

# Buderus Schleiftechnik Dry Grinding Process

MORE ECONOMICAL DUE TO INTELLIGENT CONTROL OF HARD TURNING

Following the emergence of dry machining in the green manufacturing of high-precision metal components as the accepted technical standard to a major extent over the past few years, there are growing incentives to implement this method in grinding processes for hard finishing as well.

Cost savings and production operations more compatible with the environment are crucial arguments in favor of further development work in this segment. Yet is it possible to banish the risk of overheating during grinding and soiling caused by grinding dust in the machining chamber at all, and what can be done to combat the high level of tool wear? The technology experts at Buderus Schleiftechnik GmbH have developed a method that makes dry grinding even more economical due to the intelligent control of hard turning and grinding machining.

Machining metallic workpieces without cooling lubricant is already common practice in the field of green manufacturing. Complex filter systems, energy-intensive pump systems, the environmentally sound disposal of used coolants and the strain on operators' health in the direct machining environment are all negative factors that suddenly ceased to

exist with this development. In the hard finishing segment, hard turning is the only process that can do without coolants to date. Until just recently, there had been no significant dry machining breakthroughs for grinding and other combined operations with demanding quality standards in the  $\mu\text{m}$  range. The risk of overheating during grinding, the clogging of grinding tools, greater heat dissipation and dust development that is difficult to get under control in the machinery compartment, as well as exploding tool costs, posed great challenges to the development departments of mechanical engineering companies.

In Asslar in central Hesse, engineers have been working on how to "dry out" hard finishing processes for quite some time. In several extensive series of tests on the synchronizer cones of toothed wheels in a passenger car gearbox, the engineers at Buderus Schleiftechnik have been able to take a step towards process maturity and keep tool costs within reasonable limits thanks to an intelligent combination of hard turning and conventional grinding.

To combat the high wear on the grinding tool, it makes sense to shorten the actual dry grinding process, which in turn keeps the thermal load for grind-

ing wheel and workpiece at a low level. Accordingly, the objective is to use hard turning to reduce the grinding stock allowance beyond the usual level for wet machining in order to achieve the necessary surface quality and dimensional stability through final grinding. Leaving the grinding process out of the consideration altogether was never an option, since requirements of  $R_z < 3 \mu\text{m}$  and  $R_a < 0.25 \mu\text{m}$  cannot be achieved economically under series conditions through pure hard turning. The grinding machine used for the series of tests is a CNC335 from Buderus Schleiftechnik that has outstanding thermal, static and dynamic rigidity properties. A CBN-coated turning tool is used for the turning process. Dry grinding is done by a conventional sintered corundum grinding wheel made by Naxos- Diskus Schleifmittelwerke which, like Buderus Schleiftechnik, is a member of the DVS Group.

In order to solve the grinding dust problem, the dust is blown out of the grinding gap by a compressed air nozzle during machining. The air cools the machining spot at the same time. A dedicated extraction unit collects the dust directly where it is produced and thus avoids heavy soiling in the machinery compartment. Where dry grinding is



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used, cooling lubricants are not required either. This is a cost factor that is often underestimated.

The various dry hard finishing processes introduced by different gearbox manufacturers up to now are convincing in many respects, but there is a certain amount of dissatisfaction among the users particularly on account of the high tool costs. For optimum matching of the hard turning and grinding processes to reduce tool costs, Buderus Schleiftechnik has developed an intelligent grinding stock allowance control which uses solid-borne sound sensors. The solid-borne sound sensor signal is transmitted without contact from the rotating grinding spindle to the measuring electronics. After turning, the residual machining allowance during grinding is measured by the solid-borne sound sensor. Technicians are walking a thin line when it comes to determining the optimum residual machining allowance, however. Whereas visible turning grooves must still be expected if the allowance is too small, an excessively large allowance will draw out the grind-

ing process too much, increasing the risk of overheating during grinding and wear on the grinding tools.

