KISSsoft Introduces New Features with Latest Release

Tooth contact under load is an important verification of the real contact conditions of a gear pair and an important add-on to the strength calculation according to standards such as ISO, AGMA or DIN. The contact analysis simulates the meshing of the two flanks over the complete meshing cycle and is therefore able to consider individual modifications on the flank at each meshing position.

The tooth contact analysis (TCA) is therefore mainly used to reduce noise that is caused by the effect of shock load at meshing entry due to elastic bending of the loaded teeth. It is further used to optimize load distribution by analyzing the effectiveness of gear profile modifications considering the misalignment of the gear axis due to shaft and bearing deformation under load.

Basic Calculation Method

The tooth contact analysis simulates the meshing contact assuming a constant nominal torque. The calculation procedure has been defined by Peterson: For a given pinion rolling position (rotation angle ϕ_1) the corresponding gear rolling position ϕ_2 is determined with an iterative calculation (Fig. 1).

The calculation considers the local elastic deformation due to several effects and the corresponding stiffnesses which appear under load: stiffness from bending and shear deformation c_Z, stiffness from Hertzian flattening c_H and bending stiffness of the tooth in gear body rim c_{RK}.

This calculation procedure is repeated for the entire meshing cycle. Comparisons with FE calculations showed a very good correlation.

The final stresses include the load increasing factors calculated by the standard, such as application factor K_A, dynamic factor K_V and load distribution factor $K\gamma$ in planetary gears or gear pairs. For the tooth root stress, the gear rim factor Y_B according to ISO6336 is also considered.

Before the release of *KISSsoft 04-2010*, the load distribution factors $K_{H\alpha}$, $K_{H\beta}$ for Hertzian pressure and $K_{F\alpha}$, $K_{F\beta}$ for root stress were considered. This has been changed for the enhanced tooth contact analysis.

What's New in Version 04-2010?

With *KISSsoft 04-2010*, the TCA for cylindrical gears has improved significantly. In addition to the preceding releases, the stiffness model was extended to better take the load distribution in the width direction into account, which is a significant characteristic of helical gears, but also other effects are now considered, finalizing in the 3-D display of results.

Coupling between the slices. For a tooth contact between helical gears, the meshing field is different than for spur gears. The contact lines for a spur gear are parallel to the root line, and herewith also the load distribution in length direction is uniform. The contact lines for a helical gear are diagonal over the tooth, which means the load is not uniformly distributed over the length of the tooth. Still the unloaded part of the tooth has a supporting effect and influences the deformation of the tooth as well. This supporting effect of the unloaded areas has to be considered for the contact analysis of helical gears.

For this purpose, in *KISSsoft 04-2010*, the gear is in lengthwise direction, divided in slices. The single slices are then connected between each other with the coupling stiffness c_c so that a supporting effect between the slices can be considered (Fig. 2).

$$C_{Pet} = f(C_Z, C_{RK}) \qquad (1)$$

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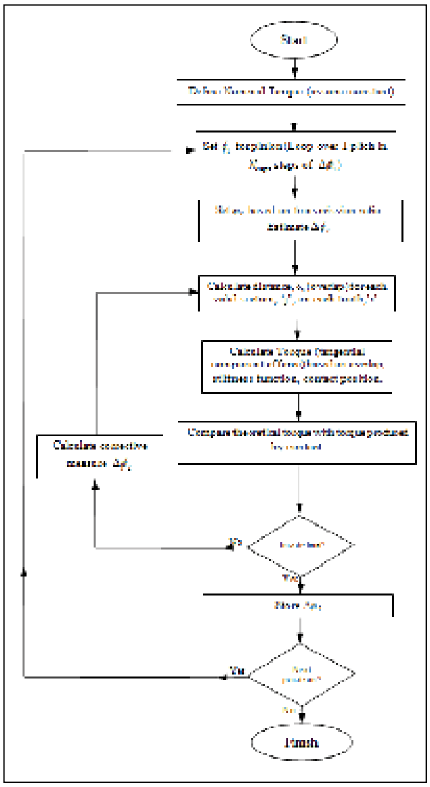

Figure 1—Tooth contact analyses according to Peterson.

