

Bevel gear cutting using INDEX turn-mill centers

TECHNOLOGY INTEGRATION AT ITS BEST

INDEX has developed a technology package for bevel gear hobbing, which consists of a special control cycle and four INDEX cutter heads with module-dependent inserts. Equipped with these features, the INDEX R200 and R300 turn-mill centers become gear cutting machines on which spiral bevel gears (module from 0.6 to 4 mm) can be produced – also from bar stock.

For a long time, there have been turn-mill centers at INDEX that master the two chipping techniques almost equally well. Grinding technology is also fully integrated on various INDEX machines. INDEX now offers a technology package that also makes the INDEX R200 and R300 turn-mill centers full-fledged gear cutting machines. By hobbing using a continuous indexing method – which corresponds to the Klingelnberg Zyκλο-Palloyd® method – spiral bevel gears can be produced with constant tooth height in a module range of 0.6 to 4 mm, all in a single setup. Compared to the conventional process chain with classic gear cutting machines, users can achieve shorter cycle times and better geometry and position tolerances. And it is much more flexible.

The starting point of this development lies in its manufacturing, governed by the principle: Quality-determining components are made in-house.

When the tool holder production was reorganized several years ago, the decision was made to produce the required bevel gears in-house. After all, their quality is largely responsible for smooth running, the transmissible torque, and wear. Since no sufficiently productive, modern gear cutting machine was found on the market for these parts, the management decided to upgrade the technology of its own turn-mill center accordingly.

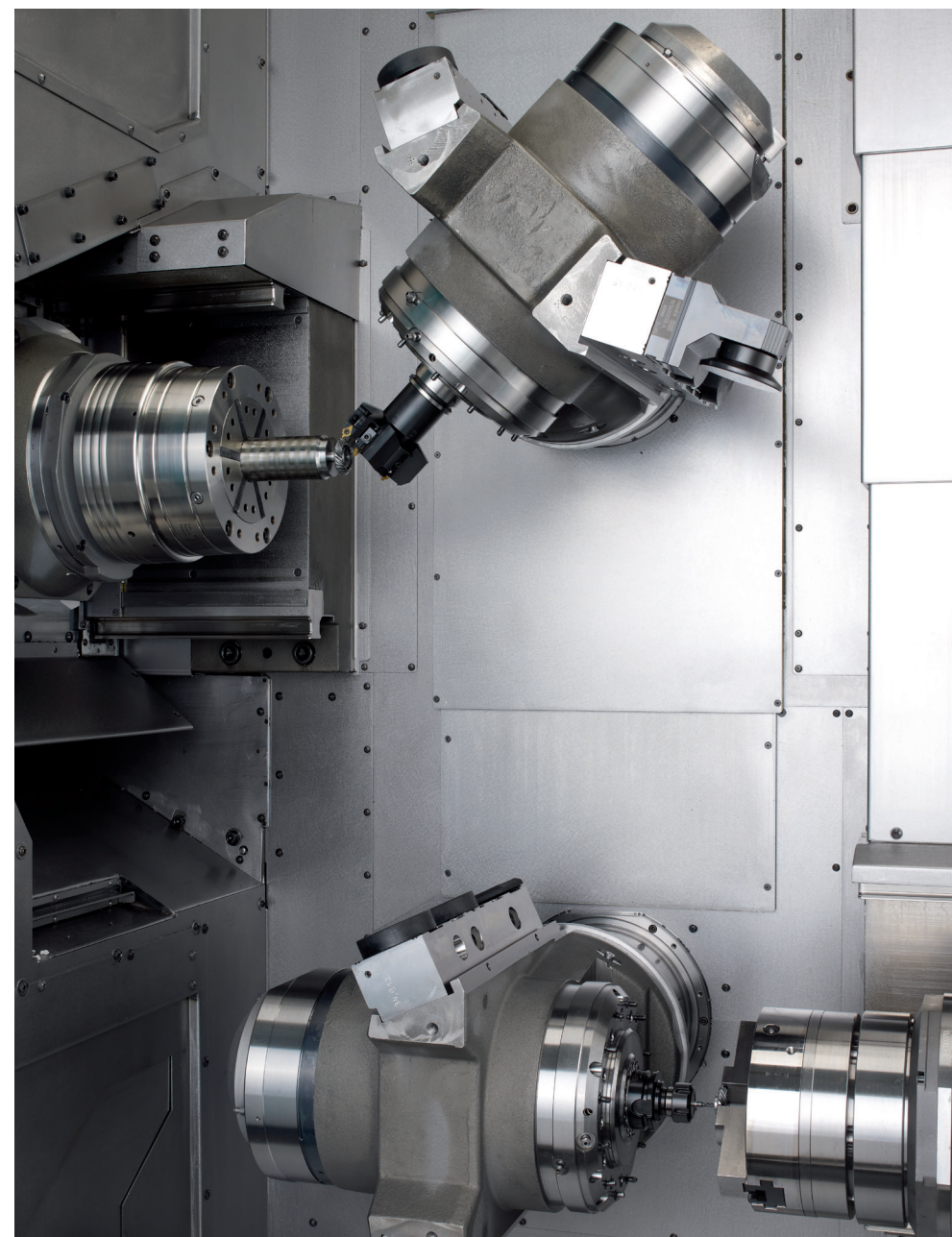
To sum it up: The technology integration was so successful that INDEX meanwhile covers its high in-house demand for bevel gears using an INDEX R200 and is now offering the technology to the broad market. Dr. Volker Sellmeier, Head of Technology Development, explains: “My team is committed to offering our customers a significant added value through the integration of machining processes such as gear cutting. We have achieved this with the new INDEX method for bevel gear hobbing, which enables complete machining on one machine. Because you can achieve significant advantages in terms of cycle time, process, and quality.”

