Moving Parts

Machine Tools Boost Speed and Throughput with Automation Technology

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In order to streamline gear manufacturing equipment in 2014, many shop floors are utilizing some form of automation (gantry, robotics or pallet-based systems). These automation concepts, prevalent to the automotive industry, have become advantageous in off-highway, alternative energy, commercial gearbox production and more. The end game is separating personnel from machine operation time and making these manufacturing cells both cost effective and extremely fast.

"Internal and external automation facilitates higher productivity as well as streamlined management of equipment," says Alois Mundt, managing director at Liebherr-Verzahntechnik GmbH. "Reducing long set-up times, minimizing costs and extending performance is a must for most machines in gear manufacturing today."

"When perfectly matched, automation and a gear-cutting machine mesh like gears, achieving productivity and precision benefits for the end user," says Alan R. Finegan, director, marketing at Gleason Corporation. "Productivity improvements come through reduced chip to chip time and the possibility of autonomous operation, enhanced process consistency and repeatability, and improved material handling, reducing operator fatigue and injury. Also, automation allows for more than just part handling, where other operations such as part washing, inspection, part marking can be integrated."

"Companies can achieve quality that is better and much more consistent by increasing the level of automation in the production process. This is only possible if the initial quality of the components that are being machined is defined and constant," says Hartmuth Müller, CTO, Klingelnberg Group. "Variations in the initial quality mean that the operator has to continually adjust the process parameters, which ultimately leads to greater quality variance and therefore loss of consistency. It is not the human factor that causes fluctuations in the production process, but rather the lack of consistency in the upstream processes."

A key aspect of automation is shortening the setup time, according to Bill Miller, vice president, Kapp Technologies. "Most calculations are automated. Onboard quality inspection, including corrections, is automated. Tool change in many Kapp machines is semi-automated. Combined, these innovations save, on average, over 50 percent of batch processing time. Modern machines, tools and processes increase productivity anywhere from two to four times, over machines which are 10 to 20 years old. So, manual workpiece mounting and truing time becomes a large proportion of the total cycle. Palletized systems are designed for semi-automatic workpiece change. Mass production applications also prioritize setup and/or changeover time. Equally important is the economy of the automatic part loading solution."

The RLS is a cost-effective, entry-level solution for users with very small batch sizes (batch size 1 and above) or small batch manufacturers (courtesy of Liebherr).

Get the Balance Right

Challenges abound for factory automation, from cost concerns to floor space to the speed of the entire automation process. "Customer philosophies differ with respect to production goals and priorities. Optimizing for safety, speed, flexibility and cost efficiency often require very different solutions," Finegan says. "Even within a given philosophy, covering the full spectrum of customer parts with respect to size, weight and configuration is a challenge, as is the integration with the machine tools and automation of other manufacturers, and with established systems in the plant."

"The biggest challenge is to combine automation and flexibility characteristics that appear to be conflicting at first glance," adds Müller. "It is ultimately a balancing act between these two requirements, and the fundamental question is the degree of automation that should be chosen."

Müller believes past experience has shown that flexibility is lost at high levels of automation. "A fully automated gear machining tool lacks the flexibility to deal with batch sizes that are becoming increasingly smaller, and a machine without automation lacks consistency in terms of machining time and component quality," Müller says.

Kapp's Miller says that many automation concepts are available and customers may prefer a certain supplier. "The result is a vast number of available options, which is not efficient for the machine builder to implement."

"Automation is a cost-driven system," Mundt explains, "The money customers want to spend on certain solutions might not work. So you have to create a cost-effective product, and that can be a big challenge. The other challenge is to speed it up like hell. These automation solutions need to be fast. It shouldn't take longer than 10 percent of the machining time."

"First-time buyers of automation often succumb to 'sticker shock' as they perceive the automation to be a non-process and thereby a non-value added cost. Existing users tend to look more for continuous improvement, faster speed and minimal footprint," says Patrick Seitz, president at Felsomat USA. "We collaborate closely with our customers and calculate the overall benefits in terms of machine uptime, efficiency, reduced manpower, potentially reduced number of machine tools, reduced utilities, and reduced floor space."

Covering the full spectrum of customer parts with respect to size, weight and configuration is a challenge, as is the integration with the machine tools and automation of other manufacturers, and with established systems in the plant (courtesy of Gleason).

Automation in Gear Manufacturing

So what options are available to gear manufacturers considering automated work cells? Gantry and pallet robotics systems are available and many machine tool companies combine elements of each. We asked our experts to break down the advantages and disadvantages of these various automation concepts.