Accordingly, it is important to determine the optimum grinding stock allowance during systematic tests before starting production. The multiple integrated measuring procedures make the method process-reliable. The actual dimension is read out during the first cut and compared with target dimension  $\pm$  tolerance. In the event of any deviation, the turning process is corrected accordingly for the very next workpiece. Correction limits and damping can be adjusted in addition. This guarantees process-reliable adherence to dimensions and surfaces.

The cone of control gears is often interrupted. This makes special demands on the process. For this reason, a somewhat higher residual machining allowance must be selected to achieve process stability. Burr on the interrupted edge can be prevented by changing the direction of rotation between hard turning and grinding.

After one series had been ground, Cm values of 3.1 were achieved for the cone

diameter and Rz values between 2 and 3  $\mu$ m. The circularities were consistently less than 1.5  $\mu$ m and thus lower than the usual 3  $\mu$ m requirement. The structure of the unmachined and machined synchronizer cones were examined in order to investigate the heat input into the edge zone of the hardened workpiece. Longitudinal and lateral samples were taken from both the machined and the unmachined synchronizer cones and examined. All the points examined reveal a martensitic structure and a residual share of austenite in the carburized edge zone. It was thus proved that no edge zone damage is caused by overheating during the grinding process (Figures 5, 6).

The development at Buderus Schleiftechnik shows that dry machining can be offered as a cost-saving and more environmentally compatible alternative to conventional wet-machining processes.

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## Fässler HGP-400 Honing System

DESIGNED FOR SMALL BATCH SIZES

At Gear Expo 2015, Fässler by Daetwyler Industries unveiled the new Fässler HGP-400 gear honing system, a gear honing machine that purports to be designed for "batch size one," bringing gear tooth honing to job shops and other smaller production run environments.

Previously, gear tooth honing required the use of an expensive diamond dressing gear to transfer the necessary geometry for a part onto the honing stone. This made the process economically feasible only for larger batch sizes. The HGP-400, however, uses a commercial, dressable grinding wheel to transfer the geometry to the honing stone.

According to company literature, the new technology reduces process development time from several weeks down to just a few days, as corrections can be carried out and transferred to the honing stone much more quickly than if a new diamond dressing gear were required for each iteration.

The HGP-400 is capable of honing workpieces with internal or external teeth, using either a single-flank or double-flank honing process. Also, the machine is capable of profile grinding, and it can accomplish both gear tooth grinding and honing in a single setup.

The machine can accommodate workpieces with modules from 0.5 – 6. It is capable of external honing workpieces from 20-270 mm diameter, and internal honing from 50-350 mm diameter. The profile grinding range includes workpieces from 20-320 mm for external grinding and 50-380 mm for internal grinding.

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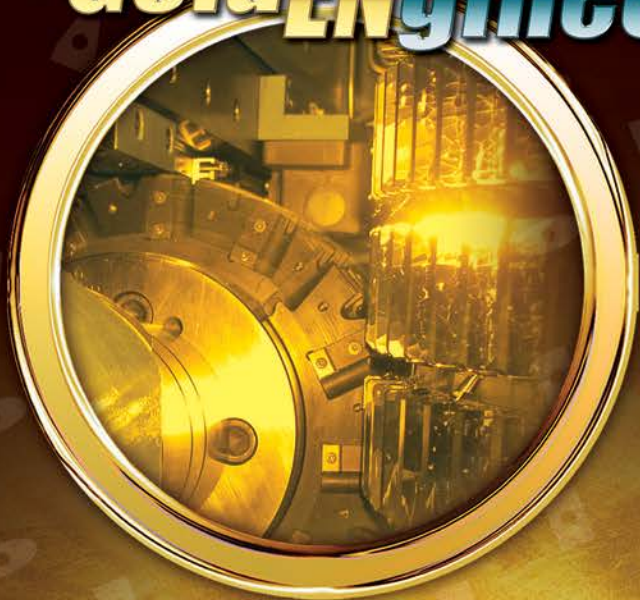
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# BCG-Minweight Software

## OPTIMIZES GEAR DESIGNS FOR SIZE AND WEIGHT

A new software tool specifies basic parameters for gear designs in order to optimize for size and weight. By providing inputs for design ratio, power and input RPM, along with contact and bending stress parameters, a set of design outputs can be generated that specify center distances, face widths, normal diametral pitches, pitch diameters and numbers of teeth.

