The Technology Shift

HSS vs. Indexable in Gear Hobbing

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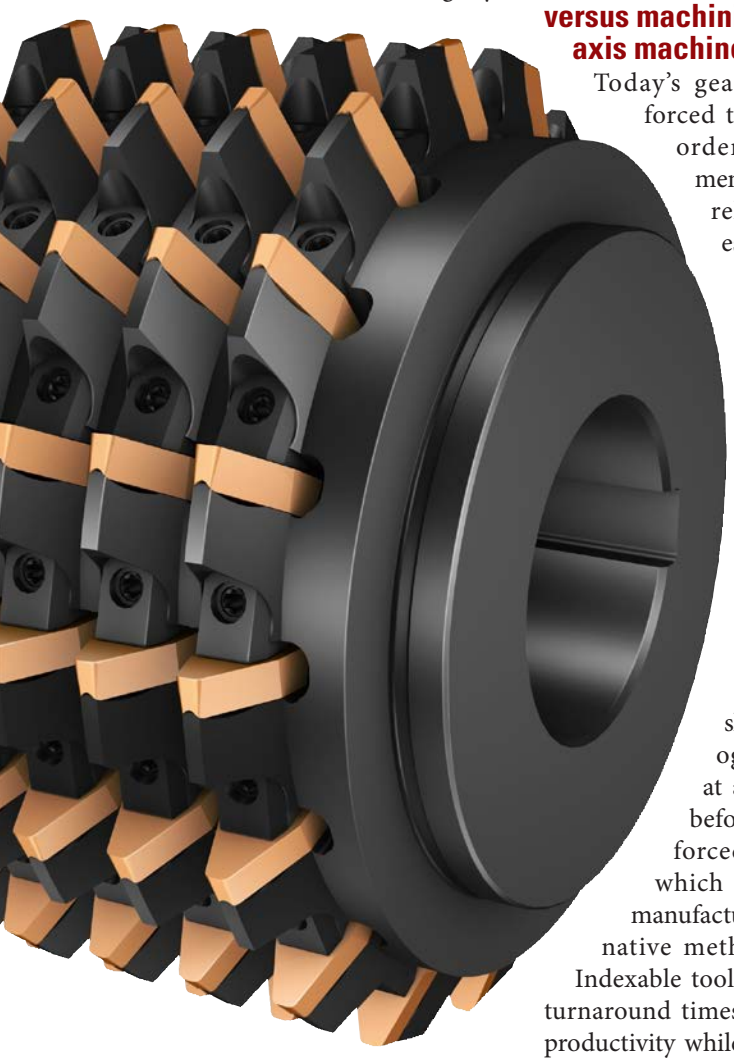
Decades ago, technology shifted from HSS to indexable inserts in turning and milling. This movement wasn't immediately realized in gear hobbing because coated PM-HSS hobs and complex gear profiles remained highly effective and productive methods. Only fairly recently have gear manufacturers started to take a serious look at indexable technology to cut gear teeth. A shift away from conventional gear machining to machining centers/five-axis machines is one of the major factors in this shift. Furthermore, advances in both productivity and quality in indexable gear tooling also play a central role in this development. Finally, new materials in gear production are making indexable tooling attractive to many gear manufacturers.



Conventional machine tools versus machining centers/five-axis machines

Today's gear manufacturers are forced to be more flexible in order to satisfy requirements for shorter runs and relatively small batches of gear profiles with greater variety in specifications from run to run. We all know that HSS machining is still the most common process for gear hobbing, but for aerospace, automotive, construction and heavy machinery industries alike, the pace of change is accelerating. Product lifespans are getting shorter as new technologies are implemented at a faster clip than ever before. Part runs are then forced to become shorter, which in turn requires gear manufacturers to consider alternative methods of gear cutting. Indexable tooling can provide faster turnaround times, providing improved productivity while retaining quality and better consistency.

The technology shift from HSS to indexable tooling and from conventional machining to machining centers/five-axis machining can be advantageous not only for small-volume gear producers, but also for medium- to high-volume gear producers. Tooling technology is moving away from special tooling and toward standard tooling, which means an operator of the future will be able to get all the necessary tooling in one to two days. Large-volume gear shops are attacking the new landscape with indexable tooling flexibility, augmenting and replacing the traditional HSS lineup of tools.

Industry trends toward smaller batches and more variety are similar for larger- and smaller-volume gear production facilities alike. But for dedicated shops, total gear volume is high regardless of batch size. The shift from a single, specialized tool for every job, to increasingly standardized tooling systems capable of addressing a variety of gear machining, is a major change for the gear industry as a whole.

InvoMilling, for example, uses standard tools. This technology allows operators to machine the tooth gap and gear on a multitask/five-axis machine as customer needs change. One indexable tool with inserts can be used for a range of modules, which means that no dedicated tools need to be ordered.

Previously, specialized tooling had to be ordered 10 weeks before any production could start. The flanks, which provide the contact length between two mating gears, can be machined in any way the gear transmission designer chooses. The same can be said about the root of the gear, which provides the transmission's strength.

