AUTOMATION
Need Not Break the Bank

Today's technology comes in simple, affordable packages

Toellner's loader travels straight in and out of a hole cut in this lathe's door to change the workpiece.

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Loading automation needn't cost an arm and a leg, as the engineering staff at Norlen Inc. (Schofield, WI) discovered recently. The contract fabricator had been looking for a way to eliminate the huge productivity variations that manual loading was causing on the Okuma turning center operated by its machining division. During their search, the engineers learned that a pneumatic loading device could enable them to automate the chucker for about $55,000.

So, the 100-employee shop installed the loader and joined the growing ranks of small-to-medium manufacturers reaping the benefits that automation can deliver. These shops have learned that clever twists to technology can give them greater consistency and a measure of untended machining for less than $150,000. The much higher price tags on conventional automation, and the cost of hiring specialists to program and maintain the technology, no longer keeps automation out of their reach.

In Norlen's case the loader, made by Toellner Systems Inc. (Wisconsin Rapids, WI) automated a turning center that does about 30 sec of drilling, tapping, and boring on a family of six aluminum castings. It mounts on the lathe's door, and loads the castings through a doggie-door-style hole cut in the door. While

it's in the machine, the loader pushes a spring-loaded flap open. Otherwise, the main door remains closed until the operator needs to change the chuck jaws or cutting tools. This approach allows Norlen to continue to use the safety interlocks already built into the machine, making the installation of expensive fences and interlocks unnecessary.

Automatic pallet changers are the most common form of simple automation for machining centers. An operator in Haas Automation's factory swaps raw material for machined pieces while the machine cuts the workpiece on the other pallet inside the machine.

The castings arrive at the machine in crates that contain 1500–2000 pieces, and the operator stacks them in four staging towers that feed the loader for about an hour. Once the loader's dual-gripper end effector grabs a raw casting, its arm travels along one axis, straight in and out of the loading hole. The gripper removes the finished part from the chuck, rotates 180°, and loads the raw casting. Next, the arm retracts and puts the finished casting onto a conveyor that drops it into another crate for shipping to the customer.

"The loader performs the same function as a gantry or a robot, but faster and for less money," notes Dennis Toellner, president of Toellner Systems. "It doesn't open and close the lathe's door, which the gantries and robots usually need to do. Just opening and closing the door eats up five or six seconds. So that and the simpler motion lets our unit load and unload in 4–5 sec what might take those other forms of automation 15 sec."

Norlen's operators had been averaging about 62–63 parts/hr when they were loading the lathe manually. Some operators could produce 80–90 pieces an hour, but only for a short time. Others processed closer to 50 pieces per hour. Such a wide variation in output made it difficult to schedule and deliver the increasing orders for the castings. The loader solved the problem, boosting the machine's output to about 85 parts an hour. Not only did the company not need to buy another machine to process the castings, it also created capacity.

Despite the advantages of faster processing speeds and greater consistency, the reprogramming and changes in end-of-arm tools necessary at changeover can make justifying automation difficult in small-to-medium shops. In Norlen's case, because the loader is a simple in-and-out device that is handling a family of castings, reprogramming isn't necessary. Because the gripper's range of motion is great enough to accommodate the variation in the family, the only changeover occurs on the machine side. Planning limits the number of chuck-jaw sets to two, and the quick-change system from Pratt Burnerd America (Kalamazoo, MI) keeps any necessary changes short.

Another problem when you're trying to justify automation in small shops is accommodating the short runs that make up a substantial part of the business. Norlen was no exception. The family of castings represents only 70% of the machine's workload, and the remaining 30% is a mix of a wide variety of parts. When it comes time to process these short runs, the operator disengages the loader and swings it out of the way so he can load the machine manually. "Engaging and disengaging the loader is quick; it takes only a minute or two," says Dachyk.

Perhaps the simplest and cheapest way to automate machining centers is with the automatic pallet changers that some builders offer on their products. Some of these machines are priced below the $150,000 mark, and they often give users the flexibility needed these days.

At one of its facilities, for example, Excalibur Machine Co. (Conneaut Lake, PA) has automated eight of its 21 CNC machines with automatic pallet changers (APCs) from Haas Automation Inc. (Oxnard, CA). Four of its Haas horizontals have two pallets each, and two of its Haas verticals have four pallets each. Another of the horizontal machines uses a pallet pool that contains six pallets.

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Such automation helps this 300-employee operation machine the heavy parts that the fabrication division (situated up the road) produces for the construction-equipment industry. The facility supplies finished structural members to a customer that runs just-in-time, with only a two-day supply of components on its floor. To control its own invento-

No Breaks for This Inspector

Loading machine tools isn't the only job that robots can automate in a machining facility. These flexible forms of automation also check parts, taking them in and out of a gage. Consider a family of components coming from a series of machining operations. Before they emerge from the cell, a robot grabs them from a conveyor and puts them into a Quick Set modular gage from Marposs Corp. (Auburn Hills, MI) to measure diameters, lengths, and other features (see photo).

