Gear Shop of Tomorrow

Machine Innovations Hint at Future for Gear Manufacturing

Matthew Jaster, Senior Editor

It's Monday morning, December 15, 2036. An autonomous vehicle drops off two engineers in front of a gear manufacturing facility in Metro Detroit. They punch in for work on their wristwatches and pay Uber for the ride on a smartphone. One of the engineers begins walking the shop floor, monitoring a series of collaborative robots using a tablet the size of a paperback novel. These robots interact right on the floor with the minimal staff scheduled to oversee manufacturing operations. Another engineer wears an interactive headset and begins training a group of new engineers (in real time) from China using some form of augmented reality.

Digital message boards across the factory prioritize jobs and prep machining cells for the upcoming production schedule. Automated Guided Vehicles (AGVs) move carts across the floor carrying cutting tools to various machine tool stations. As tools and systems breakdown, automation and additive manufacturing capabilities help maintain deadlines. Everything is orderly, automated and optimized.

Could your average gear manufacturing facility look something like this in 20 years? What can we expect from machine tool technology over that period of time? What advancements and innovations are going to change the way gear manufacturers work and collaborate in the future? Many of the concepts above were readily available if you roamed the halls at AMB 2016 (Stuttgart) or IMTS 2016 (Chicago).

Technologies such as collaborative robots, automation cells and intelligent machining will no doubt link components, processes and analytical tools together now and in the future. With IMTS fresh in our minds, we felt it was the perfect opportunity to ask machine tool builders and gear manufacturers "What's next?"

Scott Yoders, vice president of sales, Liebherr Gear Technology, Inc. has been in the gear industry for about 20 years. "From my persepective, it can be said that the rate of change in the past five years has been exponential, when compared to the prior 15. The advancements in cutting tool and abrasive technologies have vastly improved, resulting in significantly more efficient processes. Moreover, the intelligence of machine tools and the technology infrastructure in machine controls have also drastically improved."

For Fred Young, chairman, Forest City Gear, the easiest way to look at the future is to review the past. "Historically Forest City Gear has invested in new technology to the tune of 25-40 percent of our gross sales each year. Naturally we benefitted from the obvious increases in

EMAG's automation technology hints at what the future gear shop may look like. (Photo courtesy of EMAG)

productivity and quality and versatility. What we've also discovered is that these investments inspired more creativity and they've led to more experimentation with all sorts of productivity increases not only with our gear equipment but also our peripheral manufacturing, inspection and process improvement efforts," he said.

IMTS has always been the gateway into future machine tool technology here in North America. This is why Young finds it so important to take 30 or more Forest City Gear employees to the show every two years. Young challenges his staff to identify new equipment and systems that could help grow and expand FCG's operations.

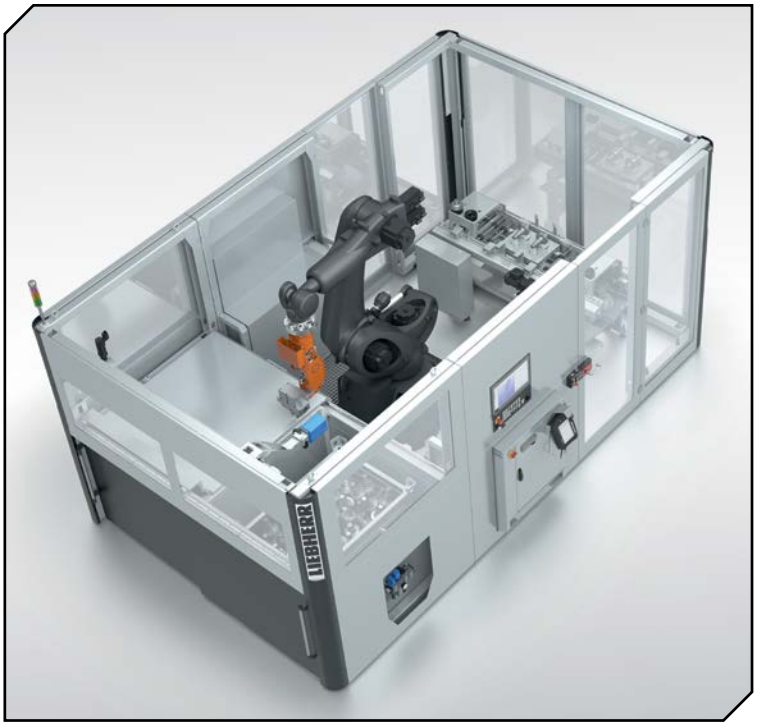
This year's show had everything from interactive exhibits, multifunctional machine tools and virtual and augmented reality headsets to 3D-printed vehicles, houses and medical implants. It also included robots serving coffee and ice cream with minimal human intervention. The potential for Industry 4.0 (or the Industrial Internet of Things) was evident across all pavilions.