Additional controlling factors used in the *BCG-MinWeight* optimization process include pitch-line velocity, face width to pitch diameter ratio, web thickness, housing weight, planetary carrier weight and others. Additional outputs include estimates for actual contact and bending stresses, pitch line velocities, load distribution factors, dynamic factors and AGMA quality levels.

The primary goal of *BCG-MinWeight* is to maximize the fidelity of initial designs so that size and weight estimates can be accurately defined before the center lines are established and the gear ratios are locked down. It's relatively easy to change design parameters such as pressure angles or face widths during the development process, but it's much more difficult to change reduction ratios and center distances after the preliminary design concept has been approved.

Another reason for using *BCG-MinWeight* is to establish optimal ratio splits for complex configurations that involve more than one mesh. Modules for two-stage and three-stage systems along with idler, planetary, star and reverted geartrain configurations have been developed. In complex gearbox systems, such as those in wind turbines, a sub-optimal split of the ratios in the gearbox can result in literally thousands of pounds of excess weight in the final design. Additionally, existing designs that are sub-optimal may benefit from the optimization process by re-specifying the diametral pitches and tooth counts in

order to increase power capacity without adding weight.

For those companies who have developed gear materials and processes that result in improved properties and wish for them to be incorporated into new customer designs, *BCG-MinWeight* can be used to justify their use by quantifying reduced size and weight. In the accompanying illustration, three designs are shown, which utilize properties from AGMA Grades 1, 2, & 3 gear steels. All designs are specified to transmit 250 Hp through a single-stage reduction ratio of 2.5 with an input rotational speed of 2,000 rpm. For the three AGMA grades of steels using the carburization process, appropriate allowables for contact and bending stresses would be:

- Grade 1 – 180 ksi contact and 55 ksi bending.
- Grade 2 – 225 ksi contact and 65 ksi bending.
- Grade 3 – 275 ksi contact and 75 ksi bending.

The results of the optimization process reveal the following:

- Grade 1 – center distance = 6.813", estimated gear weights = 41.9 lbs.
- Grade 2 – center distance = 5.500", estimated gear weights = 29.5 lbs.
- Grade 3 – center distance = 5.583", estimated gear weights = 21.0 lbs.

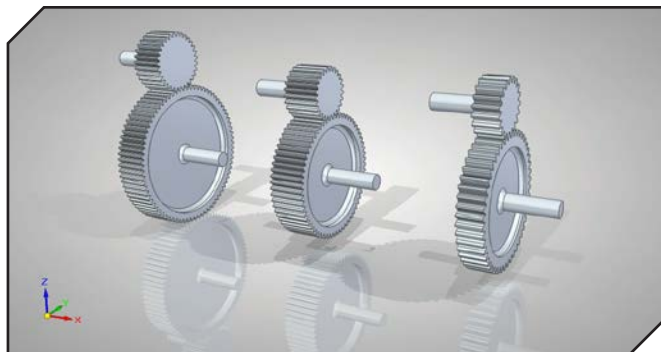
The results indicate that the potential exists to reduce the overall weight of the specified design by 50 percent by using a Grade 3 material instead of a Grade 1 material.

### For more information:

BC Gear & Engineering, Inc.

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# Index New CNC Multi-Spindle Lathe MS16 Plus

HAS A TOTAL OF 27 NC AXES

Designed to supplant cam-controlled multi-spindle lathes up to 22 mm bar diameter, the new Index MS16 Plus of the Index MultiLine series includes six CNC spindles for up to 22 mm diameter parts, accomplishing turning, drilling, milling, tapping, deep hole drilling or slotting in each of its six spindle positions. Workpieces are automatically indexed through the six positions, receiving two or more operations at each position. The result is high production of precision turned workpieces.

