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➤ BY ALAN RICHTER, EDITOR

Applied Robotics

Productivity PICKUP

Pick-and-place robots boost productivity and, say experts, may save U.S. shops.

When it comes to increasing profits and remaining competitive in a global economy, automation of the manufacturing process is a better bet than offshoring. That's the message from "Save Your Factory," an initiative sponsored by robot manufacturer FANUC Robotics America Inc.

"Data supports the fact that through automation, robotics and other lean manufacturing operations, North America can be cost competitive with countries like China," stated a white paper on the initiative's Web site at www.saveyourfactory.com.

According to data from the Robotics Industries Association, North American manufacturing companies are cognizant of the benefits robots provide. The trade group reported that last year such companies purchased 14,838 robots valued at nearly $1 billion, a 20 percent rise in units over 2003.

And robots are no longer the domain of only large manufacturers. "Historically, robots have been used in some larger automotive plants, but we are starting to see robotic automation being introduced into some smaller manufacturing facilities that are nonautomotive," said Isabel Roberts, who is in charge of business development for BRIC Engineered Systems Ltd., a manufacturer of robotic systems and automation equipment. She is based at the company's Oshawa, Ontario, location. "It's certainly a growing industry."

Even smaller job shops can reap the

rewards of automation by integrating a pick-and-place robot into an automated parts handling system.

"If I were running a job shop, machine load/unload is the process from which I would gain the most," said Kapyoung Choi, program manager for FANUC Robotics, Rochester Hills, Mich. The level of risk is low and, "from a complexity standpoint, it's not as complicated of an automated task [as robotically] removing material from a part by deburring or deflashing."

To begin the process of installing a pick-and-place robot, contact an integrator and have him visit the shop. "At least get him to evaluate your process or do a survey of what you're doing and let him point out some of the areas where it could be automated and where some efficiency and productivity gains can be achieved," Choi said. "That's always free."

Peter Gratschmayr, senior application engineer for Rimrock Automation Inc., New Berlin, Wis., noted that when implementing a pick-and-place robot, the end user needs to identify—at a minimum—the part size and variation, throughput rate and locations of the pick-and-place points. "With this information, the system integrator can determine the robot size, speed and mounting configuration," he said. "Furthermore, operator access requirements are needed to define the location of the automated equipment and to communicate with the machine tool supplier the access door requirements."

Main Elements

Choi said there are four main elements of a pick-and-place robot: the robot arm, the controller hardware, the software and the robot's end-of-arm tooling. He added that for the machine tending system, the main components include a feeding device to present the parts so they can be picked and placed, and a master control to coordinate activity among the various pieces of equipment, which might include a conveyor. This is in addition to the robot and the machine the robot will be feeding parts into and out of. "There would also be some type of guarding, because it's important to isolate the operator from the cell for safety purposes."

The complexity of the robot, of course, depends on the application. "It can be something as complex as a multiple-axis unit, with four axes or more," said Walter Saxe, market research manager for Applied Robotics Inc., a Glenville, N.Y.-based provider of specialized end-of-arm tooling and connectivity products. "Or it can be nothing more than some linear slide-type mechanisms, depending on the requirements. For example, a multiple-axis

Handling microcomponents

As products continue to get smaller and smaller, the components that make up those products decrease in size as well. Many tiny components are not machined from a piece of metal, but are micromolded using engineered resins.

Regardless of the material, microparts generally need to be transported automatically from the injection-molding machine to packaging or some other workstation.

"You do your best, ideally, to eliminate any contact with the human being," said Stu Kaplan, president of Makuta Technics, a micromolding company located in Columbus, Ind. "In our place, the rule is you can touch them once, but not in the manufacturing area. You get to touch them in shipping or somewhere like that."

By definition, a micromolded part is tiny, but what qualifies it as such, be it size or weight, is open to interpretation. The entire part and all of its features need to be considered—not just the part's OD. "For example, you can have parts with an OD of 22mm, which from looking at the OD would not be considered micromolding," Kaplan said. "But, on the other hand, you could have features on that part that have a tolerance of ±2 microns."

The same holds true for weight. Kaplan noted that his company molds parts weighing 0.0001 g to about 4.0 g. "The configuration of the part is what you're looking at."

When handling micomolded parts with an automated system, it's not simply a matter of scaling down the equipment required for handling conventional parts. "Some parts are so small that you can't use what would be called 'grippers,'" he said. "You would invent venturi systems to bring them off the tools."

In addition to transporting parts through a tube, Kaplan noted that venturi systems could be designed to clean the mold components in an automated fashion. "In your automation configuration, you have to consider if the components of the mold have any debris left in them from the manufacturing process," he said. If the user wants to clean cores and cavities each time, then a venturi system could be used.

When a pick-and-place robot with grippers is appropriate, the usual metal fingers may not be desirable. "There are some unique ways to use polycarbonate, for example, as your end-of-arm tooling," Kaplan said.

Of course, conveyors can be one component of the parts handling system, but they are much smaller—along with the conveyor's rollers—than what would be considered "normal."

