

Benefits of Asymmetric Gears

LIEBHERR EXAMINES PRODUCTIVITY AND QUALITY ADVANTAGES

Gear wheels often rotate in only one direction throughout their entire service lives. This applies particularly in the case of cars, commercial vehicles, ships, lifting gear or generators. In the case of these gear drives, the tooth load on one flank is considerably higher than on the opposite one. This means that little or no load is applied to opposite-coast flanks during a relatively short work cycle. An asymmetric tooth shape reflects this functional difference.

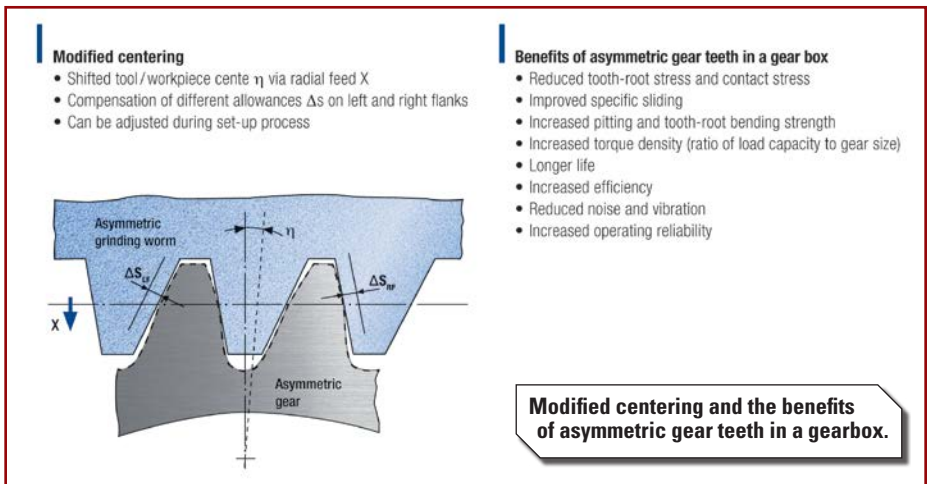
“One of the design objectives of asymmetric gear teeth is to improve the performance of primary drive profiles at the expense of opposite-coast profile performance,” Dr. Alexander Kapelevich, president of AKGears, explained. He is an expert in the mathematics of tool profiles and other parameters for asymmetric gear teeth.

“Asymmetric tooth profiles make it possible to simultaneously increase the contact ratio and operating pressure angle beyond those limits achievable with conventional symmetric gears,” Kapelevich said. Gear tooth stiffness can be significantly improved by means of latitudinal and frontal load-sharing as well as by altering dynamic contact. Tooth-flank load capacity also benefits from an increased pressure angle on the stressed tooth flanks. Tooth-root load capacity is also improved.

The main advantage of asymmetric gears is contact stress reduction on the drive flanks. That results in higher torque density, i.e. ratio of load capacity to gear size. Another key advantage is the opportunity afforded of designing opposite-coast tooth flanks differently to drive tooth flanks. This effectively manages tooth stiffness, whilst at the same time retaining the desired pressure angle and contact ratio of the drive flanks. This allows for increased tooth tip deflection, thus damping tooth mesh impact and resulting in a reduction of gear noise and vibration.

Dedicated Tools Required

Kapelevich defines asymmetric tooth-root geometry irrespective of the model of gear rack used, which distin-



guishes him from other gear technology researchers. Kapelevich's Direct Gear Design approach enables asymmetric gear tooth and tooth fillet geometry to be optimized to achieve maximized performance for specific gear applications. Such an approach of course requires special tools. Once tooth-root geometry has been optimized, Direct Gear Design also defines tool profiles and other parameters. “One of the design objectives of asymmetric gear teeth is to improve the performance of primary drive profiles at the expense of opposite-coast profile performance,” he said.

Smart Contouring

Roughing, tempering and subsequent hard finishing (skiving or profile-grinding) have been the industry-standard method of producing asymmetric gear teeth for years. Skiving is effective, although it does not quite deliver maximum gear tooth quality (DIN 6 to DIN 7). Profile-grinding delivers a significantly higher standard of quality, but takes longer than a continuous generating method. Liebherr-Verzahntechnik GmbH developed its asymmetric gear tooth generating grinding method upon customer request. This method combines maximum productivity with superior quality.

