While robots have been deployed in high-profile surgical applications in recent years, using a specialized apparatus like the da Vinci surgical system, the majority of industrial or commercial medical uses for robots are somewhat more commonplace. Industrial robots are used extensively for polishing and finishing orthopedic implants, where robots alleviate the risks and tedium of such tasks for factory workers, and robots also are widely used automating operations in medical-device manufacturing, as well as in pharmaceutical, R&D laboratories, and hospital settings.

Orthopedic implants are a staple at Acme Manufacturing Co. (Auburn Hills, MI), a surface-finishing specialist that manufactures turnkey robotic finishing systems. An authorized integrator for Fanuc Robotics America (Rochester Hills, MI),
Acme is the largest producer of robotic finishing equipment in the world, according to Acme Manufacturing President Fritz Carlson, with more than 100 robotic finishing systems in production.

For medical finishing applications, Acme generally uses Fanuc robots with 20–50 kg payloads. “In the old days, we used to use 10 and 12-kg robots,” notes Carlson. “People have that idea of bigger is better, but I don’t know if that’s the case, because we’ve got a lot of those old robots that are still running today. And then we actually have some applications running in medical in the foundry side of the business, where we’re using 165-kg robots, for cut-off and gig grinding.

“They’re investment castings, so they cast a tree of parts and then our robot picks up that tree of parts, uses vision to find the parts on the tree, and then it takes it to a high-horsepower, abrasive cut-off wheel and cuts the parts off,” Carlson says of the medical implant finishing process. “After they’re cut off, the parts go to another operation, where we actually grind down the gate that’s left on the part. Most knees are cast, and because they’re cast, they start out with a tree. They start out with wax molds and then they build a silica coating over these wax molds, that’s where you get the mold for, and that’s where they pour the cobalt chrome in to make the part.”

Acme designs and builds automated systems for centerless grinding, robotic finishing, flat-stock grinding, and custom turnkey finishing solutions. The 101-year-old, family-owned company has about 70 employees worldwide, and it offers buffing, polishing, grinding, deburring, and micropolishing for automotive, aerospace, medical, and other industries at its 50,000 ft² (4645 m²) engineering and manufacturing facility in Auburn Hills. The company polishes and finishes medical implants including knees, hip stems, hip cups and balls, hip shells, tibia trays, bone plates and nails made of chrome cobalt, zirconium, titanium, and stainless.

“We built our first cell for the industry in 1990, and since then we’ve built over 100,” says Carlson, noting that exports account for about 70% of Acme’s business. “We have them in North America, Brazil, Ireland, England, Taiwan, and soon we’ll have them in China and India.”

Most knee implants are made of cobalt chrome, he adds. “It’s a high-nickel alloy, and it’s an expensive material. The problem with castings is that it’s hard to produce an accurate, repeatable casting, so that affects the grinders that you use,” Carlson observes. “If the castings aren’t good, then it’s going to affect the robot, too, for grinding and polishing and buffing.”

While some companies may try alternatives, robotic finishing offers manufacturers a stable, cost-effective process for medical implants. “At the end of the day, it’s all about unit cost,” he adds. “You want to have a process that’s going to deliver the lowest unit cost. What is it costing you manufacture a part a certain way? Then you have to look at how they tolerance these parts—is it three decimals, or four decimals? There are some customers we’ve got around the world that don’t even use a grinder—they just let the robot do everything, but we’re not going to be able to produce the tolerances that a five-axis CNC grinder’s going to produce. It all depends on what’s on their part print.

“Generally, we can polish probably down to plus or minus six to eight thousandths. Every manufacturer has their own specifications. It varies from company to company. But there’s definitely a cost when somebody throws some really tight tolerances on there. Hopefully, there’s some value in the tolerance; otherwise, you’re paying a lot of money for something that’s just going to add cost to your process.”

Deploying robots for finishing applications can off-load what is an often dangerous and difficult job for factory-floor personnel. “We call it the three D’s—dirty, dangerous, and demeaning. That’s what hand polishing and buffing and grinding are all about,” Carlson states. “You get carpal tunnel or other injuries. It’s very hard, at least in the US, to find people to do
this job. In fact, even in China we’re embarking on a huge program with a company that’s not in the medical industry that wants to automate all their finishing with robots. Even though Chinese labor is so cheap, the turnover is 30%. They can’t tolerate that.”

