# SOFTWARE BITS

William R. Stott

*Image courtesy of Professor Xiaodong Guo, Chongqing Institute of Technology.*

## GEAR AND GEARBOX DESIGN

*KISSsoft* is a software tool for the design of machine elements such as gears, shafts, bearings, bolts, splines and springs. The main features of *KISSsoft* were developed for gearbox design and analysis.

The software calculates most of the machine elements according to methods specified in the current versions of DIN, ISO and AGMA standards. If no standard is available, elements are calculated based on well recognized and accepted literature, says Stefan Beermann, marketing director for KISSsoft AG, located in Hombrechtikon, Switzerland.

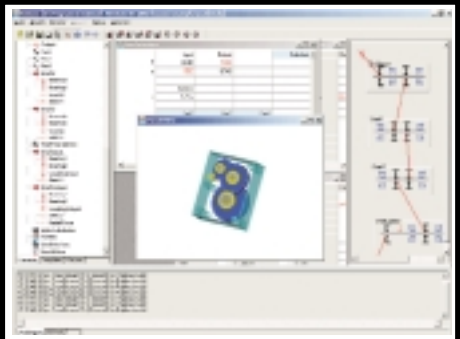
In addition to calculating geometry, the software performs load rating calculations against static and fatigue loads, and it includes a number of functions to help designers optimize the parts.

One of the most powerful functions, Beermann says, is the software's ability to iterate through a given set of parameters for spur or helical gears. This allows the software to determine the geometrically possible solutions and rate them according to strength, stiffness, noise, weight or other functions.

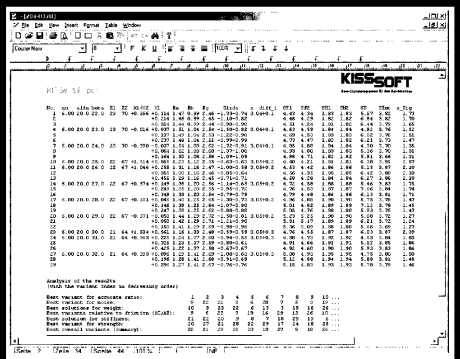
*KISSsoft* was originally developed by Kissling & Co. AG, a Swiss gearbox manufacturer, but development and sales are now being handled by KISSsoft AG, an independent engineering consultancy. "During the last 25 years, the software has been constantly improved, and more functionality is added every day," Beermann says.

Beermann adds that one of the strengths of *KISSsoft* is that it has been developed by trained and experienced mechanical engineers, helping "to ensure that the design engineer gets a practical tool for his daily work."

In addition to *KISSsoft*, the company offers an add-on package called *KISSsys*, which was developed for the definition of complete systems such as gearboxes or complete powertrains. With *KISSsys*, all parts—including gears, shafts, bearings and couplings—are linked, and the strength and life analyses are performed simultaneously for all elements.



***KISSsys* allows a whole system of machine elements to be presented, making it easier to size the elements to fit in a given housing.**



***KISSsoft* allows a designer to quickly see the results of changes in parameters. The example above shows how varying the helix angle affects criteria such as noise, weight and stiffness.**

*KISSsys* presents a 3-D graphic of the current state of the system. The graphic presentation shows the geometric influence of every change in parameter. "This approach greatly accelerates the design process and results in a much more balanced design," Beermann says.

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# The Gear Processor

*HyGEARS* version 2.0, "The Gear Processor"™ is a 3-D gear modeling program for the design and development of hypoid, spiral bevel, straight bevel, spur, helical and face gears, as well as involute splines.

*HyGEARS* allows the design, analysis and optimization of gear sets through functions such as tooth contact analysis (TCA) and loaded tooth contact analysis (LTCA). It supports the design and development of gears manufactured under Gleason's Face Hobbing™, Fixed Setting™, Duplex Helical™, Modified Roll™, Spread Blade™, Formate™ and Helixform™ cutting processes.

The software was developed by Dr. Claude Gosselin of Involute Simulation Softwares Inc., located in Sillery, Quebec. According to Gosselin, "The software has been extensively tested in industry."

Blank geometry, cutter blade shape and machine settings can be modified through the program's "Summary Editor," or those parameters can be optimized through more advanced user-guided functions.