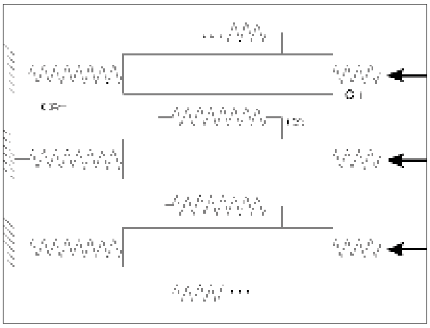

Figure 2—Stiffness model according to Peterson and *KISSsoft 04-2010*.

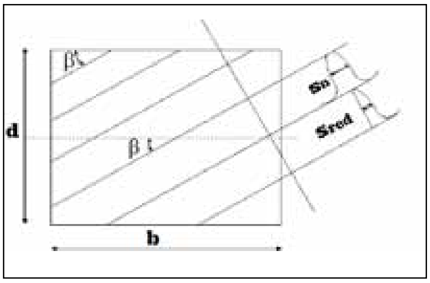

Figure 3—Decreased rigidity on the side borders.

c_{Pet} stiffness tooth root following Peterson
c_Z stiffness from bending and shear deformation
c_{RK} stiffness from deformation through rotation in the gear blank
c_H stiffness from Herztian flattening following Peterson

The coupling stiffness c_C is defined as follows:

$$c_C = 0.04 \cdot A_{\sec}^2 \cdot c_{Pet}$$

c_C coupling stiffness
$A_{\sec}$ Number of slices

The coupling stiffness is related to the contact stiffness and hence individual for each gear pair, and is verified for different gear types with FE calculations and other established software. The number of slices A_{sec} depends on the accuracy setting which is defined from the user. However, the single coupling stiffness c_C is defined in a way that the system coupling stiffness is independent of the number of slices and therewith also independent of the user settings.

In Figure 4, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a spur gear (helix angle β= 0°) with a larger face width for the pinion (b_1 = 50 mm) than for the gear (b_2 = 44 mm). The supporting effect of the unloaded face area outside the meshing contact causes an increased edge pressure within the meshing contact. This effect can now be considered with the coupling stiffness between the slices.

In the previous *KISSsoft* releases, the forces remain constant (Fig. 4a), whereas in *KISSsoft 04-2010*, the normal force at outer ends of meshing contact is increased (Fig. 4b). Note that Figure 4a shows the pinion face width b_2 = 50 mm, whereas in Figure 4b only the common face width b = 44 mm is displayed.

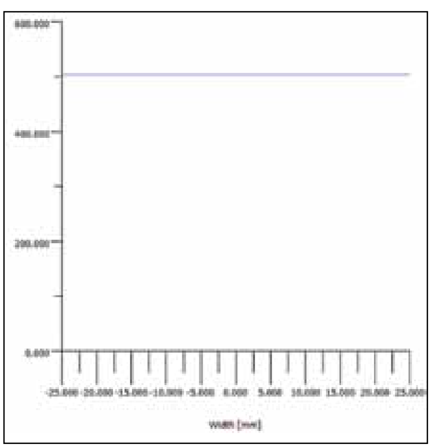

Figure 4a—Previous *KISSsoft* release shows constant normal force (line load) over face width.

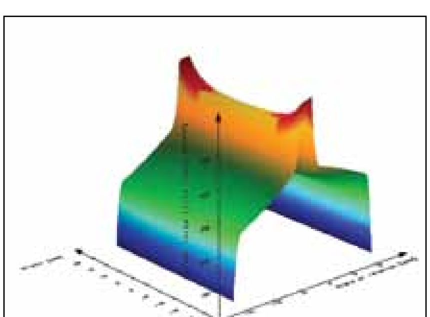

Figure 4b—*KISSsoft 04-2010* shows the increased normal force (line load) at edges of contact area.

