Fraunhofer
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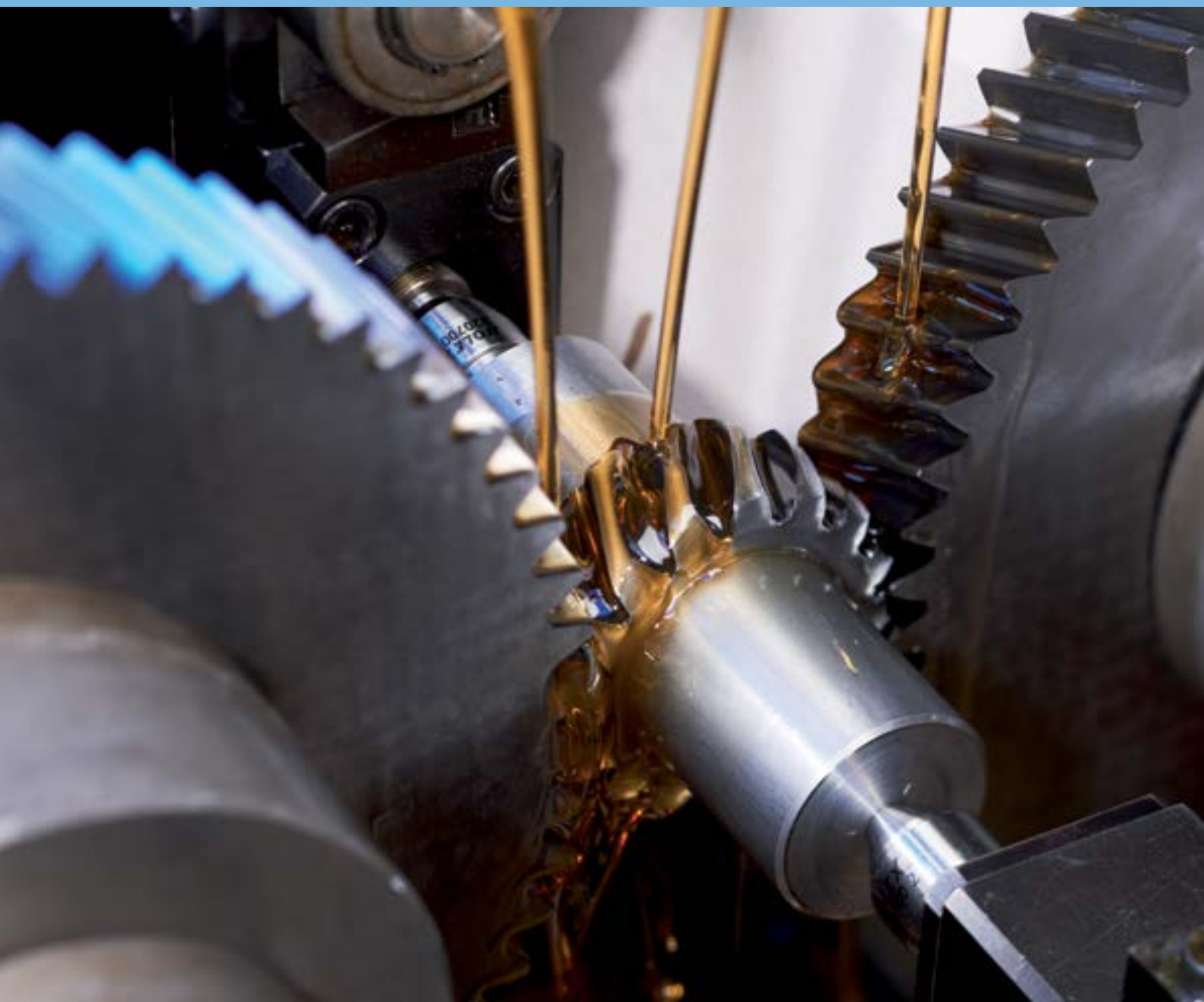
FRAUNHOFER INSTITUTE FOR MACHINE TOOLS AND FORMING TECHNOLOGY IWU

GEARING TECHNOLOGIES



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Process

Cross-rolling with round tools is a partial forming process with rolling kinematics between tool geometry and the emerging workpiece profile. The rotationally symmetric pre-form is clamped between two tips in the axial direction. The formation of the gear profile using rolling kinematics is achieved by means of a process in which the tool teeth penetrate in a radial direction in relation to the diameter. The rolling process is split into the three phases of initial rolling, penetration and calibration. The round rolling processes using two and three profiled tools are industry-oriented.