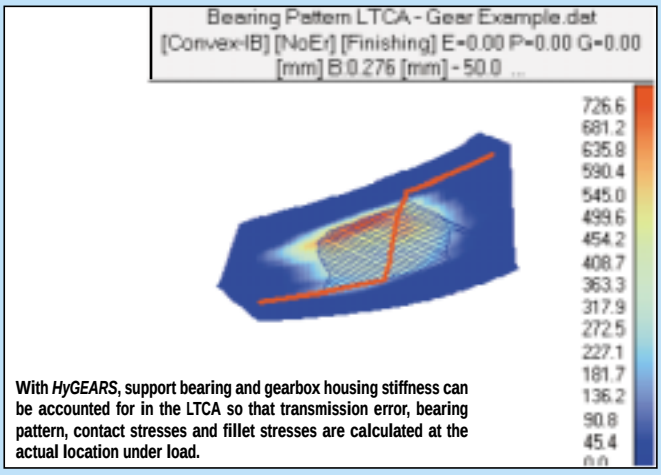
Transmission error, unloaded and loaded bearing pattern, torque transmitted by meshing teeth, bending and contact stresses, bearing reactions, thermal-EHD oil film thickness, temperature increase and scoring factors are all calculated in real time, Gosselin says.

Also, the axial and radial positions of meshing gears, their alignment and shaft angle can be modified to analyze worst-case conditions or to automatically produce grid-like projections of the unloaded and loaded behavior of a gear pair.

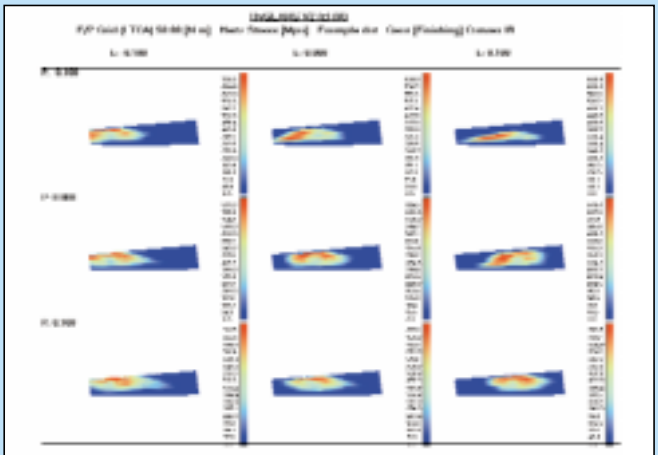
Some of the advanced functions offered by *HyGEARS* include finite element analysis pre-processing for meshing and load applications, as well as the analysis of gears under load using *HyGEARS'* proprietary finite strips, which Gosselin describes as "an ultra-fast subset of the finite element method." Also, the software's "Contact Element" module allows the evaluation of contact stresses at any point on the tooth surface.

The software can output target files for coordinate measuring machines, including Zeiss Ram/RFD, Gear Bevel or Höfler formats. *HyGEARS* can import CMM output files from the same types of machines as well as Klingelnberg inspection machines. This allows the software to calculate corrective machine settings or to reverse engineer existing gear teeth, Gosselin says.

"CMM results can also be used to estimate the TCA and LTCA behavior of a real gear pair," Gosselin adds, "and this allows troubleshooting problematic gear sets."




**With *HyGEARS*, support bearing and gearbox housing stiffness can be accounted for in the LTCA so that transmission error, bearing pattern, contact stresses and fillet stresses are calculated at the actual location under load.**



**The axial and radial positions of meshing gears, their alignment and shaft angle can be modified to analyze "worst case" conditions, or to automatically produce grid-like projections of the unloaded and loaded behavior of a gear pair.**

The software can be modified for customers in order to add specific functions or results, or to automate tasks, Gosselin says.

**For more information:**

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## Simple and Easy to Use

**The philosophy behind software at DR Gears, a gear consultancy based in Tunbridge Wells, England, is to keep it simple.**

**"In my 38 years in the gearing industry, I have used a lot of gear software. I have also worked with a lot of colleagues who are brilliant engineers but are scared of the gear field and consequently put up walls against this 'black art,'" says David Robinson, president of DR Gears. "I have tried through our software to bring a simple 1-2-3 method of use by offering simple, easy-to-use software that can be used for a single purpose."**

**Robinson offers a number of these simple programs through his website, *www.drgears.com*.**

**For example, *GeaRatio* allows the user to determine the number of teeth needed in each member of a gear set, based on entering a decimal ratio. It can be used to determine change gears for milling, hobbing, shaping or grinding machines. *Base Tangent* is used for calculating tooth size based on number of teeth, pitch, pressure angle, helix angle and profile shift. It will accept module, diametral pitch or circular pitch measurements. *Pin Diameter* calculates dimensions over or between pins for internal or external gears.**

**Each of those programs is available at the company's website for U.S. $50. The website also has a number of free utilities available for download.**