Decreased stiffness on the side borders of helical gears. For helical gears, the tooth may be cut by the cylindrical bodies (Fig. 3), which results in reduced tooth thickness s_{red} compared to a tooth that is not cut having a tooth thickness s_n. Whenever force is applied to the tooth with reduced tooth thickness, it will result in higher deformation due to lower stiffness. This effect is considered with the reduced coupling stiffness c_{Pet_border} for the slices of teeth.

In *KISSsoft 04-2010*, the following formula is applied, which is also verified with FE calculation and other established software.

$$c_{Pet\_border} = c_{Pet} \cdot \sqrt[2]{\frac{s_{red}}{s_n}} \quad (2)$$

c_{Pet_border} coupling stiffness for slices with reduced tooth thickness
c_{Pet} standard coupling stiffness
s_{red} reduced tooth thickness at border
s_n standard tooth thickness

In Figure 5, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a helical gear (helix angle β = 15°) with the equal face width b = 44 mm. In the previous releases the effect of reduced coupling stiffness at border wasn't considered; therefore the normal force (line load) at border isn't increased. In *KISSsoft 04-2010*, the normal force at the start as well as end of contact is increased.

Revised calculation of tooth stiffness of helical gears. For helical gears, the contact stiffness c_{Pet} following Peterson is calculated based on the effective tooth form in normal section. In earlier *KISSsoft* versions, the tooth form was based on the transverse section multiplied by the factor cos

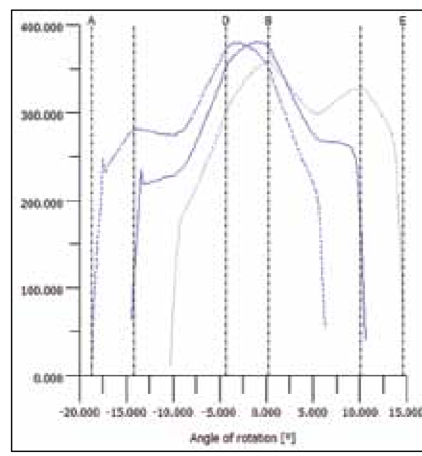

Figure 5a—Previous releases don't show higher normal forces (line load) at ends.

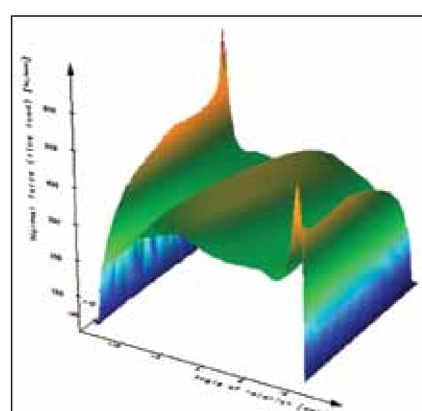

Figure 5b— *KISSsoft 04-2010* shows higher normal forces (line load) at start and end of contact.

β, which is a less accurate procedure. Therefore the results slightly differ between this and older releases.

In Figure 6, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a helical gear (helix angle $\beta = 15°$) with the equal face width $b = 44$ mm. In *KISSsoft 04-2010*, the tooth stiffness is slightly different from the previous *KISSsoft* release. Since the transmission error is strongly related to the stiffness, the transmission error slightly differs, too.

Load distribution considerations. In previous *KISSsoft* releases, it was not possible to consider any unequal load distribution correctly since the slices were not coupled. Therefore the load distribution was added taking the factors KH_α, KH_β as well as KF_α, KF_β (ISO) and K_M (AGMA) from the standards calculation. These were multiplied to the stresses from the tooth contact analysis. In *KISSsoft 04-2010* these factors are no longer used. However, the displayed stresses are still multiplied with the application factor K_A, dynamic factor K_V and load distribution factor K_γ in planetary gears or gear pairs.