Bill Miller, vice president at Kapp Technologies, however believes that potential has yet to be realized in the gear industry. "Industry 4.0 already describes the interconnectedness of all devices including gear machines. Yet the power for immense diagnostic features are scarcely utilized and barely understood. This technology will be fully evolved and enable rapid capture, sharing, analysis and corrective action prescriptions on a global basis."

And Miller believes these "smart" machine features will one day be essential for a gear company's success and growth. "Currently, case studies abound where new ownership or management either emphasizes quarterly results over long term continuous improvements and/or rapid deployment of too many new technologies that are not digested wholly. Neither is smart," he added.

The Machine Tool Perspective

Industry 4.0 or IIoT alone can't take the gear industry into the future. Machine tool technologies, cutting tools/materials and inspection capabilities will continue to evolve at a rapid pace. The future accomplishments of the gear grinding machine tool, for example, will greatly depend on the types of gears to be ground.



With the automated bin picking solution, Liebherr sets new standards in the handling of un-machined parts that are fed into a modern production system. (Photo courtesy of Liebherr)

"Assuming that in 20 years time some 30 percent of cars will be electric; this will put higher demands on the quality of ground gears, regarding both the gear flank geometry and the surface structure," said Walter Graf, marketing manager at Reishauer AG. "Gears of electric drives systems turn at much higher revolutions than those of the internal combustion engine. Presently, for electric drives, we are looking at 15,000 rpm and this may be as high as 30,000 rpm in 20 years."

Therefore, the question of noise suppression will be much more pertinent as noise generation is exponential to the rotational frequency. "The future hard-finishing machine tool will have to be able to deal effectively with gear noise. This will not be limited to the machine tool itself but will extend to the tooling such as the grinding wheels and the diamond dressing tool, and as a consequence, to the perfect symbiosis of all three. Grinding wheels, for example, will have to be absolutely constant in their homogeneity from lot size to lot size," Graf added.

According to Graf, new abrasive materials will also be invented in the next 20 years that will positively impact surface quality and grinding cycle times. "However, it is also reasonable to assume that the gear materials will evolve to be more lightweight and more wear-resistant. Hence, these gears will be harder to machine and the future machine tools will have to be capable of coping with this," Graf said.

In the past a new coating might come out every five or 10 years, according to David Goodfellow, president and CEO at Star SU. "Today, it seems we get one every two to three years and who knows what the future will hold. We might get a new coating material every year, possibly every month, but the fact remains that you have to validate every process change that comes along."

D. Kirk Stewart. Jr., director of sales at EMAG LLC., envisions more intelligent utilization of robots for tool and fixture exchanges in the future. "Further automation will be necessary to stay competitive in our markets going forward. Our equipment will be connected to the users, manufacturers, tooling and accessory suppliers like never before."

The smart gear factory will feature a highly automatized production floor with flow optimization between all manufacturing and inspection equipment involved, said Christian Albrecht, director of global marketing at Gleason.

"Here manufacturing systems will benefit from self-learning mechanisms, based on data analytics that can run in the cloud or in a local system."