Productivity and quality in indexable gear tooling

In most cases, an indexable hobbing tool like the CoroMill 176 from Sandvik Coromant not only replaces HSS hobs, but also can be used as a roughing hob next to an existing solid HSS hob on the same arbor, when quality demands cannot be reached only by the indexable hob. The road to increased productivity is all about freeing up time on a shop's existing hobbing machines, and mini-

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mizing downtime. This is the main driver for gear manufacturers to begin incorporating indexable hobs in their shops.

Indexable hobbing systems like these can more than double tool life and reduce cutting time by more than 50 percent, depending on the situation, compared with traditional HSS hobs. But a multitude of factors need to be taken into account. For instance, for all of their potential in increasing productivity, current models of indexable hobs cannot outperform the ultra-precise tolerances that *new* HSS hobs are able to hold. After a traditional hob's first regrinding, however, most quality parameters that influence the quality of the gear wheel are in the same tolerance range for both the HSS and indexable hob. Indexable hobs don't require regrinding or recoating; instead, the inserts can be swapped out as necessary. What's more, the minuscule cutting deviations that can occur on a gear wheel as a result of changing from a worn insert to a new insert in an indexable hob are normally much less pronounced compared to the deviations that can occur between a worn HSS hob and its first regrinding.

Cost per part is a major consideration. Operators can produce more parts in the same machine, and postpone investment in new machine tools. Another factor is speed of delivery, as adding new inserts to an indexable hob is a lot less time-consuming than ordering and waiting for a specialty HSS hob or sending the hob away for regrinding, coating etc. And keeping extra hobs on hand to keep production going during regrinding is adding expensive inventory to an operator's tool selection.

However, indexable hobs serve a specific window of gear sizes, ranging from module 3 to 10. Typical components are large gear wheels for heavy vehicles, aerospace gears and industrial transmissions. For even larger gear operations, hobs like the CoroMill 177 cover module ranges 10 to 26. Insert grade, coating and geometry also must be considered with indexable hobbing solutions, as they factor directly into the tool quality.

Increased machine capacity and uptime aren't the only advantages of some indexable tools. With the CoroMill 176 hob specifically, operators are also able to capitalize on modular capabilities.

With this versatility, an operator is able to speed up tool changes, reduce downtime and increase quality – independent of the existing hobbing machine brand in the shop. (See Figures 1-2)

Tool setup time can be reduced thanks to the modular nature of a hob with a Coromant Capto toolholder and spindle interface. Setup time can drop to five minutes for a job that once took 30 minutes. The high accuracy of the Coromant Capto couplings automatically minimizes runout in the tool assembly. When using a modular solution, the operator no longer requires an arbor, spacer or hydraulic nut, reducing the number of connections to create a more rigid, faster-to-set-up tool assembly. This directly translates to improved gear wheel quality and process reliability. The improved stiffness of the CoroMill 176 modular

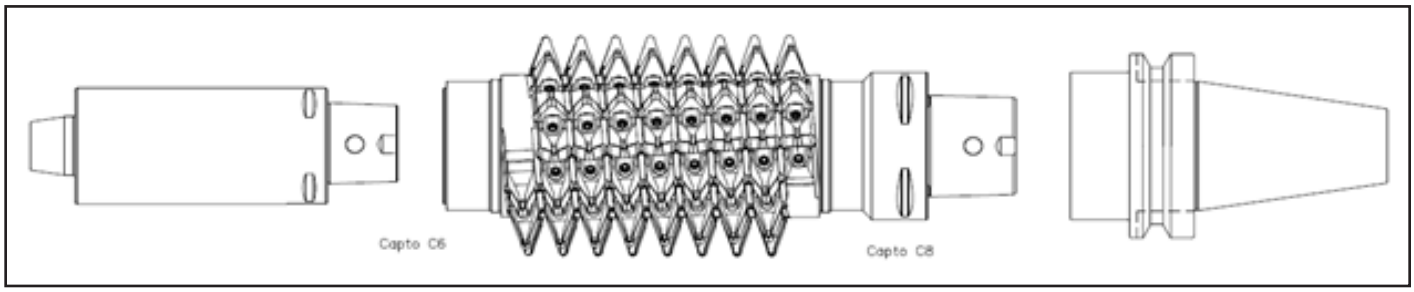

Figure 1 CM 176 Modular hob is equipped with Coromant Capto couplings. Only three parts are needed for tool assembly; Adapter to support side, CM 176 hob and adapter to spindle side.