In Figure 7, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a spur gear (helix angle $\beta = 0°$) with the equal face width $b = 44$ mm. It's

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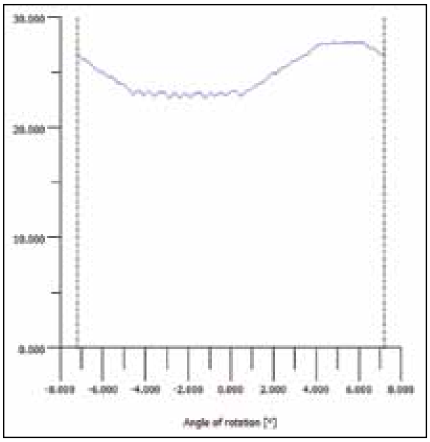

Figure 6a—Previous releases calculate slightly higher tooth contact stiffness.

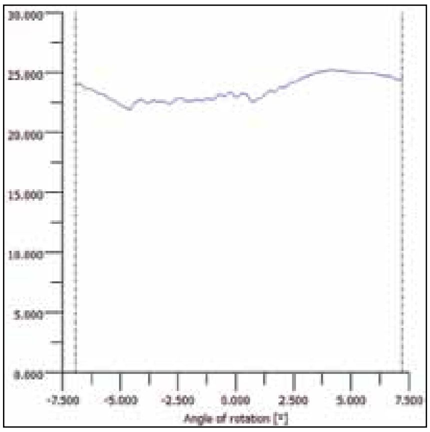

Figure6b—*KISSsoft 04-2010* calculates slightly lower tooth contact stiffness.

an overhang design, meaning the gear is outside the bearings. This results in an increased load distribution factor according to ISO standard calculation with KH_{β} =1.27 and KH =1.0.

The tooth contact calculation is done without considering any misalignment of the gear axis; values for deviation error and inclination error are set as 0. In *KISSsoft 04-2010*, flank pressure and root stresses are lower compared to the previous release. For a realistic contact analysis, the gear axis misalignments should be defined with shaft and bearing calculations, i.e., from *KISSsys*.

Calculation of Hertzian pressure. The calculation of the Hertzian stress is based on the Hertzian law in the contact of two cylinders. This gives realistic results in most situations. However, a problem is encountered when the contact is on a corner of the flank, i.e., corner at the tip diameter, corner at the beginning of a linear profile modification or corner at the beginning of an undercut. Then

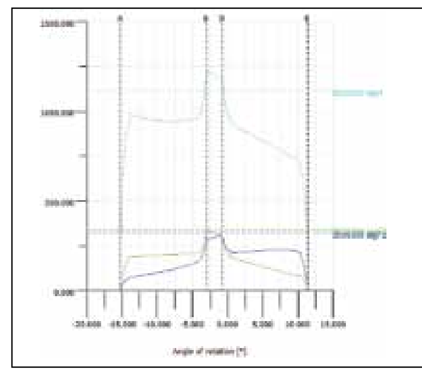

Figure 7a—Previous releases consider load distribution factors in tooth contact analysis.

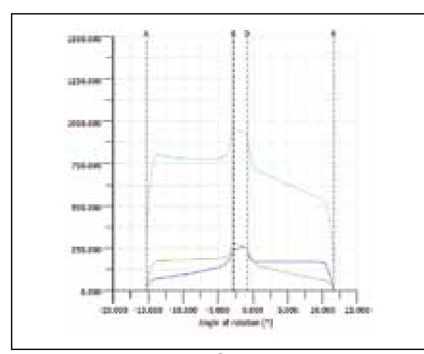

Figure7b—*KISSsoft 04-2010* doesn't consider load distribution factors from standard calculation.

