➤ BY ALAN RICHTER, EDITOR

The Flexible Manufacturing System from Fastems enables work in progress to be adjusted to meet just-in-time demands. Rush jobs, based on customer needs, can be inserted into the job queue.

Fastems

FLEX TIME

Targeting only certain processes for automation and maintaining flexibility can pay big dividends.

In manufacturing, flexibility and automation go together like man and machine. Being flexible enables cost-effective automation even when producing small lot sizes—down to a single part.

"Twenty years ago, when people talked about automation, they talked about a lights-out factory and automating everything and putting in giant conveyors all over the place," recalled Brian Carlisle, president of Precise Automation LLC, Los Altos, Calif. "That turned out to be very expensive, not very flexible and only practical for a few extremely high-volume factories."

David A. Dornfeld, professor of mechanical engineering at the University of California at Berkeley, concurred. "A while back, when people in the U.S. were trying to employ robots for all kinds of reasons, they essentially said, 'Let's build a factory and have it totally automated,' which was spectacularly unsuccessful because a lot of the processes were not suitable for automation," he said. "The Japanese, by contrast, only automated what was very reliably and repeatedly operating."

The trend now is to take a lean approach, keeping inventory low and reaction time quick, according to sources interviewed for this article. "This whole idea of lean has [people looking] at automating individual cells and still maintaining a lot of flexibility in how the material moves through the factory and how those cells get reconfigured for a new production run," Carlisle said.

The lean approach often reduces the amount of automation equipment and relies more on workers to get the job done. Dornfeld described how a Japanese machine tool builder eliminated automated guided vehicles "tumbling around the factory" and high-bay automated storage and retrieval so employees can see exactly what is on the shop floor. "They don't want anything hidden," he said, adding that the only robots remaining are for handling sheet metal being moved in and out of a press and for some painting operations.

Now, the builder performs cell-type assembly, where a team or a couple of individuals handles everything in the cell. "It's almost as if the automation is being done using humans in place of robots," Dornfeld said. "You're designing the system as if you were using a robot but getting the flexibility of highly skilled workers." Because labor represents only about 15 percent of the machine builder's cost, "it doesn't pay to build in China or any low-labor-cost place," he added.

Where to Start?

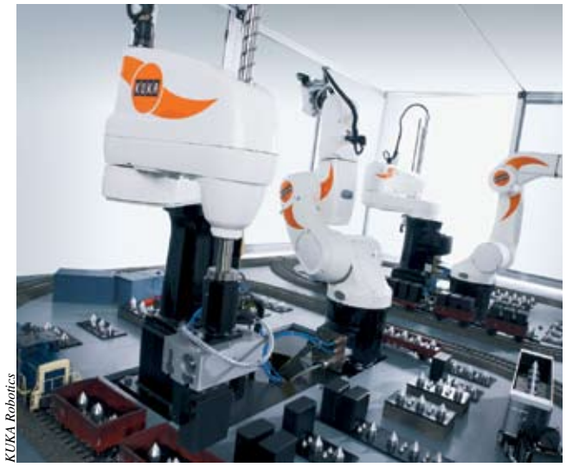
Before automating a process, the manufacturer needs to be sure it designs the part for automation. A properly designed part ensures it will be gripped correctly in a robotic gripper for a pick-and-place procedure or seated appropriately in a fixture or carrying device that presents it to the next stage of the production process.

The question is "can you repeatedly and reliably, given the variability that's inherent in the manufacturing process, orient, grip and transport all of the components that go onto the next stage?" Dornfeld asked. "If you can't do that, then you're really in trouble."

Robotic machine loading and unloading is one of the simplest automation categories and typically doesn't require significant—or any—part redesign to function properly. Product assembly is more difficult to automate. Carlisle of Precise Automation pointed out the importance of designing parts so they don't become tangled during automatic feeding. For example, parts that have springs with closed ends won't interlock while ones with open ends can.

In addition, if the process requires assembling more than two parts, a manufacturer might require a line of robots and a conveyor, as well as parts feeders and, possibly, a machine vision system to perform inspection. "I would categorize assembly as the most complicated," Carlisle said.

