transmission TECHNOLOGY INTERNATIONAL

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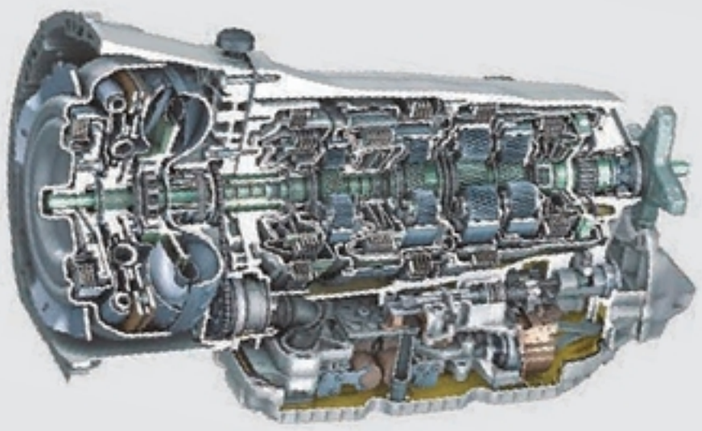

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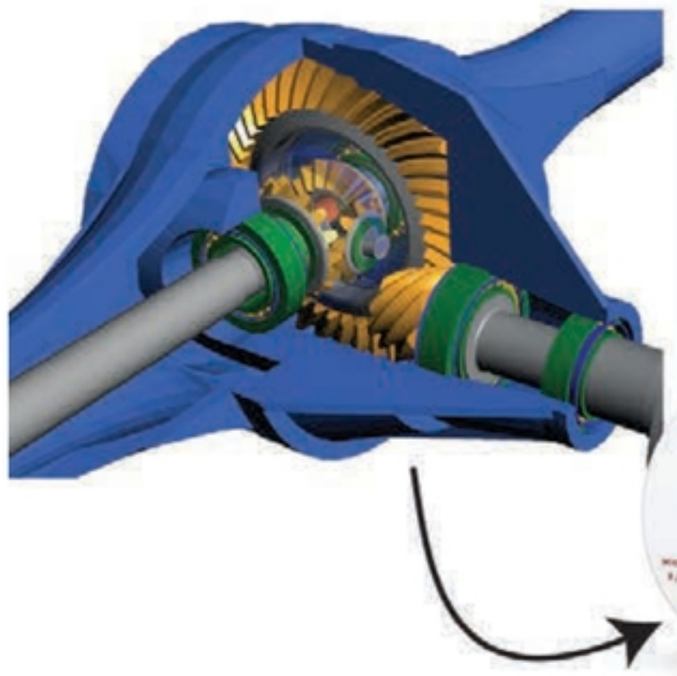
Cloud nine

ZF creates the world's first 9-speed automatic transmission for passenger cars. Exclusive tech details inside!

Gear design innovation

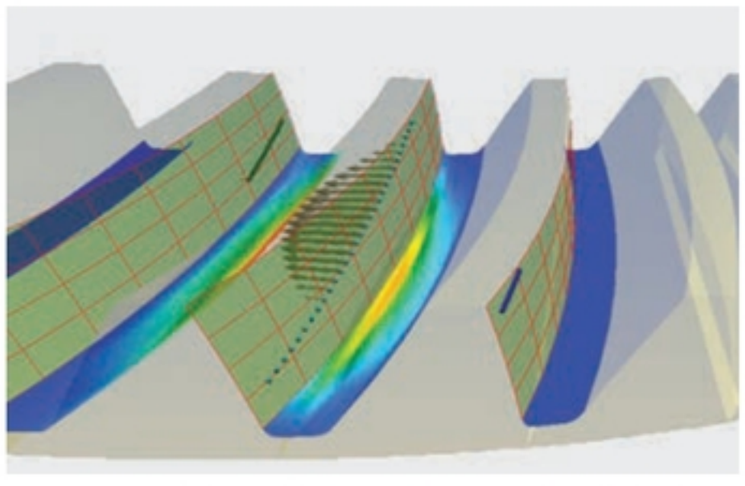


A new and unique collaboration is bringing together bevel and hypoid gear design, advanced analysis and state-of-the-art manufacturing machine settings calculation within the context of a full transmission development or new driveline system

Bevel and hypoid gears are commonly used in transmissions and drivelines for a wide variety of applications, across a wide range of industrial sectors. Although each sector has different requirements, there is an overall trend towards higher durability and lower noise, with development costs and time being two other factors that are very important. With the bar being raised on the performance requirements of geared products, developing a high-efficiency design/development process has become increasingly challenging.

