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*With advances in robotics and automation systems,  
innovative manufacturers spur*

## Shop-Floor Productivity

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Milling with KUKA robots is demonstrated as this unit mills a large prototype piece for the Spanish bullet train.



Staying competitive in manufacturing demands the utmost in automation. To keep factories from moving offshore, manufacturers must invest in the latest technical advances in robotics, automation software, and conveyor systems to compete more effectively with low-cost producers.

Among the latest advances are robotic milling techniques, faster six-axis robots, and vision-based systems that enable new applications deploying robots in the factory. New factory software solutions aimed at increasing productivity on the shop floor, and the latest automated conveyor systems also are helping manufacturers boost their efficiencies.

**Robotic milling** holds promise for robotic rapid prototyping applications and for machining softer materials including aluminum, says Joe Campbell, director of strategic alliances, KUKA Robotics Corp. (Clinton Township, MI), a subsidiary of KUKA Roboter GmbH (Augsburg, Germany). "We're seeing this transition now where robots are being used for a lot of machining processes, in softer materials and prototyping. This is an area that was previously dominated by machine tools."

Production applications using KUKA robots for milling workpieces already have been done in Europe, Campbell says, and the first projects are currently queuing up in North America. Applications in Europe include milling a prototype of the front of the Spanish bullet train. The KUKA robotic milling techniques are aimed at robotic machining softer materials at lower precision, including cutting of aluminum to  $\pm 0.030 - 0.040$ " (0.762 - 1.02 mm), depending on the application.

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"We think there's a crossover point on the technology, where the robot and the control structures are becoming precise enough," Campbell notes. "Robots are stiff enough, frankly, and the control schemes are delivering enough accuracy, too. Generally what we say is if you have either hard materials, like steel, or you have very, very high tolerances, then it's probably not appropriate."

For machining aluminum or materials including bend board or clay for prototyping applications, robotic milling works very well, he says. "We're lab-testing aluminum jobs right now," Campbell says, "and we'll have some in production here very quickly. It's modest precision in aluminum."

"It'll be process-dependent, and it also depends on how you're going to program," he adds. "If you're going to do taught points, obviously you're going to be much more precise. If you're doing complete offline programming from a CAD system, then we start dropping precision."

**Programming the robots** plays a key role in machining by robot, and to that end, CAD/CAM developer Delcam plc (Birmingham, UK) recently announced an agreement with KUKA to develop tools for its PowerMILL machining software that can be used with KUKA's control systems to more easily program robots for a much wider range of applications.

"We anticipate that the main applications will be in pattern-making and in trimming of composite components," says Peter Dickin of Delcam. "However, the technology can be used in any area where softer materials need to be machined to accuracies of tenths of a millimeter. While this does not match the tolerances possible with a machine tool, it can often be more than adequate for components that might be several meters in length."

Delcam's collaboration with KUKA will develop easy-to-use routines within the PowerMILL CAM software. "These routines can quickly generate programs for its robots that allow smooth machining of large components," Dickin adds. "Now that this development work has been completed, we will be working together to promote this new approach to large-scale machining operations."

Machining with robots makes sense in some applications due to the much lower cost of a robotic arm when compared to a full machine tool. "A robot's work volume, on a per-dollar basis, is a fraction of the cost of a machine tool's work volume," Campbell notes. "In a lot of cases, we see people doing big parts and doing relatively small machining processes on them, but these are big parts that wind up getting fixtured and tooled on a big machine tool at a very high capital cost, and a very low throughput."

"We have a couple of customers who swear they're going to go do some work on low-grade stainless, but we'll wait and see. What I've been telling people is, it's an unknown process. With a machine tool, you know how much material you can take off, with a given tool, with a given spindle and a given horsepower. That's well characterized, and we're not there yet."

**Six-axis robots** also are finding new niches for automating the factory, such as KUKA's lower-cost, shelf-mount six-axis robots that help save factory floor space. The full-size six-axis systems feature capacities to 60 kg and offer a reach of 2200 mm. "We're seeing growth of specialized kinematics, and we have this whole family of robots we call 'shelf-mounted,'" Campbell says. "They're actually designed to be hung on top of a machine, whether it's an injection-molding machine, or a die-casting machine, or a machine tool."