“At the end of the day, it’s all about unit cost.”

As many Baby Boomers near retirement, Carlson sees upcoming difficulties in replacing the many experienced hand finishers at most of the major implant makers located in the Warsaw, Indiana, area. “The turnover’s not that high here, but you’re not going to find a young person today that’s going to want to sit in front of a hand jack and polish parts,” Carlson says. “That’s what I think is one of the challenges facing Warsaw, which is like the Mecca of the implant world—you’ve got Zimmer, DePuy, and Biomet there. This probably goes back a few years, but I was told over the next five years, they’re going to have 200 polishers retiring in that small town. Young people today don’t want to do that kind of work. It’s just not good, from a health and safety standpoint.”

With robotic finishing, medical manufacturers can avoid exposing their workers to abrasive metals and risks of injury on the job, says Carlson, who notes that the costs for safety gear alone can easily exceed $2000 per year. “They wear respirators, earplugs, safety glasses, gloves. You spend a lot on just safety apparatus.”

For medical part finishing, Acme developed a flexible Ultra-Light Floating Head that uses automatic force control for the finishing heads with variable-speed spindle motors that optimize compliance, response, and reaction to suit the operation. If one surface area needs more pressure, it gets it; a few seconds later, pressure is lessened as the robot repositions the part to another surface. Meanwhile, speeds and feed rate are adjusted. The result is greater uniformity and improved surface quality.
Acme also has developed universal tooling concepts for knee and hip finishing to help reduce system design, build, and operational costs.

“It’s nice for cobalt chrome, but we really developed that for titanium and zirconium,” Carlson notes of the floating heads. “Because those metals burn a lot easier, you need a lighter floating head so that you don’t burn the part. If you burn the part, you pretty much scrap it. So you need a lighter floating head and we developed that specifically for titanium and zirconium.”

Acme also lends customers its off-line programming expertise and uses Fanuc Robotics’ Roboguide simulation of robotic finishing operations, even for complex parts and shapes, that help customers speed up the application development process and increases utilization. The company offers integrated dust collection, with an exhaust system in a fully-enclosed cell that confines airborne polishing and grinding particles to protect the plant environment, and it builds robotic workcells to RIA and CE specifications.

Robotic packaging for medical-related industries can run the gamut from kitting to medical devices and pharmaceutical uses, notes Dick Motley, senior account manager, national distribution, Fanuc Robotics America (Rochester Hills, MI), who works with Fanuc’s integrators in all industries. “Packaging operations, which can involve some kitting or test kits, are a big area. Medical devices are as well, and there's also quite a bit done in terms of research laboratories,” Motley says.

Pharmaceutical companies use robotic automation with work on assays, running repetitive tests to shrink the field down. “There’s a ton of testing going on, and also pharmacy automation, typically in a mail-order or an institutional setting,” Motley observes. “Sometimes there’s some in-process testing that's done by the robot, with a quality audit that the robot would do 100%. As far as broad categories, in principle, it’s not that far from why our traditional automotive customers automated—it's either boring and tedious, there's some type of ergonomic issue, or there's a quality impact, where a robot can deliver better process consistency.”

Vision-guided systems and force-control sensing are advantages for medical users of robotic automation. Using Fanuc’s iRVision, users can check the integrity of the process, with in-process verification and traceability, Motley notes. “It’s very easy to implement with a sighted robot. In the case of those implants, you can have very flexible presentation of a variety
of different parts that you don’t have to tool up specifically for each part. You can have a generic presentation of the parts, and the robot just finds them as they’re delivered. You also can do some in-process verification on critical features.

“We call it the three D’s—dirty, dangerous, and demeaning. That’s what hand polishing and buffing and grinding are all about.”

**Medical robots tend to be smaller** machines that are widely used in high-speed, pick-and-place applications. “When people talk about medical robots, there’s three or four different main classes,” notes Joe Campbell, vice president, US Robot Products Group, ABB Robotics North America (Auburn Hills, MI). “There’s lots of activity there with our Flexpicker robots kitting products like blister packs, and we also do a lot of polishing of hip and knee replacement components.”