In recent years, tools such as MASTA from Smart Manufacturing Technology (SMT) have enabled engineers to consider the design and optimization of bevel and hypoid gear geometry within the context of the full transmission/axle system. Advanced analysis capabilities enable many design iterations to be performed and compared quickly, with manufacturing simulations and prototype testing carried out within a virtual environment while still considering the system within the context of its surrounds, either on a test rig or within the vehicle. Such virtual prototyping can reduce design/development costs and time by minimizing production and testing trial-and-error iterations. Advanced tools can also prove invaluable when trouble-shooting existing problems such as gear whine.

Overcoming gear whine within vehicle axles can be difficult, time consuming and expensive when using traditional methods involving the testing of multiple prototype parts featuring different design iterations, over a wide operating torque and speed range. However, performing such design and test iterations within a virtual environment – provided the models and analysis tools used are sophisticated enough – can deliver solutions much more quickly.



Accurate calculations of tooth contact and root stresses in MASTA enable assessment of NVH characteristics

The design of bevel and hypoid gears is – unlike cylindrical gears – entirely dependent on the manufacturing process and thus, so are their NVH and strength characteristics. This means that the design of hypoid and bevel gear tooth flanks, via the manufacturing machine settings, needs to be considered again within the context of the full system.

MASTA contains some functionality for the simulation of the manufacture and loaded tooth contact analysis of bevel and hypoid gears. However, specialized gear design tools such as CAGE, available from Gleason Corporation, not only enable gear designers to analyze spiral bevel and hypoid gears, but also to generate data for Gleason gear production machines to manufacture the gears. While CAGE focuses on individual gear pairs and doesn't fully consider the context of the larger system they are designed for, it does enable designers to input misalignments, which are used in tooth contact analysis. However, these misalignments are obtained from external sources and not automatically from system level deflections calculated by tools such as MASTA.

Fully integrated solution

Used independently, MASTA and CAGE have provided substantial increases in productivity and reductions in cost for a number of years, by enabling designers and engineers to work in a virtual environment before committing to manufacture. Despite these benefits, Gleason and SMT identified a need for a complete system level design to further optimize the end manufactured solution.