The 27 NC axes of the MS16 Plus include five NC grooving or boring slides, five NC cross-slides, one NC cutoff and/or back-boring slide, six work spindles and one NC synchronous spindle, drum indexing plus an additional five free NC axes of possible CNC-controlled auxiliary equipment are controlled by an Index C200-4D CNC.

The compact Index MS16 Plus provides the speed of a cam-controlled machine with the flexibility of CNC technology yet requires no more floor space than a cam-controlled multi-spindle machine. In addition, the MS16 Plus offers high ease of setup and more versatile machining options compared to cam-controlled machines.

Each of the six spindle positions can include a stable grooving or boring slide with one NC axis and a cross-slide with two NC axes (X- and Z-axes) that are arranged around each work spindle in a V-shape, allowing easy use of several tools simultaneously on each work spindle.

The NC-controlled synchronous spindle for gripping the workpiece and an NC cutoff and back-boring slide provide optimal conditions for efficient production of turned parts with simple to medium complexity and up to approximately 70 mm length.

The speed of each of the six spindles can be controlled separately. Spindle speeds can be varied during cutting for each



spindle position and each cutting edge of the tool. Speed changes and positioning of the spindles are possible even during spindle drum indexing, avoiding secondary processing times. Additional advantages include maximum surface quality, short production times per piece, and extended tool life.

For rear end machining, the MS16 Plus is equipped with a synchronous spindle driven by a hollow-shaft motor allowing speeds up to 10,000 rpm and which can move 140 mm in Z at 30 m/min to engage several rear end machining tools on the NC cutoff slide with the X- and Z-axis in succession more quickly. To achieve the shortest cycle times possible, the synchronous spindle accelerates to a maximum of 10,000 rpm in less than 0.7 s.

## For more information:

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# Riten Heavy Duty Spring-Loaded Live Center

AUTOMATICALLY COMPENSATES FOR THERMAL EXPANSION

This center from Riten Industries is capable of adjusting the load on the workpiece. Utilizing Bellville washers, it automatically compensates for thermal expansion. Three color-coded rings illustrate the pounds of axial force that is being applied. This is beneficial when the tailstock on the lathe or grinder cannot display the required clamping pressure for accurate machining.

The center is offered in 3 to 6 Morse taper, in standard and tracer point. Maximum axial loads range from 1,150 to 5,600 lbs. RPM up to 4000, and weight of workpiece up to 7600 lbs. Accuracy guaranteed to  $\pm 0.0001$ .

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# Adcole Model 1310S Inline Camshaft Gage

FEATURES SUB-MICRON ACCURACY

Adcole Corporation recently introduced a new high-speed, fully automated end-of-line camshaft measuring machine that features sub-micron accuracy and sub 25 second cycle times.

The Adcole Model 1310S Inline Camshaft Gage can measure up to 28 features including lobes, journals, chatter, and timing references with sub-micron accuracy and repeatability. Designed to be gantry or robot fed for 100 percent end-of-line inspection, this high-speed gage is fully automated to maintain the production machining process for up to 200 parts per hour in real-time.

Incorporating proprietary follower modules capable of 3,600 data points per revolution per follower, the Adcole Model 1310S Inline Camshaft Gage has an adjustable tailstock and headstock which engages all follower modules simultaneously. To assure high reliability, there are minimal moving mechanisms, and the menu-driven software provides instant data collection.

