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   □ Miscellaneous Manufacturing
   □ Wholesale/Trade/Durable Goods
   □ Other Manufacturing NEC

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   or service performed. (please specify)

4. Number of employees at your company.
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Whether heavy, tall, light or small, lifting and moving parts can be a challenge. Cover image courtesy of Verti-Lift Inc.

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**CTEPlus Online**

Watch a demonstration of a Universal Robots UR5e arm and a Robotiq dual Hand-E gripper on a 2012 Haas ST20SS that helped a shop raise productivity by 34%.

http://cteplus.delivr.com/2ew8v

Platinum Tooling Technologies Inc. highlights products that the company would have exhibited at IMTS if the trade show had not been canceled.

http://cteplus.delivr.com/2n55y

Jeffrey Badger, Ph.D., aka The Grinding Doc, published “The Book of Grinding” for shops that want to educate themselves about grinding.

http://cteplus.delivr.com/2jv78

If you missed the Video Showcase in August’s issue, check it out on ctemag.com to see the latest offerings from CGTech, Vollmer of America, Marubeni Citizen-Cincom, OSG USA, Kyocera Precision Tools, Tungaloy America, Hainbuch America and Anca CNC Machines. Cue video! See this and more on CTE social media.
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ADDITIVE DIRECT ENERGY DEPOSITION. DP Technology Corp. unveiled the first commercial version of Esprit that includes additive direct energy deposition cycles. The product features three-, four- and five-axis direct energy deposition support. Combined with the subtractive processes and embedded into a single software, this brings a full spectrum of support to hybrid manufacturing.

DP Technology Corp.; www.espritcam.com

CIRCULAR SAW BLADES. Designed for the most demanding applications, the metalcutting circular saw blade line from Milwaukee Tool reportedly lasts longer and cuts cleaner and faster – without lubricant. Engineered with a hand-tensioned, hardened alloy steel body, the blades are equipped with carbide-tipped teeth with an alternate top bevel grind to shear through metal, leaving burr-free and cool-to-the-touch cuts.

Milwaukee Tool; www.milwaukeetool.com

CENTERLESS GRINDING MACHINE. Glebar Co. developed a machine platform capable of processing carbide cutting blanks. The GT-610 EZ centerless grinding machine is said to excel at through-feed grinding of hard materials, such as steel, carbide, PCD inserts and technical ceramics, while operating with a small footprint.

Glebar Co.; www.glebar.com

TOOL GRINDING MACHINE. Rollomatic Inc.’s GrindSmart 630XW tool grinding machine has new capabilities for grinding solid-carbide boring bars and other stationary cutting tools. Grinding boring bars on the machine offers exceptional flexibility compared with conventional single-purpose grinders. With six fully interpolating CNC axes and a six-station wheel/nozzle changer, the machine can be adapted for individual boring bar designs for short and long runs.

Rollomatic Inc.; www.rollomaticusa.com
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A PICK-AND-PLACE FIRST

By William Leventon

Good machining starts with parts that are placed accurately and oriented the same way each time. Machine loading can be done by an operator, but it is a dull, repetitive job and normally not the best way to utilize valuable manpower on a shop floor.

Furthermore, manual loading “never achieves the highest efficiency or machine uptime,” said Joe Campbell, senior manager of applications development and marketing at Universal Robots USA Inc. in Ann Arbor, Michigan.

So the company has introduced a pick-and-place kit to automate the job without the major integration and programming efforts usually required to install and set up an automated bin-picking system. The kit, which is called ActiNav, includes a 3D laser scanner camera meant to be located in a fixed position above a bin; a Universal Robots USA collaborative robot, or cobot; and a special motion control module. In addition to the items in the kit, users need a mounting frame for the components and end-of-arm tooling that allows the robot to pick up parts. The end effector can be a gripper or vacuum system.

The task for the robot arm is to pick a part out of a bin, safely move the part to a machine and then properly load the part. Because the locations and orientations of all parts in the bin are different, the path that each part travels to be loaded into the machine is different as well.

“With other systems, all those different path configurations have to be taught,” Campbell said. “This requires days of programming and hundreds of lines of code.”

With ActiNav, however, path planning for each part is automated thanks to the Autonomous Motion Module, a separate controller that interfaces with the cobot controller. To determine part orientation, the module gets information from an image capture of every part to be picked up. The module plans the optimal paths for placement of parts in the machine and controls the cobot moving the parts. He said no other pick-and-place system automatically plans loading paths and then moves parts accordingly, which is why ActiNav is billed as the first autonomous bin-picking kit for machine-tending applications.

Universal Robots USA also touts the fact that ActiNav requires no machine vision or robotic programming expertise. Setup is a wizard-guided process presented to a user by the cobot’s teach pendant, which is a hand-held unit with a screen that interfaces with the control system.

The process relies on both “teach by demonstration” and “scan to teach” procedures. Employing the former, a user touches objects in an environment with the cobot arm so the system will know their positions to avoid collisions. A user also

ctemag.com
For more information about ActiNav, view a video presentation at www.ctemag.com by scanning the QR code on your smartphone or entering this URL on your web browser: cteplus.delivr.com/2ayz2

about the author
William Leventon is a contributing writer for CTE. Contact him at 609-926-6447 or wleventon@gmail.com.
touches the top, bottom and sides of the bin with the cobot arm to teach the system the bin shape.

After importing a 3D CAD model of a part into the system, a user attaches one of the parts to the end effector in the correct orientation. The part then is positioned under the camera, and the user presses “scan to teach” to take a picture that captures the relationship between the part and the end effector.

To train the system for part placement, a user simply moves a part and the arm to the place location. The system will remember that location, as well as the part orientation.

The wizard-guided process enables in-house personnel to finish setup work in just six steps. Initial setup can be completed in a couple of hours, according to Universal Robots USA. What’s more, the company reports that programming is reduced from the hundreds of lines required by conventional systems to a dozen lines or less.

In addition, autonomous motion allows ActiNav to operate inside deep bins.

“In a deep bin, there are so many possible part orientations and locations that it’s much more difficult to program all the different path scenarios,” Campbell said. “But because ActiNav generates its own path for final placement, it can operate quite well in deeper bins.”

Since deeper bins hold more parts, the bins need to be refilled less often, which increases machine uptime.