Gantry

According to Seitz at Felsomat, gantries, in conjunction with Felsomat patented vertical buffer systems, offer the fastest and most efficient solutions in the smallest footprint.

"Gantry-based systems are sometimes considered the lower end of automation due to their relative inflexibility. However they may be optimized to one part or family of parts and are thus very fast,"

Finegan says. "Operating in a narrow and well-defined range and paths, safety and security issues are generally reduced."

Gantry systems are much less flexible than robots, since the different options for depositing components are extremely limited, according to Müller. "Components are usually loaded from above and thus can essentially only be stacked in two ways (adjacent to or on top of one another). The major advantage of gantry loading is simple operation and programming. Almost any machine tool operator is capable of operating and loading a gantry."

"Gantry systems offer a closed envelope approach to allow for quick loading without the floor space or mess of a robot. However they tend to be more costly and certainly less flexible," says D. Kirk Stewart, Jr., director of sales at EMAG LLC.

Robotics

"The major advantage of robotics is without doubt the significant flexibility that it provides. Because any loading method can be used, these systems provide maximum freedom for determining how individual components are deposited and brought into the system. Everything that is needed and desired in this respect is possible, including stacked components, components placed in baskets, or components deposited onto conveyors. However, this technology requires in-depth knowledge on the part of the operator, who must know how to program a robot," Müller says.

"Robotics offers the benefits of replacing an operator in front of a machine with some of the physical articulation required to accomplish this demand," says Stewart at EMAG. "However, the tradeoff is significant floor space utilization, a fenced in area which does not allow easy access to the machine for an operator for tool change or setup, and in many cases a less than clean working environment with residual chip and coolant debris on the floor."

"Robots tend to be more flexible, versatile and re-deployable, and such systems are generally easier to replicate in cells at multiple customer locations. Representative of the higher end of automation, they are able to adapt to several or many part sizes and configurations, and they may facilitate the integration of multiple cells," Finegan says. "However, robotics tend to consume more floor space and demand robust safety and security measures surrounding the entire operating envelop."

Basket or Pallet Systems

"Particularly for gear technology involving small batch sizes, the biggest benefit in terms of automation is obtained with basket or pallet systems. It does not matter whether the parts are supplied via a gantry, a robot or a machine in a basket or pallet system. The advantage of pallets and baskets is that they provide an easy, flexible way of transporting parts inside the plant," Müller says.

"A palletizing system is quite popular," adds Mundt. "You can transport parts that have been machined wherever you want to. A palletizing cell can be connected to the material flow inside the shop so you can complete a combination of tasks such as honing, deburring, grinding, etc. It's one of the most successful forms of automation in manufacturing. "

"Pallet systems also require a large amount of floor space and often create physical barriers in the plant," adds Seitz.

Combining Technologies

"Most automation systems combine a robot with a conveyor with a basket stacker, etc.," adds Miller at Kapp. "The machine is designed with standard optional features to adapt to most types of available automation. This allows customers to take responsibility as the integrator."

Liebherr takes advantage of the external and internal automation concepts to create a system that is dedicated to the specific needs of the customer. "Most of our machines have multiple automation solutions," Mundt says. "You start with the part carrier, followed by the conveyor belt and the ring loader before gear cutting on a hobbing machine, for example. The overall efficiency of a machine manually loaded is 60 percent if people are in front of it all the time; this goes up to 80 percent with automation."

"The movements of a machine-integrated part transportation system can be designed to be synchronized with the machining axes of the machine tool at CNC level, and are therefore significantly faster than a conventional automation interface," adds Müller at Klingelnberg. "Another advantage lies in the flexibility of automation. Any gantry or robot system can be used, and any degree of automation can be selected."

"At Felsomat, we do not have one automation solution that fits all applications. We have a wide variety of standard modular building blocks which are easily configured to achieve the highest efficiency possible on each operation which

Consistently high machine utilization results in a greater number of components per hour and also reduces the energy consumption of the machine tool (courtesy of Klingelnberg).

is calculated to achieve the lowest overall investment for the customer," Seitz says.

The Current Market

While a single article cannot provide all the automation products and technologies available in the gear market today, here are some highlights:

Liebherr's Rotary Loading System (RLS) offers cost-effective entry into high-efficiency production with one or two machines – delivering utilization of more than 90 percent.

Using the RLS to extend a machine's running time makes investing in an additional machine completely unnecessary in certain cases. "This solution is clearly more effective than marginal increases in productivity that could result, for example, from optimizing CNC programs or the tools of machines that are manually fed or partly automated. One or two machining centers can be docked to the system. For batch size 1 and above, the RLS unleashes considerable efficiency potential," Mundt says.

