Keeping Up with the Latest Technology

Observations on robotics, machine tools and heat treating

Joe Arvin

In terms of technology, we certainly live in amazing times. Think about it: We live in a world where you can interact with artificial intelligence via your smartphone, which essentially possesses the collective knowledge base of humanity.

The advancement of technology reaches into every corner of our civilization, and this certainly applies to the manufacturing sector. Many new developments are taking place, and as I've said for decades, the key to remaining competitive in manufacturing is to embrace the latest technology and implement it to the best of your abilities.

You might be thinking, "That sounds great, Joe, but come on. I've got my hands full getting quality parts out the door for our customers. How am I supposed to keep up with everything that's going on with technology? And what about the cost?"

This is certainly a challenge. Regarding the cost of investing in technology and its critical importance for future success, I suggest reviewing my Arvin's Angle article in *Gear Technology* from February 2023, titled "Remaining Competitive—Don't Let Technology Pass You By." This presents a few insights about navigating the cost issues associated with updating your technology.

Then there is the issue of keeping pace with technology. Since I have had the privilege of visiting numerous gear plants and research centers in the U.S., as well as 170 in 33 countries, and I closely watch the progression of technology, I wanted to share my observations about some technological advancements.

For the purpose of this article, I will focus on three key areas: Robotics, Machine Tools, and Heat Treating.

Robotics

Regarding robotics, we've all seen online videos of how robots are now taking human form, coupled with artificial intelligence, and even equipped with facial expressions. While this is happening, what about applications for manufacturing?

Robotics in the factory is nothing new, as this technology has been in place since the 1970s. Today, most people think robots are used in manufacturing for lifting heavy loads, performing repetitive non-precision tasks, loading and unloading machine tools, and welding. However, the field of robotics has also been greatly impacted by technological advancements. Today, the application of robotics has expanded into areas such as hazardous environment tasks, police work, military, space exploration, caregiving, and even microsurgeries. With the rapid development of artificial intelligence, we will certainly see more advanced robots becoming available with better accuracy, agility and flexibility, making their integration into manufacturing a logical fit.

Not long ago, I met with Bryan d'Ouville, director of FANUC America's Midwest Robotics Group in Hoffman Estates, IL. There, I had the opportunity to see some of these advanced capabilities firsthand. I strongly recommend finding time to visit.

Additionally, I have had several project-related discussions with Matrix Design, an integration company located in Bartlett, IL.

To get the latest information on robots and their integration, I also spoke with individuals from both FANUC and Matrix to get their perspectives.

David Bruce, Manager of Engineering for FANUC America's Vision Group

Q: What are some of the latest developments in robotics technology?

Bruce: A key advancement is 3D vision guidance. With the assistance of 3D vision, robots are now used for assembly and part picking in warehouses. This allows for sorting and packaging. In the case of [FANUC's] iRVision Robots with 3D vision guidance, they can locate and retrieve parts that are not uniformly placed.

Furthermore, there are 3D Vision Systems that continually monitor a robot's position, motion, and direction. If a person enters the robot's work envelope, this safety vision system will stop or slow down the robot depending on the relative motion of the robot and the person. Robot vision also prevents collisions with the workpiece or the machine tool itself.

3D vision is certainly an amazing enhancement, as people could not work around previous robotic systems due to obvious safety reasons. Bruce had additional comments.

Bruce: Often, in vision-guided applications, a task will be split between two robots. One robot will pick a part using a rough-pick method and place it so that a second robot, also using vision, will pick the part more accurately for the next step in the process. Bin picking is a good example of this, where retrieving a part from a bin of piled-up parts cannot be done very accurately. The second step is required to achieve the necessary accuracy for the next step. Sometimes, the same robot will do both steps, with the second snap done while the robot is still moving, which is referred to as "snap on the fly."

Virgil Wilson, Staff Engineer at FANUC Robotics (Retired)

Q: What are some other capabilities of today's robotic technology?

Wilson: FANUC's line of CRX collaborative robot models (cobots) is equipped with a built-in force control feature. There is no need for an external force sensor, mounting hardware or cabling. The integrated force control offers a wide range of ICON-based force control options suitable for material removal and assembly tasks. The force control capabilities are advantageous for various applications, including assembly and material removal processes such as gear deburring.

From my time at the FANUC demonstration facility in Hoffman Estates, I saw that precise robotic inspection is also possible. The workpiece can be removed from the machine and placed on an inspection table. An advanced vision robot can precisely grasp the part and perform the inspection with preset gauging—and this is not just the simple use of go/no go gauges. The gauging results can be forwarded to the CNC machine for auto adjustments for control of size and length.

With the advancements of robotic capabilities comes the natural expansion of applications as robots become more capable and flexible. I also spoke with Patrick Bertsche of Matrix.

Patrick Bertsche, CEO of Matrix Design

Q: What are you seeing in terms of the applications of robots based on their advancing capabilities?

Bertsche: The types of applications in which robots can be used have changed considerably over the years. Many companies are now thinking holistically about their processes and not just automating an isolated operation.

There have been several advancements in distributed control systems (DCS)—flexible zone controls, and being able to control robot speeds and receive reliable feedback via the robot controllers.

There are still a great number of industrial robots being used, with their reliability, robustness, and speed. These are very different from collaborative robots, but there is a place for both, and companies now have more choices when integrating robotics.