Although vision systems have improved during the past 2 decades, differences in part gloss or reflectivity or the amount of metal spring-back because of temper variations can frustrate the automation process. The solution is not to spend more on a "smarter" robot but to understand why the variability is occurring and overcome it. "We always try to beat stuff to death with machine intelligence or computers rather than trying to find the simplest way to solve the problem in the first place," Dornfeld noted. "That's kind of why the highly automated schemes weren't successful."



KUKA Robotics

The high-speed SCARA robot family from KUKA Robotics is for customers needing pick-and-place automation for long-reach tasks.

Automate Wisely

High levels of automation don't work for the vast majority of manufacturers, but, obviously, it makes sense—practically and economically—to automate many processes. For example, automating machine loading and unloading is desirable when part volume increases and the machine tool is capable of handling it but the operator is not. Other scenarios may not be so obvious. "There is one category that's often forgotten when talking about automation," said Edwin H. Zimmerman, director of technical operations for Apex Automation Inc., Elizabethtown, Pa. "It's what I call 'the three Ds:' dirty, dull and dangerous tasks. These frequently need to be automated in the interest of safety to keep operators out of harm's way."

However, he recommends against automating troublesome processes that are not achieving the required part rate. "If you automate what is currently a high-error-rate process, the only thing automation is going to do for you is allow you to make those mistakes faster," Zimmerman said.

This can cause frustration and lead to an end user abandoning potentially productivity-boosting automation altogether.

Instead, the focus should be on automating repeatable and reliable processes. "Or make it very repeatable and reliable before you even think about automation," Zimmerman added. "The act of improving a current process sometimes results in a method that doesn't require further automation."

Once a process is proved out, the trend is to target problem parts using automation, according to Kevin Kozuszek, director of marketing for KUKA Robotics Corp., Clinton Township, Mich. "Smaller, complex pieces or jobs with multiple parts having lots of changeovers are good candidates for robotics because robots are flex-

Production tooling: picking the right level and grade

When a company is considering automating a process, one of its first tasks is to decide—at least tentatively—on a level and grade for the production tooling. The company can choose from five levels and three grades of tooling for manufacturing and assembling products. These levels can be applied to the entire process line under consideration or to each subprocess or station that together comprise the total process.

Level I is strictly manual. All parts positioning and manipulating and any work done to the workpiece comes from human exertion. Level I can be characterized by the absence of utility hookups on tools the operator uses. The throughput rate is totally operator-dependent.

Level II is semimanual, where operators manually locate and remove product components from the processing device. However, a mechanical, electrical, hydraulic or pneumatic device supplies power for work done during the process.

Level III is semiautomatic, where all processes are performed automatically, but an operator feeds components to the device. The operator has to feed the machine on a one-for-one cycle basis whether by piece or by group. The operator of a Level III tool often manually feeds preoriented workpieces into a magazine. The machine pulls them from the magazine during each machine cycle. The process rate is machine-dependent, but the operator needs to keep the machine pickup point supplied with workpieces.

Level IV is automatic; the operator normally handles product components in bulk, loading them into a device that orients and feeds them to the process. In addition, output is handled in bulk or in multiples. Many times, the output of a fully automatic machine has been inspected and packaged, and is ready for shipment. The throughput rate is strictly machine-dependent, as long as parts feeders and other input devices do not become empty.

Level V is highly automated. Economical in rare circumstances, a highly automated system approaches the much-touted lights-out manufacturing milestone. An operator or automated storage and retrieval system supplies a Level V system with bulk components.

Many possible system grades exist within each of these five levels. Like the different levels, the system grade influences cost.

The potential grades of production equipment form a continuum, but a reasonable breakdown includes three grades: alpha, beta and gamma (plus the nongrade designation of prototype, which is not considered production tooling).

Apex Automation

A semiautomatic pick-and-place loader for a pipe-fitting tapping machine automatically transfers fittings from a conveyor to the fixture in a machining center. However, an operator loads the fittings onto the conveyor.

Alpha grade is top of the line. This designation is for systems expected to remain in production for more than 8 years. Alpha-grade systems are flexibly engineered to accommodate change to another product version or newer process technology.

