Gearwheel manufacturing in ultra-small module range

Skiving of filigree gearbox components

The miniaturisation and multi-functionality of products has long since also affected gearbox manufacturing. As a result, precision gearwheel production in the ultra-small module range is in demand. And that's exactly what the µ-skiving process offers.

BY RAYMOND GRAF

→ A basic requirement for modern product development is that an increasing number of functionalities must be provided in an ever-smaller space. This is the case not only in the field of electronics, but also in mechanical systems. As a result, the importance of ultra-small gearboxes is constantly growing as miniaturisation increases. Applications such as medical and dental technology bear witness to this, as do robotics and the automotive and aerospace industries. And of course, the dental drill turbine, the robot arm and the automatic boot lid must also operate with the highest possible rpms, have a high load-bearing capacity and be low-noise. All this places demanding quality requirements on the toothed components of the micro-gearbox.

Classic manufacturing of gearwheels is carried out with hobbing, with which the tool and the workpiece are moved while rotating synchronously to each other in accordance with the number of teeth to be produced. With conventional machines, this synchronisation is assumed by a mechanical gearbox. Machines of newer generations synchronise directly driven motor spindles electronically, resulting not only in improved accuracy, smoother running and in several times the rotating speed and productivity. As a result, gear cutting machines, for example from Affolter in Malleray, Switzerland, can hob at up to 16,000 rpm (Fig. 1), while conventional machines usually reach 3,000 rpm. In addition, the noise level is considerably reduced and the quality of the surface and the toothing parameters can be greatly improved.

With regard to production machining in the hardened state, hob or profile grinding is hardly used for small gearwheels. On the one hand, because the suitable operating equipment is lacking or is not adapted to the small sizes and, on the other hand, because manufacturing of grinding

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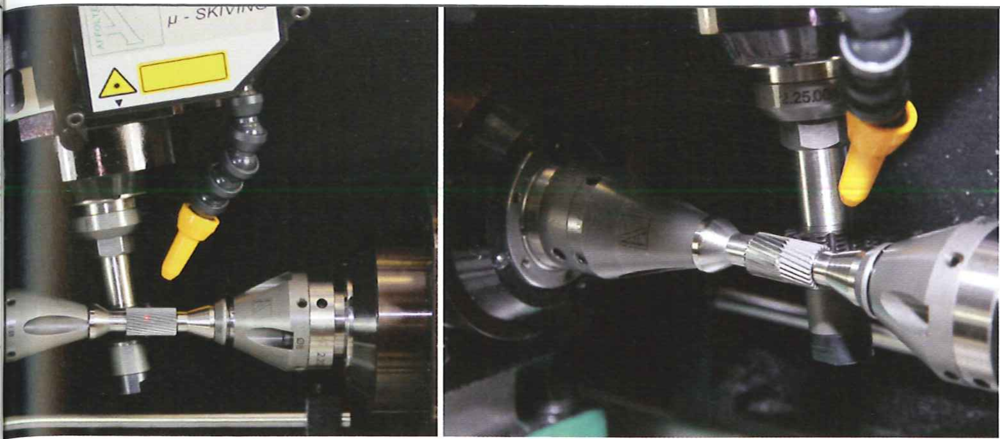
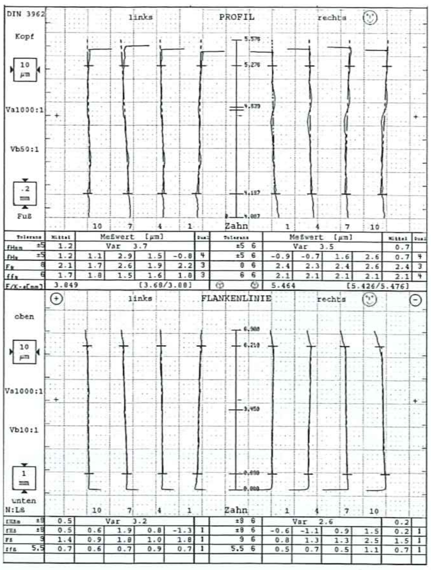
1 The Gear AF100 gear cutting centre from Affolter operates at speeds of up to 16,000 rpm

Figures: Affolter Technologies



2 The µ-skiving technology enables high-precision manufacturing of gearwheels in the module range from 0.1 to 1.0 with the skiving method



3 Measuring log of a gearwheel with a module of 0.35, helical–toothed with β 11.5°, hardness 61 to 63 HRC finish-machined with skiving on a Gear AF100

tools in small sizes reaches technological limits – among other things due to the given grain size.

Finish-machining in module range from 0.1 to 1.0 can be achieved

For these applications, Affolter has developed the ›µ-skiving‹ technology, which applies the skiving process already used in the larger module range to the smallest modules. According to this principle, the gearwheel is pre-toothed in the soft state with an oversize per tooth flank and then hardened. Then the workpiece is loaded onto the gear cutting machine again and finish-machined with a specially designed hob cutter. Due to the tool geometry, chips are formed in the process, which is referred to as ›peeling‹. With this process, highly accurate finish-machining in the module range from approximately 0.1 to 1.0 can be achieved in the hardened state.

To be able to precisely position the milling cutter in the pre-toothed gap, each workpiece is automatically measured following clamping in the machine. In this case, the angle position of the tooth gap is determined. For ultra-small modules far below 0.5, this is achieved for the first time with a high-precision measuring system from Affolter. The accuracy of this system guarantees a positioning accuracy in the micrometre range. At the same time, the measuring process is extremely fast: The position is determined in approximately one second.

With the µ-skiving process, now even the smallest gearwheels can be precisely and economically finish-machined following hardening. Extremely short cycle times are achieved with the high rotating speed of the dynamic machine and the fast detection of the angular position of the workpiece. Of course, various automation solutions are available to guarantee autonomous processing. The precision of the machine kinematics and the measuring system of the NC axes result in toothing qualities which can be classified as grinding quality. Proof of this is provided in Fig. 3, which shows a typical measuring log of a helical-toothed gearwheel with a module of 0.35.

One of the main applications for small, high-precision gearwheels is gearbox construction, and typically planetary gearboxes. These in turn are used in medical technology, robotics/automation, the automotive industry and aerospace. ▮

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