Short-term production of a finished gearwheel

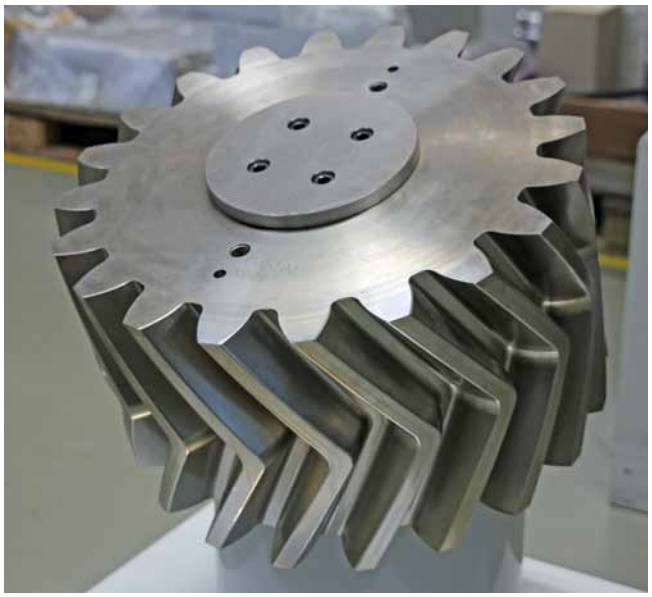
Flexible gearwheel production with high-precision 5-axis machining centres

High-quality gearwheels are produced from hardened blanks within a very short time on 5-axis milling centres supplied by Röders (Photo: Klaus Vollrath)

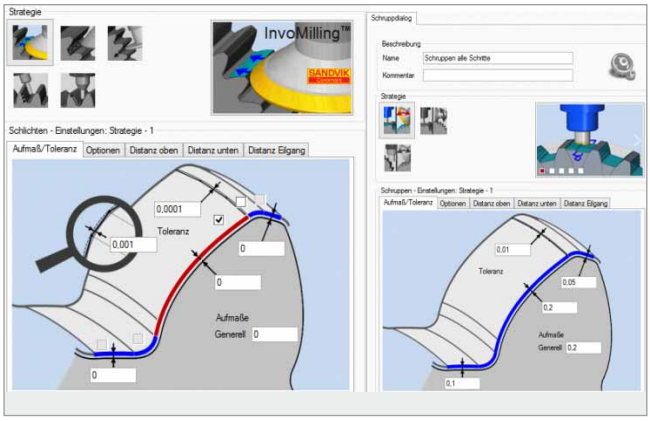
The manufacture of gearwheels for machine building applications usually involves machines especially designed for the purpose. Important techniques include gear hobbing, gear shaping, gear-generating planning, profile milling and profile broaching. Generally, specialized tools whose geometry is precisely adapted to the workpiece are required. Due to the stringent requirements placed on the hardness of the gearwheel surfaces, manufacturing is often carried out in three steps: soft machining, hardening and finishing. New developments in the field of hard machining now enable fast, single-stage manufacture with general-purpose 5-axis machining centres.

Satisfied faces all round: Project Manager Carsten Wendt, Managing Director Dipl.-Ing. Jürgen Röders and Sales Manager Dr Oliver Gossel (l to r) (Photo: Klaus Vollrath)

"In the production of gearwheels for industrial use, such as in mechanical engineering, speed and flexibility are often crucial factors", explains Dipl.-Ing. Jürgen Röders, Managing Director of Röders GmbH in Soltau. While sectors such as the automotive industry prioritize large quantities, the batch sizes in mechanical engineering are significantly smaller. Sometimes less than ten items are required and in the occasional case even only single pieces. However, the time pressure is frequently considerable. This is particularly so when the multi-stage character of the machining and the elaborate advance production of tools with a specially adapted geometry prove to be a handicap. A plant technology which enables a



This herringbone spur gear with a diameter of 450 mm and a tooth face width of 250 mm made of 16MnCr5 with a hardness of 60-62 HRC was ready for immediate use after being milled on a Röders RXU 1001 DSH in just 18 h and 45 min (Photo: Klaus Vollrath)



Euklid GearCAM helps users to produce high-precision gearwheels on standard milling machines (Graphic: Euklid)

The RXP 601 DSH used as pilot plant for gearwheel machining (Photo: Röders)

The large-format tools for gearwheel manufacture are stored in a separate magazine below the portal (Photo: Klaus Vollrath)

medium-sized gearwheel to be produced in good quality from a hardened blank within roughly one working day is of particular interest for sub-contract job shops, who have specialized in the manufacture of industrial gearwheels in small quantities and short deadlines.

