Overlapping Pursuits

More than any other field, IIoT overlaps directly with metrology's mission to analyze and measure as much of the manufacturing process as possible, and it's no surprise that the latter is utilizing the former.

Alex Cannella, Associate Editor

Metrology experts have been in the business of analyzing and measuring tools and gears for a long time. It's just one step of the gear manufacturing process, but also an established, essential one. With demands for manufacturing accuracy and process repeatability growing increasingly exacting, the need to make sure your products are up to specifications down to the micrometer is ever more pressing, and metrology experts are always there to step up and meet those demands.

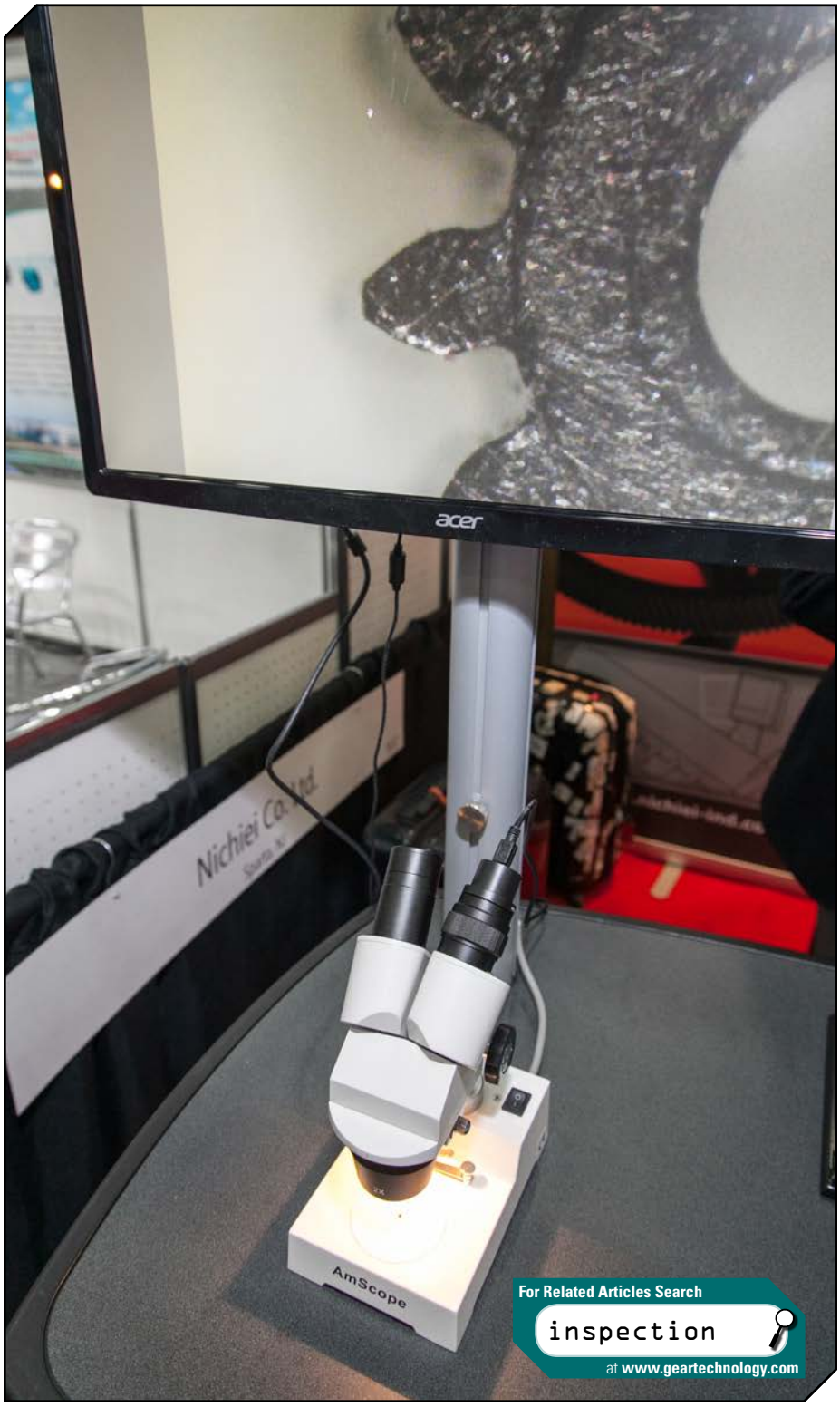
The Industrial Internet of Things, or Industry 4.0 as some in Europe call it, is all about that. From RFID tags to big data operations capable of analyzing heaps of digital information orders of magnitude vaster than ever before, IoT technology is a colossal leap forward, the largest we've seen since the advent of computers, in how we study and understand our own production processes.

