As the automotive industry’s reawakening continues, less-expensive high-payload robots are gaining traction over more conventional fixed tooling among automakers focused on cutting costs while improving manufacturing productivity and processes. In many cases, automotive OEMs are finding that heavy-payload robots can easily take the place of fixed hard automation, often at a fraction of the price. Other technical advances that automakers are deploying include greater use of machine-vision systems and vision-enabled robotics, newer force-sensing technologies, dual-purpose robots and robotic machining techniques that include grinding, polishing and deburring applications.

Flexible Automation for Automotive

Larger-payload robots start making inroads while other new automation innovations help spur auto industry productivity

Patrick Waurzyniak
Senior Editor
Paced by strong automotive-related sales, overall robot orders jumped 20% in units and 29% in dollars during the first half of 2012, according to the Robotic Industries Association (RIA; Ann Arbor, MI), following a record-setting 2011 for robot sales in North America. The RIA estimates 10,652 robots valued at $747 million were ordered from North American robotics companies in the first half of 2012. Orders for spot-welding robots, used primarily in automotive solutions, jumped 68% in the first half compared to the same period last year.

**Moving Heavy Metal**

Automotive automation has always employed a heavy dose of robots for welding, assembly and robotic vision applications. But with robotics developers’ improved price points on newer, stronger, heavy-payload robots, OEMs and Tier suppliers increasingly are seeing the big robots as viable alternatives to very expensive large-part fixturing and lift systems.

“In many cases today you have these custom-built lifting stations that work and do the job, but when you have a variety of different vehicles and platforms you’re trying to run through the same line, the complexity that you get with these custom lifters starts to get rather pricey, quite frankly,” notes Neil Dueweke, general manager, New Domestics Group, Fanuc Robotics America Corp. (Rochester Hills, MI). By employing a robot such as the Fanuc M-2000iA/900L or the M-2000iA/1200L, which offer 900-kg and 1350-kg payload capacities respectively, Dueweke says that automakers are replacing million-dollar fixed tooling with robots costing less than half the price.

“Think of all the underbody marriage stations that you have where you’re taking parts of a chassis and marrying them to the body structure,” Dueweke says. “Before you couldn’t do that, because that was just way too heavy to lift, you needed some sort of sensing system to detect if you could fasten, say, the engine cradle to the body. Now that technology is pretty routine and you’ve got a custom-built system that includes the robot, system peripherals and end effectors for about a half million to replace equipment that was $1 million to $1.5 million.”

“OEMs have recognized the role flexible automation can play in reducing overall cost of automation.”

Heavy-payload robots like the Fanuc M-2000iA/900L and M-2000iA/1200L can easily pick up a full chassis assembly with the engine subframe and suspension attached, he adds, with a maximum payload over more than a ton and a vertical lifting stroke of 20.4’ (6.2 m) for heavy-part transfers.
“There’s lots of applications that are starting to happen with the M-2000,” he says. “One is lifting just the Body in White—the robot can easily handle that—but another one is an underbody marriage of either the rear suspension components or the front suspension and engine cradle being attached to the Body in White. We haven’t found where that

Automated Metrology Boosts Shop’s Quality, Process Capabilities

A high-volume automotive parts specialist, Metal Technologies Inc. (MTI; Bloomfield, IN) was faced with a serious problem: the shop was making too many small mistakes involving sample size, sampling frequency, part identification, and making errors on offset adjustments to its CNC machines. The solution was to automate its metrology processes to reduce or eliminate mistakes entirely.

Founded in 1997, in recent years MTI has undergone expansions to reach full utilization of its current 130,000 ft² (1290 m²) manufacturing capacity. MTI’s production machining includes a contract with Ryobi Die Casting Inc. (Shelbyville, IN) to build the aluminum oil pans for the Power Stroke diesel engines available in the Ford Super Duty pickup. To build the part, MTI decided to fully automate its line that includes eight Mazak HCN 5000i HMCs, nine Fanuc Robotics R-2000 robots, five leak testers, and four Brown & Sharpe CMMs from Hexagon Metrology.

“We needed to improve our efficiency and eliminate mistakes,” says Doug Williams, MTI quality manager, of automating the metrology line, which was launched last October and is the shop’s most automated cell. The line uses vision systems that read Ryobi part information and put that in a 2-D data matrix that is pin-stamped on the parts. MTI puts 11 different components into the oil pans to complete each assembly, with the final part measuring approximately 27 × 12 × 10" (685 × 305 × 254 mm) and weighing about 30 lb (13.5 kg).

For quality control, parts coming off of each CNC machine are inspected on the Brown & Sharpe 7-10-7 CMMs in a one-out-of-10 frequency, Williams notes. “It’s a shop-floor-hardened machine,” he says of the CMMs, which were chosen for their proven shop-floor reliability. “It has some temperature compensation built into it. There’s no air bearings on it and it has linear guides to move the axes.

