

RomaxDurability

The complete simulation environment for durability of transmission systems



Reliable design, determined durability

Over the last few years steadily reducing development times has led to reduced times for prototype-testing. As an alternative, 'virtual testing' by efficient software packages has grown. RomaxDurability enables you to look into the system behaviour of your gearbox. A unique calculation approach allows you to accurately evaluate the life-time of all components within a fully flexible and interactive gearbox system early in the design stage. This accuracy supports you to meet your design targets with the first prototype.

Reduce number and length of design cycles

With RomaxDurability it is now possible to reduce the number and length of design cycles by considering all system effects in the whole transmission. The whole system is represented at the concept stage including all interacting and flexible components. The all-in-one-model enables you to look at the system level and component level simultaneously. The effects of even the smallest changes in gearbox component design are immediately visible within a transmission system meaning the number of concept or parameter studies can be significantly increased.

Robust design based on well proven concepts

Whether you are comparing simple concept designs or evaluating a fully detailed model, you can now access durability information at every step to allow you to make design changes and quickly assess their effects. Beginning with the concept level, where not all details are needed, you are able to add the details step by step in order to find a robust design. Automated algorithms support you to find the best parameter sets for your targets, including the check against manufacturing tolerances.

Automotive

- Design more reliable transmissions, drivelines and axles
- View the whole gearbox as an interacting and flexible system
- Predict gear, bearing and shaft life-times in the design concept phase
- Accurately and efficiently compare complex gearbox arrangements or concepts such as AMT, DCT, Hybrid and CVT
- Reduce gearbox weight by using component strength
- Minimise noise and vibration by influencing the transmission error
- Identify the weak points in the whole system under realistic load conditions
- Consider the impact of manufacturing tolerances in the concept design phase
- Improve the bearing choice by unique accurate prediction of bearing behaviour
- Interact with dynamic solutions for your full vehicle design
- Predict the affects of generators/e-engines on the gears and its components in your hybrid system

Wind turbine

- Understand and benchmark operating load and extreme load scenarios
- Design gearboxes to meet life-time targets
- View the gearbox as one complete system, without the need for sectioning and sectional boundary conditions
- Analyse the behaviour of complex planetary systems within the whole system
- Accurately predict loads, deflections and interactions of all components
- Calculate detailed bearing behaviour to identify excessive loads
- Direct loads or reduce misalignments to improve the system quality
- Predict load sharing in the fully flexible system instead of assuming load sharing factors
- Reduce weight and cost without reducing component lifetime
- Minimise noise pollution caused by transmission error
- Create technical documentation for certification

Aerospace

- Improve reliability for critical parts
- Reduce gearbox weight
- Predict bearing behaviour under extreme load and climate conditions
- Optimise gearbox size

Off-highway

- Design heavy duty transmissions
- Accurately represent multi-gear mesh situations
- Optimise gearbox weight without compromising durability
- Predict system behaviour under mis-use conditions
- Compare different lubrication situations
- Precisely define micro-geometries to avoid edge-loading of teeth under extreme load conditions
- Consider split-torque system load

Industrial equipment

- Design for improved reliability in process machinery, material handling, power take offs, speed reducers and production line equipment
- Improve accuracy of high precision machinery by understanding and predicting system and component deflections
- Reduce failures in gears and bearings due to precise prediction of misalignments

Consumer and office appliance

- Optimise weight and size of power tools, food processors, washing machines, printers and photocopiers
- Improve product quality by reducing unwanted deflections
- Predict changes of working accuracy over a product's life
- Design casings that fulfil the requests for look and function simultaneously without wasting material
- Consider new materials for new or existing product concepts