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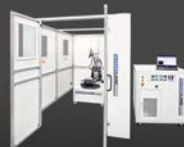
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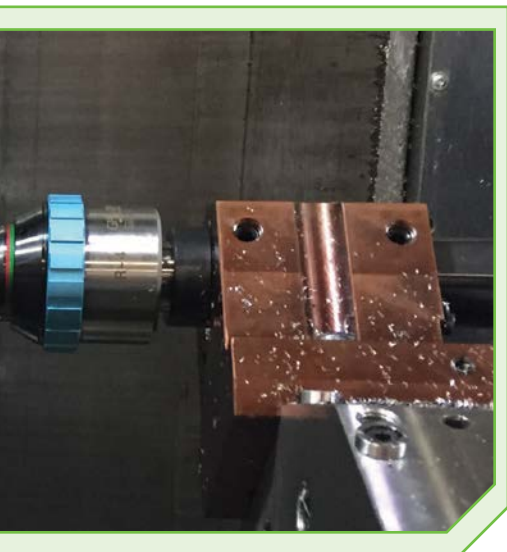
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# Heller 5-axis Machining Center

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The recently introduced CP 4000 series horizontal machining centers accomplish horizontal, vertical and tilted turning with A and B axes with high dynamics and chip removal rates. Designed for a wide range of applications, the five-axis mill/turning center CP 4000, equipped with PCU 63 swivel head unit and HSK-T 63 spindle taper, has a work area of 800/800/1,045 mm (X, Y, Z).

With 44 kW power, 242 Nm torque and up to 10,000 rpm spindle speed, the CP series achieves complex mill/turning operations, precise control of speed and acceleration and variable adjustment to achieve workpiece-specific precision and surface finish.

The CP 4000's machine concept is designed for turning operations, using a fifth axis provided by the tool. Vertical and horizontal turning operations of outer and inner contours can be accomplished with the C axis and optional A and B axes.

Common to all Heller machine tools, the CP 4000 enables productive cutting using economically efficient cutting parameters. High cutting performance is achieved due to the stiff swivel-head geometry, torsional stiffness and form fit provided by a spindle locking feature.

When the workpiece must be rotated against the tool, the rotary table with direct torque drive delivers the required power and speeds up to 1,000 rpm.



To identify imbalances on the workpiece or the rotary table, Heller developed a machine function which uses internal drive signals to identify even the slightest imbalances on the workpiece, enabling precise centric clamping. A specially defined user interface supports the operator in correcting imbalances. For turning tools, Heller addition-

ally offers a standard tool measurement system using tactile sensors. The CP 4000 is typically equipped with Siemens Sinumerik 840 Dsl control.

## For more information:

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# Comet's New Cloud-Based Gearbox Durability SimApp

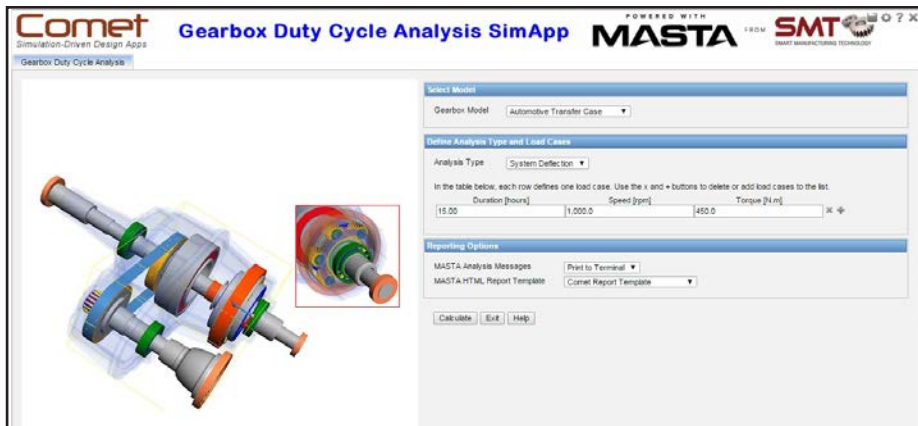
WILL PROVIDE MANY AUTOMATED PROCESSES

Comet Solutions, Inc. recently announced a program in support of gearbox design and manufacturing. The Comet Gearbox solution, consisting of a suite of solution-specific Gearbox SimApps, will provide automated processes integrating the broad spectrum of tools frequently used throughout gearbox development: CAD, FEA, multibody dynamics, gear/bearing simulation and CFD in order to predict and optimize

performance in the areas of acoustics/vibration/dynamics, durability/reliability, efficiency and management of cost and weight.