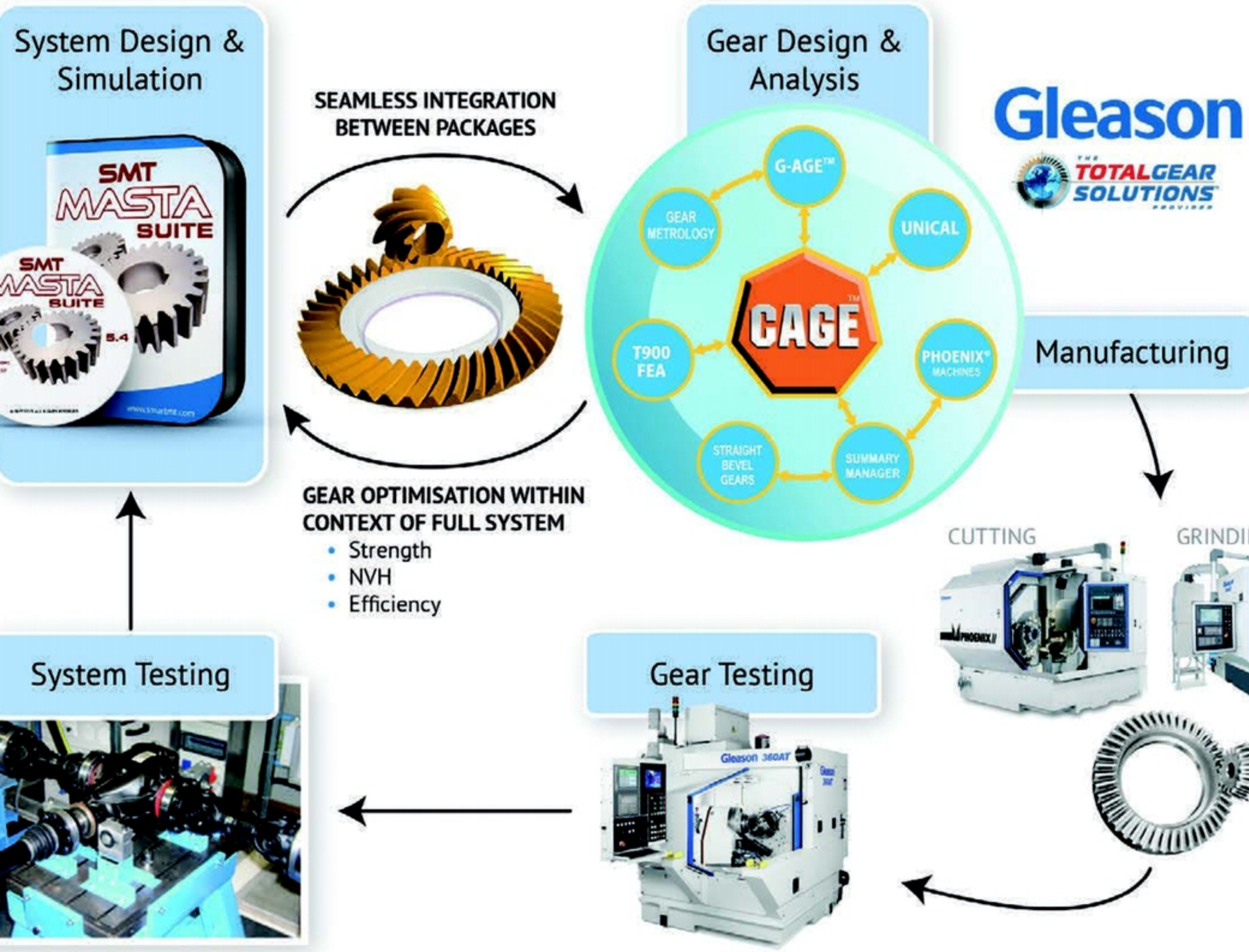
Recognizing the opportunity to provide the user with a fully integrated solution, Gleason and SMT announced a strategic partnership in late 2012 with the goal of delivering to end-user designers and engineers a revolution in bevel and hypoid gear transmission design, analysis and manufacture.

The vision is to allow MASTA and CAGE to work as if they are one product without any need for manual file transfer, while best employing the strengths of both products. This vision enables a new design-to-manufacture process with key benefits over current processes.

The process begins in MASTA, with the building of a system level model including bevel and hypoid gears. Within MASTA the bevel and hypoid gears may be designed using the familiar geometry calculations of CAGE – for example, presenting Gleason Dimension Sheets in MASTA. Furthermore, Gleason Special Analysis files may be imported to MASTA for rapid modeling of existing designs. Gleason's rating methods can be calculated within MASTA, taking into account the operating loads of the system. As a result, gear macro geometry optimization may be performed for a specified duty cycle. The manufacturability of the final design is dependent on the manufacturing machine settings required to achieve good tooth contact and low transmission error.

To design good tooth contact, ideally the engineer requires an intuitive way to modify tooth flank shape independent of machine settings or counterintuitive control parameters. Within the Gleason-SMT solution, this is provided via simple parameters such as crowning, linear relief and tip relief in a similar way to the common practice for cylindrical gears. To analyze the tooth contact conditions, experience suggests that a full system-level tooth contact analysis is required.

