications are not matched to the machine they buy. As a result, they're always fighting the machine. Make sure you communicate your application demands to your salesperson."

Mori Seiki employed finite element analysis (FEA) to help it design the castings for its new Series MT-1500 multi-axis turning center. The computerized simulation of actual cutting conditions permitted the behavior of a casting to be predicted accurately.

Mori Seiki Applications Manager Gerald Owen said FEA allows the company to reduce weight where support is not needed, and precisely reinforce areas where support is required.



Mori Seiki U.S.A.

Finite element analysis lets Mori Seiki engineers predict and modify the behavior of a machine tool casting before the prototype stage.

The analysis can predict dynamic as well as static behavior, allowing unwanted resonance to be eliminated.

Said Austin, "If we find a resonance [at a speed] where customers like to cut—say, 1,000 rpm—we alter the vibration characteristics of the casting to bring it to where you would never experience any resonance in practical cutting conditions."

Perhaps the true power of FEA, though, lies in the fact that several iterations of a design can be virtually evaluated and tested before the first prototype of a machine is built.

Another factor affecting machine strength is its system of ways. The two basic way systems are linear guides and box. A linear guide consists of a rail attached to the base casting, capped by a slide with ball or roller bearings. A box way is, in fact, a box, cast into or bolted onto the base and surrounded by a moving column.

Linear guides are considered fast and responsive and appropriate for lighter cuts, because they're less rigid. Box ways, conversely, can handle heavy cutting and have a reputation for being slower.

Owen noted, though, that advances in way technology are making box styles faster and linear guides more rigid.

Gustafson said Fadal "finds that linear guides work fine at lower spindle speeds. Anything below 8,000 rpm is usually a good application for linear guides."

Fadal matches way systems to machine performance. It equips low-horsepower, low-spindle-speed vertical machining centers with linear guides. Higher-performance machines may have linear guides on the X and Y axes and a box-way column on the Z-axis. The reason why is because as the machining envelope increases on a VMC, the mechanical advantage of the cantilevered spindle also increases and side thrust becomes more of an issue. Fadal's highest-performance machines feature box ways throughout. Gustafson said, "Box ways offer more forgiveness. You can push a machine harder and not [experience] vibration and chatter."

Austin added that the best box ways are cast in and not bolted on, and he recommends that buyers carefully examine the ways system of a machine they're considering purchasing.

How Precise?

The machine chosen must be able to meet and hold the tolerances of the parts it makes. And, not surprisingly, precision requirements vary from one manufacturer to the next.

Manufacturers of high-tech products, such as disk-drive masters and lenses, must achieve surface finishes as fine as 2 nanometer rms. They accomplish this with single-point-diamond turning machines that feature air-bearing spindles, linear motors and positional feedback via high-resolution scales.

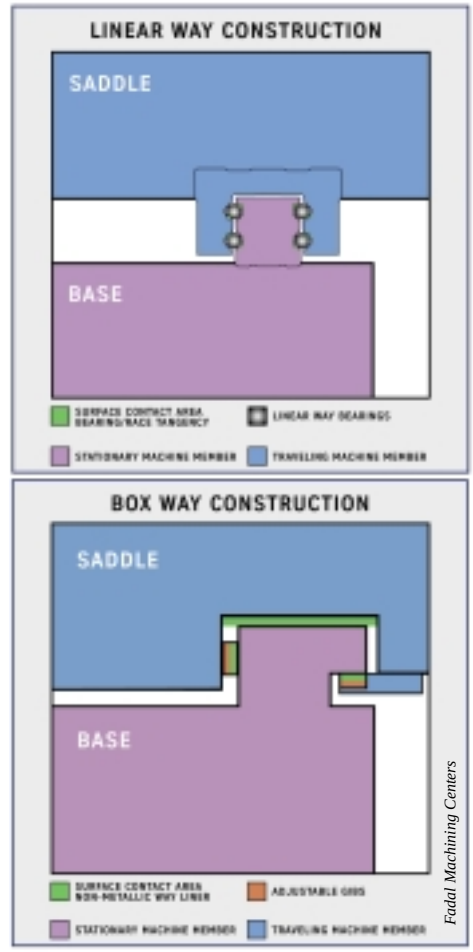
The majority of manufacturers work to less-stringent tolerances, of course. The production manager at an aluminum-parts manufacturer said his company works to "general commercial tolerances." The typical tolerance on clearance hole for a bolt, for instance, might be +0.010"/-0.005."

Industry sources say a mid-size (600mm pallet) horizontal machining center typically delivers a "when-new" accuracy of around ±0.0002".

Accuracy, it should be noted, is a controversial subject.

"Many people quote the accuracy of their machines, but it's open to interpretation," said Austin. The reason why is that the basis of comparison is often undefined. It's rarely clear under what conditions the measurements were made, whether the measurements were the result of a valid statistical analysis and how long a machine will hold a stated accuracy.

"The best way to compare," Austin said, "would be to machine identical parts on competing machines, then statistically analyze the results."



Advancements in ways technology are making linear ways more rigid and box ways faster.