"When you're talking about automated gaging, the first thing to ask is: 'what are you producing?'" says Frank Powell at Marposs. "This tells you what type of technology to use in the gage. The second piece of technology to consider is the material handling that you want the gage to work with. The small-to-medium-size companies can't spend a lot of money for the high-precision automation, so we have to make accommodations in the gage for that."

The "pogo-stick" compliance device under the gage shown in the photo is a good example. Marposs and material handling supplier Weldon Solutions (York, PA) compensated for variations in the robot and parts by installing a $900 version of the compliance device. The adjustable sections of the modular gage give the user the flexibility to adjust or retool it to measure a variety of parts.

ries, Excalibur relies on the automation to operate its own production in as close to a just-in-time mode as it can.

"Automation reduced both our raw material and our finished-part inventories by about 60%," reports Kevin Keisel, vice president of manufacturing. "At any one time, we typically have no more than two weeks worth of anything finished and ready to ship." Not only does this reduce the company's investment in inventory, it also reduces the firm's risk of incurring losses should the customer alter its designs or discontinue a product line.

The automation was able to help the company slash inventories by eliminating the need for the operators to stop production at changeover. "Before, changeover required stopping the machine, putting in the new fixtures, loading a new program, and changing the tooling," says Keisel. "Now, on the four-pallet machines, for example, we can be running production on two pallets while we're changing the other two off-line on the setup bench."

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Once the machining program is written, the operator loads the pallet and pushes the ready button. The software automatically queues the job, loads the appropriate program, and picks the right tools. Keisel reports that the fixtures currently used by the shop permit the operators to change most jobs in about 5–10 min. "We're saving those 10 min on every changeover," he says. "If we change setups seven times a day, which isn't unusual, that's 70 min."

The pallet changer also saves time while loading parts during production, because it exchanges the pallets within 30 sec. "If we were to run, say, 50 of a part at a time without the automation, we would have to stop the machine, open the door, exchange workpieces, close the door, and start the machine again," he says. Now the machine can be cutting another part while the operator changes the part at the loading station. So, if loading the machine manually took 3 min, the automation saves 2.5 min per part, which amounts to 2 hr on that batch of 50.

Another advantage is that an operator can tend more than one machine. At Excalibur, the operators tending the automated machinery often also tend other CNC machines that they load manually, depending on what jobs the shop is running. Once they load the pallets, they can let the machines run while they work at other machines.

Robots are another option, of course, for automating the loading of machines. Although they offer the flexibility to automate jobs that come in batches, they can be difficult to justify if the batches don't have enough volume. The initial investment can be deceiving. "You might be able to buy a six-axis robot for $30,000, but integrating the robot with the machine, providing the safety devices required by law, designing the end-of-arm tools, and writing the programs can cost two to two-and-a-half times that," says Denny Rowe, Weldon Solutions (York, PA). "Single-machine tending applications will run between just under $100,000 to $180,000."

Nevertheless, Excalibur has found that it could justify the gantry robot on one of its Haas lathes. The robot picks up a new workpiece from a 30-station metal rack attached to the machine, and puts it in the lathe. After the machine completes its cycle, the robot grabs the finished part, flips the dual-gripper end effector 180º, puts the next raw workpiece into the chuck, and returns the finished part to its original place in the rack.

Haas Automation uses the automation that it sells. A Motoman robot in Haas's factory tends two lathes and a machining center. The untended machine tools were set up by an operator during the day and average six spindle hours for every man-hour. Based on its experience in its own shop, Haas plans to introduce a Robot Ready option to its CNC machines at this year's EMO.

Because jobs on this machine typically range between 20 and 40 pieces a week, the operator can easily change the machine over three or four times a day. "The robot is a little more difficult to change over than the pallet machines," admits Keisel. "If you've run a job before and have the tools you need already in the lathe, you can swap the jaws on the robot, call up the program, and verify it in about half an hour." Excalibur designed its own gripper jaws so the operators could slide them in and out in about 10 min when the differences in part diameters demand doing so.

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Quantity is a significant hurdle for justifying robots. "If you're a mom-and-pop shop running a few pieces at a time and doing multiple setups, robotics may not be the best solution for you," notes Trevour Brown, a machine shop manager at Haas Automation. "Robots are typically best for producing batches that will run for at least a day, contain hundreds of parts, or both. With robotic workcells, you can simply load raw material, install fresh tools in the machines, load the programs, push the green button, and go home. In the morning, if everything went as planned, you will have a batch of finished parts ready."

