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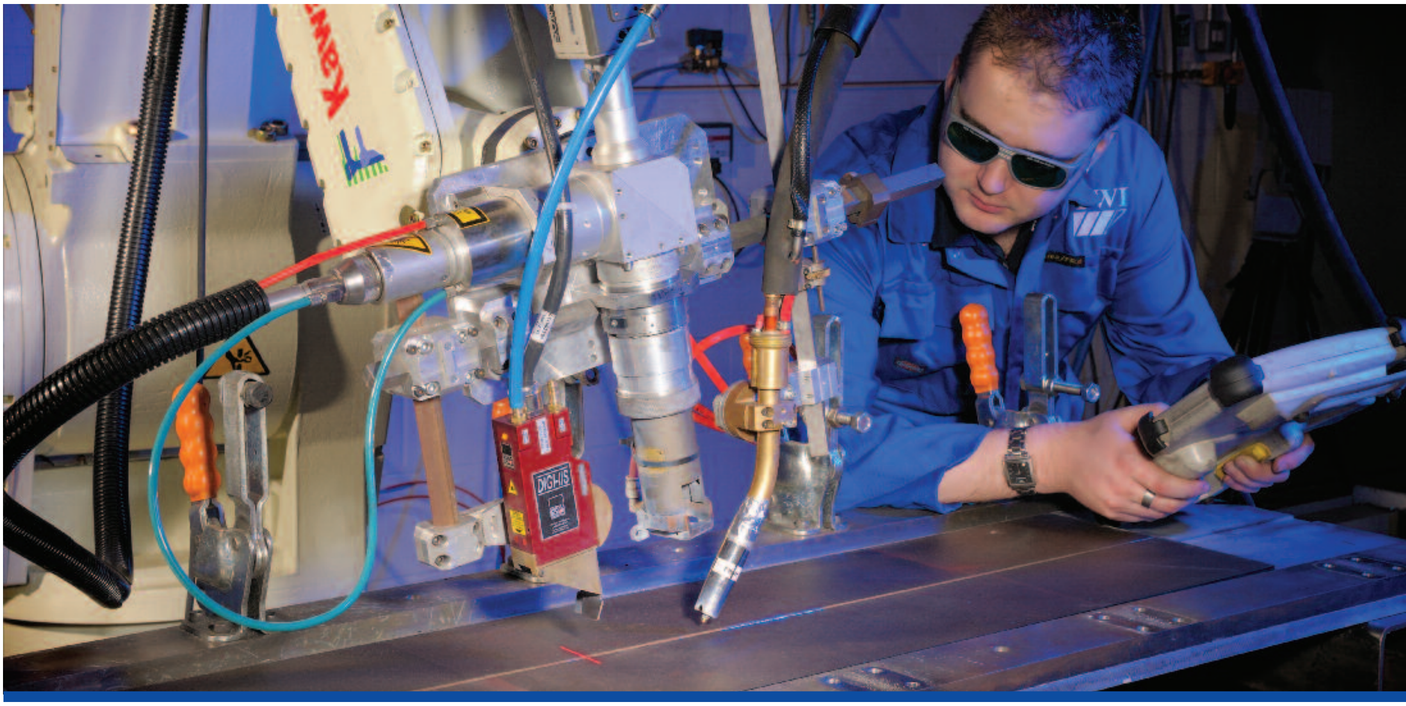
TAKING **ADAPTIVE** MEASURES

Adding senses of vision and touch to robots offers huge production potential for job shops and manufacturers alike

Vision systems enable robotic welders to adapt to welding paths if there are part irregularities. Force control ensures a robot maintains torch distance from the workpiece.



Servo-Robot's adaptive vision systems give this hybrid laser-arc welder the flexibility to compensate for material warpage, should the material shift out of place. The robot keeps welding, without downtime. Photo: TWI Ltd.

For decades, modern pop culture has harped on the notion of what it means to be a robot. From the multifunctional R2-D2, to the deadly T-1000 and ominously sentient computer HAL 9000, the androids all have a common denominator: adaptability. In reality, most robots are integrated into an automated operation of some type—in this case, metal manufacturing. They can be programmed to weld, pick, hold and feed. But the efficacy of any of those tasks is contingent on external parameters upon which the robot acts.