Overall Process – Whole System Approach

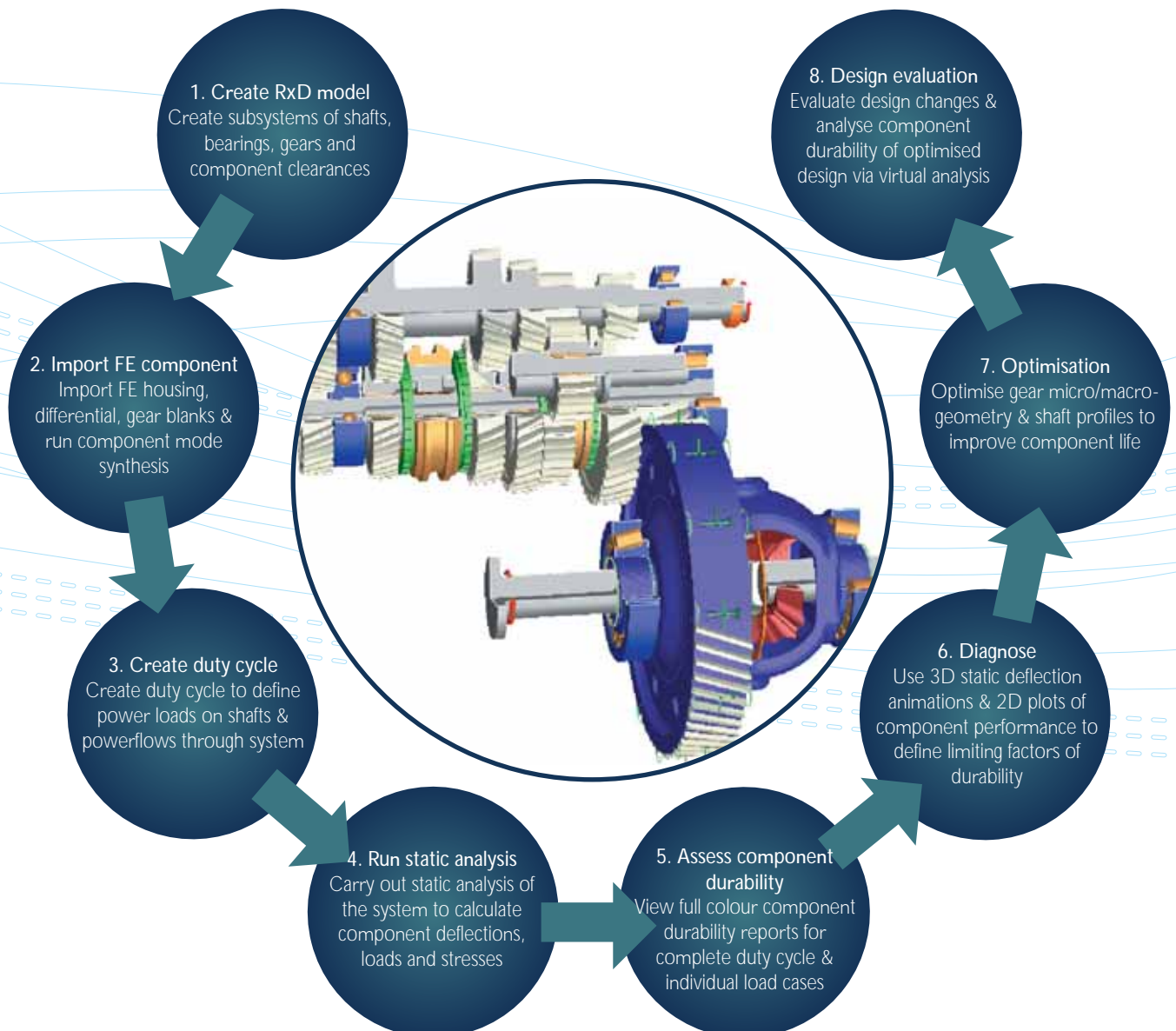
The RomaxDurability software offers you a completely integrated solution to analysing and developing geared transmission systems. From simple concept designs to fully detailed systems, RomaxDurability allows you to predict the performance of the design right down to component level. Thanks to Romax's unique 'whole-system' approach, each and every component in the system has the ability to influence each other providing one of the most accurate and comprehensive methods for system durability analysis.