Asymmetric gear teeth however represent more of a challenge in terms of the generating-grinding method, as well as grinding and dressing tools, rather than

in terms of the grinding process itself. Developing this grinding method raised a number of issues all at the same time. “We were faced by twin challenges,” said Dr. Andreas Mehr from Liebherr-Verzahntechnik's grinding and shaping technology development and consultancy team. “On the one hand we required dressing technology to produce an asymmetric grinding worm. On the other hand we needed to develop the entire grinding process, including centering the grinding worm in the tooth fillet.”

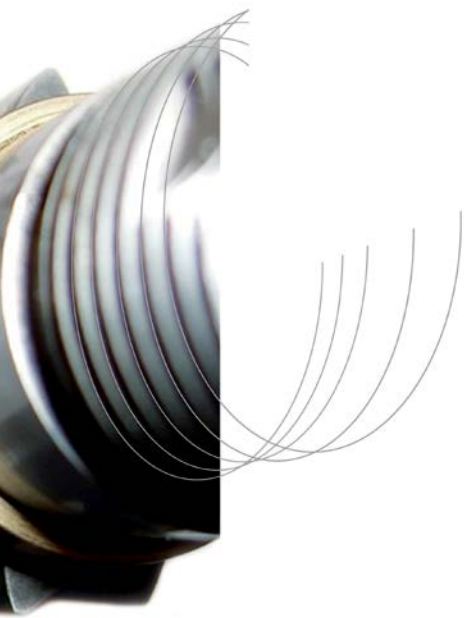


Profile Angle Adjustment During Dressing

For dressing purposes the experts developed a software package that can work with both asymmetric and symmetric dressing units. "An asymmetric dressing unit is ideal for serial production purposes. A symmetric dressing unit can also be pivoted as appropriate for prototype construction purposes," is how Mehr describes the corresponding benefits. The machine features a pivot range of up to 7.5 degrees. A major challenge as far as dressing was concerned were the complex mathematical calculations of the degree of pivot travel required by the dressing unit. During the dressing process the diameter of the grinding worm is reduced, which in turn necessitates a profile-angle correction – after each dressing sequence.

A quite different dynamic in respect of tooth-flank contact between the grinding worm and workpiece occurs during the grinding process itself, as compared with conventional, symmetrical grinding processes. Since left and right tooth flank offsets change during the asymmetric gear wheel grinding process, given differing pressure angles,

Asymmetric gear.



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this requires electronic correction. This degree of correction is determined by means of modified centering during the set-up procedure. In the case of asymmetric gear teeth, this so-called centering procedure, i.e. centered meshing of the grinding worm with the tooth fillet, has to be slightly shifted and maintained during the grinding process using precision monitoring and control technology.

Asymmetry's Time Has Come

Asymmetric gear wheels will be used more frequently, thanks to this new grinding process. "Their benefits are obvious and have been generally known for a long time," said Mehr. "Dr. Kapelevich's calculations have facilitated a simple interpretation of the mac-

ro-geometry involved. The generating grinding process can now be reliably managed as well. At the same time our customers can use the generating-grinding process for initial prototyping purposes without any great effort, the software package is up to the job. Customers need to invest in an asymmetric dressing unit once they get to the serial production stage." It seems that asymmetric gear wheels' time has come at last.

For more information:

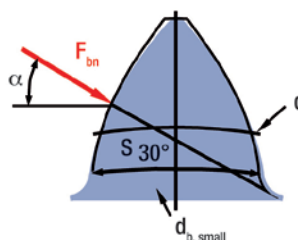
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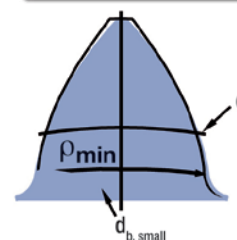
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Benefits of large pressure angle



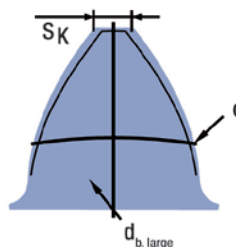
- Larger tooth-root profile

Benefits of large and small pressure angles as well as their combination.