What is becoming real, and affordable, is the ability to add senses to robots, giving them greater adaptability. The technology is nothing new for two specific senses: vision and tactile force control. A robot with multiple axes can impressively contort itself to lay down a tight bead that a welder can't reach, though without advanced sense technology, the robot's added manufacturing value is limited.

However, more than ever, the programmability behind these senses is user-friendly, making the robots more accessible to operators who might otherwise do the job themselves if the control interface is too complicated. The right combination of software, hardware and savvy operator reduces downtime, improves part handling and minimizes maintenance—all beefing up the bottom line. And the ROI is more pronounced in larger manufacturing operations with lots of automation in use.

In this article on automation, we take an industry pulse on what segments of the robotic world—from OEM to manufacturer—are harnessing vision and force control systems for added value.

Eye on the prize

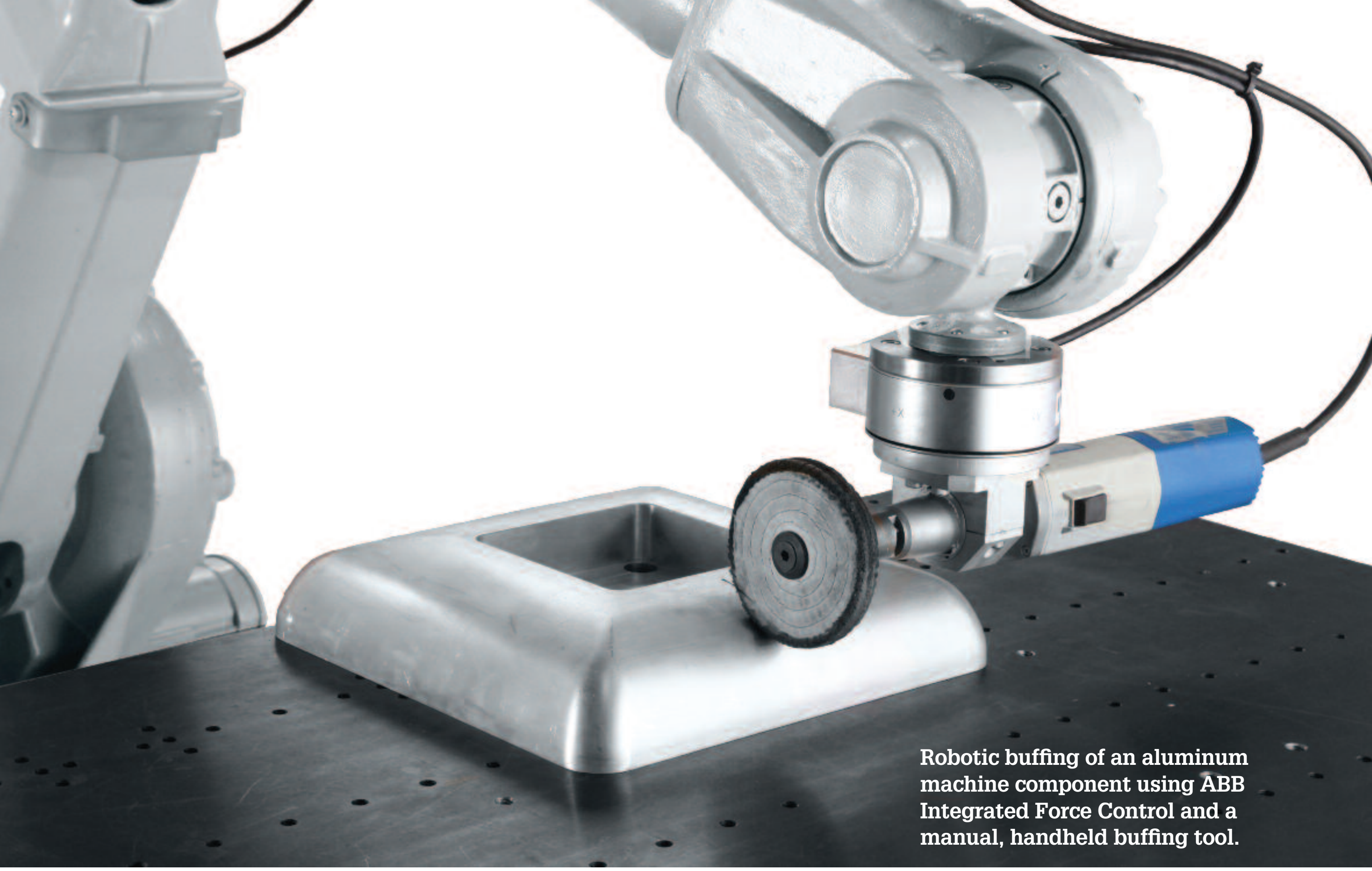
As more OEMs and integrators see the light that improved vision systems shed on robots, end users across a broad swath of industries stand to benefit. There are still manufacturers and job shops out there without much household knowledge about this technology. Robotic welding of all types is one of the most common automated processes, and one where some of the biggest advancements are being made.