“As the parts come in through the washer, every tenth part gets into the CMM. There’s software inside the Mazak machine, from Ovation Engineering Inc. (Romeo, MI), and it feeds that into the system, analyzes it and takes a five-part average,” Williams explains of the package, which makes automatic instantaneous adjustments in the machining program. “When the fifth part comes in, the next one drops out, and it compares that. The limits are ±20 µm—if it’s outside that ±20 µm limit, the machine tool automatically adjusts and it runs one more part, like a first-article inspection.

“The CMM will measure a part, and then feed the report back to the CNC machine,” Williams says. “Settings in the machine control will analyze the data and when certain parameters are met, it will automatically adjust the offsets in the machine.” The Ovation software was purchased through Hexagon Metrology, he adds, and is specific for Mazak machines.

The key feature of the line is hidden deep in the PLC and data collection software, according to Williams. “At each process point, automated and manual, a time stamp is recorded into the database for that serial number,” he says. “At each measuring point—leak test, torque gun reading, CMM—that data are also uploaded to the database. At each monitoring point [camera pass/fail, contamination test, Loctite application] that data, too, is uploaded into the database. Even the 12 shots by the final inspection camera taken before packaging are recorded into the database linked to the serial number.

Since adding the automated metrology line, the cell runs nearly lights-out and quality has dramatically improved, Williams says. “This was our first go with it. We struggled a little bit with it at first,” he adds. “You want to make sure the process is in control to begin with, or it starts compensating for every part.”
robot, the 1350 kilo, has been taxed yet, as least in automo-
tive, although we’ve come across some foundry applications
that are pretty daunting.”

Flexible tooling for automotive is a key trend, notes
Nick Hunt, manager, automotive technology, ABB Robotics
(Auburn Hills, MI). “OEMs have recognized the role flexible
automation can play in reducing overall cost of automation.”
Hunt states. “This trend is reflected in the rise of requests for
larger payload robots for assembly transferring.

“In short, articulated robots with their programmable
auxiliary axes are considered to be more cost-effective
and reliable than conventional pneumatic tooling and hard
fixtures,” Hunt adds. “This allows robot-to-robot hand-offs
and robots to operate on an assembly being held by another
robot, and it enables very quick implementation of engineer-
ing changes because the robot tooling itself is also closed-
loop servo-controlled, and therefore programmable in the
robot controller.”

Robots with Vision, and Touch

Wider use of machine vision as well as structured light wave-
fronts will aid robotics users in the future, Hunt adds. “Moore’s
Law is alive and well, and vision sensor companies are racing to
leverage the power of the latest CPU technology,” he says. “Not
only machine vision hardware companies, but software compa-
nies that write the algorithms and CAM programs and academia
have joined the fray with a supply of PhDs racing to create the
efficient optical capture processes and transform functions
needed to quickly capture and process physical geometry to
produce highly accurate robot paths. In short, it allows robots
access to the ‘visage’ of the part, and from that to determine
how it varies from the nominal CAD dimensions. This new vision
technology will become an important part of quality assurance
and eventually take the place of conventional CMMs.”

Force/Torque (F/T) sensor technology also is making
headway, Hunt notes. “Assembly robots fitted with a six-
degree-of-freedom [6DOF] sensor allows the robot to ‘feel’ its
way through a process that previously required a human to do," he says. The technology is being used very successfully in material-removal operations such as grinding and polishing, Hunt adds, many of which are highly repetitive, mundane, and often lead to repetitive-stress injuries.

Automated Balancing Act

Automating tire balancing has been an area that most automotive OEMs have historically put less emphasis upon, until a recently developed fully automated balancing system came on the scene. It employs a patented composite balancing weight from 3M that replaces the standard balance weights made out of lead.

With the AutoW8t tire balancing system, co-developed by 3M Automotive in collaboration with Esys Automation (Auburn Hills, MI), auto OEMs and aftermarket tire suppliers can offer faster, more accurate tire balancing than previously was available. The system, which builds on a more manual Dispense and Cut System (DCS) system that Esys Automation first offered to BMW and General Motors, can cut cycle times in half, according to Scott Taylor, new business development manager, 3M Automotive Div. (St. Paul, MN, and Livonia, MI).

The AutoW8t automated tire balancing system from 3M Automotive and Esys Automation offers faster, more accurate tire balancing using 3M's nontoxic polymer composite wheel weights.

Dispense and Cut System (DCS) system that Esys Automation first offered to BMW and General Motors, can cut cycle times in half, according to Scott Taylor, new business development manager, 3M Automotive Div. (St. Paul, MN, and Livonia, MI).
The AutoW8t system automates the use of 3M’s composite weight material in a system Esys Automation designed using partner Kokusai Co. Ltd.’s (Japan and Indianapolis, IN) existing balancing machine frame components, and adding controls, software, and a light-payload Fanuc robot, or other robot brand depending on the buyer’s preference, equipped with special Kokusai-designed end-effectors for quickly and accurately automating the balancing process. The 3M material is a polymer composite designed by the company that is highly filled polymer composite that maintains physical properties of the neat polymer, Taylor notes.

“Moore’s Law is alive and well.”

“Typically highly loaded polymers lose flexibility and become brittle,” Taylor explains of the composite, which is dubbed 3M Wheel Weight material. The AutoW8t system, winner of an Automotive News 2012 PACE award, builds on the earlier DCS system, Taylor says. After reviewing the DCS technology, he recalls that “GM engineers immediately concluded they could automate the weight installation process.”