Past and present techniques of system investigation have often neglected to take account of the coupling influence between components, and life predictions have become increasingly inaccurate leading to costly over- or under-design. By using RomaxDurability to model a simple system using the intuitive and logical user interfaces, you can quickly develop the model to any level of detail. With RomaxDurability you can perform preliminary analysis on concept systems, making significant time and costs savings compared to prototyping and traditional design iteration processes.

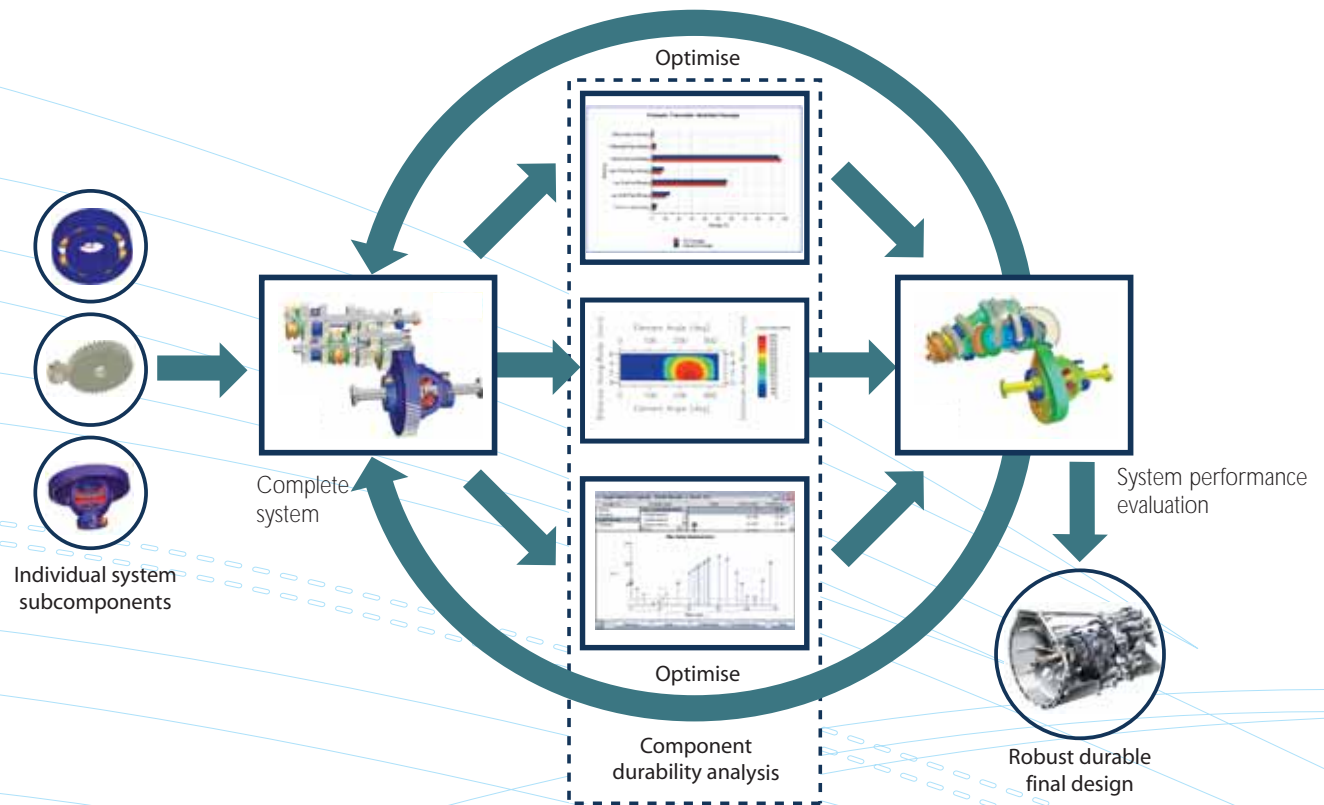
RomaxDurability delivers you some of our most powerful assets to provide confidence and reliability in your solution. Advanced bearing analysis, gear design and optimisation, and sensitivity studies are just some of the capabilities available as part of the streamlined process that RomaxDurability allows you to work with. Without the need for third party software: housing influence, shaft fatigue analysis, micro-geometry influence and lubrication are just some of the factors taken into account to provide you with the results you need.