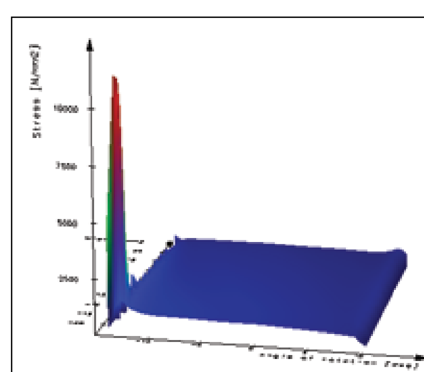

Figure 8a—High pressure peak due to no tip rounding.

the radius of curvature becomes very small, which results in a high peak of Hertzian stress calculation. This is not a realistic issue, because the part of the flank near to the corner will be joined in the contact. An algorithm checking the joining flank parts and increasing the radius of curvature is implemented. However, it may be that high peaks still remain. *KISSsoft* recommends adding a realistic radius to the corners and using circular profile modifications instead of linear.

In Figure 8, the same gear calculation is compared between *KISSsoft 04-2010* and the previous release. It is a spur gear (helix angle β = 0°) with the equal face width b = 44 mm. In Figure 8a there is no tip rounding applied, whereas in Figure 8b there is a tip rounding of 0.5 mm. The pressure peaks are drastically reduced with the tip rounding.

3-D Display

With *KISSsoft 04-2010* the graphical evaluation has been enhanced with 3-D graphics. However, the 2-D graphics remain as a good comparison to the previous releases. The 3-D graphics show a three-axis diagram, where the color indicates the stress level. In some cases there may be points where the stress data is missing. In such cases the colors are interpolated directly between two neighboring stress data values. This may result in unequal color display. Figure 9 shows an example of this effect at start and end of contact.

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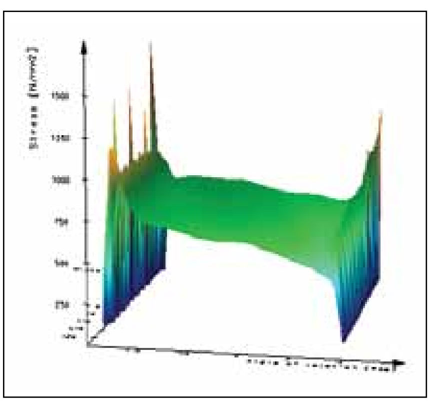

Figure 8b—Much lower pressure with tip rounding of 0.5 mm.

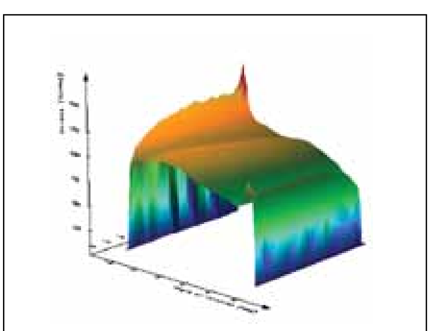

Figure 9—3-D presentation of stress level.