How Flexible?

How flexible should your new machine be? Base your answer on the types of operations you perform. Simple, low-volume holemaking might dictate a drilling machine. A general-purpose machine can handle the bulk of metalcutting tasks. And long part runs might call for dedicated or semi-dedicated equipment.

A general-purpose machine will cost less than dedicated equipment, be easier to tool and will likely have a shorter delivery time. Moreover, when it's time to replace such a machine, it would have wider appeal in the resale market.

The marketing product manager at Oxnard, Calif.-based Haas Automation Inc., Scott Rathburn, said fewer shops are investing in machines dedicated to turning out a specific part by the thousands. "Most companies today can't afford to rely on just one industry," he said. "They are looking for machines that are versatile and easy to change out quickly so that they can respond when their job mix changes suddenly."

Makino's Rentschler said many manufacturers are seeking both sim-

plicity and high productivity. The company responded to these manufacturers' needs by introducing a series of lower-cost machines that utilize much of the technology found in its top-line A-series machines.

The first in this new "small-a" series is the a51. The HMC features a 12,000-rpm spindle, axes travels of 22" (X) × 22" (Y) × 19.7" (Z), a table with a 15.7"×15.7" work surface and a load capacity of 881 lbs. Rentschler said, "We simplified the machine. It has 40 percent fewer parts, and it doesn't have all the options of our premier A-series machines."

He added that a "shop with complex machining operations might need a more sophisticated machine, like our A55E, to hold tight tolerances on a particular feature."

How Many Axes?

Just as certain areas of manufacturing continue to remain steady, there are areas of machine tool technology that continue to pique buyer interest. A case in point is multi-axis, multipurpose machines.

They combine the capabilities of a lathe and a machining center, with one or more turning spindles and a machining-center head, or B-axis. The head can move the tool around the part during a turning operation, as well as rotate it for milling and holemaking.

An example of these machines is Mori Seiki's new MT-1500 multi-axis turning center. It features a standard 12,000-rpm tool spindle, a B-axis with a range of motion of ±120° and a programmable Y-axis with ±2.8" of travel.

AMT's Carter said these "true" multipurpose machines represent a step forward, noting that machine tools with mill/turn capabilities and a live spindle in the turret have been around for a long time.

"What manufacturers have done is put more power into the live spindle so you can really do some heavy-duty milling," he said. "This has made it into a true multitasking machine. You can show the customer that he doesn't have to move the part around the shop. When you're moving parts, you're not adding value; these machines let you spend more time adding value."

How do you decide if you need one of the new multi-axis machines? "It's a difficult task," said Mori Seiki's Owen. "We have to really understand what the customer's objectives are. In a lot of cases, cycle times might actually be longer on a multipurpose machine, but you still get more parts out the door because parts aren't moving from one machine to another.

"We had a case where the company was taking 25 days to get a part across the floor, and we completed the part in 4½ hours on one machine," said Owen.

In addition to boosting throughput, multipurpose machines also improve part accuracy. Performing multiple operations in one setup reduces the cumulative errors that can arise as a part moves from machine to machine.

How Much Control?

A machine's control runs the show. It stores and processes part programs and commands the movements of the tools, spindles and ways. A control should be matched to your machine's capabilities and be easy to use.

Rathburn said, "If an operator has to jump between different screens or page through complex menus, the control can be difficult to learn and the potential for errors increases."

Haas' controls, he said, are designed from the operator's and programmer's points of view, with clear function markings and a logically laid-out keypad. To further facilitate use of the controls, the company offers Visual Quick Code programming as an option. The VQC system is interactive and conversational, and incorporates graphical templates of common operations.

Haas also offers a control option that manages the feed rates utilized in high-speed-machining operations. Through motion algorithm it "looks ahead" and changes the feed so tools can follow complex paths in the most efficient way. Haas says that its HSM option allows feed rates up to 833 ipm without any distortion to the programmed path.

Handling the Intangibles

Choosing a machine tool is not easy, and it can't be done simply by the numbers.

Curt Roskelley, president of Roskelley Machinery Corp., a machine tool dealer in Salt Lake City, advised, "Don't get caught up in spec lists." Spec lists are great for referencing, but machines with the same specifications do not necessarily perform identically.

Roskelley also encouraged potential buyers to attend a trade show to "kick the tires" on a number of machines and consider factors such as delivery time and the presence of a skilled local service operation.

He added that buying a brand that's popular in your area can be a double-edged sword. On the one hand, local service and familiarity will be a plus. But if the machine's capabilities don't fit your application, you will limit your productivity potential.

Finally, within your own organization, include everyone in the decision-making process who will be affected by the new equipment: operators and supervisors, as well as personnel from plant maintenance, facilities engineering and purchasing. Their ideas will help ensure that the machine best-suited to your company's needs is chosen, and seeking their input will foster a sense of ownership that will multiply the benefits of your new equipment.

Haas Automation

Haas Automation says it designs controls from the operator's and programmer's points of view, with clear function markings and a logically laid-out keypad.

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