In the case of EMAG solutions, the automation is inherently built into the machine. The inverted vertical spindle is loading and unloading the workpiece by itself, thus not requiring an operator or robot to load into the spindle. "This allows for EMAG to provide a standalone automated cell with very predictable productivity," Stewart says. "The new Modular Standard and Modular Customized solutions EMAG offers on the VL and VLC platforms, respectively, offer machines tied together with various automation configurations to meet the customer's requirements. These modular systems can be set up to interface with downstream and upstream systems, for Chaku-Chaku loading, for buffered loop conveyors, or for common highway solutions."

Flexible and intelligent automation solutions allows for a new generation of machining capabilities (courtesy of EMAG).

"Our Genesis line of machines have fast part loading systems with options to chamfer and deburr in parallel, and our Phoenix 280CX Bevel Gear Cutting Machine provides fast loading from the cutting spindle to an auxiliary chamfer & deburring spindle that runs in parallel to the cutting cycle," Finegan at Gleason says. "Agilus is a combined process machine that combines gear hobbing with turning, chamfering & deburring, and drilling. Our Titan series of large cylindrical gear grinders offer

The Kapp KX100 offers practical efficiency gains of 10 to 20 percent (courtesy of Kapp).

Power Grind, which combines the benefits of threaded wheel grinding productivity with the precision of profile grinding. We also offer the BPG Stick Blade Grinder with a standard includes blade load/unload system capable of running in an unmanned mode."

Klingelnberg is working on making automation more intelligent. "An automated machine tool depends on coordination between the workpiece, the workpiece fixture and the workpiece program. In this respect, an automated machine tool is not fault-tolerant. The first process involves gripping a new component using the automated system. Another important point is to standardize the interface between the machine tool and the automation system. Every manufacturer has its own original interface, which has to be adapted or at least coordinated for every automation manufacturer. An international standard would help to reduce the effort involved and make the customer more competitive in terms of costs and flexibility," Müller says.

"A fully automatic solution using our basketized FlexStackingCell is the most appropriate solution in highly developed and high labor cost regions such as North America and Europe," says Matt Skelton, sales manager at Felsomat USA. "Customers operating in these regions are also demanding highly flexible systems that can be quickly changed from one part to another without tools within 5-10 minutes. Also required is the ability to re-tool and re-deploy automation assets to meet rapidly changing product lifecycles. In developing countries with low labor costs, our customers demand a manual/automation hybrid solution with lower investment criteria."

"The Kapp KX100 breaks new ground by applying a proven design to gear grinding where the work spindle also performs the loading function, as well as aligning and spinning. Cost and space are conserved," Miller says. "Practical efficiency gains of 10 to 20 percent are easily possible with this machine."

Intelligent Machining

The future of automation technology revolves around making the machines smarter. Initially, these concepts might make operators nervous (and replaceable) but the truth is that an intelligent machining platform can only be as effective as the operators utilizing the technology. Smart machining will become more beneficial when they are running 24/7 or during lunch or coffee breaks. These automation systems aim to make the entire production process much more efficient.

"Our vision is to have seamless transparency throughout the production process: Each step of the process is stored in a database, meaning that all product-related information is clearly documented in chronological order. This allows the entire production process to be tracked down to the last detail for each component. The advantage: Users can identify correlations, for example, and draw conclusions as to steps in the production process that require readjustment," Müller says.

Felsomat is striving to influence the design of machine tools to reduce the level of automation required. "To that end Felsomat has developed twin spindle turning and hobbing machines with integrated automation where the idle spindle is loaded automatically while the second spindle is in production. This reduces idle time, or "chip to chip" time to the absolute minimum and on large automotive gear manufacturing programs there is the potential to significantly reduce the level of machine tools and automation investment. Felsomat is also leading developments in the field of heat treatment of gears within the gear manufacturing process thereby further reducing separate independent automation processes," Skelton says.

"Well trained machine operators are still difficult to find in manufacturing," Mundt adds. "We've set up intelligent program structures at Liebherr to do most of the work. Instead of the operators telling the automation what to do, the automation will tell the operators what to do. The ERP system (enterprise resource planning) will point out the production needs and the machine will answer the call. This (along with adaptive controls) is already taking place within the gear industry."

And how do some of these machine tool manufacturers feel about the potential downside to some of these new technologies? An automated system, for example, might make it possible for a customer to purchase two machines instead of four, saving energy and valuable floor space in the process.

"As a manufacturer of machines, I'm not happy about the situation," says Mundt, laughing. "But we are fighting for the benefits of our customers."

(*Additional information for this article was provided by William McGlasson, Michael Walker, Craig Ronald and Matthias Philippin at Gleason Corporation*)

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