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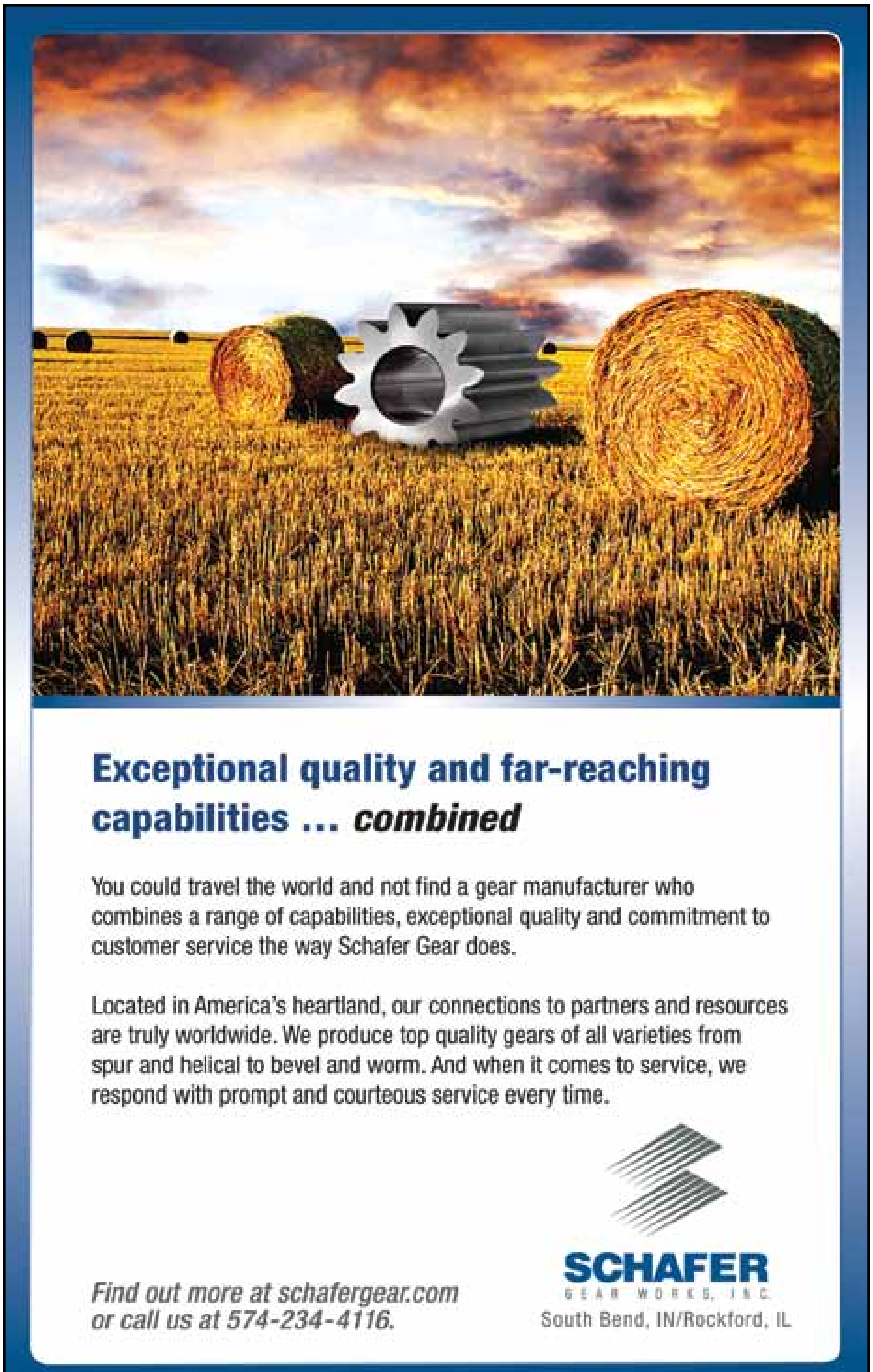

Shot Peening System

DESIGNED FOR AEROSPACE GEARS

Guyson Corporation has introduced a 7-axis robotic pressure-blast shot peening system that is designed to support compliance with the most demanding process specifications and to enable automated peening of a wide variety of dissimilar components. The Model RB-10 was developed for technical surface treatment of gears and aerospace components.

The 60 x 60 x 60-inch blast cabinet is mated with a 6-axis robot, such as the FANUC M10iA, as a blast nozzle manipulator. The shot peening machine's rotary table has a diameter of up to 52 inches and is servomotor driven to be controlled as a seventh axis of robotic motion.

Locating hardware is provided to allow interchangeable component-holding fixtures to be positively and repeatably positioned on the turntable.

During the shot peening cycle, the orientation of the component and the motion of the robotic nozzle manipulator are synchronized to precisely replicate the programmed tool path, following the contours of complex-shaped parts, yet constantly and accurately maintaining the required angle of shot impingement, the correct offset of the peening nozzle from the target surface and the right dwell or surface speed to control the cold working process.