Is it any surprise that these two fields would go hand in hand?

There isn't merely overlap between metrology and IoT technology — metrology stands squarely in the epicenter of innovation. By virtue of a common goal, metrology systems may stand to grow and improve more than any other field of manufacturing from the "Fourth Industrial Revolution," and we're already seeing the field being revolutionized by its pioneers.

"Metrology tools are in the business of providing data and the Internet of Things is a way to handle that data," Pat Nugent, vice president of product management at Mahr, said.

Take, for example, all the new doors the Internet of Things has opened for Klingelnberg. Closed loop systems, accurate digital twins, smart tooling systems, and uniform digital design data sets are just a few of the many new directions Klingelnberg's digital efforts are exploding out in.



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"All measuring- and production-machines do produce and collect huge amounts of data," Dr. Christof Gorgels, director of the measuring machines division at Klingelnberg, said. "Systematic evaluation of this data helps our customers to improve their processes, to decrease process times and to increase their profitableness and reliability."

One pillar of Industry 4.0's many advances in particular that has been most critical for Klingelnberg is interconnectivity. Many of Klingelnberg's most recent IoT-related advances come back to this one critical concept, most notably their closed loop system. At its absolute core, the Internet of Things is all about making machines communicate more effectively with each other, and more than any other new product or system coming out of Klingelnberg, the closed loop system takes advantage of this fact.

This closed loop system connects every machine in the manufacturing process together into a single system. Technically, closed loop systems are much bigger than just metrology machines. Design programs, grinding, cutting and finishing machines, and digital tooling are all connected alongside them. But inspection systems are one of the most critical elements in that chain.

Klingelnberg's closed loop system starts with a digital design of a workpiece, including digital recreations of the tooling and manufacturing processes utilized to make it. According to Gorgels, this digital design is the "expected outcome in a perfect manufacturing world," what the workpiece should look like without any outside forces or unexpected complications arising during the process.

Metrology machines come into the closed loop process after the workpiece has been ground down. Their job is to check each workpiece against that digital ideal, note any inconsistencies or imperfections, and if they find any, send that workpiece back to the grinders complete with information on what corrections need to be made to fix the piece.

And according to Gorgels, metrology machines in Klingelnberg's closed loop system can execute their tasks automatically, even on more complex workpieces.

In order to make this process possible, Klingelnberg has not only needed to know the parameters of their workpieces, but also of the tools used with them, and to that end, they've developed their most recent new release: smart tooling products. Many of Klingelnberg's tools now come with a data matrix code that identifies the tool. The tool's information is already part of the database, but scanning the code brings up that information, along with additional

details such as the tool's accuracy or how many workpieces it has cut. All this combines to create a digital twin for your manufacturing machines to utilize.

A digital twin is exactly what the name suggests: a digital recreation of a physical object that exists alongside it throughout the entirety of its lifecycle and often reflects not just its basic parameters, but also how that object changes over time. If set up to do so, digital twins can even make note of changing parameters such as when a gear is reground or how a tool is being worn down as its performance shifts over time.

In many cases, digital twins are used to follow individual workpieces from their inception all the way until they're eventually discarded by whoever purchases them. This gives manufacturers unprecedented and increasingly granular insight into the typical lifecycle of their products. In automotives, for example, the information from multiple digital twins can be collated and studied to inform a manufacturer about trends such as how often an individual part needs to be replaced, which in turn can identify weak points in a product's design that can be iterated upon.

Klingelnberg's smart tooling technology, however, creates digital twins of the tools and their associated workholding equipment, not the workpiece, which gives entirely different benefits that tie back into the closed loop system. It's no secret that your tool can affect the finished product and introduce variance into the process, so in order to create a fully digital design of the entire process before ever putting a gear to the grinder, Klingelnberg needs to understand how the tool will interact with the workpiece.

By having all of that tool's digital information available already in the system, Klingelnberg can understand exactly how every individual tool in the system should theoretically interact with a workpiece and incorporate that into the design process.

"If the process is known and the tool (e. g. a hob) is measured a simulation can show which errors on the workpiece are coming from the tool inaccuracy," Gorgels said.

Metrology machines are intrinsically tied to this step of the process, as well. In addition to their role of scanning workpieces for imperfections, they can also be used to scan tagged tools during setup to double check that they've been properly set up as initially programmed and reduce the risk of incorrect machining or an outright crash of the machine.

"By tagging the tools and scanning them before each use a lot of data is generated in order to improve efficiency, productivity and thus profitability of manufacturing processes," Gorgels said.