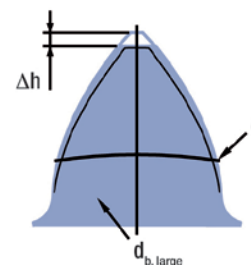


- Large radii of curvature close to root form circle

Benefits of small pressure angle

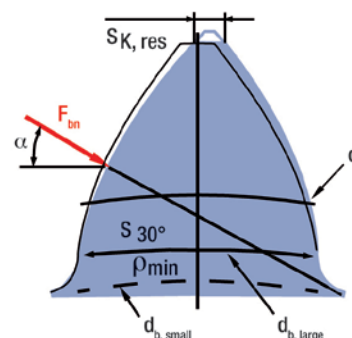


- Large tooth tip thickness



- Increased tooth height

Combination of benefits



- Positive flank curvature properties
- Large tooth-root profile
- Adequate tooth-tip thickness
- Increased tooth height

Picture source: WZL, RWTH Aachen



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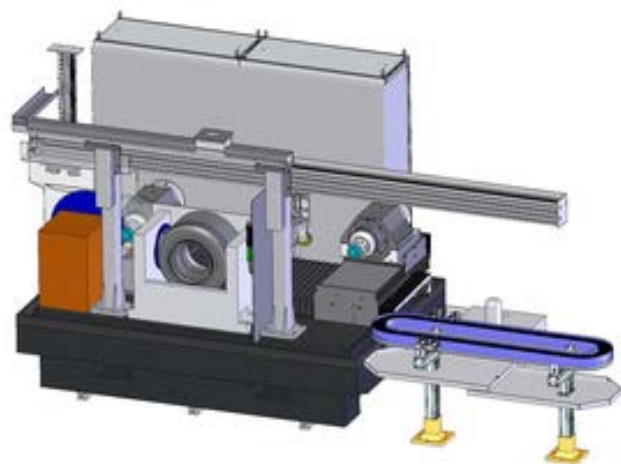
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GMTA Präwema SynchroFine 205 HS

FEATURES DIRECT-DRIVEN, DIGITALLY CONTROLLED SPINDLES

German Machine Tools of America (GMTA), now offers the Präwema SynchroFine 205 HS gear honing machine featuring direct-driven, digitally controlled spindles for the tool and the workpiece, enabling precise, rigid synchronization. The Präwema Honing gear finishing process produces quality comparable to grinding results for spur and helical gears, as well as shafts. The



machine's software checks the stock allowance and workpiece runout and then optimizes the x-axis approach distance. Measuring the workpiece does not affect the cycle time and the process can reduce cycle times by three to five seconds.

The machine features a pick-up design to enable automation. The workpieces and dressing tools are loaded and unloaded by the workpiece spindle. The large X-axis travel enables placement of additional stations adjacent to the loading/unloading station inside the machine, such as a two-flank roll-checking device. External robots and conveyor systems can also be integrated by GMTA engineering.

The honing machine is constructed on a natural granite bed to promote stability and control thermal fluctuations. The x and z axes are equipped with linear motor drives. The cutting tool is clamped with a hydraulically operated system and the tool spindle can be swiveled into a vertical position, enabling easy access. Additional options are available for machining oversized drive shafts as long as 850 mm and the Präwema SynchroFine 205 HS-D model, equipped with two spindles, is offered for further reduction of cycle times.

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Doimak RER Series

OFFERS COMPACT DESIGN AND DIRECT DRIVE TECHNOLOGY

At IMTS 2016 (Booth N-6698), Doimak will display the RER-G Combi 500 Grinding Center with Fanuc CNC and two wheel-heads. Designed for grinding OD, ID and threads, the RER-G is equipped with a fast automatic changing grinding head by means of a rotary base turret enabling multiple grinding operations in a single setup. The RER series offers a compact design, external/internal thread grinding in fully automatic transition, OD and gear grinding with optional CBN or peeling and b axis for tapers, flexible multi-task grinding, 2-axis contour dress or full form. The machine is available in a two or three wheel head design.