The software offers you a quick and effective method of fine-tuning and performing further validation. Investigating the effect of bearing pre-load can be automatically analysed using the bearing pre-load tool, and minimising component damage through gear micro-geometry modifications is achievable through a completely automated design of experiments.

By integrating RomaxDurability into your design process, you can be sure that you are working to the most cost effective, time efficient means currently available. Providing you with an invaluable insight into complete system performance, this software delivers extensive and powerful solutions for your transmission analysis needs.



A Complete Durability Analysis Tool for Transmission and Driveline



RomaxDurability Case Study: 5-Speed Transaxle - Benchmark on Bearing Race Misalignment Calculation for Transmission Durability

The issue

A top-tier automotive manufacturer needed to replace its aging and unreliable in-house transmission software suite as well as reduce its reliance on lengthy, expensive, highly sensitive and sometimes unreliable test bench measurements.

The approach

RomaxDurability was used to assess the durability of a well known transmission and calculate the bearings race misalignment. This enabled the manufacturer to compare any potential solutions against the results of its test-rigs.

The solution

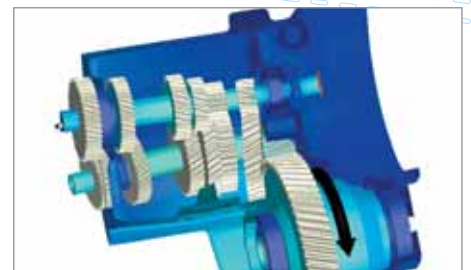
A strong correlation between the test results and those from RomaxDurability was revealed. Similar results were obtained for gear mesh misalignments. These results enabled the manufacturer to gain confidence in RomaxDurability predictions. RomaxDurability was selected as the strongest candidate and implemented based on these terms.

Improvement

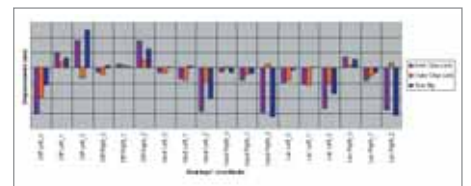
Through using RomaxDurability capabilities the manufacturer benefited initially from far more consistent results with the Finite Element deflections for the housing. An improved correlation of FE differential deflections was also revealed. Accurate housing deflections led to improved relative bearing race misalignment predictions which in turn led to far better correlation between RomaxDurability results and test-rig results. The top-tier automotive manufacturer concluded that RomaxDurability saved significant project time and costs.



Automotive transaxle model with housing in Finite Elements



Visualisation of system deflections used to calculate gears and bearings life



Correlation between calculated bearings misalignment with RomaxDurability and results from test-rigs

Types of Analysis

Gears

These are rated to the DIN 3990 1987, AGMA 2001-C95 and ISO 6336: 1996 methods.

RomaxDurability has the ability to analyse:

- bending stress
- contact life
- bending life
- safety factors
- misalignment
- mesh forces (radial, tangential, axial, separating)

Advanced analysis capabilities include:

- unequal planet load sharing (planetary systems)
- tooth contact load distribution
- contact temperature
- gear macro- and micro-geometry optimisation

Bearings

DIN ISO 281 life

Predicted bearing life calculated using the standard ISO 281 bearing life calculation, which assumes zero internal clearance, zero bearing misalignment and a correctly proportioned radial and axial load ratio.

Romax adjusted life

Predicted bearing life calculated using the actual conditions, including internal clearance, bearing misalignment and radial to axial load ratio.

DIN ISO 281 supplement 4 life

As DIN ISO 281, however this also incorporates the effect of lubrication. This rating is a requirement of the Germanischer Lloyd certification for wind turbines.

Romax advanced life

Predicted life using the Romax Advanced Bearing modules. This life is the most accurate of the four because it uses the original contact load based life equations of Lundberg and Palmgren.