"This program reaffirms our commitment to the drivetrain industry in general and gearbox design and manufacturing specifically," said Comet Vice President Steve Brown. "Earlier we announced a working partnership with renowned gearbox authority, Brian

Wilson and his company, Advanced Drivetrain Engineering & Technology (ADET). Today we are pleased to announce a strategic partnership with SMT, a leader in the gear and bearing simulation industry. We will be featuring the Gearbox Durability SimApp at Gear Expo 2015 with others to follow. Over the coming months, Comet will deliver a complete suite of Gearbox SimApps along with related products and services."

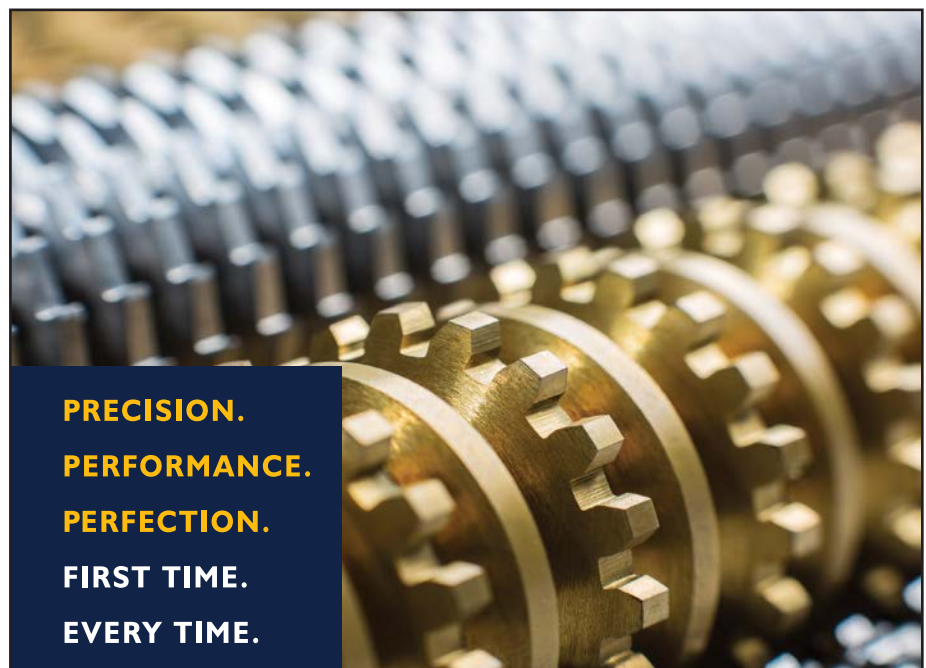


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Developed in cooperation with ADET (Advanced Drivetrain Engineering and Technology) and utilizing SMT (Smart Manufacturing Technology) MASTA, Comet's new Gearbox Durability SimApp will provide gearbox OEM companies the means to perform basic durability evaluations of various gearbox system designs.

By loading a specific duty-cycle into the Gearbox Durability SimApp, they will be able to run an automated durability analysis of the entire gearbox system, including the effects of housing, shaft and bearing deflections. Often, during early design stages, gearbox OEMs do not always have specific details regarding how customers will use their products in the field. The non-engineering staff will have the ability to demonstrate durability performance to prospective customers by entering custom duty cycles representative of actual field usage, independent of their internal engineering staff. This new SimApp allows quick turn-around time regarding product capabilities, empowering gearbox OEMs in the market, while also providing feedback to the engineering team for refinement of future designs.

"We are anticipating some exciting new avenues for our CAE software to be delivered with our new strategic partner Comet Solutions," said SMT Technical Director Euan Woolley. "Pairing both our expertise by hosting durability simulation features in the Gearbox Durability SimApp will open up powerful MASTA functionality to a wider user base of engineers and ultimately drive smarter decision making within the industry. We look forward to the possibilities this partnership will bring."



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