Kaplan pointed out that the conveyor travel time is often used to cool parts. If this is the case, the correct conveyor length needs to be determined to allow adequate cooling time.

The simultaneous separation and containment for quality purposes also needs to be considered when handling and transporting the parts. "Because we operate our factory lights-out, 24/7, parts-collection devices have to allow for a 16-hour period of operation without human intervention," Kaplan said. "If there happened to be a quality problem, there must be a 'designed in' application that separates production so the problem parts do not contaminate the rest of the production lot."

Because sorting such small parts by hand is not an option, the company developed robotic bagging systems and automated quality chutes, where reject parts are separated as they are produced.

As the need for smaller and smaller components increases, micromolding will help satisfy the demand. "Micromolding is absolutely a growth industry," Kaplan said. "If you were to ask me how small things can get, I'd say it's open-ended."

—A. Richter

robot would do more complex picking and placing, like in an assembly application where there is a high degree of accuracy needed and, maybe, throughput requirements aren't quite as high." He added that for high-speed pick-and-place applications, end users often select 2- or 3-axis linear slides.

Another area where the level of complexity comes into play is the end-of-arm tooling for the robot. "Let's say you have a 4-, 5- or 6-axis robot and it's dressed with end-of-arm tooling," Choi said. "The tooling could be a 2-jaw gripper, a 3-jaw for chucker-type parts or an integrated vision and force-sensing gripper."

Suction cups are another option for end-of-arm tooling. "The shape, size, weight and type of material, and the actual use of the part, are some of the factors that determine end-of-arm tooling," Roberts said.

If many different parts are being machined, a toolchanger can be integrated into the parts handling system. "You can have a toolchanger where you change the gripper, depending on the part you're running," Roberts noted.

Saxe added that, typically, with a toolchanger, the robot adapter resides permanently on the robot. The robot adapter has pneumatic or electrical connections that mirror the connections on the end-of-arm tool. The tool is dropped automatically into a fixture and the robot then picks up another tool. "We have many customers who have six, seven or eight different tools sitting in fixtures," he said. "Each one is unique, but they're all wired so that when the robot side comes over to pick up the tool side and the connection is made, all the electrics and pneumatics or, possibly, coolant plumbing is automatically connected."

Servo vs. Nonservo

Technically, a robot must have reprogramming capability, according to Mack Corp., Flagstaff, Ariz. Devices not capable of reprogramming are better defined as "dedicated automation."

The company, a manufacturer of grippers, actuators and other robotic components, stated that there are two basic types of robots: servomotor controlled and nonservomotor controlled. Nonservo robots are inexpensive, easy to understand and set up, have good precision with high reliability and can be a logical choice for point-to-point transfer. Nonservo robots usually operate along the axes of a coordinate system. Motion is controlled through the use of a limited number of stops and the actual path between points may be difficult to define. Programming involves setting stop locations at the manipulator and determining sequence and duration at the controller. Control can be as simple as a cam or drum timer for applications involving robots in dedicated service, while programmable controllers or PCs with simple, nonservo software are more practical where reprogramming is required.

On the other hand, servo-controlled robots provide a wider range of capabilities, can perform multiple point-to-point transfers along a controlled path and can be programmed to avoid an obstruction. Servo control allows the robot to be more accurate with regard to positioning the robot in relation to the object it needs to pick and place and provides continuous-loop feedback. "A servo-controlled robot is costlier but more intelligent than simply a dumb item that picks something up and shoves something into place," Saxe said.

FANUC Robotics' Choi noted that a robot with a payload capacity of 3 kg to 5 kg costs around $30,000 to $35,000, which includes the robot, the controller and the software that comes with it. Cost increases as payload and reach increases.


Rimrock Automation

When selecting a pick-and-place robot, the end user needs to identify part size and variation. This is in addition to throughput rate and the locations of pick-and-place points.

Most companies look for a return on investment from a pick-and-place robot in less than 2 years, Saxe said. At that point, the system might be replaced or reconfigured to handle a different application or simply continue to be used as originally intended. He added: "The bean counters tend to say, 'If you can justify the cost of this robotic cell, that is, it will pay for itself within the 18- to 24-month window, we really don't care what you do with it at the end of that time. From a cost and tax standpoint, we've written this thing off. It's paid for itself.'"

In addition, different sizes of robots require different power sources. Larger robots usually operate on hydraulics, while smaller ones operate electrically or pneumatically.

Vision and Force Sensing

A servo-controlled robot also enables a vision system and force sensor to be added. Robot cells with vision systems

The following companies contributed to this report:

Applied Robotics Inc.
(518) 384-1000
www.arobotics.com

BRIC Engineered Systems Ltd.
(905) 436-8867
www.bricengineeredsystems.com

FANUC Robotics America Inc.
(800) 47-ROBOT
www.fanucrobotics.com

Mack Corp.
(928) 526-1120
www.mackcorp.com

Makuta Technics
(812) 379-4696
www.makuta.com

Rimrock Automation Inc.
(262) 432-0600
www.rimrockautomation.com

Grip and go

When parts are small and lightweight but not too miniscule for gripping in connection with an automated pick-and-place operation, microgrippers can be the way to go. One of the features of microgrippers is their ability to grab a part without exerting too much pinch force, which is especially critical when gripping delicate, thin-wall and ceramic parts. "Otherwise, you leave an impression—a flaw—in the part," said Frank Mack, president and engineer, Mack Corp.