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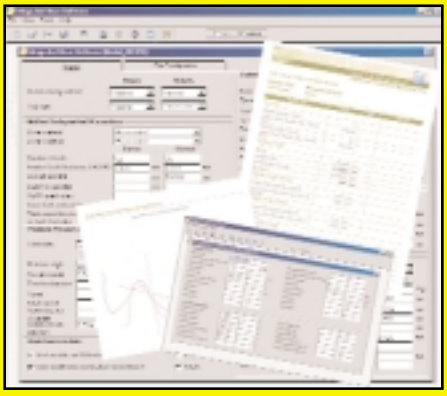
# *Integrated Gear Software* from UTS

The gear design and manufacturing software of Universal Technical Systems Inc. has been widely used for nearly 20 years. Until now, that software was composed of individual modules. Now that system has been combined into a single, comprehensive environment.

UTS's *Integrated Gear Software* (*IGS*) brings together more than 70 modules of the UTS system—each representing a particular issue or stage in the gear design and manufacturing process—into one seamless knowledge environment that calculates, shares data, archives designs, does tolerance analyses and produces detailed reports.

*IGS* retains a modular structure, and the modules are grouped in six packages: Advanced Gear Design and Manufacturing, Basic Gear Design and Manufacturing for Metal Gears, Basic Gear Design and Manufacturing for Plastic Gears, Crossed Axis Gear Design, Epicyclic Gear Design, and Spline Design and Manufacturing. However, with *IGS*, all the modules are designed to work together and to pass data back and forth seamlessly.

The metal gears basic package covers design and analysis, preliminary sizing, tooth thickness and coordinates, mesh geometry, profile shift coefficients, stress and life analysis, and measurement over pins. The plastic gear basic package covers all these and adds programs to cover such factors as temperature, moisture and mold design. The advanced package covers such issues as specific types of hobs and cutters, yield stress, involute geometry, scoring analysis, tip relief and minimum-weight gearbox.



Like the previous versions of UTS software, *IGS* is powered by *TK Solver*, UTS's mathematical and programming environment. One of the key advantages of using *TK Solver* is the software's ability to "backsolve." This allows designers to enter data in the fields they want, and the software solves for the other values.

The software also includes comprehensive project management features, so that designs can be grouped together by project and projects grouped together in packages. The project manager also allows designs from one project to be reused for another.

*IGS* comes with many standard reports, which can be printed or output to word processing files. The software also has the ability to prepare comparison reports so that values from different data runs can be shown side-by-side. Also, reports can be customized. The user can select which data should be shown, including inputs, outputs and plots, and these customized reports can be saved as templates and reused.

UTS gear software customers with a maintenance agreement can receive the upgrade to *IGS* automatically. Those with expired service agreements can renew them for a small start-up fee.

More complete details regarding the capabilities of *IGS* are available on the company's website, *www.uts.com*. UTS also offers an online demonstration of *IGS* through "Live Meeting," as well as on-site demonstrations.

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# Forging Simulation

**By simulating the forging process, engineers at ProSIM are able to reduce the design and development time for forged parts, including gears.**

**ProSim, based in Bangalore, India, is a consultancy specializing in process modeling for forged and other formed parts. The company uses finite element analysis software to develop what they call a "virtual gear forging shop."**

**"Finite element analysis-based process modeling can be a useful tool for rapid design and development of the gear forging operation," says Dr. S. Shamasundar, director of ProSIM. "The costs involved in trial and error-based die tryouts can be reduced, and the lead time brought down."**

Color bands show the strain distribution in warm forging a spur gear.

**The engineers at ProSIM use *DEFORM*, the commercial version of a nonlinear FEM code originally developed by Battelle Memorial Lab for the U.S. Air Force. *DEFORM* is produced by Scientific Forming Technologies Corp. of Columbus, OH.**

**Through the use of the software, ProSIM is able to predict defects such as laps, folds and underfills. ProSIM engineers can also estimate die load and the microstructure of forged parts, as well as predict tool and die wear and failure.**

**ProSIM uses the software to predict the flash geometry and volume produced by a forging process. Flash is excess material that has to be removed after forging. By optimizing the process, ProSIM engineers are able to reduce flash volume and decrease scrap.**