On the downside, ActiNav may have trouble keeping up when machining cycle times are very short. Campbell said cycle times of less than 10 seconds could pose a problem for the system.

Although ActiNav can be beneficial for high-volume production of a single part, he said the kit is particularly well suited for small job shops that do high-mix, low-volume work.

These shops may want to automate machine loading, but “they just can’t afford the level of programming and customization that would normally be required every time they want to change a part,” Campbell said. “So that’s where rapid setup and programming really make a big difference.”

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OPTIMIZATION FOR HIRE

By CGTech Inc.

As a CNC programmer for the proposal engineering department at Ingersoll Cutting Tool Co. in Rockford, Illinois, Mike Gampetro spends his days improving machining processes for customers. There could be an Inconel part for which he suggests ways to increase tool life, or it might be a long runner where every second of cycle time counts. No matter the situation, his job is to generate ideas that his customers can use to produce more parts in less time — and hopefully reduce operating costs along the way.

His company, which does business as Ingersoll Cutting Tools, helps machine shops of all sizes. One of the tools that provides no-cost assistance is Vericut toolpath simulation software from Irvine, California-based CGTech Inc.

“In most cases, a customer sends me their Vericut file and hopefully the NC program together with a tool list,” Gampetro said. “I’ll look at the existing metal removal rate, the cycle time, and make recommendations on how they can improve the process.”

He often needs to reprogram a job from scratch. When that happens, he runs a comparison between his revised cycle time and the legacy program. Vericut validates his recommendations. When done, he sends a revised tooling list, along with screenshots of the process, to the customer. If it has Vericut — he said most clients do — he includes a Vericut file in the package as well.

The results are worth the effort. Gampetro is able to reduce most cycle times by at least 15%, with some enjoying 50% or greater improvement. Although he is unable to share any customer names, he noted that a well-known manufacturer of aerostructures in the Seattle area was one of the latter examples.

“Some of our customers are producing very large, complex parts with cycle times of 40 hours or more,” he said. “Even a modest improvement pays huge dividends in these instances.”

Gampetro has been in his programming position for several years, but his experience with Vericut goes back far longer. He started as a production programmer for Ingersoll Cutting Tools in 1991, and the company has used the toolpath simulation software at its own shop for more than two decades.

“We have extensive capabilities here and machine a wide range of complex geometries, everything from indexable turning and milling tools to special-purpose cutters for automotive transfer lines,” he said. “Every single job is run through Vericut before being released to the shop floor to verify there won’t be a crash and that we have the best cycle time possible.”

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designs and manufactures a lot of custom cutting tools, which Gamepetro has recommended on more than one occasion. As a recent example, he could not understand why a customer used a ballnose endmill to surface the bottom of a deep slot. After speaking to the programmer at the client, Gamepetro learned that it did not have a standard slotting cutter that could do the job, so it was making do with what was on hand.

“All they needed was another 0.5” (12.7 mm) of reach, so we designed a special tool,” he said. “It made a huge difference on the cycle time, not to mention much better tool life.”

Gamepetro said this situation was not unusual. Despite the best intentions, machine shop personnel everywhere are pushed to run jobs as quickly as possible, and shortcuts sometimes are taken. This is especially true at job shops, where optimization frequently is less of a concern than machine uptime.

“They’ll run into a hiccup,” he said, “do a workaround to solve
it, and then all of a sudden what should have been a really good NC program ends up taking longer than necessary.”

Customers do not always like what Gampetro tells them. One shop came to him with an NC program for a 15-5 PH stainless steel part that made extensive use of trochoidal milling strategies. When he reprogrammed the job to use plunge milling for a pocket roughing routine, the client balked.

“They said plunge milling is old-school,” he said. “And even after I showed them the simulation, which reduced the cycle time by 40 minutes, they insisted that trochoidal toolpaths are more efficient. So we ordered a block of 15-5 PH stainless, set it up at our tech center and invited them to watch. Fortunately, most of our customers don’t need that level of proof and become believers after seeing the Vericut simulation.”

Sometimes there is no problem with a job — only an opportunity to leverage newer cutting tool technology. When a machine shop has run the same job or material for years, it is easy to become complacent. A fresh set of eyes can evaluate a machining process so higher-performing strategies can be used.

Gampetro said this is not a backward sales pitch designed to sell cutting tools. He does recommend Ingersoll’s cutting tools when appropriate, and custom-designed cutters often yield significant benefits. But if legacy tooling gets the job done, then a customer by all means should stick with what works.

“I’ve found many times that people will program a part, prove out the process, and no one will touch it for years and years,” he said. “It’s so easy to go back in and reprogram something and show them where they can improve. I don’t even push the tools as hard as I could, and I use conservative feeds and speeds so that the customer can make additional improvements once they get the job back on their own machine. Even so, most of our customers are very happy when they leave here. Vericut is a big part of that.”

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SURFACE FINISH ON A36 STEEL

By John Saunders

A36 steel is not a particularly difficult material to machine. However, it can be challenging to achieve an exceptional surface finish, especially when a part calls for a 63.5 mm (2.5”) axial depth of cut. The challenge for this ProvenCut recipe was to achieve an acceptable — or even excellent — finish with a tool length-to-diameter ratio of 5-1.

The larger a tool is, the stiffer it is. But large-diameter carbide cutting tools present problems. The cost goes up drastically. A 19.05 mm (0.75”) tool may cost over twice the price of a 12.7 mm (0.5”) tool — and rightfully so, as the former has 2.3 times the amount of carbide. For that reason, large-diameter endmills rarely are purchased or kept in

Tool: YG-1 V7 PlusA six-flute endmill
Tool diameter: 12.7 mm
Flute length: 66.675 mm (2.625”)
Material: A36 steel
Cut style: 2D contour

A YG-1 V7 PlusA six-flute endmill held in a Lyndex-Nikken SK16 collet holder was used.

Recipe ID: 586
inventory as frequently as smaller-diameter ones. Setting aside tool price, larger-diameter endmills also create more tool pressure, making them difficult to run on many common 40-taper machining centers.

