Combination Machines **Improve Gear Manufacture**

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Efficiency and accuracy.

They're two keys to success for all gear manufacturers and two keys underlying the recent introduction of machines that combine separate processes used to manufacture gears.

These more flexible machines are designed to increase efficiency by reducing the number of times that operators have to mount, dismount and remount gears to move them between processes. Reducing the number of mountings can raise gear accuracy, too.

Not a New Trend

Combining processes in a single machine isn't new, though. Gleason-Pfauter Maschinenfabrik GmbH started building SHOBBERs® decades ago, when it was Hermann Pfauter Maschinenfabrik. SHOBBERs combine hobbing and gear shaping in one enclosure.

The combination offered several advantages. SHOBBERs could reduce cutting times by hobbing and shaping at the same time in one setup. The two processes in one enclosure reduced transport distance. Operators didn't have to take a gear from one machine and move it to another.

These advantages speeded up production, a useful thing in gear manufacturing businesses, including the businesses that SHOBBERs were built for: companies manufacturing large volumes of the same gear or similar gears.

Besides shorter overall cycle times, SHOBBERs also could reduce accuracy errors in a workpeice. For example, two gear elements on a single workpiece, whether on a disc or shaft, usually have a pitch-line concentricity tolerance to each other. Compared with separate gear shapers and hobbers, SHOBBERs could improve concentricity between the elements because there was only one clamping.

The SHOBBER was an early example of a now noticeable trend: machine tool manufacturers creating combination machines to give greater productivity, accuracy and flexibility to gear manufacturers.

Hobbing and Grinding

In recent years, Gleason has developed other combinations, such as horizontal hobbing and worm milling. In 1998, the company combined those processes in its P 60, which could also perform other machining processes. For example, using a carbide centering tool, the P 60 could machine a recessed center into a shaft before hobbing a spline on it.

In 2005, Gleason introduced a new machine, the P 90 G, which combined hobbing and grinding. The P 90 G can hob and grind external spur and helical gears, as well as external involute splines. It can also mill and grind worm gears and can skive hardened gears. It can cut and grind keyways, too.

The P 90 G itself is an upgrade of another machine, the P 90. That machine was designed to be flexible, being able to hob external spur and helical gears and mill worm gears. Still built, the P 90 can be used in job shops making a variety of gears in small to large batches or can be used in companies making high volumes of the same or similar gears.

As an upgrade, the P 90 G, however, can include the full range of grinding processes. "This machine is even more flexible," says Stefan Windler, a product manager for Gleason-Pfauter.

Using CBN wheels, the machine can perform profile grinding (both roughing and finishing operations), worm or threaded wheel grinding, and index generating grinding.

"All of those are possible, but the threaded wheel grinding is standard," Windler says.

As an upgrade, the P 90 G has guideways designed for grinding machines and a grinder-type enclosure, so there's no leakage of oil sprayed from the grinder's high-pressure coolant nozzles. Like the P 90, the P 90 G has deburring as a standard process performed in its regular enclosure.

The P 90 can also be adapted to include a chamfering and deburring station. If added, the station would be integrated within the machine's enclosure, and the two would share the same gantry loading system.

Both chamfering and deburring would occur in parallel to the hobbing process, so hobbing cycle times wouldn't increase.

Hobbing, Chamfering and Deburring

Other machines that can combine hobbing with chamfering and deburring are the Samputensili S150–S300 hobbers from Star SU LLC.

They can perform the chamfering and deburring via the company's new chamfering and deburring module, called the CDM.

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With the modules integrated, the CNC hobbers can chamfer and deburr spur and helical gears, creating a fully automated system for use in mass production.

Once attached, the CDM is a permanent part of the hobbing machine. "You can turn it off, but you can't take it away," says Brian Cluff, Star SU's vice president of sales and application engineering.

The hobber and CDM have different fixtures that clamp workpieces by the same method or in the same clamping reference. The integrated hobber-CDM automation moves the part internally from one operation station to another. Also, chamfering and deburring are considered one operation since the tool is designed to perform both in a single operation.

A Step Further

The EMAG Group took that combination a step further by adding another operation, turning. EMAG's combination exists in a series of machines, gear hobbing centers, the most powerful of which is the VSC 400 DUO WF. These centers use a platform based on EMAG's other VSC machines, which perform other functions, including turning, drilling, milling, grinding, laser application, and gear honing.

The VSC 400 DUO WF was designed to increase productivity in the manufacture of pre-hardened external spur and helical gears. The gear hobbing center combines processes so operators don't have to reclamp workpieces between second-side turning and hobbing or between hobbing and pressure deburring. Mounting of gears between separate machines can include errors, reducing gear accuracy. Transferring gears between machines increases overall throughput times.

Also, the VSC 400 DUO WF was designed to match concentricity between tooth profile and bore, reduce idle times, lower unit production and servicing costs, and occupy less floor space than separate machines.

The gear hobbing center can be made to check workpieces' dimensional accuracy before it starts the next operation. Moreover, deviations are transmitted to the VSC 400 DUO WF's machine control and corrected.

In gear grinding, Gleason, the Kapp Group, the Liebherr Group and Samputensili S.p.A. now offer dedicated gear grinders capable of form grinding or generating grinding on the same machine and capable of using dressable wheels and electroplated CBN wheels. Modern gear grinding machines also include on-machine inspection.

Grinding and Inspection

One example of combined grinding and inspection comes from Kapp: the KX 300 P. The machine is the top of the line of Kapp's KX 300 series gear grinders. It was introduced in Europe in mid-2004 and in the United States in late 2004.

The KX 300 P was designed to be versatile, so it could be used in

job shops for making a variety of gears in small to large batches and for operations engaged in mass production of the same or similar gears.

Kapp built the machine to carry out form grinding and generating grinding of gears and to perform both processes using either dressable vitrified wheels or non-dressable CBN wheels. The KX 300 P also has a dressing system for the vitrified tools, whether they're threaded wheels or form wheels. This system makes the machine fast and flexible for various gear jobs, from making prototypes to mass production of gears.

Also, the machine has an integrated gear inspection system as a standard feature in order to reduce setup time. The system is attached to the tool spindle and has its own pivoting system, so gear inspection occurs inside the machine's regular enclosure. Specifically, the KX 300 P can measure lead, involute, pitch, spacing, runout and gear tooth thickness.

With on-machine inspection, operators could reduce the amount of time they spend walking between their grinding machines and inspection labs.

"It speeds up the setup time," says Tom Lang, general manager of Kapp Technologies. "You should be able to grind your first part good, send it to your inspection lab and be in production." However, he adds the KX 300 P isn't meant to replace inspection labs or to substitute for final inspection.

Lang says the company's Niles division started offering a new combination: form grinding and bore and face grinding.

The new machine is the ZP 25I, which is designed to form grind cylindrical gears, external spurs and helicals, with outside diameters of two meters or more.

Lang describes the machine as having a work spindle and two columns. One column holds a form wheel, the other holds a cup wheel for bore and face grinding. In operation, it's the columns that move into position with the work spindle, not the spindle itself. So teeth, bore and faces can be ground without the gear being dismounted and remounted.

Lang says the benefit is improvement in concentricity of the gear and bore. He adds the ZP 25I was offered first in September to a European company, then to a few U.S. ones.

Lang, however, declines to discuss what other processes Kapp is working on combining. Others also prefer not discussing their development of other possible combination machines. Like in a card game, no one wants to tip his hand so his cards show.

Still, it's safe to assume those developments are also aimed at allowing gear manufacturers to increase efficiency and accuracy. ■

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