GEARWHEEL MACHINING WITH EUKLID GEARCAM ...

"For the production of gearwheels, one needs purpose-designed CAM software that covers the various types of tooth profile correction", adds Carsten Wendt, who supervises the relevant development project. The technology partner here is the CAM software developer Euklid, they have developed a program designed precisely for these assignments in the form of Euklid GearCAM. This convenient software module supports the user in producing highly accurate gearwheels on standard milling machines. This solution is of particular interest for those companies which need one-off items or small batch sizes as a prototype, a special model or a replacement for failed parts in existing gears – either in parallel to or as a supplement to their normal production. The program also takes account of the usual tooth profile correction functions such as width and depth crowning as well as tip and root relief. Another benefit of producing on a 5-axis machining centre is that no correction is required for what is known as the tooth flank bias, which may cause problems in some of the conventional manufacturing technologies as a consequence of limitations to the machine kinematics. In contrast, this problem does not occur in the first place when a 5-axis milling machine is used.

...DEMANDS A HIGH-PRECISION 5-AXIS MACHINING CENTRE AS THE BASIS

"The precision of the machining centre used plays a crucial role in gearwheel production", says Sales Manager Dr.-Eng. Oliver Gossel. Since Röders develop its systems for use in particularly demanding mould and die making operations, the systems inherently meet the most stringent requirements concerning precision and dynamics while remaining highly resilient. Activities within this segment involve machining materials with degrees of hardness in excess of 60 HRC, while maintaining accuracies down to the single micrometre range. The machines used for this project, such as the RXP 601 DSH, are not only suitable for milling applications but also for jig grinding. Their accuracy is assured by a whole host of engineering design features, ranging from the use of a solid machine bed made of polymer concrete, via high-precision guide systems and frictionless linear direct drives, through to sophisticated temperature management with internal media flow channels in all essential components. Temperature-conditioned intermediate elements stop the diffusion of heat from the drives into the machine bed. Particular attention is also paid to the temperature-dependent lengthening of the main spindle, which is monitored and compensated for by the control unit. Another important feature is the exceptionally high clock rate of the controller intervals ("Racecut"), which enables even the smallest path deviations to be detected and corrected. Other positive factors are glass scales with a resolution of 5 nanometres and a patented weight compensation system for the z-axis.

The extensive compensation for all deviations in position and angle of the rotating/swivelling table additionally plays a special role. For this purpose, the unit passes through more than 400 different positions of the two rotational axes and its position is recorded with high accuracy at each step during this process. The position and angle data thus determined are stored in the control system as a reference.

PRECISION DURING TOOL CHANGES

Tools with significantly larger dimensions than is usual in milling operations are used in the machining of gears, an additional tool magazine is available for them", Jürgen Röders reveals. The magazine arranged beneath the portal can accommodate three tools with diameters of up to 200 mm. As a result, the chain magazine inside the machine remains unchanged and stays stocked with the usual tools of smaller diameters. The position of the magazine and its protective roller shutter prevents even the smallest contaminant particles or chips penetrating, which might otherwise cause angular errors between the machine interface and the tool. A further positive aspect is that the vector control of

Temperature-conditioning of all key components for the Röders machining centres is a prerequisite for high-precision milling (Photo: Klaus Vollrath)

A diamond-coated truing wheel ensures precise shaping of the grinding tools (Photo: Klaus Vollrath)

The wheel for the inner and outer grinding has integrated grinding oil feed, which is installed together with the tool during the changeover. As a result, the contact area between tool and workpiece is cooled with a sufficient quantity of oil. (Photo: Klaus Vollrath)

the main spindle guarantees the transfer of these special tools always takes place in the same angular position so that even after multiple tool changes no misalignment of the grinding tools can occur once they have undergone dressing.

Another special characteristic of these tools is a separate piping circuit for the grinding oil supply which is installed together with the tool as a single package. As a consequence, the nozzle is always exactly aligned and thus guarantees an optimal oil supply for the contact zone between grinding tool and workpiece.

EXCEPTIONAL FLEXIBILITY FOR TOOL SELECTION AND USE

"Since there are hardly any restrictions in the selection of tools, the operator enjoys an exceptional freedom of choice", Oliver Gossel is pleased to note. Instead of expensive and sophisticated special tools such as grinding worms, gear hobbing mills or shaving cutters, the jobs can be carried out with milling cutters, grinding discs and grinding wheels of comparatively simple design. In the case of the grinding tools, the use of a truing wheel makes it possible to choose between a simple planar geometry or the production of a contour with a shape adapted precisely to specifications. The latter solution permits higher productivity.