**"Gear forging process simulation means more development in less time," says Shamasundar.**

**For more information about *DEFORM* software:**
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**For more information about ProSIM's services:**
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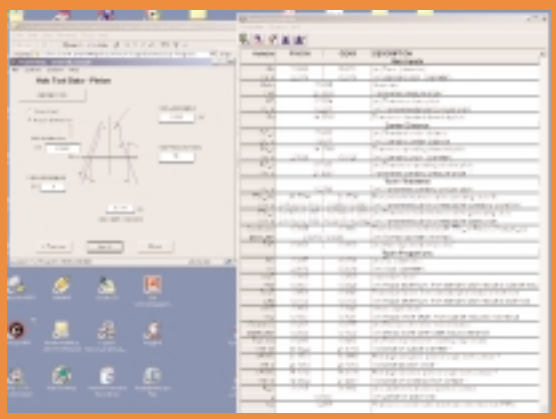

# Parallel Axis Gear Analysis

*PowerGear* is a design and analysis tool for internal or external spur, single helical and double helical gears. The software was developed by Ray Drago and Remco deJong of Drive Systems Technology Inc., located in Glen Mills, PA.

The software uses a prompted input sequence that allows it to calculate gear tooth geometry, tool geometry, bending and contact stresses, flash temperature, strength and durability ratings in accordance with AGMA 2001-C95, EHD film thickness, frictional power loss, scoring hazard rating, tooth profile kinematics, subsurface shear stress/strength, required case depth for surface hardened gears, and other calculations. *PowerGear* also produces the manufacturing data needed to prepare an engineering drawing of a gear.

*PowerGear* can operate in conventional U.S. units or metric units, and it can switch between the two. Users can directly enter geometry parameters themselves or use the software's "parametric mode" to allow the program to calculate the geometry for them.

A complementary module, *DrawGear*, is included with *PowerGear*. *DrawGear* allows gear mesh action to be viewed dynamically on screen. The gears rotate so that a visual indication of mesh action can be observed.

The full professional version of *PowerGear* costs $695. A 30-day demo version can be downloaded at *www.gear-doc.com*. Also, a limited-capability student version of *PowerGear* is included in the cost of the "Applications in Parallel Axis Gear Design" seminars presented by Ray Drago at the University of Wisconsin-Milwaukee (visit *www.uwm.edu/dept/ccee* for information about the seminars).

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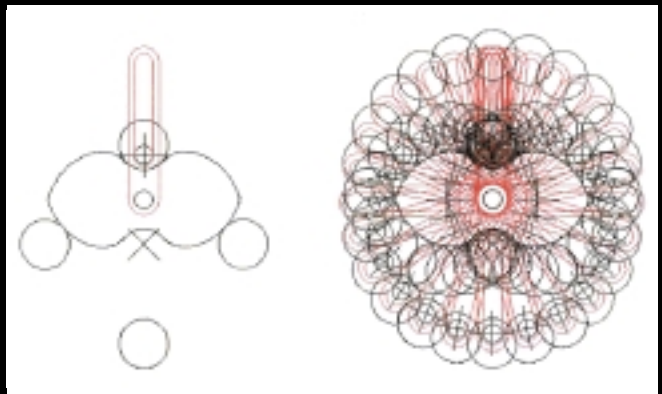

Trogetec's *ACADS* software can produce animations and motion profiles for unusual gear configurations, such as the one-station cardioid indexing device shown here.

# Animated CAD Solutions from Trogetec

A newly released software package from Trogetec Inc. of Riverton, WY, was developed "to help gear designers obtain theoretically perfect solutions for realizing specific objectives in designing gears," says president Sandor J. Baranyi. Trogetec specializes in the design, engineering and manufacturing of trochoidal and involute gear systems.

The software, called *ACADS*, provides animated images of gear systems to allow designers to visualize and understand how complex mechanisms work. The software also can provide "composite-flash" images, which are static representations of a gear system's motion.

In addition, the software allows quantitative evaluation of various engineering conditions based on corresponding numerical data files or CAD images. Examples include studies on initiating or terminating gear tooth engagements, avoidance of involute profile undercutting and fouling. Applications for involute and trochoid (cycloid) gearing include: determining gear mesh efficiency; proving studies for CNC machining; convex/concave profile enveloping for internal or external spur, helical or spherical gear meshes; and special kinematic studies of mechanism operation.

According to Baranyi, the software can be useful in researching and developing competitive new mechanisms.

Trogetec also provides the following software titles: *EZGearplot*, for designing, manufacturing and quality control engineering tasks related to involute and cycloidal gears, speed reducers, roller chain sprockets, cams, compressors and vacuum pumps; *INVOGEAR*, a companion to *EZGearplot* that expands that software's capability to include nonstandard involute spur and helical gears; and *MODOPT*, which produces high-speed motion profiles for cams, motion servos and other mechanisms.