The Flagstaff, Ariz.-based company offers a line of microgrippers, measuring from 1 sq. in. to ½ sq. in. The pinch forces range from 2.7 lbs. to ½ lb. Mack noted that determining the appropriate size needed for a gripper is based on the size of the part being gripped and its weight. "When the part goes from point A to point B, if the inertia of the part the gripper is holding is too big, the part will flip out because the pinch, or closing, force is pretty small," he said. Mack noted that the spring that closes the gripper is made of music wire.

To effectively handle a specific part, end users often machine the gripper's aluminum fingers to conform to the part's shape. Mack explained that the fingers can easily be separated from the gripper housing by removing two screws and sliding the pin out.

Mack added that the circuit for operating the gripper, which has tapped holes for attaching it to a transfer mechanism, isn't complicated. "It's just a 3-way valve where you put pressure in to open it and then remove that pressure to atmosphere and the spring closes it."

Although the microgrippers have application in an industrial setting, they are limited to gripping parts weighing less than 2 oz. "It's an item that we kind of look on as over in the 'scientific world,'" Mack said. "Optical and medical people are interested as these grippers can be sterilized in an autoclave without disassembly."

—*A. Richter*

FANUC Robotics

Example of an industrial robot with a large payload capacity (left) and one for performing metal removal.

provide part identification, part- or tray-location sensing and quality checks.

"When the vision system is used to identify parts, the robot can select the downstream processing requirements and subsequent machine tool programs without waiting for the operator to enter the change," said Rimrock Automation's Gratschmayr. "Also, fixtureless manufacturing is possible with location sensing of parts and part trays, and workpiece quality inspections confirm the condition of the parts not only after machining, but before they enter the machining center."

"If you're only doing a small number of parts and the parts are repeatable and easy to handle, you probably don't need a vision system," said BRIC's Roberts. "A vision system is good if there is part variability or if many different types of parts are coming in on a somewhat random basis and the operator doesn't run a large batch of one type of part."

She noted that vision systems run from \$10,000 to \$20,000 on the low end, for simpler applications, to more than \$100,000 on the high end. As accuracy, resolution and functionality of vision systems increase, the price often moves in the opposite direction, Roberts added. "Vision systems have come down in price, which makes them more of a solution for a broader range of applications."

If something needs to be inserted into a component, a force sensor might be required. A force sensor on the end of the robot arm provides feedback to the robot, letting it know it has inserted the object hard enough to receive a force of the specified number of in.-lbs. or ft.-lbs., Saxe explained. "Once the robot sees that resistance, it knows it has bottomed out."

A more sophisticated system combines the two. "With vision coupled with a force sensing device, you have the ability to guide the robot in a 3-D space as well as touch and feel where, for example, you're inserting a valve into a hole," said FANUC Robotics' Choi. "The algorithm that runs in the background is sophisticated enough to allow the controller to have, in a human sense, the ability to touch and feel. So if you closed your eyes and you have a part roughly right at or above the hole, you're trying to feel your way into the area where you have to insert the shaft into the hole. That's pretty much what a robot can do. We call it an 'intelligent' robot."

Simulation Verification

Once a shop determines it wants to integrate a pick-and-place robot into its parts handling system, software should be used to simulate the operation before purchasing the equipment. "Simulation packages are very helpful in terms of what robot to select," said Roberts. "Simulation can help determine what reach you need and if there is mechanical interference within the path of the robot as it moves the part from point A to point B."

A simulation program also evaluates cycle time. Applied Robotics' Saxe said a simulation determines if the robot can do what it needs to do accurately and at the speed required to provide the necessary throughput to be profitable.

More 'User-Friendly'

Half a century has passed since the first industrial robot was offered to the market. During that time, technological advancements have been considerable. "User-friendliness has been built in enough that I think there are a lot of benefits to job shops and small shops as well," said Choi. "Now, some of the standard, off-the-shelf technologies you can use to create a robot cell are much better than even 10 or 15 years ago."

Even with the increasing user-friendliness, outside assistance is advised. "In terms of the initial setup," Roberts said, "if you're a smaller shop and don't have the expertise in-house, you still need someone from the robot manufacturer or an integrator to come in and set it up for you."

Once in place, the task of running the automation is easier. "The robot programming language is user-friendly enough," said Choi. "The menus and commands are in English. You don't have to know M codes or G codes, for example."

Robots, especially in science fiction adventures, are sometimes viewed as a threat, but this shouldn't be the case in today's global manufacturing environment. "Some manufacturers are concerned that investing in automation and innovation will displace workers," stated the Save Your Factory initiative. "The fact is, if manufacturers do not innovate and embrace automation, they will leave themselves open to losing their entire facility, company or worse to outsourcing." △