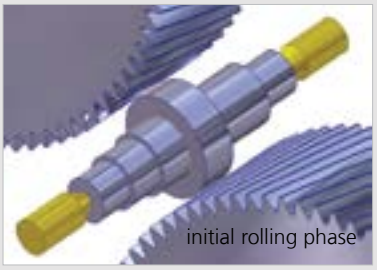
In particular, as far as rolling of so-called high gears is concerned, the new results open up huge market potential by comparison to the (currently dominant) metal-cutting production technologies.

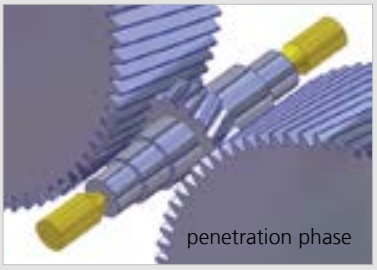
Improvements to final component characteristics (carrying capability, root strength of teeth, surface quality and minimum quenching distortion) result from a surface hardness depending on strain hardening and a contour-related fiber structure. Process-related advantages emerge due to the very short cycle times and the fact that chip disposal is no longer required.

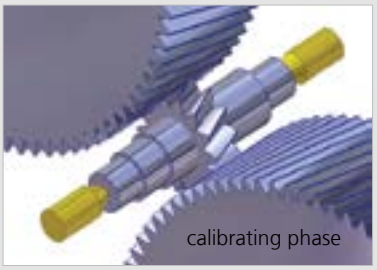
Process advantages

– Short process times
– No waste caused by forming production as well as no chip disposal
– Increase in strength of tooth contour as a result of strain hardening up to 100 percent (at tooth root range)
– Mirror-finish surface contours (Rz = 1.5 µm, Ra = 0.5 µm)
– Contour-related fiber structure
– Reduced notch sensitivity and increased fatigue strength

Rolling process with two tools







Profiles producible by rolling

– Spur gears from modules 0.5 to 4.5 (parameter-dependent)
– Diverse screw geometries up to 8 mm module
– Pitch-free hollow profiles up to Ø 200 mm
– Special profiles on request up to Ø 300 mm

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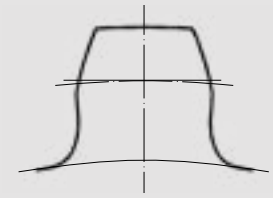
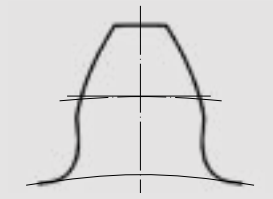
State-of-the-art
Gear manufacturing using rolling technologies

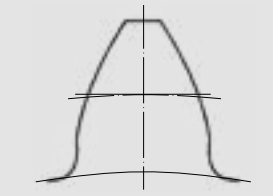


Stub-tooth gearing (tooth height coefficient y = 1)



Normal gearing (tooth height coefficient y = 1 .. 2)

Latest results from Fraunhofer IWU



High gearing (tooth height coefficient y > 2)

Research status

The Fraunhofer IWU has succeeded in achieving total tooth height coefficients up to y = 2.8 (especially in high gears). It shows that within certain limits it is also possible to manufacture high gears using rolling technologies. Future research and development aims at initiating further studies to optimize the tooth quality and to verify the industrial rolling limits for high gearing.

Range of rollable parts

– Spur gears (straight and helical teeth)
– Finish rolling, surface optimization
– Pre-forming: tempering and hobbing components
– Hollow and groove geometries
– Stub tooth gears and knurling wheels
– Worm gears and thread profiles
– Rotor and compressor components

Range of services

– Feasibility studies and prototype production as well as support during transfer to serial production
– Calculation, design and construction of rolling tools (spur gears, worm and special profiles)
– Finish rolling processes for increasing the strength of pre-toothed initial forms
– Determination of optimum process and machine parameters (process optimizations)
– Coordination and design of process chains
– Tool life studies and estimates of commercial viability
– Material investigations (texture, contour-related fiber structure, distribution of microhardness)
– Consulting and intermediary service for purchases of rolling tools and profile rolling machines
– FEM simulation and tool load analysis (Forge, Simufact, Ansys)
– Standardized measurement of components according to DIN 3962/ISO 1328
– Tool life investigations (Woehler fatigue test)
– Investigations on wear and lubricants on testing equipment FZG-gear-strain according to DIN ISO 14635

1 *Truck axle drive*
2 *Straight toothed test gear* $m_N = 4.5$ *mm*
3 *Reverse gear*
4 *Toothed gearshaft*

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