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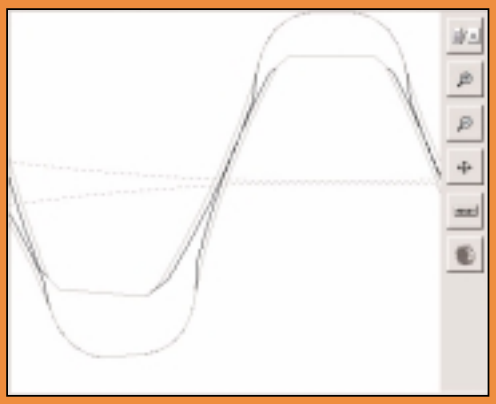

## *GearDesignPro* from Dontyne Systems

*GearDesignPro* is a new program for designing spur and helical gears, published by Dontyne Systems of Newark, England. The software, which rates gears for contact and bending strength according to ISO 6336, is intended for both novice and advanced users.

Features of *GearDesignPro* include flash temperature calculations, center distance optimization, tolerancing based on ISO 1328, measurement over balls, and partial DXF output.

The center distance optimization routine allows the designer to determine the minimum center distance that still allows all safety factors to be above 1.0. The calculation is based on the input of helix angle, material properties and other geometry constraints.

One of the advanced features of the software is a "Design Workspace Search," which allows the user to generate thousands of gear designs and analyze and compare them in minutes. Various parameters can be plotted against each other, enabling the designer to select the optimum design for his or her requirements.

*GearDesignPro* comes in three different versions: Basic, Standard and Advanced. The Advanced version costs £1,200 (about $2,080) and includes all features and functions described above. The Standard version costs £800 (about $1,390) and excludes the "Design Workspace Search." The Basic version costs £200 (about $350) and excludes the "Design Workspace Search" and the center distance optimization routine.

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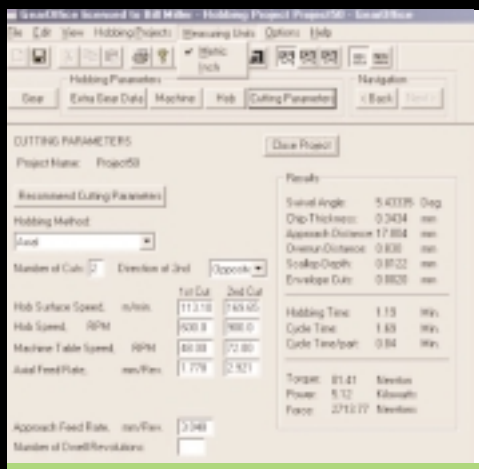

*GearOffice*© calculates hobbing parameters, including feed rates, cutting speed and number of cuts.

## Software for Gear Hobbing

*GearOffice*© is a Windows-based computer program for calculating hobbing machine settings and for organizing gear setups, hobs, machines and hobbing projects.

The software was developed and written by GearOffice Inc. in consultation with Yefim Kotlyar of Bodine Electric in Chicago, IL. *GearOffice* is available for sale through GearHelp LLC of Cincinnati, OH.

The program is capable of calculating hobbing parameters, such as cycle time, chip thickness, approach and overrun distances, hob setting angle, feed scallop depth, depth of enveloping cuts, force, power and torque. The program provides recommendations for feed rate, cutting speed and number of cuts. Also, it can recommend an appropriate cutter from the *GearOffice* database or automatically design a new hob.

*GearOffice* provides various gear calculations as well, including the relationship between tooth thickness, dimension-over-pins and span measurement; hobbing machine adjustments based on over-pins or over-span measurements; geometry and gear inspection parameters; and tolerances according to AGMA, DIN or ISO standards.

"One of the unique features of *GearOffice* is its powerful organizer that provides means to create, maintain and sort gears, machines and hobs," Kotlyar says. All data is stored in an MS-Access database. A gear, machine and hob can be combined into a hobbing project to determine or specify cutting parameters. The same gear, hob or machine may be selected in multiple hobbing projects.

"*GearOffice* can be a useful tool for manufacturing engineers and managers, hobbing estimators, hobbing machine operators, hob inventory control personnel and gear inspection personnel," Kotlyar says.

*GearOffice* costs $650, and a 30-day trial version is available.

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# *ProXpt* Expands *GearCAD*'s Capabilities

*ProXpt* is a new software package from Gearsoft Design of Lane Cove, Australia. *ProXpt* is an advanced gear profile manipulation and enhancement tool designed to be used in conjunction with *GearCAD*, Gearsoft's gear design software.