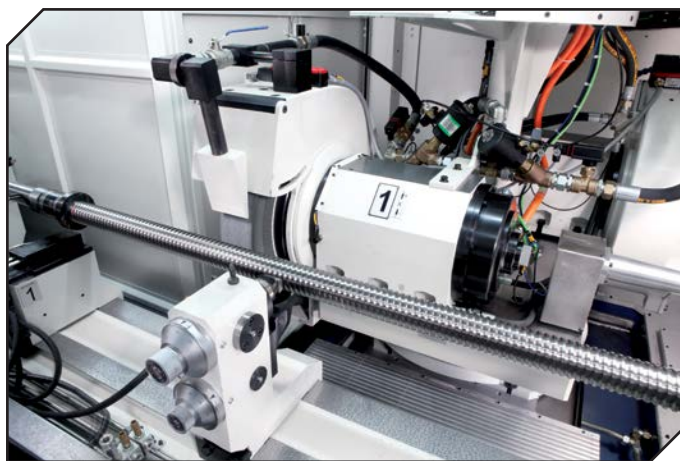
Additionally, Doimak recently delivered two REN-T spline and gear grinding machines for the machining of cycloid, helical and spur gears. Doimak tested and delivered these models that included integrated probing technology for gear inspection. The machine inspects gear diameter, run-out or teeth alignment just after grinding takes place, reducing machine setup times and providing a more efficient overall machining process thanks to the integrated inspection technology. The following is a brief rundown of some of Doimak's other machining capabilities:

Thread Grinding

Thread grinding machines for all types of threading technology is the most representative product line of Doimak. The latest CNC technology is implemented with built-in drives and linear motors. These machines include a wide range of spindle designs offering optimum stiffness and damping response. Any type of profile can be dressed thanks to the flexible contour dresser, which also accommodates plunge forming rolls. Multi-ribbed wheels are used for improving process productivity and mass production machines are equipped with robot or gantry type loaders. They offer higher degree of process automation thanks to different probing and component measuring solutions.

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cations including extrusion screws and barrels, power generation, printing and more. Different disposition of wheels, including OD/ID solutions with multiple grinding heads mounted in a single swiveling base are available for any type of application requirement. Productivity is improved through the use of in-process measuring systems, steady rests and wheel contact sensors.

Gear Grinding

Doimak has also developed several machining solutions for the gear and transmission field. Based on the RER thread grinding platform, straight and helical involute gears can be ground using latest CNC technology which includes built-in drives and linear motors. Involute, as well as cycloidal gear profiles, are automati-



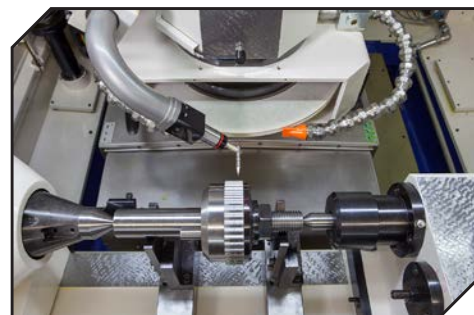
cally calculated according to standard gear parameters. These machines offer a higher degree of process automation thanks to different probing and component measuring solutions.

Automotive

Automotive components such as steering racks, engine and transmission components and crankshaft and camshafts require the latest machining advances. Doimak provides in-process measuring gauges and high performance tools in order to optimize productivity. Mass production machines can be equipped with robots or gantry-type automatic loaders. In most cases, these machines are equipped with hydrostatic drives in order to avoid wear in moving components minimizing production stops due to maintenance requirements.

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Norton Century45 wheels are available with ceramic, aluminum oxide, silicon carbide grain and abrasive blends to maximize user grinding safety and efficiency. These wheels reduce cycle times by up to 50 percent, improve stock removal by over 30 percent and increase wheel life from 30-100 percent versus standard products currently on the market.

Norton Century45 provides a continually sharp wheel face that achieves over 30 percent more stock removal, reducing grinding times through fewer passes to achieve optimal results. Operators will generate more parts through reduced production cycle times when using Norton Century45 wheels.

Norton Century45 centerless grinding wheels also can decrease grinding noise levels by as much as 23.2dB, even when grinding hard-to-grind alloys such as Inconel 718, thus increasing operator safety.

To put this reduction in context, many commercially-available foam ear plugs offer Noise Reduction Ratings in the range of 25 to 28dB.

Norton Century45 is ideal for bar grinding, fastener and tool grinding, automotive or aerospace components, as well as bearing applications. Whether in a high production grinding facility or job shop, Norton Century45 can significantly reduce grinding costs while increasing safety and production throughput.

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