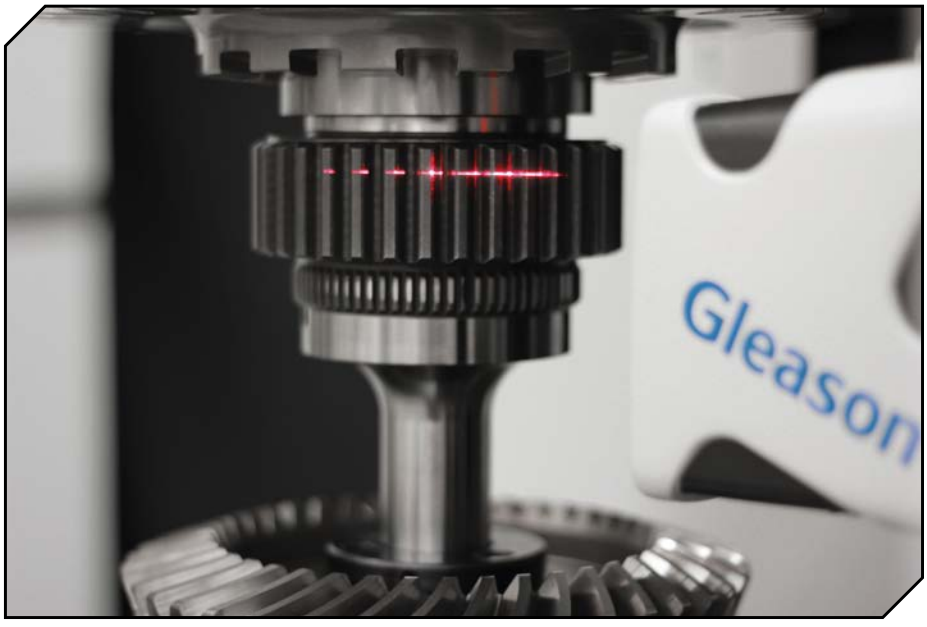
With new capabilities for advanced data analytics, self-learning systems, virtual testing and real-time correction loops optimizing design changes, Albrecht thinks it will be easier to perfect the evolution of contact patterns and flank forms prior to making a single chip. Non-contact inspection systems like laser scanning open up new possibilities for rapid in-process inspection and closed loop systems.

"Also auxiliary assets like perishable tools and workholding become smarter and will transfer valuable data to the machine to produce higher quality products with maximum productivity and tool life," Albrecht added.

There are a plethora of monitoring systems on machine tools nowadays, and this will be further enhanced in the future. "Many are mistake-proofing operator assistance features, like our Liebherr Collision Control feature, to avoid any major machine breakdwons. Further, tool life monitoring systems in Liebherr gear hobbing machines have been in use now for five years — like Artis tool monitoring — so these will undoubtedly operate in an adaptive mode for operator assitance," Yoders said. These features will continue to progress in gear manufacturing in the future.

For many in the industry, gear machines will be faster, more efficient and consume less energy. But in 20 years, it won't be as futuristic and automated as some might expect. A typical gear manufacturing operation will look remarkably similar to today's gear shop, said Adam Gimpert, business manager at Koepfer.

"Look a bit closer and it will be cleaner, faster, with less humans on the shop floor. Intelligent (relative to today's) robots will replace some operators and will be able to move and adapt to existing machines that may still be decades old. Teaching those robots, however, will still be a human occupation. Digital standardization of gear manufacturing information will allow more seamless operations — even between organizations. This will increase the velocity of all processing and tracking from the conception of a gear through the entire life of the gear," Gimpert said.



Machines in the future will produce higher quality products with maximum productivity and tool life. (Courtesy of Gleason).

The Gear Manufacturers' Perspective

Mike McKernin, president of Circle Gear and Machine, envisions a future gear shop where blueprints no longer exist and automated part movement is the norm. "Employees will have tablets (or similar devices) to access all the information they need for the project at hand. Display screens will replace message or white boards throughout the factory."

He also believes mechanical machines built in the 1950's through the 1980's will still be producing a decent industrial grade gear. "Unfortunately the market will not need as many industrial grade gears. Early generation CNC machines will have been discarded due to a lack of electronic components. Creative operators will still be required to determine workholding on challenging parts. Determining machine rates will be much easier. I also think *The Machinist's Handbook* will be a flash drive that contains 100 times the information currently printed."

Software advances will help gear manufacturers achieve difficult setups with less experienced workers in the future, said Young at Forest City Gear. "Visual instructions will be more common place as well. I would anticipate the equipment to have more diagnostic equipment to avoid maintenance issues (perhaps even some self-repairing machines). New machinery will be able to be upgraded without the necessity of complete replacement thereby lowering cost for new advances and reducing time for the ordinary job shop. These machines will feature integrated inspection capabilities for self-correcting. We should expect to load the prints into the machine and have them research any specification with which they are not familiar off the Internet or its successor."

In the future there will be more focus on core competencies with heavier cost reduction and On-Time Delivery (OTD) pressures. "This may lead to more specialization shops instead of trying to be everything to everyone since companies won't be willing to pay for any machine downtime in pricing structures," said Patrick Kay, controller at Forest City Gear. "I also think the focus will be so heavy on cost that one-stop-shopping may not be possible. This is contrary to the current FCG model."