*GearCAD* performs geometry calculations for internal and external spur, helical and planetary gear sets using module, diametral pitch or Fellows stub tooth formats. Features of *GearCAD* include addendum modification, non-standard center distance, selectable backlash, tooth sizing and load checking. It also includes subwindows for cutter selection, center distance calculation, permissible load approximation and other calculations.

"The visual design concept makes the program an ideal tool for the novice gear designer as well as an expert," says Gearsoft manager Stan Koch.

*ProXpt* takes the gear design a step farther, Koch says. "It is especially suited for designing profiles for plastic gears, sintered gears or high performance gears."

With *ProXpt*, the gear profile can be visually or numerically modified by applying tip relief and tooth rounding. The values can be exported as DXF files, which can be used as input for NC programs or CAD programs. *ProXpt* also converts DXF line output to arc output to reduce the size of the DXF files, Koch says.

*GearCAD* costs U.S. $895, and *ProXpt* costs U.S. $345. Demo versions of each are available at the company's website.

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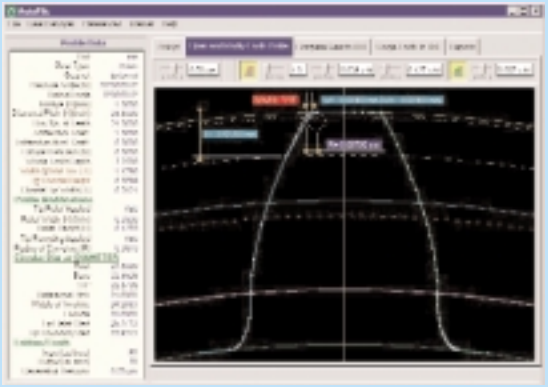
***GearCAD* is used for calculating internal and external spur, helical and planetary gears.**



***ProXpt* allows the user to modify the tooth profile of gears designed in *GearCAD*.**

## Gears and the Internet

The Mechanical Design and Concurrent Engineering Research Laboratory at The Nottingham Trent University in Nottingham, England, has been working on a number of projects aimed at bringing the gear industry into the Internet age.

"Application of Web-enabled technology into gear design and manufacture is one of our major research interests," says Professor Daizhong Su, head of the research group.

One of the projects the group has worked on is the development of a Java-enabled database that can create DXF drawings of gears on the fly. This prototype database would be used on a gear manufacturer's website. Instead of storing DXF drawings for each variation of a part, the team's software would create the drawings for users at the click of a button.

Another project at the research group is the development of a gear design optimization routine created to run over the Internet without downloading any software. The group is also working in other areas of Web-enabled collaborative design, Su says.

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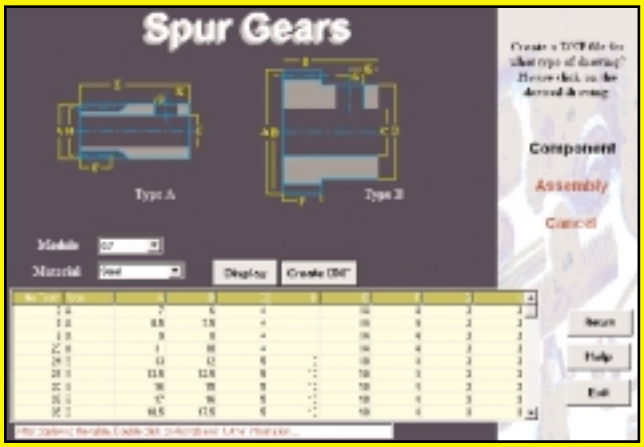
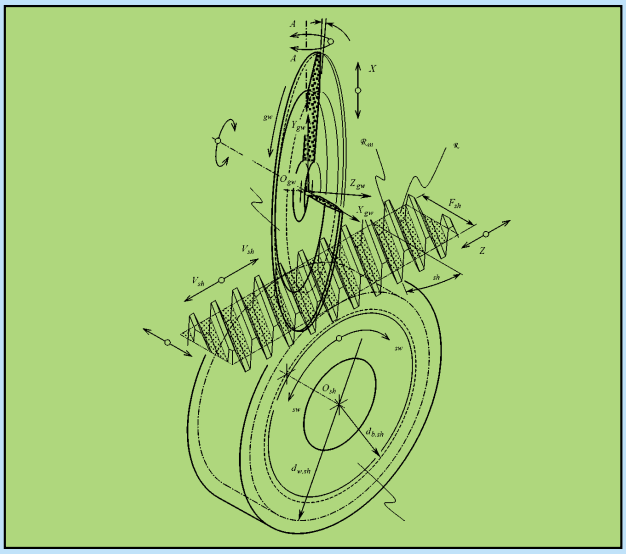



**Researchers at The Nottingham Trent University have developed an interactive database that will generate DXF drawings of gears on the fly.**



## Modified Shaving Cutters for Low Noise

Dr. Stephen P. Radzevich, a former professor of mechanical engineering and consultant to New Venture Gear in Syracuse, NY, has developed software for reducing noise in automobile transmissions that use pinions finished by gear shaving.