One tip from automation experts for generating enough volume to justify robotics is to organize like parts into families. Many times, similar parts can use the same loading routines, and thereby reduce the amount of programming and the number of end-of-arm tools that you have to develop. Erowa Technology Inc. (Arlington Heights, IL) uses a similar tactic for a modular magazine of pallets that can go into machining centers, electrical-discharge machines, and other units. Its four-axis robot handles the pallets, instead of the parts.

"Because the pallets are exactly the same, the robot is always loading the same thing," says the company's Tom Watkins. "Therefore, the parts could be different from pallet to pallet, which opens the possibility of loading short runs robotically. The key is an accurate and reliable clamping mechanism and a reference system that allows putting the pallets into your machine repeatably."

Units can hold as many as 240 pallets and operate in one of two modes. The first mode is the stripped-down version. The operator uses the CNC to associate the correct program with the pallet number, which defines its location in the magazine. When the machine calls for the pallet, the system loads it and runs the assigned program.

As for the second mode, it offers users more flexibility, but costs more because it relies on PC-based job-management software and a RFID chip in the pallet. The operator uses a handheld device at the setup bench to scan the pallet number, choose the part program, and enter offset data for the fixtures as he sets up the pallets. As the operator loads the pallets into

the magazine's loading station, a reader retrieves the pallet number from the chip so the software remembers where the magazine stores the pallet. While the machine operates, the system loads the appropriate programs and pallets according to the priority that the operator assigns to the jobs.

The robot on Erowa's modular magazine can handle small batches economically. A combination of the pallets, clamping mechanism, and reference system fools the robot into thinking that a series of small jobs is one large one.

Advanced Engineering Technologies (Croydon, PA) uses the more flexible version to tend two five-axis machining centers and a CMM. The loading automation is an important piece of the engineering company's lean manufacturing strategy of touching its aerospace parts as little as possible. On a typical day, the operator will load a mix of 50–100 pieces, then let the machines run untended the rest of the day and overnight.

"We can load one or 100 of any of the 300 part numbers that we cut here," says Chris Sharp, owner and CEO. "The order doesn't matter, as long as the machining programs and inspection routines are written." This ability to automate a mix of low-volume lots is crucial to his ability to justify the automation.

The lean strategy also includes a proprietary dovetailed workholding technique that the company's engineering staff developed to eliminate fixtures. Not only does the technique streamline attaching workpieces to the pallets, but it also eliminates the cost and headaches associated with carrying an inventory of custom fixtures.

The five-axis machines cut the parts complete in one operation, except for a web that connects the workpiece to the pallet. They even finish holes by circular interpolation to avoid the need for boring bars, and break edges to avoid time on a separate deburring machine. The next day, the robot runs the parts through the CMM, and sends the inspected parts back into the machines to whittle the web down to 0.030" (0.762 mm) so a person can easily break each workpiece off the fixture. As someone else does this, the operator reloads the machine with raw stock.

Another style of robotic loader from Distech Systems (Rochester, NY) uses a similar modular concept, but gives it a different twist. Instead of storing pallets, its loader uses trays, which a seven-axis articulating robot at the top of the module's enclosure loads either from or to a machine or conveyor. Because the module contains the controls, guarding, and tools, users simply put the modular loader in front of the machine, connect power, and teach the robot the new loading point, according to Dan Schwab, president and chief technical officer.

The first of three basic configurations has only two trays, but is portable and costs about $75,000. A built-in jack allows users to move it from machine to machine, depending on the shop's workload. Intended to be stationary, the more expensive second configuration works with a cart of trays that sits in a bay inside the unit. An operator wheels the cart in and out of the bay. While the third configuration also uses a cart for managing several trays, it has an extra bay that can house a supporting operation, such as an inspection station or a parts washer.■

Do-it-Yourself Automation

If you're up for it, you might consider building your own automation. A trend among manufacturers of automatic clamps, cylinders, grippers, shuttles, slides, lifts, and robotic tooling components is to engineer their products as modules that fit together, much like pieces of old-fashioned Erector sets.

"We've been developing modular automation subsystems that connect directly together," says Eric Ringholm, director, pneumatic automation products, De-Sta-Co (Auburn Hills, MI). "You won't have to design adapter plates or anything like that." The company's technical service group can even help you with the applications engineering.

Among the modules that fit together in De-Sta-Co's product line is a machine loading device. Its gripper can pick a part from the machine, rotate, and insert a new part in one set of motions while the arm is in the machine. "We are also developing a line of programmable electric actuators," says Ringholm. "You'll be able to build a motion system from several servoslides."