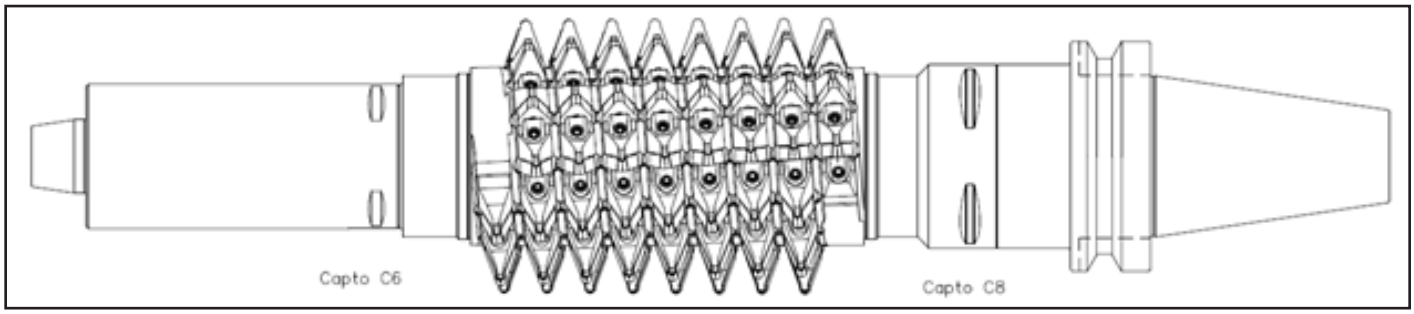

Figure 2 Stiffness and runout accuracy in the assembled tool are very good.

hob design makes the tool much more solid; neither bore nor arbor is required. Increased stiffness also reduces vibration, leading to better gear quality. It is a real problem-solver in cases where smaller-diameter hobs are needed.

Older machines still get the job done

Even with all of the movement towards gears on multitask machines, indexable hobbing tools offer plenty of benefits to traditional, dedicated hobbing machine operations. It's a common misconception today that productivity gains from the latest tooling technologies can only be realized with the latest in machine tools and equipment. In reality, operators can greatly benefit from the latest tooling even if you choose not to invest in new machine tools at the moment.

Older machines can indeed be limited in spindle speed and table feed compared to a state-of-the-art machine tool. But tests show that productivity improvements between 50 and 300 percent are still regularly achieved, even on older machines. Modular flexibility improves productivity via improved tool setup time and a higher-quality gear wheel, regardless of the spindle speed or table feed.

Partnerships breed innovation

Partnerships between tool makers like Sandvik Coromant and machine builders like DMG Mori and Klingelnberg/Höfler push gear tooling technology forward. New machine capabilities stretch the barriers of what tools are able to do, so tool manufacturers need to constantly evolve to keep pace. And to a certain extent, tooling technology pushes machine tool technology, as well. In a frequently changing landscape, constant collaboration helps tool maker and machine tool manufacturer evolve together, building in efficiencies and streamlining in ways that wouldn't be possible without cooperation. The feedback loop between machine tool builder partners is crucial to Sandvik Coromant's service to the end user, making it key from a quality perspective to get these tools into various machines and get feedback on the machine tool side.

In addition to using the tools themselves, both Höfler and DMG Mori use a Coromant Capto interface in the machine spindle. Coromant Capto, together with the modular technology, improves quality and setup time considerably. And because these partners use Coromant Capto, introducing the CoroMill 176 indexable hobbing system is simple – just another example of how co-evolution of tooling companies with machine tool manufacturers results in simplified experience for the end user.

The machine tool manufactures that Sandvik Coromant partners with are also skilled in software development for their machines. Since the machine, clamping and tool each has an effect on the quality of the gear wheel, it is really important that they all be designed to work in unison.

The InvoMilling technique is a recent example of this type of collaboration. Sandvik Coromant developed the software, but has been working closely with machine tool builders to implement it correctly, optimize it for a machine or group of machines, and ultimately benefit the end users' experience.

Gear material and design development

Corporate social responsibility and sustainability are setting new standards for the future of gear machining. Increased pressure in combustion engines improves combustion and reduces emissions. Power density on existing transmissions is increasing. This translates into new gear materials and new steels – clean steels.

With indexable tooling, it's easy to dry-machine gear profiles. Keeping coolant and oil out of the chips allows operators to eliminate any additional or exter-

nal process that might be required to sanitize chips or remove oil.

This not only provides clean chips with a higher scrap price and less work for operators, it saves time and money. Coolant oil is expensive, and removing the oil mist in production makes life in the shop cleaner, healthier and more comfortable. Plus, limiting the use of these types of oils is a positive for the global environment.

Also, current gear development leans toward increased contact lengths on the flanks of the gear tooth. This means asymmetrical gears are more and more common. Because of the basic rack profile, these gears are more difficult to produce with conventional HSS gear tools and conventional gear machines.

What's next

More indexable tooling will be introduced to the market in coming years. One area of interest includes bevel gears, which are mainly made with conventional machining today. Power skiving indexable tooling, together with monoblock finishing tools, also offers a lot of potential over conventional machining. Through one setup, an operator can do all necessary machining. So by eliminating runout and center deviations that result from multiple setups, average gear component quality can be maximized. On top of that, an operator can considerably reduce the cycle time, in most cases by more than 50 percent.

As we look to the future, many different factors and trends are working in unison to bring indexable tooling to the forefront in gear manufacturing. New machine tool technology and capability, better performing inserts and insert geometries, environmental and sustainability requirements on what OEMs are producing, special requirements of new, hard materials used in gears, and the increasing pressure to turn around high precision gears more quickly and for less – each has had a hand in the ongoing technology shift.

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