Man Versus Machine Tool

Though we can't forecast the percentage of robotics and automation that will play a daily role in the gear shop of the future, Albrecht at Gleason is sure future

manufacturing systems will rely less on traditional human experience, but will demand a highly trained engineering staff supporting advanced systems reacting to real-time data exchange. "The role of the machine operator will change to a highly skilled systems specialist," he said.

And this could lead to some interesting problems in manufacturing. "What happens when you increase the complexity of the machine tool? Automation improvements will be great opportunities in gear manufacturing, but when you complicate the machine, you make it more difficult to get the right kind of people to run it effectively," Goodfellow said. "Instead of hiring a machine operator or two, you'll need to find an engineer with an additional set of skills. Where are we going to find these people in the future?"

Miller at Kapp expects the diversity gap to widen over the next two decades. "The investment required to stay ahead will outpace potential profit for most gear manufacturing businesses that don't serve a niche market. The decision-making requires empowered, nimble, educated and risk-oriented human resources. These resources have to be grown and not outsourced. Management must prioritize staff development over task management."

No matter what technologies push the industry forward, academics and industry will have to come together to prepare the next workforce for the gear shop of the future. And while electric cars make headlines and direct drive motors replace gears, this industry will be fine 20 years down the road.

A Kawasaki robot serves ice cream during IMTS 2016 (photo by David Ropinski).

"Gears will still be in the differential box, they'll be in the all-wheel-steering and you'll find them in all the gizmos and gadgets utilized for the automation of the vehicle," Goodfellow said. "Gears are still going to be a huge part of our life; they just might have different characteristics."

He also warns of accepting new technology and innovation in haste. "I have a car that will brake if I don't stop to avoid the car in front of me. I haven't tried it yet, simply because I don't trust it. The feature is there, but I'm not comfortable testing it out. We're going to have to look at things differently and trust that these technologies will work in the future."

Koepfer's Gimpert thinks we're still a long way from the automated factory that techies and futurists envision in manufacturing today. And there will be plenty of time to work the kinks out.

"I think of the comments made by Michael Rogers (*The New York Times* author and futurist-in-residence) at the 2015 AGMA Annual Meeting where he referred to the building industry as leading the way in futurizing digital 3D models and shared information," Gimpert said. "Having spent the start of my own career in the building industry, I know firsthand the challenges and difficulties involved in moving an entire industry into the promise of the future. As much as we want to imagine artificial intelligence running factories without people, this is probably more than 20 years away."

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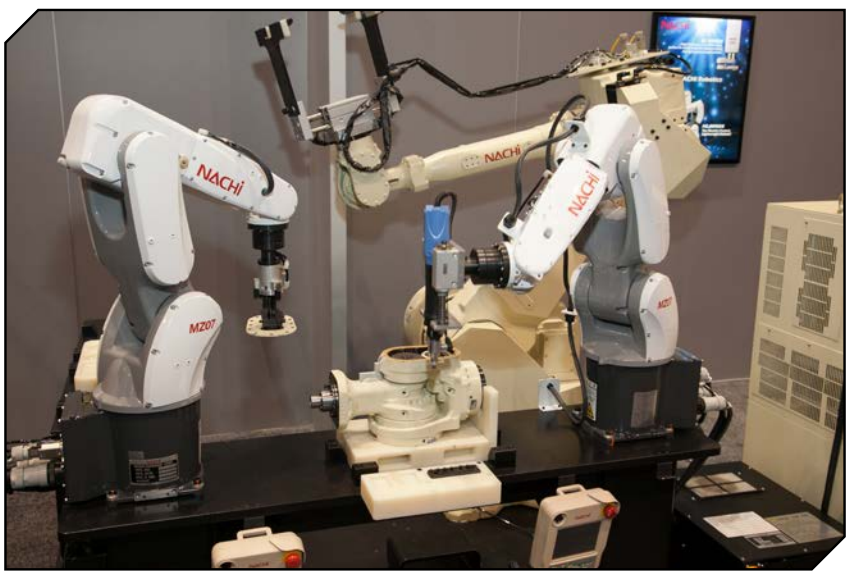

Nachi Robotic Systems featured an array of robot technologies during IMTS 2016 (photo by David Ropinski).

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