One OEM, Motoman, the robotics division of Yaskawa America Inc. in Miamisburg, Ohio, has a customer who uses several laser-based seam tracking systems on its welding robots. The customer, based in Mississippi, fabricates electrical transformers using sensors for precision, rather than focusing on improving part consistency.

"They viewed their ability to handle part variation as an asset," says Chris Anderson, product marketing manager for welding at Motoman. "Rather than have tight incoming material specs, their purchasing agents have latitude to buy steel that other companies would reject," and thus save significant money.

What that means is every single blank doesn't need to be precisely cut or formed to spec for a quality part to be fabricated. The weld quality standards are high because the transformers are filled with oil and must be leak tight. The robots, equipped with sensors, had repair rates consistently lower than manual welding operations.

The demand for this adaptive automation is growing, but it's equally being pushed to the market by OEMs and integrators. As manufacturers want equipment that can adapt to their changing environment, suppliers are integrating sensors and working to simplify how they interface. But



Robotic buffing of an aluminum machine component using ABB Integrated Force Control and a manual, handheld buffing tool.

applying a technology like vision requires some basic knowledge of optics, lighting and image processing on the operator end.

"A successful application of vision is easily done with off-the-shelf components as long as the basics are followed," Anderson says.

For the most part, robotic OEMs don't manufacture sensors. Rather, they leave that to a company that specializes in making them, then the OEM integrates their hardware. Among the bigger vision systems makers is Servo-Robot, based in Quebec. It makes specified iterations of vision systems, such as arc and laser weld seam finding, seam tracking, weld inspection, material handling and range measurement.

Servo-Robot's vision sensors are integrated in robotic systems by OTC Daihen, as well. Daihen manufactures the robot, welding power source, torch and all equipment that make up a welding robot package. It also makes wire touch sensors and through-the-arc seam tracking sensors, but not laser sensors.

Generally, advanced automation systems are found in bigger manufacturing or assembly operations—think automotive or aerospace. But Tipp City, Ohio-based Daihen, which manufactures welding and positioning robots, actually sells most of its systems to the small- to mid-size job shop type customers.

Aside from some of its larger customers, "We sell to the middle and to the small guy," says Darryl Swann, national sales manager at Daihen. Its job shop customers, in the 50- to 100-employee range at most, can be a difficult sell because of the sticker price associated with sense-equipped robots. "But if they can justify having it and can see a return, they'll go forward with purchasing a [laser welding] robot package."

According to Daihen, one of the factors driving fabricators to shell out resources for such a system is reduced downtime. When productivity goes up, fabricators of any size will produce more. And it's not necessarily the robot itself that will justify a purchase, it's adding the senses like a welding vision laser tracking system, for example, that will.

"For a job we did a few years ago, the customer had parts that were similar in dimension, but of varying length," says Tony Gist, technical supervisor at Daihen. "They had seven different programs, and they were able to come in with our laser and cut it down to one program. It also cut down on robot re-teaching time and new program creation by about 60 percent."

With arc welding, through-arc seam tracking has been around for about 30 years, says Anderson at Motoman. But adaptable sensor use is also growing with the need to identify varied workpiece locations and help error proof or detect variations in parts prior to indexing a part for welding in a cell, for example. "The vision system is independent of robot operation, but does the work of proximity switches and PLC logic for the part tooling," which cuts downtime that can occur when parts are loaded incorrectly, and nixes the cost of individual sensors and the maintenance they require, he says.

Use the force

Force control technology, also referred to as tactile feedback, gives robots fine-tuned instructions based on how much force is being applied to a part, before it reacts. Humans are infinitely more adaptable than robots, but once the latter is programmed for a task, it doesn't forget.