A key to this recipe was finding a stiff 12.7 mm dia. endmill. That's right: The diameter of an endmill isn’t the only factor in determining the stiffness of a cutting tool. The higher a flute count is, the thicker the core of a cutting tool is. However, higher flute counts must be balanced with increased tool pressure, which can lead to chatter due to more points of contact with raw material.

ProvenCut recipe 586 struck a wonderful balance, machining a piece free of chatter and yielding an extraordinary finish using a YG-1 V7 PlusA six-flute endmill held in a Lyndex-Nikken SK16 collet holder. The 2D contour finishing operation was programmed with Autodesk Fusion 360 and run at 210 m/min. (690 sfm) at 0.015 mm feed per tooth (0.0006” feed per tooth) with a 0.203 mm (0.008”) radial DOC and 63.5 mm axial DOC.

about the author

ROBOTIC AUTOMATION FILLS A NEED

By Craig Zoberis

As a CNC machine-tending robot integration company, we have come across machine shops that range in size from small family businesses to Fortune 500 companies. One recent experience with a family-owned contract machine shop resonated with our entire team and showed how critical it is to have a keen ear and demonstrate flexibility to meet customer needs.

The lead came from a Haas Factory Outlet salesperson. After a five-minute phone call with the owner of the shop, it was clear he was ready to automate. To ensure we can meet or even exceed customer requirements, we normally follow a thorough set of qualifiers prior to meeting in person. However, in this instance, a few minutes spent talking with the owner was all it took. He was frustrated by a lack of reliable operators available to manage his equipment, and he was exhausted from trying to recruit. The owner cited ongoing difficulty with finding dependable workers to complete dull tasks day in and day out.

He was lost and unsure of what his next steps should be, so I offered to meet him to determine if and how we could support him. When I visited his shop, it immediately became obvious that by automating two mills in a six-machine cell, we could turn around his inconsistent output. We presented and quoted a solution within 48 hours. Less than a week later, he placed the order, and the equipment was installed in four weeks.

The shop now meets production demands with predictable daily output and has won new business. The owner sleeps well, knowing he does not have to worry whether an operator will show up the next day.

Fusion model: FC03
Robot make: Universal Robots USA Inc.
Robot model: UR5e
End-of-arm tool: Schunk dual pneumatic parallel gripper
CNC machine make: Haas Automation Inc.
CNC machine model: Mini Mill
CNC machine year built: 2008
Shifts per day: one
Shifts per week: five
Productivity increase: 34%

about the author

Craig Zoberis is founder and president of Fusion OEM, Burr Ridge, Illinois. For more information about systems integration services, contact cobotics@fusionoem.com or visit www.fusionoem.com.

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Whether heavy, tall, light or small, lifting and moving parts can be a challenge.

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Each day, workers across the entire manufacturing supply chain lift, transport and position a plethora of parts, raw materials, components, finished assemblies and more. These workloads are often hefty and awkward, thin and wobbly, top-heavy or experiencing some other center-of-gravity issue. Placing the objects where they are needed may require personnel to twist their bodies or reach out or up with their arms. They may perform the task all day. This effort can be exhausting and even harmful.

That is where modern lift-assist devices come in. “Workers might have to lift a 50-lb. (23-kg) part off a conveyor, pick it up and set it down, and they may have to do that a couple hundred times a day,” said owner Mike Shannahan of Cynergy Ergonomics Inc. in St. Louis. “By the end of the day, that 50-lb. part feels like 200 lbs. (91 kg).”

He said a job could call for more than just lifting and lowering. Parts may need to be positioned for machining or other operations. “You might need to load a CNC machine,” Shannahan said. “The part may be light, but having to reach inside the machine and align it on the chuck several times a day can be a source of repetitive motion injuries.”

Statistics bear that out. According to the National Safety Council, lifting is one of the main causes of injuries at workplaces. Every seven seconds, an employee is injured on the job. Of the workplace injuries that result in lost workdays, overexertion from lifting, lowering and repetitive motion makes up more than a third of such accidents.

“When it comes to moving lighter-weight or medium-weight items, such as 60-lb. (27-kg) boxes, injuries typically don’t happen all at once,” said National Sales Manager Bob DeBusk of Tawi USA Inc. in Bolingbrook, Illinois. “They happen over time. It starts to wear certain parts of a body. Then one day, the worker bends down to pick up a tissue and throws out their back.”

Lift-assist devices can take the strain out of tasks by reducing overall weight and easing movement. Types of lifts include hydraulic, air, chain, crane and portable units. In addition to reducing workplace injuries, devices give workforce flexibility to company management, he said. A job that once took two people now might necessitate only one. Lifting requirements for employment also may change. “A roll of material can weigh 100 lbs. (45 kg) and normally might take two people to do it, and you might still have injury issues,” DeBusk said. With “lift devices, one person can do the job, and (this) allows management to hire from a larger pool of people. Workers that might normally not be able to physically lift these heavy and hard-to-handle loads can do so easily with a lift-assist device.”

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and a vast number of accessories to tailor a lift to an application. Shan-
nahan said intelligent-assist devices from Cynergy Ergonomics, for ex-
ample, feature a servodrive motor with a load cell and a programma-
ble logic controller that communi-
cate back and forth. The tools sense
the movement of the hands holding
them and adjust loads accordingly.
“If you just put a miniscule amount
of lift force into those handles, it just
lifts the part up,” he said. “I can grab
a 100-lb. part, and it will feel like it
weighs a half a pound (0.2 kg).”
Because items to be moved vary
so greatly, many lift-assist devices
must be customized. For instance,
a lift may be equipped with ex-
tending arms. At their ends might
be customized suction feet, mag-
nets, grippers, vacuums, probes or
hooks. Cynergy Ergonomics utilizes
a quick-change system that uses a
pin to release and replace tooling in
less than 10 seconds.
Tawi USA is well tooled to mod-
ify its vacuum-lift technologies and
other equipment to meet job re-
quirements. Recently acquired by
the Piab Group in Taby, Sweden,
the company sells products through
a distribution network. While the
distributors are highly schooled in
lifting technology, some jobs re-
quire deeper understanding. Tawi
USA’s vacuum-lift systems can be
modified with a variety of acces-
sories, such as top and bottom
swivels that allow parts to be ori-
ented as needed, turntables to
bring parts nearer to workers or
extended handles that prevent
employees from having to bend
over to reach the back of a pal-
let. The company has a team of
engineers devoted to crafting so-
lutions for job specifications. The

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Can I Get a Lift?