Laboratory automation is a large part of robotic medical applications, he adds. “One of these is drug discovery, where the task is to come up with a compound that they think kills bugs,” Campbell says. “They load the compounds into thousands of microtiter plates, which are very small and have lots of individual wells.” Faster, small robots are best suited to this process, which has many iterations. “It’s typically...
done with Cartesian robots, and with SCARA [Selective Compliance Assembly Robot Arm] or with small six-axis robots like our IRB 120. There’s been such an explosion in that testing arena,” says Campbell. “It is being automated aggressively.”

Large drug manufacturers like Novartis have exploited the speed of robots such as ABB Robotics’ FlexPicker line and other smaller robots built for speed. “You could use the FlexPicker for that, it really depends on the builder’s strategy,” Campbell says. “You can also use tabletop six-axis robot; it’s small, light payload stuff. Cartesian is two to three linear axes bolted together, so it’s like a gantry robot; it’s X-Y-Z, and then there’s usually a fourth rotary axis down on the wrist. SCARA is a kinematic configuration with four revolute axes, which are revolving, circular axes, not linear, that are stacked together.

“The last class is where you’ve got patient interaction. There are a number of applications now with direct patient contact,” Campbell adds. “There’s a company called Restoration Robotics that has come up with a process for harvesting and implantation of hair follicles, and then there are other classes of robots that are manipulating instruments around a patient, like Accuray’s CyberKnife.”

Autonomous mobile robots are making headway in pharmaceutical, testing labs, and in hospitals, notes Erin Rapacki, product manager—mobile robots, Adept Technology Inc. (Pleasanton, CA). Improvements in mobile robot navigation software and in the cost equation, Rapacki says, have led the healthcare field to be more open to adopting mobile robotic systems.

In August, Adept and Swisslog Healthcare Solutions (Denver, CO, and Switzerland), a supplier of logistics automation solutions for healthcare, signed an agreement for Adept to be the exclusive provider of autonomous robots to Swisslog for use in hospitals, labs, and clinics for transporting specimens, lab samples, and pharmaceuticals. Last year, Adept acquired MobileRobots Inc. (Amherst, NH), a 15-year-old developer of autonomous robots, in a deal valued at approximately $4.5 million.

“One of the reasons for the partnership is Swisslog definitely realizes why our robots operate differently than other AGVs, or automated guided vehicles.”
Rapacki says. “AGVs in the hospital are not a new concept—they’ve been around for decades, but they’re not that highly adopted. Now, Swisslog has fielded about four or five installations of mobile robots at hospitals that have been running continuously for four or five years.”

**Building on the MobileRobots acquisition,** Adept has expanded the technology it acquired, she adds. “MobileRobots has been around 15 years,” Rapacki notes. “It’s quite impressive what they did. They’re rooted in the research community, so colleges and universities across the world, robotic labs, and computer science labs bought these robots to use so their students can develop on them. Over time, these roboticists across the world contributed to the software base, and it was robust

“Over that time, roboticists got really good at making robots do point-to-point navigation.”

Along with another partner, RMT Robotics (Grimsby, Ontario, Canada), a manufacturer and integrator of the ADAM line intelligent mobile robots, Adept has expanded the market for medical applications. “We built on the navigation software. We have what we call Natural Feature Navigation,” Rapacki adds. “It evolved out of the robotic research community from something called SLAM, or Simultaneous Location and Mapping, where SLAM algorithms are open source. They’ve been available to everyone in the robotics community over a decade, and over that time, roboticists got really good at making robots do point-to-point navigation.”

The current crop of Adept mobile robots cost much less and function much better than older mobile robot systems, which typically used tapes on the floor to navigate. The new Adept robots are smaller, less expensive, and safer for people to be around, Rapacki adds, and are equipped with laser range finders and 3-D cameras to help with navigation. “It’s safe around people; it allows you to stop and go around,” she adds. “Standard AGVs are a fire hazard, they’re too heavy, and too fixed. These automated robots are good for hospitals because they cost much less to deploy. It’s about having people doing higher-value jobs.”

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