The peening media delivery system includes an ASME-certified pressure vessel of 3.5 cubic foot capacity fitted with high and low shot level sensors, a 3 cubic foot media storage hopper that automatically adds shot when a low level is detected and, if required, an electronic shot flow controller to continuously maintain the correct blast pressure and shot flow rate specified for the shot peening process.

In addition to a cyclone separator for dust extraction, the shot reclamation system includes a vibratory screen classifier to deliver only shot of the specified size, as well as a spiral separator to remove any peening shot that is not perfectly spherical.

For metallurgical shot peening applications in accordance with SAE aerospace peening specification AMS 2432, Guyson offers a SCADA controls package combined with a custom-designed touch screen human-machine interface (HMI) to enable data verifying all critical process parameters throughout the shot peening procedure to be captured and logged for documentation purposes.

Prospective users of robotic shot peening equipment may submit sample components for evaluation in the application engineering laboratory at the blast machine builder's factory in northeastern New York State.

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Low Inertia Couplings

REDUCE CYCLE TIME

Zero-Max's low inertia, lightweight coupling with high rotional stiffness for servo motor applications comes with its aluminum CD model in single and double flex versions.

The CD coupling has a robust though lightweight aluminum design. The working part is made of a composite material. The composite disc design handles the stresses of a servo motor's high acceleration rates and high torque capacity. The result is lower energy requirements, longer life of the motor and other operating components with uninterrupted system operation.

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"We surveyed design engineers to find out what was the most desirable feature when specifying couplings for servo motor applications," says Robert Mainz, Zero-Max sales manager. "Low inertia was the most important. These engineers said they continually look for ways to reduce cycle time and improve system productivity. A lightweight yet high strength coupling design will enable the designer to increase the speed of the actuator. The combination of the lightweight aluminum hubs and unique composite disc provides the necessary characteristics to increase speed and cut cycle times. Lightweight couplings will also have an effect on the energy consumption in their designs. The aluminum CD couplings meet those objectives and more."

Applications include automated packaging systems and assembly machinery where precise, high speed positioning is required. The Zero-Max CD couplings are available in single and double flex models with or without keyways. The double-flex version is for precision applications requiring misalignment capacity greater than the single flex design. The single flex models have a torque capacity range from 40 Nm to 1,436 Nm and higher with speed ratings from 4,400 rpm to 17,000 rpm.

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Bodine

REDESIGNS W MODEL GEARHEADS

The WX gearhead from Bodine Electric Company is a high-torque gearhead built to provide longer life and higher performance than similar gearmotors in the same size range. It is being introduced in conjunction with its upgraded 34B-frame brushless DC motor. It is designed to drive applications such as conveyor systems, packaging equipment, metering pumps, medical devices, commercial appliances and solar powered outdoor equipment.

The exterior of the WX gearhead is identical to Bodine's old W models, but the inside has been completely redesigned. The gearmotors feature all-steel helical gear trains and synthetic lubricants, so the type 34B-WX can produce up to 65 percent more torque than previous models. The steel gearing is designed to AGMA 9 standards or higher for quiet operation. The lubricant used improves efficiency and allows the gearmotors to operate in a range of temperatures. Forty-eight stock models feature 12 available gear ratios, ranging from 4:1 to 312:1 and rated output speeds from 658 to 8 rpm.

The WX gearhead is available with Bodine's type 34B, TENV, 1/5HP (149 watts) brushless DC motors. The BLDC motors require less maintenance and last longer than other brush-type PMDC motors. They can be used in place of brush-type motors in applications where high starting torque and linear speed-torque characteristics are critical. The 34B-WX gearmotors are available with 130 VDC and 24 VDC windings and are available with or without accessory shafts for external encoder or brake installation.

"Bodine Electric has over 20 years experience in design and manufacturing of brushless DC motor and control systems," says Terry Auchstetter, manager of business development. "We also manufacture a complete line of matched 24V or 130V brushless DC motor speed controls. When customers purchase the 34B-WX with a control, they get a complete drive system from one source."

continued

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Fluorescent Dye

PINPOINTS OIL LEAKS

Dye-Lite TP-3100 fluorescent dye pinpoints engine oil, hydraulic fluid, lubrication fluid, compressor oil and gearbox oil leaks.