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solutions then can be developed in-house at Tawi USA’s Chicago-area warehouse, fabrication shop and testing facility.

“Distributors come to us with an application,” De-Busk said. “And we ask, ‘What’s the voltage? What’s the capacity? What’s the vertical travel? What’s the size of the product that we are handling?’ And then we begin to work with them to develop a lift system.”

Putting It Together

Another common lift-device application is positioning parts and assemblies to make them easier and more ergonomic for assembly workers. As assemblies build up, personnel might need to raise or lower an assembly, tilt it on an angle or turn it toward them. A solution for this scenario is a scissor lift table like those offered by Verti-Lift Inc. in Louisville, Kentucky.

“Lift tables accomplish the ability to load and unload and handle material at an ergonomic, safe work height,” said President Wayne A. Dodge. “And options, such as turntables, help orientate the part.”

The company sells a variety of lift tables that can be modified based on standard products to fit applications — for example, enabling a standard table to lift, tilt and rotate parts.

“You’ve got standard lifts and accessories, such as tilt (tables) and turntables and conveyors, and independently they are just standard products,” Dodge said. “But put together, you’ve got the ability to customize for specific applications.”

Width and length are easily adjustable. Verti-Lift’s standard tables, which can be used in various configurations, have vertical travel ranges from 610 mm (24”) to 1,524 mm (60”) and capacities from 907 kg (2,000 lbs.) to 2,722 kg (6,000 lbs.). A double-wide table is theoretically two scissor legs with one common platform and one common base. A tandem wall table is two lift tables front to back.

Dodge mentioned an electrical control panel assembly and its wide range of components and connections that require an operator to work at different heights at different locations on the board.
There’s nothing wrong with off-the-rack tools. But if you need that extra boost in cycle time and tool life, it’s time to consider your custom-made option: GWS Tool Group.
Because this multilevel assembly crosses multiple axes, Verti-Lift developed a lift table that would lift, tilt and turn and that has a limitless range of motion.

"With the lift, tilt and turn, you have an infinite range of travel vertically, horizontally and rotationally," he said. "You've got 360° of full rotation capability to the product, and in terms of tilt, the operator may start at (assembly) level and tilt it anywhere from zero to 90°."

By rotating a part, an operator can stay in one area and bring work to him or her, such as in a work cell.

"I like to think of that more as a product positioning versus simply raising and lowering," Dodge said.

Shannahan agrees that depending on the application, positioning can be critical.

"Let’s say I need to put two halves of a die together," he said. "A 600-lb. (272-kg) half coming down on a bottom piece has to align to pins with very tight tolerances, and the positioning has to be spot on. That is why it is important that that 600-lb. part moves like it weighs 1 lb. (0.5 kg)."

Another example of positioning a product is with shipping, such as "This side up" packaging or for inventory control. DeBusk said Tawi USA’s lift systems can include a top or bottom swivel that allows users to “spin” an item 360° while it is suspended in the air.

"So they can pick up a box, spin it for position and then place it on a pallet," he said. "Sometimes the customer needs the label facing out or in a particular direction, so their distribution center can bar-code-scan the item."

Holding the Position

In production, a part might need to be oriented at a specific angle. Cabinetmakers, for instance, often use panels that are 1 m × 2 m (4’×8’) and weigh several hundred pounds. The sheets are shipped lying flat and must be stood vertically for machining with a vertical saw.

“We have an angle adapter that allows them to pick that up and move it 90° vertical and put it on (a) vertical saw in the position that they need," DeBusk said.

Positioning at such extreme orientations can be challenging.

“When we work with a customer,” DeBusk said, “we collectively determine what they are handling, how they want to handle it, how their procedure or process works and how their employees do it. We

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develop a different strap, a clamping mechanism or an arm that will capture it to ensure safety and to ensure that the sheet is not damaged.

Uneven surfaces or porous materials can present challenges as well. With these scenarios, Shannahnan said, “It might be hard to pull a good vacuum. We address that by designing and building our own vacuum cups or designing the system to work around these contours or steps.”

Tawi USA provides standard and custom suction feet to grip items, as well as rubber grommets that hold gaskets in place and allow feet to flex in any direction.

“So if one surface is at an angle and another surface is flat,” DeBusk said, “then you can still pick it up.”

This multifunctional lift-assist table can lift, tilt and turn heavy parts.
Hybrid manufacturing technologies require CAD/CAM software.

By Alan Richter

In addition to needing a machine tool that can perform both additive manufacturing, such as laser metal deposition, and subtractive machining, hybrid manufacturing requires a CAD/CAM software package that accommodates building and removing material.

One such package is hyperMill from Needham, Massachusetts-based Open Mind Technologies USA Inc., a subsidiary of Open Mind Technologies AG in Wessling, Germany.

“Hybrid to us is very similar to subtractive machining in some ways where we are using many strategies for planar and nonplanar building materials followed by the machining process to typically bring a slight oversize condition to a finished component,” said Managing Director Alan Levine.

“Additionally, on the hybrid side we’ve built in the necessary technology to properly control the heat source whether it’s powder- or wire-based.”

He said the foundation of the hybrid manufacturing market began with powder bed, which is considered a simpler method than the directed energy deposition technique. However, when manufacturers want to add a hard coating of material to repair a part, such as a mold, turbine blade or disc brake, they tend to turn to directed energy deposition.

Lothar Glasmacher, head of additive and process technologies at ModuleWorks GmbH in Aachen, Germany, said other common hybrid applications include building aerospace parts like blisks and propellers; prototyping structural parts, including those made of multiple workpiece materials; and creating modular parts that...
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cannot be machined from stock material because of their part geometry. The company developed software for MU-V Laser EX hybrid machines from Okuma Corp. that combines additive path planning and subtractive toolpath calculation components.

He said ModuleWorks can deliver single modules to close the complete process chain from workpiece input to path planning and simulation to NC output. With its post-processing framework, the company is able to send the appropriate NC code and specific commands to any machine or controller for additive manufacturing.

“The closed-chain manufacturing from CAD to the hybrid machine allows productive part manufacturing without manual toolpath editing or teaching,” Glasmacher said.