The software offers the choice between various machining strategies and tool preferences for roughing and finishing. Using the tooth geometry and prescribed tolerances, GearCAM automatically minimizes the number of tool paths in such a way that the tolerances are maintained exactly. The corresponding cutting and performance data can be obtained from a configurable tool database. Depending on the specifications, the tooth quality may reach level 2 or 3. A further advantage of the new solution is that cylinder surfaces such as the bore or shaft can be machined in-line on one clamping position.

The latest tooling option now available in the form of InvoMilling provides a combination of special milling tools developed in collaboration with Sandvik and a correspondingly optimized milling strategy.

AUTOMATION AND SUPPORT

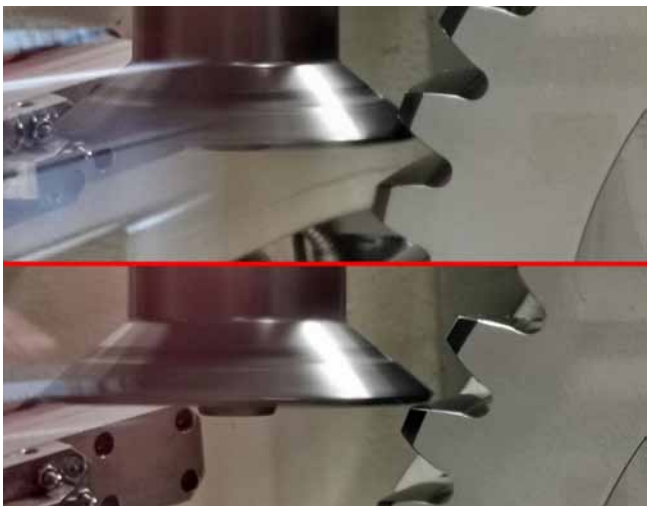
"The system has recorded such a success among our customers that we have since developed special options for automating the processes as well", says Carsten Wendt summing up. First and foremost, these are compact RCS workpiece and tool magazines with integrated handling that enable automated changing of the

Conical grinding wheel for precise finishing of the tooth flanks (Photo: Röders)

Roughing of the tooth contours in the hardened sprocket is carried out with a conical InvoMilling disc cutter (Photo: Röders)

Standard milling cutters from the internal tool magazine are used to produce the tooth root relief (Photo: Klaus Vollrath)

workpiece so that the milling centre can be operated 24/7 almost without interruption. This makes it possible to achieve low manufacturing costs even for one-off items. Thanks to the technology partnership with Euklid, Röders now reports that it is able to provide the customer with full application support not only for the milling centre, but also for the Euklid GearCAM software. Hence, selecting a system such as this would give customers two highly interesting options at once. Firstly, the user is enabled to produce a ready-to-use gearwheel of high quality from a hardened blank in an exceptionally short time. Additionally, the customer would simultaneously have an extremely precise and powerful 5-axis milling centre that could also be used for a wide range of other operations within the firm.
Klaus Vollrath, b2dcomm.ch



The bevelled shape of the machining tool enables work to be performed on both the left-hand and right-hand tooth flanks without any need to change sides (Photo: Klaus Vollrath)

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THE RÖDERS RXP 601 DSH

The Röders RXP 601 DSH five-axis HSC milling centre has been designed for the most demanding requirements with respect to precision while at the same time maintaining high cutting performances even during the machining of hard materials. It has frictionless linear direct drives, which in combination with 32 kHz controllers in all axes enable both dynamic and highly precise machining. Fulfilling a key requirement for this are the extremely accurate optical standards in all axes – when it comes to precision, no compromises are made. Because of its accuracy and dynamics, this machine can also be used for jig grinding. In addition, the z-axis has a patented frictionless vacuum weight compensation system in order to avoid any reversing marks in the z-direction.

To ensure maximum thermal stability, the centres have a sophisticated temperature management. The temperature of the medium that flows through all key components of the centre, is controlled with an accuracy of ± 0.1 K, and even ± 0.02 K for certain applications. Another special feature is a proprietary control unit based on PC technology, the functionality of which is precisely tailored to the specific demands of HSC high-precision milling and jig grinding. Röders also offers updates for the control unit so that obsolescence of the plant due to outdating of their control units or its software cannot occur. The current upgrade stage for the control unit, the Racecut, has made it possible to achieve further significant reductions in machining time. <<