To see excerpts of my interviews with David Bruce and Patrick Bertsche on robotics, please visit our website at *AGSLearningCenter.com*.

I saw another interesting robotic application in an automated cell in Europe.

I observed auto inspection operations integrated into a completely automated machining cell utilizing five machine tools. Using vision, a robot removed forgings from a bin with parts positioned randomly. The part was loaded into the machining cell and came out the other end as a finished part. It was then auto-loaded into a shipping container for heat treatment or for shipping to the customer. These capabilities mean dramatic potential for increased productivity.

Machine Tools

Machine tools have continuously evolved, incorporating the latest technologies to enhance their capabilities. While avoiding references to specific manufacturers, here are some notable advancements in the field.

One notable development is the introduction of an internal grinder designed to generate internal spur and helical gears with AGMA Class 14 quality. Unlike traditional methods that rely on form grinding and single indexing for internal gears, this machine utilizes a more advanced approach.

It employs a vitrified, dressable, multi-start threaded grinding wheel to generate gear teeth through continuous motion. The cross-axis angle facilitates high tool speed at the tooth surface, improving efficiency and precision.

With tool spindle speeds reaching up to 15,000 rpm, this method achieves high metal removal rates, making generative internal gear grinding both productive and cost-effective, particularly for high-volume production.

Additionally, these machines feature the capability to make profile angle adjustments during production. Full multi-axis control allows for precise adjustments to symmetrical and asymmetrical pressure angles ($fH\alpha$), as well as involute crowning and tip relief.

For instance, a gear with a 1.22 normal module, 24-degree normal pressure angle (NPA), 92 teeth, 20-degree helix, 120 mm reference diameter, and 25 mm face width would have a cycle time of just 183 seconds, including proportional dressing time. This impressive efficiency highlights the machine's ability to meet demanding production requirements.

Several gear companies are now grinding the gear teeth on spur, spiral and hypoid gears from solid. This eliminates the need for standalone gear cutters, heads, blades and sharpening machines. While this is not a new method, it is becoming more common.

With the latest grinding wheel technology, cycle times for grinding from solid can be faster or equal to the cutting operation, depending on the gear's diametral pitch.

A significant advantage of grinding teeth from solid is the elimination of stress induced during various cutting operations. This stress can be unpredictable and cause problems during heat treatment in the form of distortion as it is released.

Several companies are using large CNC machining centers to cut the gear teeth on large bevel gears. With this method, quality is equivalent, but there is no need for single-purpose gear cutting machines.

Integrated Machining Operations

Several gear companies are performing turning, drilling, milling and hobbing gears or external splines in one machine tool. Typically, these operations are performed in a multi-axis CNC machine with dual chucks, live tooling, and in some cases, two turrets (upper and lower). Depending on the part configuration, they could be ready for heat treatment with no other machining required.

One gear company was able to turn, drill, mill, hob, cut internal splines, and straight tooth bevel gears in one machine. They were also working on the ability to cut spiral bevel gear teeth in the same machine.

The takeaway is that the future of gear manufacturing will involve machine tools that can perform multiple operations in one machine. My advice is to keep an eye out for this capability because of competition and profitability concerns.

Heat Treat

So we've talked about robotics and machine tools. What about heat treating?

A major concern with heat treating is related distortion. There are multiple causes of stress-related distortion from heat treating operations. These include the condition of the forging or bar stock, stress induced by stock removal operations, cutting tool pressures, part racking during carburization, and differences in cooling rates between thick and thin sections during quenching. (Don't get me started on the condition of the heat treating equipment.)

The Vacuum Process

It appears that vacuum processes for carburizing, hardening, and quenching are becoming more standard in the industry. As with grinding from solid, vacuum technology is not new, but it is becoming more common. One of the key benefits of vacuum carburizing is improved gas flow, which yields a more uniform depth of case.

Additionally, using vacuum for quenching eliminates the need for washing parts to remove quench oil. This also addresses EPA concerns and costs related to disposing of contaminated oil and parts washing fluids. Furthermore, vacuum use eliminates safety concerns and costs from quench oil fires and can potentially reduce insurance costs.

There is also new advanced gas quenching technology that can be paired with vacuum heat treatment that eliminates the need for most die press quenching operations. This technique achieves a more uniform cooling rate as it quenches one piece at a time. The quenching nozzles have varying gas flow volumes directed at the desired thick and thin sections while the part is rotated, yielding a uniform cooling rate across all geometric features. As a result, in many cases, it is unnecessary to leave excess material on sections of the part to manage distortion. This technology is flexible such that it can quench parts in-line after single-piece flow furnaces, either vacuum or atmospheric.

Conclusion

In conclusion, I am amazed to compare the advances in manufacturing technology over my career in the gear business. With the emergence of additive manufacturing and artificial intelligence, we need to hold onto our hats for the next wave.

Finally, I would like to thank those at FANUC and Matrix for their contributions to this article. Be sure to watch my interviews with them on *AGSLearningCenter.com* for additional information.

A Final Word

If you have any questions or comments, I would look forward to hearing from you. Also, if you missed any of my previous articles, below is a list of them by issue number and page. They are also available on the *Gear Technology* website. If you'd like for me to send you a copy, please send me an email or just give me a call.