In addition, he said 3D constant step-over and offset slicing for additive path planning ensure a stable additive process without gaps in the weld bead. This capability provides a smooth look-ahead function for five-axis orientation motions and effective mesh- and surface-based path planning.

**New Versus Repaired Parts**

Another CAD/CAM package for additive and hybrid manufacturing, such as programming cladding on five-axis milling and mill/turn machines, is available from SprutCAM America in Waunakee, Wisconsin. Founded in Naberezhnye Chelny, Russia, SprutCAM Technology Ltd. also has an office in Germany.

According to one Greek client, 95% of its applications are for part restoration with revisions and corrections accounting for the remainder. Another customer from Greece noted that restoration accounts for 100% of company applications, including propellers, propeller shafts, turbine shafts and turbine impellers. Both companies concurred that there are no problems with integrating the CAD and CAM systems in SprutCAM’s software.

Nonetheless, Glasmacher said one of the main deficits of conventional CAD/CAM systems is that they are positioned well in the milling area but do not offer effective additive solutions to optimally support the process. As a result, an operator often has to use several systems that interact with each other in a cumbersome manner, and a continuity from component preparation to hybrid path planning to NC output therefore is not possible. However, he said this chain can be closed because of ModuleWorks’ expertise in both subtractive and additive applications.

Levine agreed that integration of the CAD and CAM sides is not an issue for hyperMill software. “For us, you are simultaneously working in the CAD and CAM
environments,” he said. “It’s very easy to access any functions you need at any time.”

Lattice Optimization

Glasmacher said lattice support structures, which only can be produced additively, make it possible to reduce the weight and amount of workpiece material with constant mechanical properties. “The combination of lattice structures and additive processes has also created a completely new possibility for component design,” he said.

“Parts with lattice structures are typically made with a powder bed 3D printer,” said David Bourdages, product manager for hyperMill at Open Mind Technologies. “The functional areas of these parts often require finishing, as well as some machining operations, to remove the support structure. Because parts are not perfect and the clamping is done on (a) raw model, hyperMill offers a best-fit automation capability, which finds the best position of the

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For more information about hybrid manufacturing, view video presentations by ModuleWorks and Open Mind Technologies USA at www.ctemag.com by scanning the QR code on your smartphone or entering this URL on your web browser: cteplus.delivr.com/2ep9s
Beyond Conventional Machining

theoretical part in the existing 3D-printed part. The CAM software should also offer tools to generate an adequate toolpath for finishing the functional areas and for removing the support structure while keeping track of the stock.”

Offsetting Not Needed

However, Glasmacher said there is no need to manually offset a part with ModuleWorks. Options exist instead to add offsets to any part of a model, and this occurs with path cycle calculation. For example, a user can give additional or negative offsets to surfaces and curves. This capability can compensate for differences from a CAD model to an actual part or add more material than needed for extra protection during machining.

Another challenge when hybrid manufacturing is to manage tolerance stackup across additive and subtractive operations. Overall, he said ModuleWorks has optimized toolpath planning to avoid layer stackup, such as with automatic starting point rotation and process control features on the toolpath, which are designed for continuous buildup per layer. After depositing each layer, the software can combine a scanning operation and a layer adjustment for the next layer.

Resolving Heat Distortion

Bourdages said to help resolve any heat distortion issues that occur during hybrid manufacturing, research continues on an industry-wide basis.

“There is much to learn, and it’s really complex,” he said. “This will evolve. But for now, knowing all the parameters and how they are connected to each other is not predictable.”

A five-axis additive manufacturing repair process is performed on an Okuma MU-V Laser EX hybrid machine (left) before five-axis milling takes place (right).
Levine said engineers currently apply common sense to solve problems. For instance, when creating a long, slender rectangle, rather than moving in the shorter direction and focusing heat in one area for an extended time, long strokes might be taken so the heat in one area cools down before returning to it.

“In the future,” he said, “technology and analysis will guide people toward better build processes that will be cognizant of thermal situations and distortions.”

To avoid overheating a workpiece, Glasmacher said ModuleWorks provides special path planning strategies like sorting strategies about how to build up material. In addition to the path calculation, temperature behavior can be taken into account via NC code. For example, waiting commands can be inserted into NC code through the “posting framework,” which can be switched depending on part geometry.

Thermal distortion ultimately is a complex, largely uncontrollable process influenced by numerous factors, such as indoor and outdoor temperature, humidity and the season, according to SprutCAM’s customers, which rely on experience in 99% of cases.

When selecting CAD/CAM software for hybrid manufacturing, Levine recommends that end users first understand how simple or complex their parts are and then consider not just the theoretical experience of a software developer but its real-world experience working with partners.

“We know some of our partners have choices, but we believe they are using our system nearly exclusively,” he said. “That helps with knowledge exchange and building up the experience base.”

Although hybrid manufacturing has been performed for years, Levine said the market still is burgeoning.

“Broad usage is not quite there in the market,” he said.
There are cutting tool considerations when machining molds and other complex components using hybrid manufacturing technology.

By Dan Doiron

Hybrid additive manufacturing is a process in which selective laser melting in a powder bed is combined with subtractive three-axis milling in a single hybrid machine tool. Although selective laser melting is the most frequently used AM technology, other appropriate technologies include laser metal deposition, direct metal deposition and metal powder application.

On one hand, hybrid AM achieves significantly higher part accuracies and surface qualities than are possible with conventional laser melting in a powder bed. On the other hand, zero-point definition through machine-integrated spindle coordinate systems makes it possible to generate precise reference and clamping surfaces for the downstream process chain. This capability minimizes the downstream process chain, especially with toolmaking, moldmaking, rapid prototyping and small series production, as well as providing new possibilities in terms of designs, structures and material properties.

One of the main advantages with hybrid AM is saving costs by reducing machining waste and scrap. Consider a block of 45-kg (100-lb.) steel placed in a CNC machine. If the finished part weighs only 11 kg (25 lbs.), this means that 34 kg (75 lbs.) of scrap is tossed in the chip bed. It is therefore prudent to consider hybrid AM.

Tool Trends

Cutting tools have evolved to support the subtractive part of the AM process and offer geometric shapes and coatings relative to the layering process with abrasive properties and toughness characteristics of the tool sintering procedure.