Advanced analysis capabilities include:

- element load distribution on raceways
- contact stresses (inner/outer raceway)
- contact footprints and ellipse truncation
- rib loads
- film thickness
- needle roller skew

Shafts

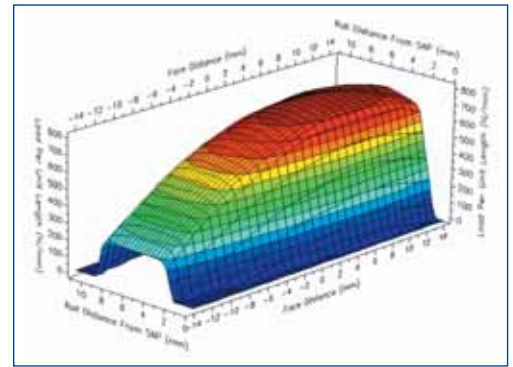
Calculate shaft forces, moments, displacements, and stresses from system analysis to determine the shaft fatigue durability to GM or ANSI methods.

Splines

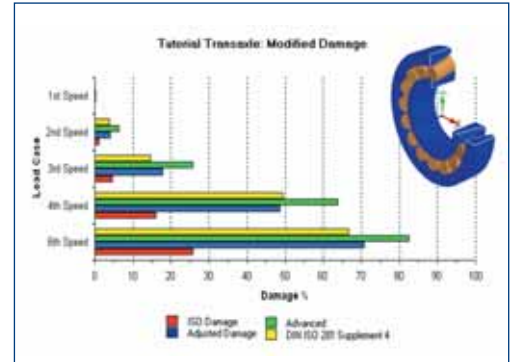
These are rated to DIN, ISO and SAE methods.

Finite Element (FE)

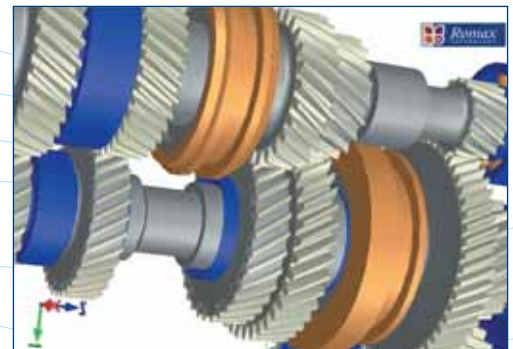
Static deflections of FE components are solved within the RomaxDurability environment using a leading FE based solver, taking into account all component interactions.



Gear tooth load distribution



Bearing damage reported in RomaxDurability



Details of elements that can be analysed using RomaxDurability

System Deflections, Flexible Structures

RomaxDurability has the unique ability to calculate linear and non-linear deflections of every component in a transmission. This can be done by either calculating the flexibility of components such as shafts, gears and bearings, or by using imported Finite Element (FE) models of structures, such as housing and differential assembly.

The preliminary method is ideal for the very early stage of conceptual work where only the basic layout of the transmission is known. The designer can easily change the geometry and position of components through simple data input boxes or the drag-and-drop method. Changing a few details of a concept and calculating the flexibility of components along with the effects on the durability of components can be achieved in a matter of seconds.

FE structures can be incorporated with the former method when you have found an optimum concept and require more accurate deflection and durability calculations through the use of the exact component geometry. These FE models are often available only at later stages in a new transmission development. A concept then becomes a detailed model with increased accuracy and without leaving the design environment. RomaxDurability combines the best of both speed and accuracy and can be used for conceptual development, refinement, and optimisation as well as for upgrades.