Force control sensors are affixed between the robot's arm and the end effector

Force control sensors, like the one attached to the end of this robot, precisely govern how much force an end effector applies during a job.

(gripper, hand, claw—any end of arm tool). Depending on the job, a force control sensor acts not unlike a torque wrench, where a user can adjust the tool's applied force based on the reported force. Force sensors, when integrated with a welding robot, can keep steady pressure applied to the workpiece for friction stir welding, for example. The sensor allows the robot controller to compensate by adjusting the robot's applied pressure to keep welds consistent. Too much force, and you can overheat the material. Likewise, with too little force, you risk a bad weld.

ATI Industrial Automation, Apex, N.C., a robotic tooling engineering firm, makes a line of six-axis force/torque control sensors for nearly any application and working condition, such as wet or dusty environments. For a common metal finishing scenario, ATI's sensors can report the pressure a robot-mounted sanding head exerts. Their sensors also can wirelessly transmit F/T data over a universal datagram protocol.

"You can program the robot so that it knows to keep the force sensor reading at, say 18 to 22 lbs. of pressure on that part as it grinds or sands a part," says Greg Parnell, senior force/torque applications specialist at ATI. "There are also haptic systems where the operator can feel the forces being exerted on a part, so if they're trying to apply a certain pressure with a hand grinder, they can control the robot with a haptic controller."

The force/torque sensors ensure more rudimentary skills, like part handling, too. One of ATI's customers moves a very expensive part throughout a process for which they use an F/T sensor to maintain position and eliminate the risk of damage.

When a robot's behavior is able to adapt to a process in real time, the result is improved quality and tool life. ABB Robotics, for instance, released its integrated version of their long-standing force control function package, now called IFC, released in December 2013. This version is more encapsulated and flexible, according to Nicholas Hunt, manager of technology and support for ABB Robotics in the United States, based in Auburn Hills, Mich. Force control gives the company's signature orange (transitioned to graphite white late in 2013) robots the needed sensor feedback to adapt to their surroundings by altering programmed position, path or speed to accommodate complex jobs.

Hunt gives the example of parting lines on castings as an ideal example of robot adaptability with force control. Large sections of molding flash sometimes need to be removed by grinding. A robot equipped with force sensors can give it an almost "humanlike" ability to sense when it has encountered an unworkable area of a part and make the decision to take a different approach. "Behaviors defined by the application engineer triggered by thresholds, for example, can direct the robot to reconsider the process path in favor of a less aggressive one," says Hunt.

Regardless of the force control application, the robot cannot do much without a programmer. The more adaptive the robots, the more productive a manufacturer will be. Hunt says IFC is the trifecta solution manufacturers need in their production arsenal. "Force control has three distinct benefits in material removing applications: reduced cycle time, extended tool life, and significantly reduced programming time."

Determining demand

The big question for adding senses to robots is whether there's strong demand, or if it's more an outward push by robotic OEMs and integrators to get fabricators on board. ATI's engineers see it more as a demand from customers. As the industry learns more about adaptability technology, "it's helping them, they're realizing it and creating demand for it," says Parnell.

Others, however, see it differently. Michael Gurney, co-CEO at Concept Systems, an Albany, Ore.-based control systems integrator, says customers are asking for it, but don't realize they are asking for it. "Most customers have manual processes with multiple workers that they would like to automate. All of their current workers are highly adaptable."

For other areas of metal work, it might not be an issue of demand so much as necessity. Gurney adds that in the metal creation world, adaptability is the price of admission. People have dangerous jobs mainly because no system has been successful to date in adapting to the extreme environments and surviving the dangers. "Future systems will not just bring power and durability to the processes, but must identify various dangers like humans do to survive," he says.

Vision, and especially force control, are ideal for jobs where the environment is hostile or the work is highly repetitive and physical, adds Hunt at ABB.

In any case, safety is a top priority. Most vision or force systems monitor surrounding conditions, and will shut off if a hapless operator enters the work area. (Although, a shop has bigger problems if a worker isn't where he should be.) As the word about adaptive senses like vision and force spreads throughout the industry, more robotic systems should appear in smaller job shops where the human operator currently prevails. But without the human element, a sense-equipped robot might as well be blind. **FFJ**