For optimal results, select endmills specially designed with the right geometries, tool substrates and coatings for machining molds and other components that have been additively manufactured. The selection of workpiece materials includes titanium and aluminum alloys; nickel-chrome-iron; and tool, stainless and cobalt-chrome steel. For example, ballnose and radius endmills should have a special neck design optimized to minimize deflection and enhance stability. This design imparts a fine surface finish while extending tool life.

In addition, a pre-milling ballnose endmill targets roughing and pre-finishing operations to produce a specific machining allowance on an additively manufactured part. The machining direction is from top (z+) to bottom (z-). For finishing operations in a part’s construction layers no longer subject to thermal stress, the finishing cutter, also with ballnose geometry, is recommended. The cutting area of the tool designed for that pull machining from bottom to top enables finishing the material layers that no longer are thermally stressed.
A solid-carbide “back taper” radius endmill, which is similar to a T-slot cutter with a radius, is for 2D machining component undercuts. The endmill specifications are aimed at pre-finishing and finishing on additively produced parts. This tool is suitable for point milling strategies and provides the ability to take deep undercuts.

Overcoming Abrasion

Tool coatings also play a significant role when machining additively manufactured components. For instance, Emuge Corp. in West Boylston, Massachusetts, offers the new ALCR coating, which is an AlCrN-based coating that provides high wear resistance even under severe thermal stress.

Because machining must be performed without coolant application as a cutter removes material while partly in the powder bed, the cutting tool experiences a high level of abrasive wear.

Dry machining is necessary for these hybrid AM applications because an inert gas atmosphere and elevated temperatures prevail in the machine chamber. Therefore, the coating prevents adhesion of a built-up edge even when cutting difficult-to-machine materials at elevated temperatures, extending tool life while imparting fine surface finishes.

Some hybrid AM applications may need solid-carbide microendmills designed to meet the demanding requirements of micromachining applications. When this is the case, microendmills with special neck geometries enable these tools to effectively cut deep contours. A high radial bending strength allows the tools to withstand alternating radial stress on the cutting edge and thus on the relieved neck during machining.

Requirements for a cutting tool always depend on the application for which the tool is intended. But in general, the ultimate goal is to find a balance between flexibility and rigidity.
Balancing Basics

A balanced tool can help tremendously to reduce costs.

By Yesenia Duran

Unbalanced tools are a problem. They generate vibration, which may lead to broken tools, shorter spindle life and higher workpiece roughness.

Implementing balancing protocols for a machining process helps protect a machine tool. Balanced tools reduce vibrations and are needed whether cutting at 44,000 or 3,000 rpm.

Like many things, tool balancing merits a cost-benefit analysis. While new technology might affect the way balancing is performed and justified, the need for analysis is unchanged.

Cause of Imbalance

Tool imbalance is caused when the center of gravity of a rotating mass is not aligned with its rotating axis.

“So the unbalance is a distance that creates an eccentricity,” said Manager Francesco D’Alessandro of Balance Systems Corp. in Wixom, Michigan. “This
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eccentricity creates vibration.” Defined as the distance from the center of rotation of a tool to its true center of mass, eccentricity measures the extent to which tool weight is off-center. If eccentricity is measured in microns and tool mass is measured in kilograms, these units yield imbalance in gram millimeters, a common unit.

President Thomas Hoenig of GTI Spindle Technology Inc. in Manchester, New Hampshire, agrees that tool balancing is extremely important. Imbalance damages spindle bearings and other spindle components. Imbalance also causes chatter on machined and ground parts. And unbalanced tools cause premature tooling wear through taper damage to the tooling interface.

“Tooling balance should be done almost always,” he said. “The only time it does not apply is on very slow rpm machining operations, such as tapping holes, or some slow lathe cuts. Any machining operation over 3,000 rpm, balance is critical.”

However, President Brendt Holden of Haimer USA LLC in Villa Park, Illinois, said in many cases, some of the most dramatic advantages of balancing tooling assemblies can be found at low rpm for things like boring heads or facemill arbor assemblies.

“Our advice is to always look at applications that present challenges that no one can figure out how to solve,” he said. “Maybe they looked at the fixturing or the machine condition or the cutting tools, but still they are not getting the performance they wanted. Did they look at balancing? If not, this would be the time to investigate balancing.”

Holden said people today want to reduce cycle time, which may mean decreasing the number of tool changes. If a shop formerly used roughing, semifinishing and finishing tools to complete a part but now prefers to use only one tool for the job, that can cause issues with balance. Also, a special tool might be designed to drill, counterbore and chamfer. With pockets in different positions, more attention must be paid to balancing to achieve quality specifications.

Necessary Balancing

“Theoretically speaking, balancing is always necessary,” D’Alessandro said. “Although in case of very low spindle rpm (less than 3,000 rpm) and poor workpiece finishing goals, tool balancing might be skipped.”

That said, modern machine tools tend to have high spindle speeds to achieve greater cutting volumes or reach high cutting speed requirements — for example, when machining Inconel.

“The increases of these values have also raised the demands for better tools and holders, which then require to balance the tool more frequently than before and at a lower residual imbalance,” D’Alessandro said. “In order to monitor this phenomenon, it may be helpful installing on the machine a permanent spindle monitoring system, such as the B-Safe sensor, which is able to give visual aids and alerts to the operator when the vibration is too high.”

Sources said companies gain 15% to 25% in productivity and tool life on average when they begin balancing tooling assemblies, with even better gains if they started with poor balance situations. Although balancing will not solve every problem with a cutting process, estimates are that balancing can solve at least a third of machining issues, especially ones

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about the author
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that never seem to go away.

D’Alessandro said the most common problems that end users experience before calling Balance Systems are tool breakage and workpiece chatter. Analysis often reveals that these difficulties are due to vibration, which is generated mainly by tool imbalance.

“The imbalance is sneaky because it cannot be seen and can be felt only when it is too late,” he said. “For this reason, I like to call it the silent killer of machine tools.”

Holden said his most frequent questions from customers are not about balancing — at least at first.