"The measuring machine is in this case the nucleus, where a tool and a data set are combined."

Currently, this smart tooling system is only available in Klingelnberg's bevel product line, but the company is working to expand it across their processes and is currently implementing it into their cylindrical gearing line, as well.

Data consistency is another challenge systems like Klingelnberg's closed loop can solve. Here again, the Internet of Things' focus on interconnectivity lubricates the process. By keeping each machine perpetually interconnected, every machine can draw on the same single digital data set, as opposed to being manually updated separately, removing the risk of errors arising from old data floating around in one machine or operator error.

"Connecting machines using exactly the same data ensures the consistency of data over multiple machines," Gorgels said. "This improves the quality and reliability of measuring results especially for companies with manufacturing sites distributed throughout the world. When measured data can be accessed via network, communication with machine tools can be established easily. This enables the closed loop in manufacturing around the whole manufacturing chain and thus the creation of a digital twin of each manufactured part."

According to Gorgels, this singular digital design data set is still rare in the gear world, but Klingelnberg utilizes modern techniques such as their KIMoS (Klingelnberg Integrated Manufacturing of Spiral Bevel Gears) software package to generate that data.

Gleason has seen similar advances brought about by IoT technology. Everything from closed loop systems to predictive analysis back through the gear design itself have been improving gear design, manufacturing and measurement processes there, as well. Douglas Beerck, vice president and general manager at Gleason Metrology Systems, has watched these innovations be implemented and has a few ideas on what might be next in the future.

"With the expansion of closed loop capability between the inspection machine and the machine tool, the predictive capability goes beyond the state of each machine individually and is being developed into a predictive capability of the gear manufacturing process itself," Beerck said. "With identification and part recognition technology, the machine, part, tool, operator, workholding, etc. can all be tracked and monitored and performance trends analyzed automatically in a lot of cases. The IIoT adds to the seamlessness and speed of the transfer of the data...Industry is really just beginning to tap into the capability IIoT tools have to enhance the manufacturing process, but the results are already driving significant throughout, uptime and quality improvements beyond what was thought possible just a few years ago."

Beerck also has a few ideas on how the industry might dig deeper into the Internet of Things' possibilities. In particular, he pointed to artificial intelligence as a future possibility. Perhaps not necessarily a full on AI as we might imagine one in a science fiction story, but a machine capable of learning and developing decision trees from the data we give it. As we continue to make data easier and faster to pass between machines than ever before, Beerck believes that machines will only grow smarter.

Of course, the Internet of Things may be providing massive benefits to both manufacturers and metrology experts alike, but its not without its challenges. As Nugent noted, a lot of manufacturers have been tempted by IoT networks such as those being developed by Amazon, but are cautious due to those networks' open nature. Wanting to keep one's cards close to the chest is a natural instinct in a competitive business environment, and Nugent's found that the prospect of having to show those cards intimidates many manufacturers.

"I think there's a lot of concern in the world of manufacturers about sharing this big data that would be created by really leveraging the Industrial Internet of Things somewhere outside of their walls," Nugent said. "While we all love the idea of working in the cloud, I think having the product data on every part you make be out there on some Amazon server out there makes a lot of customers of ours nervous."

And that's why Mahr has been working with an open source platform, ADAMOS (Adaptive Manufacturing Open Solutions). The main advantage Nugent has found with ADAMOS is that even though it's open source and cloud-based, individual companies can use the platform on their own private servers, thus keeping their data only in their own system instead of intermingling with everyone else.

ADAMOS is a joint venture being undertaken by DMG Mori, Zeiss and several other German manufacturing and software experts, but companies like Mahr have been adapting to incorporate the system. Mahr, for example, has been retooling their interfaces to work with the platform.

Mahr has also been bringing IoT to hand metrology tools, implementing wireless transmission capabilities across an increasing number of calipers and micrometers. Mahr is using the ANT+ protocol as the basis for connecting their hand tools to a single network. Nugent cited the protocol's low power consumption as a primary factor in choosing to use the protocol, as battery life is a concern with hand tools.

"We think that making it easy to collect that data is critically important," Nugent said. "The old days of — even with simple hand tools — measuring and writing down data on paper is gone."

The old days of a lot of things are fading in the manufacturing sector. As ever, the Internet of Things has already started changing how we do our jobs, and as Beerck noted, it still stands to potentially change everything a lot more. And metrology is not only being transformed by it, but also being made an an ever more indispensable part of the manufacturing process.

And just as it's no surprise that metrology and the Internet of Things go so well together, it won't be a surprise when both continue to rapidly evolve in tandem.

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