The software, called *SHAVER*, was developed for use with the Mitsubishi ZA30CNC shaving cutter grinder. The main function of the software is to modify the tooth surfaces of shaving cutters in order to provide modified tooth surfaces of pinions manufactured by them. Those modified pinion tooth surfaces help to create quieter transmissions.

"Application of topologically modified pinions allows the reduction of transmission error up to two times," Radzevich says.

*SHAVER* allows computation of the desirable shaving cutter tooth surface, the grinding wheel axial profile and the actual shaving cutter tooth surface that will result. The software also computes the actual pinion tooth surface that will result from using the cutter, as well as predicted deviations between the actual pinion tooth surface and the desirable pinion tooth surface.

According to Radzevich, the software could be expanded to allow for optimization of parameters such as grinding wheel diameter, grinding wheel axis tilt angle, and worktable acceleration/deceleration. Radzevich is also working on versions of the software to be used with cutter grinding machines from Kapp and other manufacturers.

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## Transmission Analysis

The *TYCON* software package from AVL List GmbH is a specialized tool for the analysis of valve trains, timing drives and transmissions. *TYCON* can help engineers calculate the dynamic behavior of gears and shafts in transmissions or gear units. Those calculations can be useful in assessing contact behavior and forces and investigating noise mechanisms, such as gear rattle or whine.

*TYCON* determines tooth contact forces in gear meshes as well as changes in flank contacts. The software can also calculate forces in belts or chains, as well as torques in shafts. The displacement, velocity and acceleration components of gears, pulleys, sprockets and shafts are also calculated.

Gear elements are represented by mass and moment of inertia. They're modeled with up to six degrees of freedom. Variable gear mesh parameters include backlash, stiffness, damping and geometry. Friction forces can be defined as constant or dependent on friction and velocity. Contact geometry, meshing stiffness and damping can be calculated in a pre-processing module.

The software also includes a variety of related elements in its modeling analysis. Those elements include shafts, bearings, belts, chains, sprockets, pulleys and guide elements.

*TYCON* has an interface to another AVL software package, *EXCITE*, which is used for acoustic analysis of engines and transmissions.

AVL, founded in 1948, is a privately owned, independent company specializing in the development of powertrain systems for internal combustion engines as well as instrumentation and test systems.

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Phone: (734) 414-9618 • Fax: (734) 414-9690
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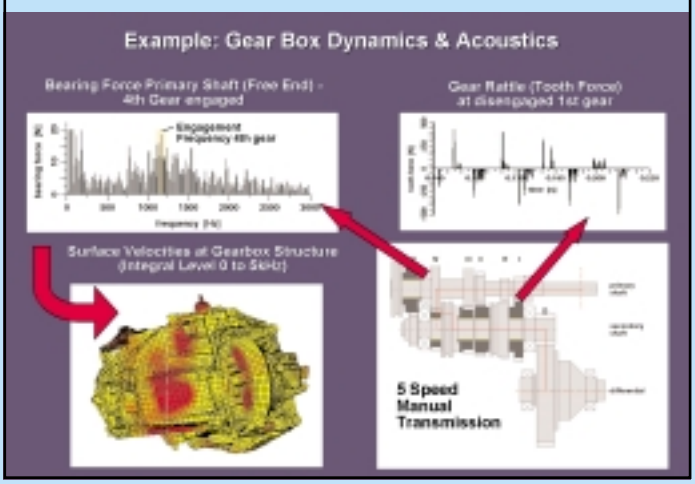
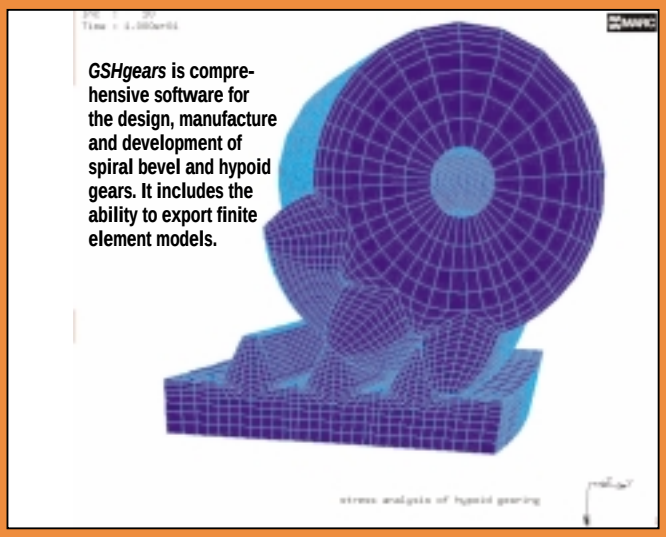
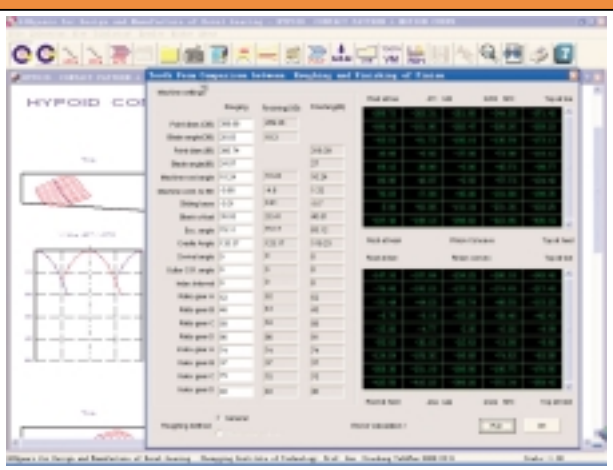