“However, during our discussions the topic of balancing comes up as a clear need as it relates to solving their problems,” he said. “For example, our customer might call about surface finish or tool life issues. Then upon examination, we determine that they have a runout problem. While that runout might not be visible via static checking on a tool presetter or during a slow manual rotation in the machine spindle, once the tool is spinning dynamically at the machine-set rpm, the runout increases if the toolholder assembly is unbalanced. Then we run a test to balance the assembly and find that once balanced, the runout goes away and the customer is happy.”

Holden said customers also complain that they are not able to run at desired speeds and feeds when machining a part.

“Diving into things, we realize that some of the toolholder assemblies used in the production process had unbalance,” he said. “Then they balance the assemblies, and the customers are then able to machine their parts at the appropriate feeds and speeds as they had originally planned.”
Hoenig said spindle installation issues, such as balance, misalignment and encoder faults, are what he hears about most from customers.

“When a spindle is sent for repair by the customer,” he said, “many times they are sent without all the rotating components.”

Pulleys, rotary unions, hubs, drawbars and other items are left behind for various reasons. When those components then are mounted on a newly rebuilt/balanced spindle, it can be thrown out of balance and alignment.

“So it’s very important that all the parts be sent together to be balanced together,” Hoenig said.

Most service technicians and end users unfortunately do not have the balancing equipment to perform necessary corrections in the field. GTI Spindle Technology typically has to perform a service call when that happens.

**How to Balance**

The balancing process of a tool is pretty straightforward. Almost every tool on the market has a balancing grade indicated with a G followed by a number, according to ISO standards. This is a reference declared by a tool manufacturer. If a user types the information into the software of a balancer, along with the tool assembly weight and rpm, he or she gets the target residual imbalance that should be achieved during balancing. The machine then indicates the mechanical corrections based on the selected tool dimensions and balancing mode: A) by “sliding weights,” B) by “adding screws,” C) by rotating “eccentric rings” or D) by “free balancing.”

When milling, if vibration is too high, the No. 1 problem with a workpiece is chatter.

Hoenig said precautions should be taken with particular metals when balancing. Some carbide tools need special grinding wheels to remove weight for balancing. Weight removal always is recommended for high-speed tools because extra weight could fly off and cause damage or injury.

He said the best way to figure out how to balance a tool is with a vibration analyzer/balancer. GTI Spindle Technology produces a wireless...
version that runs on Apple’s iPad.

Holden said a shop needs an in-house balancing machine to check the condition of tooling assemblies.

“Even if you order special form tools to come to you balanced, how do you know if it really arrives to your facility balanced?” he said. “We have some larger customers that simply use the balancing machine as a go/no gauge in order to confirm that their assemblies are balanced every time.”

Holden said a balancing machine tells how to remove or displace weight from or add weight to a tooling assembly to balance it. To determine balancing, it is important to look at the makeup of a tooling assembly. Can material be removed from all areas of the holder without damaging it? For example, would material be removed from coolant ports or hydraulic chambers? Or if weight will be displaced via balancing rings, will there be interference with the workpiece?

“All of these things need to be considered,” he said. “But in almost all cases, there is a good method to bring a tool within balancing utilizing one of these methods (removing, adding or displacing weight).”

Haimer USA’s most popular balancing machine is the Tool Dynamic TD Comfort, which Holden recommends based on its ease of use and accuracy.

“We use a spindle that clamps the tooling assembly as if held in the machine tool spindle, and the machine itself has a hard-bearing spindle that uses centrifugal force sensors to measure the unbalance of the tooling assembly,” he said. “The ease of use comes from the software that guides the
Balancing Basics

user through an easy modification process.

Balance Systems’ offerings are for machine shops, machine tool field maintenance and tool and holder manufacturing.

“For end users of machine tools,” D’Alessandro said, “at present the most popular machine for this application is our BVK3-10.”

He explained that an operator places a tool into the BVK3-10, loads the related part program and closes the guard. The machine starts measuring the initial imbalance and then tells the operator the correction to apply to the part.

For field maintenance, D’Alessandro recommends portable balancing equipment, such as the Best Balance 1000. The main benefit of this model is that a user does not need to remove a tool from a spindle and put the tool on the balancer. The balancing process can be performed directly on a machine tool. The same equipment also may be used to balance other types of spindles, including those on grinding machines.

“For manufacturers of tools and toolholders, we also developed a specific automatic balancing machine: the BVK4,” he said. “We have vast experience in machine automation and can balance these parts automatically. This model has a proprietary touch detection system that removes the material — i.e., balances — very precisely. BVK4 is used in mid/high-volume production contexts.”

GTI Spindle Technology’s BalancePro for Field Balancing is an iPad/iOS app for balancing one- and two-plane rotating machinery. By connecting to GTI Spindle Technology’s acceleration measurement system and tachometer, the app utilizes vibration amplitude and phase signal to automatically calculate corrective balancing weights and their angular positions. Balance jobs may be stored and loaded for later use.

Tool balancing may not always be necessary but is generally a good idea.

“To make it easy to understand,” Holden said, “would you ever consider that there is a time that it is fine to drive your car with unbalanced wheels? Probably not.”

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GROOVING CAN BE BUMPY

There are valuable lessons to learn.

By Christopher Tate

Cutting grooves is one of the more challenging turning operations performed by machinists. Grooving tools are often thin and fragile. They have three sides in contact with a part, and chips can be difficult to extract.

After many scrapped parts and broken tools, I learned important lessons about grooving.

My first turning experiences were on a 1947 Monarch 10EE lathe, which was completely manual, as you probably would guess. After a little instruction and some practice, most people can make a turning tool that cuts. I learned to grind my own turning tools and became fairly good at offhand grinding. However, grinding usable grooving tools is tough. It takes lots of practice to achieve fine results. I could make a usable grooving tool in a pinch, but the process was slow and cumbersome.

A hook-fit tool (left) is more complex than it looks. Used for internal grooves, this standard lathe grooving tool (right) is from a catalog. Mitsubishi Hitachi Power Systems Americas has used the tool in milling machines for hot jobs.
Lessons

Lesson one. Buy a good grooving tool from a company that knows what it is doing. For manual machines, that frequently means purchasing a parting blade. Parting blades are made of high-speed steel and ground with proper clearances, so a tool does not rub the sides, which is the most common problem with hand-ground tools. Parting blades are available in many sizes and can be modified easily for special purposes.