Beta-grade systems are engineered to have a productive life of 2 to 10 years. They may have a modicum of flexibility to accommodate a similar product in the future.

Gamma-grade systems are intended for short-term production—less than 3 years. Emphasis on first-cost efficiency results in prime movers, such as pick-and-place devices, walking beams and part shuttles, often being pneumatic. These provide relatively low production rates compared to alpha or beta grades. Gamma-grade systems are placed into production quickly, run for a short time and then scrapped or used occasionally as backups or supplementary equipment during spikes in product demand.

Information adapted from the book "Getting Factory Automation Right (The First Time)" by Edwin H. Zimmerman; Society of Manufacturing Engineers, 2001.

Tooling level	Tooling grade		
	Alpha	Beta	Gamma
Level I	---	I-B	I-G
Level II	II-A (rare)	II-B	II-G
Level III	III-A	III-B	III-G (rare)
Level IV	IV-A	IV-B	---
Level V	V-A	V-B (rare)	---

ible," he said, noting that high runs of relatively simple parts should be produced on fixed CNC machines. Fixed CNCs are focused on handling one type of process. Robots, on the other hand, are flexible pieces of automation equipment and, therefore, can handle multiple processes.

Kozuszek added that a robot is appropriate for craftsman-type work previously done by hand because a robot works in multiple planes. "Robots have the ability to reach around a workpiece due to their inherent flexibility in six different axes," Kozuszek explained, "whereas parts are mounted inside a CNC machine and need to be rotated inside the machine so the milling or other machining work can be performed on the opposite side."

With advances in technology, such as lower-cost, more user-friendly software and pressure-sensitive tooling, robots are able to perform more machining operations than in the past. One example is deburring, where a feedback loop on the robot's end-of-arm tooling now enables a robot to deburr more effectively. "A person might do the polishing portion for a part after a robot does 80 to 85 percent of the deburring work," Kozuszek said.

Volume Matters

Although manufacturers have traditionally automated high-volume production runs, lower and lower volumes are being automated. Liberty, Mo.-based Pride Manufacturing Co. Inc. doesn't machine large volumes of parts, but it does have a robot for loading/unloading a Swiss-style machine, said Tom Goodpasture, company president. Pride does see orders up to 100,000 pieces, but, being a job shop, it usually sees shorter runs and has to continually look for new orders to keep making chips—i.e., money. That makes automation appropriate for reducing setup times, but the lower volumes limit the shop in its automation efforts. "It's harder on our end to do automation with short-run production," he said.

In addition to reducing setup times, robotics enables an operator to support more machines and allows Pride to perform lights-out machining and compete against low-labor-cost countries. "We run overnight, so we use zero labor," Goodpasture said. "If you have zero labor, it doesn't matter if you're here or in China."

For shops with horizontal machining centers or other types of machines that interface with palleting systems, flexible manufacturing technology is available to schedule and automate a variety of smaller-volume runs. One option is the FMS (Flexible Manufacturing System) from Fastems LLC, Cincinnati. "Our system would run as well with a one-part lot size as with a 100-part and up lot size," said Mark Walker, company president. "We're also a Fanuc robot integrator, so if somebody has to run a million pieces on a single machine and that machine is never going to be changed over, that's the way to go, not this FMS."

The FMS works with one machine or multiple machines and can incorporate nonmachining activities, such as parts cleaning. Once a process is proven out, the end user sets up pallets based on the system's instructions of what needs to be done to meet the production schedule and the system takes and stores those pallets.

When it's time to run the pallets, the FMS puts them into the machine or machines and Fastems' carrier transports pallets from one station to the next, moving the pallets linearly, horizontally and vertically as needed.

"Our system is nonsequential," Walker said, "so it wouldn't have to be a production line where it goes from one machine to the other to the other."

He noted the FMS is an open system, where a manufacturer can incorporate appropriate machines from various builders into a cell to provide more flexibility and control, as opposed to a system dedicated to a specific machine. "The counter to that argument is if you do it through a machine tool builder, you have a single-source supplier that has its own system," Walker said.

Either way, "the whole idea is that if everything is ready to run and we have parts in the rack," Walker said, "the machine should never stop running." △

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