Bevel gear cutting requires a machine with high rigidity and a B axis as the basis. Due to their excellent static, dynamic, and thermal properties, the innovative turn-mill centers of the INDEX R-series sell themselves, particularly when they are equipped with the “bevel gear hobbing” technology package. Their axis configuration and equipment with two milling spindles on Y-B axes with hydrostatic bearings make it possible to machine on the main and counter spindle simultaneously in five axes. However, according to Dr. Sellmeier, this is not necessarily limited to just the R machines: “In principle, it is possible to transfer this technology to other machines, such as the INDEX G220. For mass production, it is absolutely possible to port the technology package to a multi-spindle turning machine.”

Of particular importance are the tools that are developed and distributed by INDEX. Two cutter heads are required per bevel gear. These cutter heads differ slightly in their cutting circle radius to produce the longitudinal crowning. INDEX offers the cutter heads in four different sizes that can be fitted with up to six carbide inserts and feature internal cooling. In contrast to the classical Zyκλο-Palloyd method with a two-blade cutter head, the INDEX method uses two separate cutter heads per bevel gear.

“The complete machining of bevel gears on a single machine provides the user with considerable added value.”

Dr. Volker Sellmeier, Head of Technology Development at INDEX



The INDEX R200 and R300 turn-mill centers have a main and counter spindle. There are two tool carriers in the work area that each have a motorized milling spindle. The axis configuration makes machining possible on both spindles in five axes.

Dr. Sellmeier explains: “With two separate cutter heads, we can improve cutter head mobility, which allows us to achieve an increase in cutting performance and more freedom for contact pattern correction.”

The control cycle developed by INDEX is another essential part of the technology package. There, the user enters the same parameters as on a conventional gear cutting machine. These include, for example, machine distance, eccentricity and auxiliary angle. The cycle translates these values into the movements of each axis so that, in the end, the same relative movements are effected.