Unfortunately, HSS tools do not always work well with hard or abrasive materials, which I discovered while machining cast-iron parts. Carbide grooving tools become a necessity with difficult-to-machine materials and bring their own challenges, especially on conventional machines. Carbide is significantly harder and more wear-resistant than HSS but very brittle and not as forgiving. Carbide tends to chip and break if not used properly. I learned this while feeding a carbide grooving tool by hand on cast-iron parts. That is lesson two.

Lesson two. Use a light feed rate, and let the machine feed the tool. Only hand-feed at the end if necessary.

Lesson three. When cutting grooves on a lathe, make sure that the grooving tool is on center or slightly below. Turning and facing tools can tolerate being above centerline, and small errors are often unnoticeable. But a grooving tool above centerline provides hours of aggravation as the part tries to climb up on the tool, the cutting edge continually is rubbed off or half a day is spent gingerly coaxing a piece of broken tool out of a shaft that is 99% complete.

I thought that grooving would be simple after we purchased a shiny new CNC turning center with a control that had canned grooving cycles. That is lesson four.

Lesson four. A CNC does not eliminate grooving challenges. Computer-controlled machines offer limitless combinations of cutting speeds, feed rates and cutting paths, which make grooving easier. But CNC turning centers separate a machinist and his or her senses from a tool and the work. Tool turrets are usually behind the work, and tools frequently are run with inserts toward the bottom of a machine. So it can be difficult for a machinist to see what is happening. Being able to read the chips and view the way a tool behaves is important to get the best cutting parameters, and CNC machines might make this hard. Many people never imagine that a tool turret on an expensive turning center would be off-center, but it is extremely common. When a turret is not set on center, a machinist may have to shim tools, modify holders or, worst-case scenario, adjust the turret.

Lesson five. Face grooving can be difficult, and success requires having the proper tools. I learned this while machining very deep face grooves. This face grooving tool is used for very large-diameter grooves. The curved blade creates clearance between a tool and part.

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about the author

The face grooving tool is used for very large-diameter grooves. The curved blade creates clearance between a tool and part.
After many scrapped parts and broken tools, I learned important lessons about grooving.

grooves in pump impellers. My first attempts were made with tools we had ground at my shop. (I was still in the process of learning lesson one.) Progress came when we purchased an indexable tool with carbide inserts that was made specifically for face grooves. A face grooving tool is made with a curved shape, so the heel of the tool does not rub the curved groove. Each tool is limited to a range of diameters, which means that one tool cannot be used on all face grooves. If tools are used for diameters outside their design limits, they rub and damage a part. I also realized that face grooving tools with clamps held in place with a screw are much better than the other styles in which the insert is pressed into a slot.

Lesson six. Not every cutting tool manufacturer can make special grooving tools. Grooves are common on power generation equipment like blade rings. These grooves are known as hook-fits, and they are used to hold smaller components in place. Hook-fit geometry is the same as a face groove, but hook-fits are made in areas where a normal face groove tool does not fit. Many grooving tool manufacturers are in the market. Most make excellent stock tools for grooving, but only a few are good at making special tools.

Machinists cannot see the tool tip when machining a hook-fit, so they do not know if there is a tool rub before the groove is done. Hook-fit tools must have perfect geometry so there is no question they will work properly. We tried several cutting tool manufacturers before finding a company that had the experience needed to make small quantities of special holders and inserts.

We now use the supplier for all our special grooving tools.

Lesson seven. If it isn’t broken, don’t fix it. I learned to propagate results across different parts and avoid deviating from successful tools and techniques. In an era of continuous improvement, it can be difficult to watch a machining process that seems slow or uses expensive inserts without wanting to change it. After many failed attempts at enhancement, I recognized that a process making a satisfying part may not need improvement.

Grooving can be hard. For some of us, the lessons are painful. I found that the best outcomes came when I engaged cutting tool experts and explored options at trade shows. Being open to experimentation and making time to test are also important for developing good processes.
A 1.5 mm × 1 mm (0.06"×0.04") chip that consumes just 28 microwatts and has a range of up to 21 m (69') has potential for manufacturing applications. Developed by electrical engineers at the University of California San Diego, the chip uses 5,000 times less power than Wi-Fi radios.

“It definitely can be used in manufacturing environments,” said Dinesh Bharadia, assistant professor of electrical engineering at UCSD’s Jacobs School of Engineering. “The benefit is a very small form factor. The best part is, everything connects directly to your Wi-Fi.”

He said one possible use is to tag objects and utilize a cellphone to track them on a conveyor and find out the efficiency of a manufacturing unit. Robots could use the chip to locate items equipped with a very lightweight tag.

“You don’t need to buy any equipment or software,” Bharadia said. “It works with any type of phone, any type of tablet, any type of laptop.”

Another potential use is to help analyze vibration. He said a user could attach a tag to a vibration sensor whose readout would be sent to a smart device to determine if a piece of equipment vibrates too much.

“You can connect your phone, your smart devices, even small cameras or various sensors to this chip, and it can directly send data from these devices to a Wi-Fi access point near you,” Bharadia said. “And it could last for years on a single coin cell battery.”

Besides vibration, sensors could monitor such things as moisture or temperature. He said the chip even can be used with Raspberry Pi in a Wi-Fi card.

“Typically,” Bharadia said, “Wi-Fi signals take a lot of power to create them. What the chip does is take existing Wi-Fi signals — i.e., ambient Wi-Fi signals — and reflect these ambient signals in a specific way, thereby changing the data of the reflected signal. And these reflections are decodable by any Wi-Fi device that can receive the signal. A smartphone can read and figure out information sent by the tag device.”

For the project, he teamed up with Patrick Mercier, UCSD associate professor of electrical and computer engineering, to develop an integrated circuit, which combines the reflection-based communication with a lower-power Wi-Fi wake-up radio. The Wi-Fi radio awakens only when it needs to communicate with Wi-Fi signals, so it can stay in low-power sleep mode for the rest of the time, during which it consumes only 3 microwatts of power.

Bharadia said research is ongoing to increase the range of the chip and reduce its cost. Researchers are looking for partners to commercialize the chip. For more information about the work, visit www.ece.ucsd.edu.
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