The AutoW8t system, which currently is in production at GM and is scheduled to be installed at a second major OEM, builds on the simplicity of the DCS, he adds. “It’s like plugging in a printer,” Taylor says. “The DCS is where most are getting started with this—it’s a very low-cost investment. The material handling system and the unwind system for the material are identical. The difference in the DCS is the [balancing] product gets cut automatically, but is manually installed to the wheel instead of with a fully automated process. But with the automated system, your cycle time is much faster, about 10 seconds versus more than 20 seconds for installation of two balance weights.

“What people are finding is that because they’re not stopping the line, the rest of the line is running smoother,” he adds, “so that the mount and inflator, and the soaper tire lube, all run smoother and there’s less downtime.”

The system speeds tire balancing, but also results in much more accurate tire balancing, adds Chris Marcus, Esys Automation CEO. “It’s a safe bet it’s at least a 2:1 cycle time improvement, possibly 3:1, depending on line configuration,” says Marcus. “Moreover, the improvement in quality is truly remarkable, and it becomes a lights-out process at that point.”

In designing the AutoW8t system, Esys used six-axis robots, smaller ABB or Fanuc units, with an emphasis on speed and accuracy. “There is somewhat of a payload requirement,” he adds. “As we reach out and up with the robot, it’s doing some cantilevering. With the Fanuc LR Mate 200i or with an ABB IRB 140T robot, we’re right at the limits of that. We like to be robot-neutral. We’re working on a Kuka design, and also Motoman and Kawasaki are on the roadmap.” The system’s primary PLC design is Allen-Bradley, but the company is also using Siemens and Mitsubishi models as well, he adds.

“The success of this machine is measured in residual imbalance, how much imbalance is left in the wheel after we’re done,” says Marcus. “It’s a significant decrease. I think the number that we’re all comfortable with is a 20% decrease in imbalance, significantly lower than existing systems—it’s the biggest development since the advent of dynamic balancing.”

Automated Deburring Cell

Advances in vision-guided robotics and the latest force-sensing capabilities are spurring new applications for robotic automation in automotive, notes John Lucier, automation
manager, Methods Machine Tools Inc. (Sudbury, MA). “Vision is such a big trend in robotics and the automotive industry is certainly embracing it. With some of the robot manufacturers having integrated vision, the ability to plug the camera directly into the robot, the cost of a vision system has come down dramatically,” Lucier says. “These integrated vision systems also have been specially designed to address the needs of robotics and robot applications making it easier for the integrator and the end user to utilize.”

“A six-degree-of-freedom [6DOF] sensor allows the robot to ‘feel’ its way through a process that previously required a human to do.”

For example, in “robot-guided vision” the ability for the vision system to send positional information directly to a robot at one time would have required a computer as part of the vision system to get the information from the camera and into the robot control. “Now, with the cameras literally plugging right in, that information already resides in the robot controller,” Lucier adds.

“Automotive parts can be large, complex shapes,” he adds. “Fixturing these shapes in an in-feed system so the robot can find them was always an important part of these automated lines. Now vision is being utilized more and more to find these shapes, saving costs and reducing complexity. Additionally, with the vision already part of the cell, there are alternate uses for vision such as part-checking, where vision is used for a simple ‘go/no-go’ decision. This could be used for basic part inspection telling the system whether to continue on.”

Force sensing is another new trend, Lucier says, with force sensing enabling robots to get feedback as to force on the robot and then to act on that feedback. “An example would be the robot taking a pin and probing a hole in a part to determine the position of the hole. This feedback could tell the robot when a part has ‘bottomed’ out during an assembly operation. This option will help push robots further into automotive assembly.”

Among the advanced automation available from Methods is a production cell featuring two Feeler VMP-580 VMCs being serviced by a Fanuc M-20iA robot to perform machining on two different sides of the part and then deburring the parts prior to placing the finished parts on the out-feed conveyor.

“The deburring is accomplished,” Lucier says, “by having the robot, with the finished machined part that was just unloaded still in the gripper, bring that part over to one of three ATI-compliant pneumatic deburring heads, which are essentially pneumatic spindles designed to hold a tool,” Lucier says. “The special thing about these heads is the built-in ‘compliance’ or float in the head. Since it is difficult to ‘offset’ or shift the part or the tool in a robotic deburring operation, the compliance feature allows the robot to engage or press the part against the tool using this float. As the tool wears, some of this float is used to facilitate constant pressure of the tool against the part during the deburring operation. This float pressure is controlled by air pressure and is adjustable.

“In this application we are using the robot to bring the part to the deburring heads and articulating the part around the deburring tool. It is also possible to have the robot take the tool and bring it to the part and have the robot articulate the tool around the part. We are using three deburring heads to facilitate the use of three different types of deburring tools. One head is holding a small wire wheel, another head is holding a chamfer tool, and the last head is holding a round ‘burr ball.’ This deburring operation is being done during the machining cycle, so no additional time is added to the part cycle.” ME

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