While the workpiece has to be set up on several individual machines in the classical gear cutting process chain, INDEX’s approach is to run all the operations on the turn-mill center. The bevel gears are turned, drilled, milled, and finally cut on a single machine. Even brushes for deburring can be set up. The soft machining process is thus completely autonomous with a gear quality of IT5 in a reliable process. This is then followed by hardening. A final finishing process is usually required only for the installation dimension and the polygonal shaft/hub connection.

The benefits can already be seen with the materials usage. Since the INDEX R-series can handle bar stock, automated operation is supported even without a workpiece handling system. An integrated gantry-type removal system is available for automatic



Advantages of bevel gear hobbing on the INDEX R200 & R300

Throughput advantage

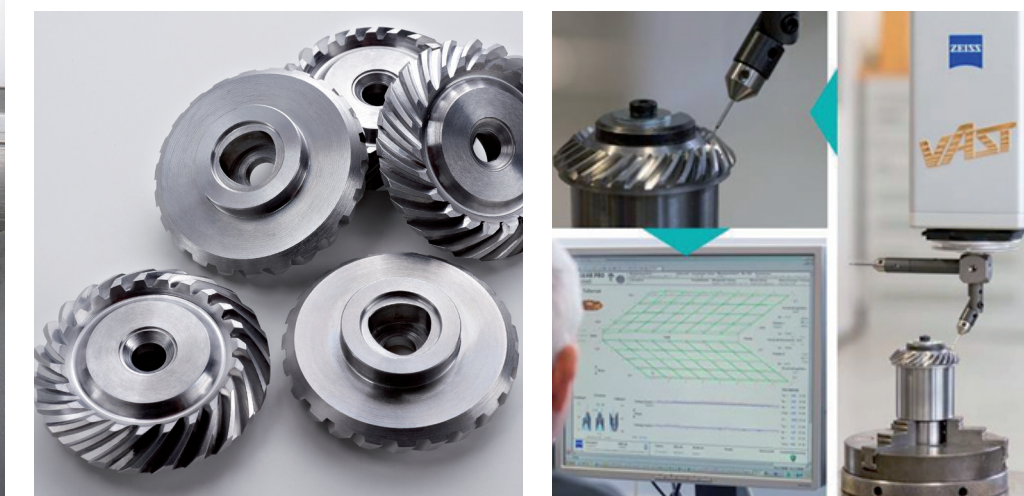
- Replacement of several machines with one INDEX R200/R300
- Machining from bar stock possible
- Reduced cycle and setup times
- Tool magazine with sibling tools

Process advantage

- Front and rear end machining
- Automatic parts removal
- Easy and stable clamping when machining from bar stock
- Machine can not only be used for gear cutting, but also for turning, drilling, milling, tapping, brushing (deburring), internal/external grinding, and measuring

Quality advantage

- Minimization of re-clamping errors
- Very tight geometry and position tolerances, achievable through complete machining in one setup
- Rear quality of IT5 in a reliable process



GearEngineer can calculate the target measurement data for the edge topology. The data is loaded on a 3D coordinate measuring machine for target actual comparison. The measured deviations can easily be entered in the INDEX control cycle, which automatically calculates the corrections for the machine setting data.

parts removal. The complete machining results in a clear advantage in cycle time. Dr. Volker Sellmeier provides figures: “When we machine the typical bevel gears with module 1.15 mm and approximately 25 teeth for our tool holders completely from bar stock, we achieve a cycle time of less than 3 min. The share of gear cutting amounts to about 30 seconds.”

While conventional gear cutting machines do not have a tool change magazine, the R200 and R300 allow the stocking of sibling tools, among others, for setup when needed, thereby allowing autonomous production over several hours. Complete machining also brings with it benefits to quality. Because the gearing and the polygonal shaft/hub connection are created in one setup, re-clamping errors are avoided and tight geometry and position tolerances are maintained.

The investment is also relatively low compared with specialized machines. With its gear technology, INDEX addresses both contract manufacturers that need to produce small lot sizes with high flexibility, and mass producers that want to produce bevel gears in large quantities at minimal cost.