Simply add a small amount of TP-3100 dye to the system and allow it to circulate for several minutes. Wherever there is a leak, the dye escapes with the oil and accumulates. Scan the system with a high-intensity ultraviolet or blue light lamp, and the dye glows a bright yellow color to clearly reveal the location of all leaks—even small leaks undetected by other methods.

After the leaks have been repaired, scan the system with the light again. If there is no glow, it means that all the leaks were fixed properly.

TP-3100 dye can remain safely in the system until the oil is changed, making it ideal for preventive maintenance. Periodic inspections with the lamp will detect leaks before they can cause damage to the system.

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Height Gage

OFFERS EASY-TO-USE SHOP FLOOR MEASUREMENT

Designed with production personnel in mind, the new Digimar 816 CL Height Gage from Mahr Federal provides highly accurate measurements without complicated procedures.

The Digimar 816 CL incorporates a precision measuring head on stainless steel guideways and a dynamic probing system. Air bearings provide light and smooth movement, while accuracy and reliability are ensured by an optical incremental measurement system with a double-head reader, which is impervious to dust and other contamination. A motorized measuring carriage minimizes operator influence on probe contact, increases accuracy, and simplifies measurement runs.

Key to measurement accuracy in production environments is the Digimar 816 CL's internal temperature compensation system. An integrated temperature sensor measures ambient temperature and automatically compensates for the thermal expansion of the workpiece.

All standard functions can be initiated with a single key stroke, and additional functions are readily available through the menu. Measured values are clearly displayed on the control unit's high-contrast, back-lit graphic display, along with the current function being measured. Users may also retrace the measuring procedure in the list of measured values directly below the current value. Dynamic functions, such as Max-Min for parallel deviation and roundness deviation, and calculation functions, such as the distance between measured values, are also included.

Operation of the Digimar 816 CL Height Gage is intended to be nearly self-explanatory, with function keys clearly defined with easy-to-understand icons. The icon for "Contact surface from above," for example, is a simple line with an arrow pointing down. "Contact from below" has the arrow pointing up. Repetitive measuring procedures can easily be automated. Complex measuring routines can be programmed using the Digimar 816 CL's teach-in mode, and can then be initiated with a single key.

The memory on the Digimar 816 CL Height Gage can store up to 99 measured values. Data can be output via USB or OPTO RS232. An integrated, rechargeable battery provides long operating time for independent measurement in addition to the main power adaptor. The Mahr Federal Digimar 816 CL Height Gage is available in two measuring ranges, 350 mm (14 in.) and 600 mm (24 in.).

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RoboMax System

AUTOMATES QUALITY CONTROL

The RoboMax system, developed by Carl Zeiss, does not require an operator and can run fully automatically 24 hours a day, 7 days a week. Parts are automatically fed, measured and sorted. Measurement logs permit verification of the quality at any time.

RoboMax can be configured as

needed. Different coordinate measuring machines (CMM) and surface measuring machines from Carl Zeiss can be integrated. Equipped with standardized controllers and interfaces, the measuring machines receive the parts being inspected via loading systems.

Data matrices and RFIDs are used to clearly identify the parts. Depending on the part, *FACS* (Flexible Automation and Control System) software loads the corresponding measuring program from *CALYPSO* measuring software from Carl Zeiss.

Such systems are intended for automotive customers and others with high part throughput and automation levels.

Because the loading systems and robots on the market today can move very quickly, the speed of the measuring machine is particularly important for part throughput. The inline CMMs in the MaxLine from Carl Zeiss—GageMax and CenterMax—are equipped with probes featuring Navigator technology. They not only measure the features more accurately, but also up to 50 percent faster than conventional probes, according to the company. These measuring machines, which work reliably at temperatures from +15°C to +40°C, are thus suitable for integration into RoboMax.

For more information:

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