***GSHgears*** **is comprehensive software for the design, manufacture and development of spiral bevel and hypoid gears. It includes the ability to export finite element models.**



***GSHgears*** **can export data for the creation of 3-D solid models through the simulation of the cutting process.**

# Spiral Bevel Design, Manufacturing and Analysis

*GSHgears*, developed by a research group at Chongqing Institute of Technology in China, is commercial software for the design, manufacture and analysis of spiral bevel and hypoid gears of the Gleason tooth system.

According to associate professor Xiaodong Guo, who led the group that developed the software, *GSHgears* can help engineers determine blank dimensions, cutter specifications and machine settings. The software can calculate stock distribution for pinion finishing, and the user can modify the roughing setting to optimize stock distribution.

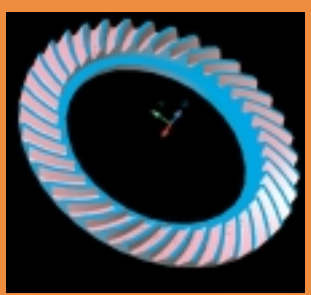
Also *GSHgears* includes tooth contact analysis for optimizing contact patterns and reducing transmission error.

The software provides an interface to 3-D gear analyzers from M&M Precision Systems Corp. The software's output data can be used to initiate the M&M gear analyzer, which simplifies the operation of measuring a bevel gear, according to Guo. Also, the inspection machine interface allows measured data to be imported into the software. After a gear's actual tooth surface is measured on the 3-D gear checker, *GSHgears* can calculate machine modifications using its own optimization algorithm designed to achieve the ideal tooth form.

In addition, the software includes a finite element pre-processing module, which allows the user to create a multi-tooth finite element model for *MARC, ABAQUS* or *I-DEAS* finite element analysis software. The FEA model is based on the designed gear parameters, such as blank geometry and actual cutter specifications and machine settings.

Cutting process simulation is achieved through an *AutoCAD 2000* model, which imports data from *GSHgears*, creates the cutter and gear 3-D solid models, simulates the cutting settings and creates a 3-D toothed gear solid model.

So far, Guo says, the software has been installed in more than 40 factories in China and one in Turkey.



**For more information:**
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## Free Gear Design Software

**If you're looking for proven gear design software but don't have the budget for an expensive system, Fairfield Mfg. Co. Inc. of Lafayette, IN, has a solution for you.**

**Since 1985, Fairfield has sold the DOS version of the company's software through the AGMA, but now the software, including a beta Windows version, is available for free via *www.fairfieldmfg.com*.**

**Fairfield's gear design software calculates geometry, rating, stress and life values for spur, helical, planetary, bevel and spiral bevel gears. Calculations are based on AGMA 2001-B88 and publications of The Gleason Works.**

**In addition, Fairfield has provided a beta version of a dimensional analysis program to aid in performing and keeping track of assembly stackups during the design phase of a project.**

**For more information:**
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US 52 South • P.O. Box 7940 • Lafayette, IN 47903-7940
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