The vision of Gleason and SMT allows analysis of system deflections under operating loads and sophisticated FEA-based tooth

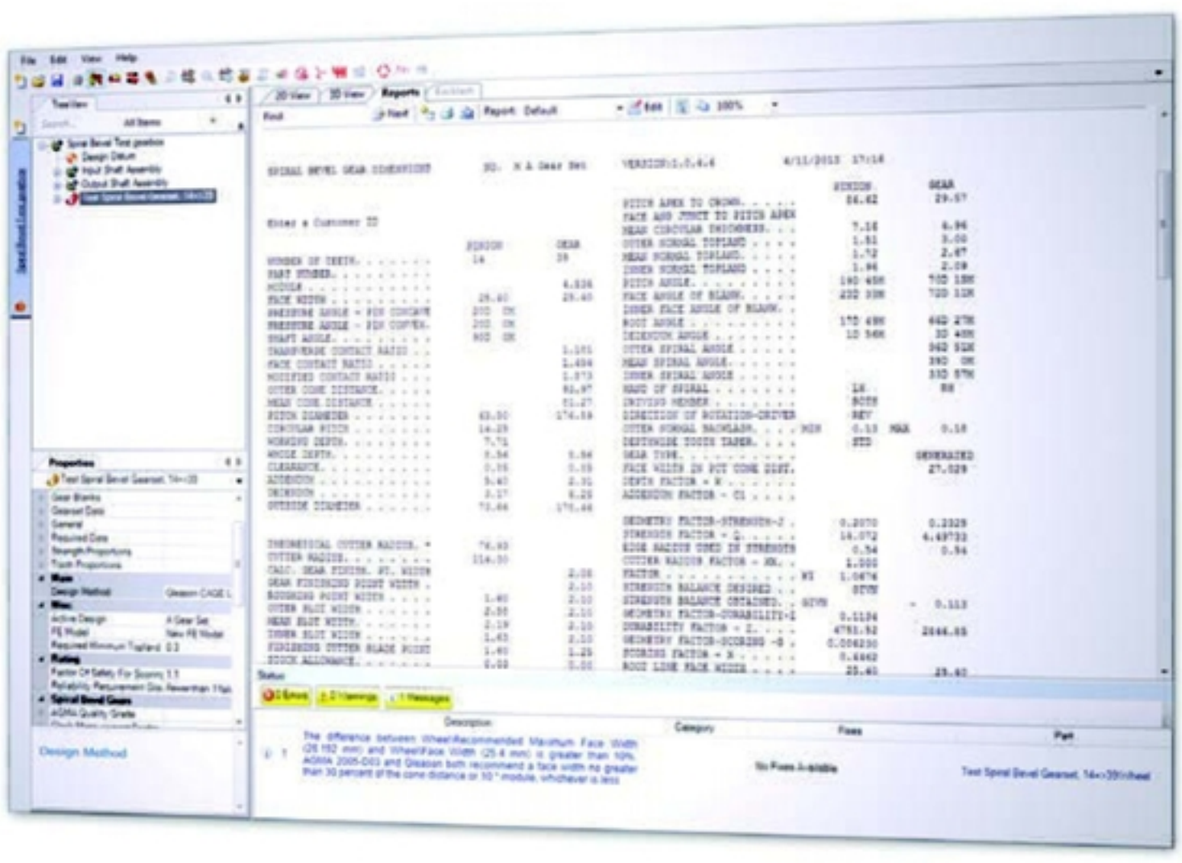


A detailed MASTA-CAGE flowchart, with system design loop illustrating the seamless and optimal interface between the two high-tech virtual development packages

contact analysis within a coupled calculation. This accurate calculation enables the design of good tooth contact conditions to be realized, while minimizing transmission error and considering the variation of load distribution during the full mesh cycle. As with any analyses in MASTA, the system may be modeled within the test rig conditions or within the vehicle. Once tooth flanks have been optimized, machine settings may be calculated for available machines via CAGE software. Further accurate analyses may be performed to verify performance for the achieved flank geometry, and corrections made if required. Once gears have been manufactured, actual geometry may be used for further analyses within the context of the full system.

Within MASTA, gear whine analysis may be performed at any stage of the design or trouble-shooting process to assess NVH performance of the full system to excitation by transmission error and the variation in load distribution through the mesh cycle.

The first release of the integration between MASTA and Gleason CAGE software was made earlier this year. For the first time, the design, analysis and calculation of machine settings for any manufacturing machine can be performed within the context of the full transmission. This realizes the first phase of the SMT-Gleason vision and provides a solution from system design and durability analysis, through micro geometry optimization and NVH assessment, all the way to gear manufacturing. *TTi*



An example of a Gleason dimension sheet displayed in MASTA as part of the gear geometry calculation and analysis

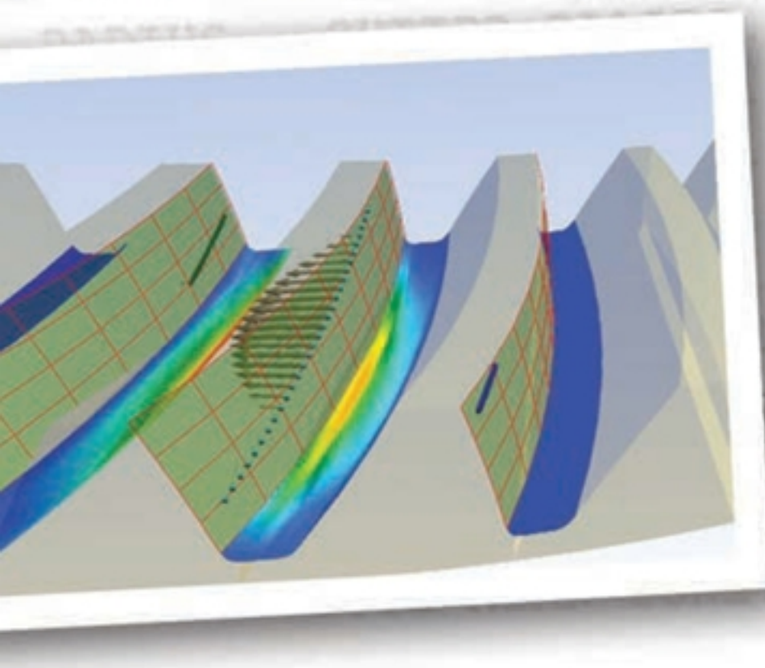
MASTA

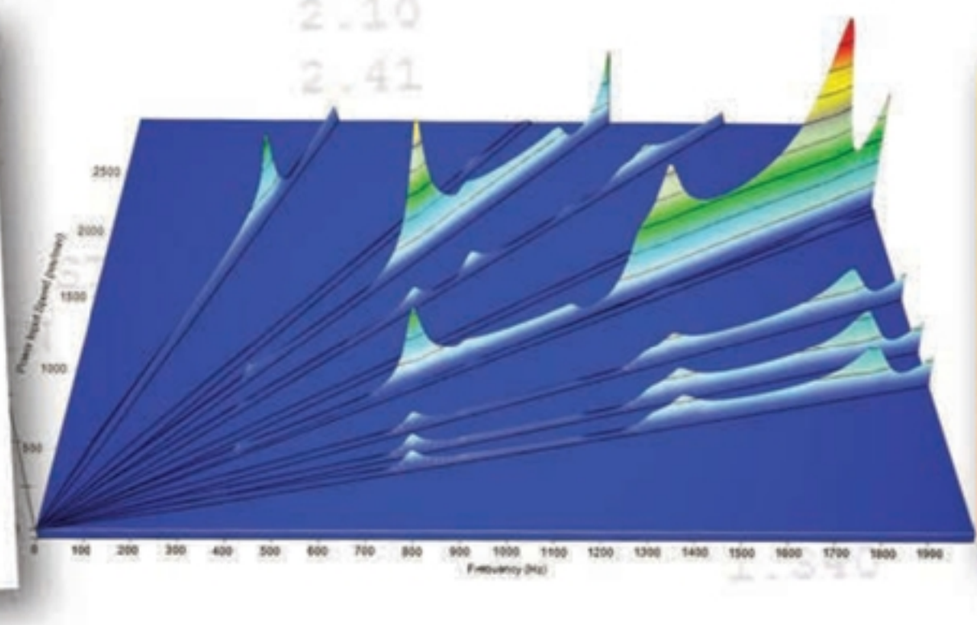
SEAMLESS INTEGRATION WITH

Gleason | CAGE™ Software

"A revolution in Hypoid and Bevel gear transmission design, analysis, manufacture and testing."

- Full system durability and NVH analysis for efficient solution of bevel and hypoid noise problems
- Avoid costly trial and error loops with virtual analysis and testing within the complete transmission system
- Hypoid and Bevel gear design, advanced analysis and machine setting calculation within the context of a full system
- System level Loaded Tooth Contact Analysis for gear flank geometry optimisation





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