Capabilities

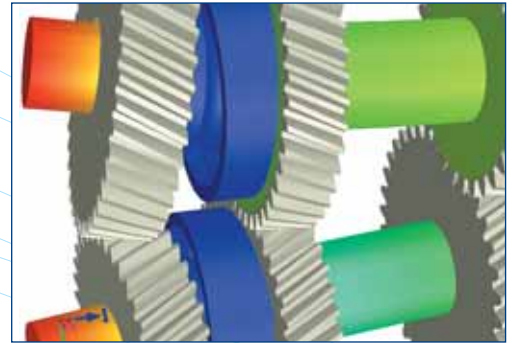
- Ability to define concept shaft and gear blank geometries as a basic functionality
- Perform simple beam-element calculations to determine the concept components deflection
- Inclusion of FE of critical parts, for example, housing and rotating parts in the analysis
- Calculate accurate stiffness of elements and their deflection based on detailed geometry

Benefits

- Quickly analyse and determine the deflection and durability of every component at the concept stage
- Investigate layout changes in a matter of seconds
- Accurately analyse deflection and durability once a concept model has been chosen



Deflection of flexible housing, shafts and gears



Detail of misalignments in bearings and gear-meshes due to deflections

Advanced Bearing Analysis

RomaxDurability's Advanced Bearing Analysis modules offer you some of the most accurate and sophisticated tools in selecting the correct bearings for your system. We have long been known for our expertise in bearing analysis: supplying many major bearing manufacturers with software to correlate with their own in-house products. As with all modules, these features fit seamlessly into the analysis process, greatly broadening the designer's ability to justify system designs and bearing choice. Many Romax users have significantly benefited from cost and time savings from alternate bearing sourcing, system torque upgrade analyses, and bearing failure prediction and diagnosis using the advanced modules that have quickly become considered invaluable to the design process.

Each module focuses solely on the individual bearing type, offering detailed results including contact stresses, ellipse truncation, individual element load distribution, and advanced damage calculation. In addition to the existing OEM bearing catalogues, Romax Advanced Bearing modules allow you to fully define any custom bearing, including internal and external geometry, roller and raceway profiles, and load ratings. Using Romax's complex algorithms, the performance of any custom bearing can be analysed in the same way as a catalogue bearing. Should the exact bearing details not be known, the software will accurately estimate the internal details meaning conceptual designs can be quickly and easily modelled without the need for 'hard to obtain' specialist information.

Capabilities

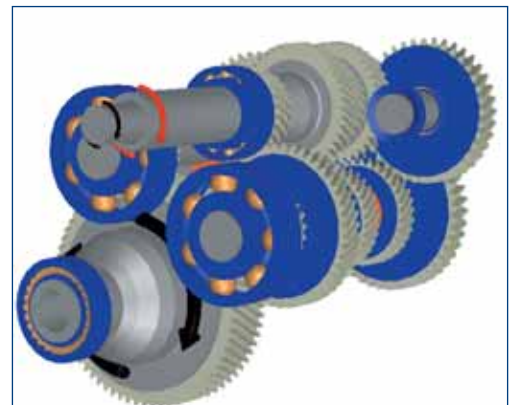
- Complete range of advanced modules for radial ball, cylindrical, thrust roller, spherical, taper roller and needle roller bearings
- Full definition of custom bearings including internal and external geometry
- Analyse performance of custom bearings

Benefits

- Full integration into the analysis process
- Improved justification of system design and bearing choice
- Quickly and easily model conceptual designs without the requirement for specialist information
- Save time and costs through our range of advanced bearing modules



High-speed bearing analysis on a hybrid transmission



Bearing analysis on a Dual Clutch Transmission (DCT)

Gear Macro- and Micro-Geometry Analysis

RomaxDurability's Helical Gear Macro- and Micro-Geometry Design and Optimisation tool offers you the ability to analyse existing gearsets and validate their performance quickly and efficiently as well as providing you with the invaluable power to instantly assess numerous variations and configurations, ensuring you obtain the ultimate gear solution. Advanced modules within the RomaxDurability package can be used for the rapid optimisation of helical gear pairs, integrating seamlessly with the overall design process.

With RomaxDurability you are able to design your gears against numerous competing criteria, including the use of rating and geometry as targets, and save iterations so you can compare and contrast at the touch of a button. As concept designs and bearing packages change, gear sets can be adjusted accordingly leaving the user confident all components of the design are working together, providing a complete solution to the design brief.

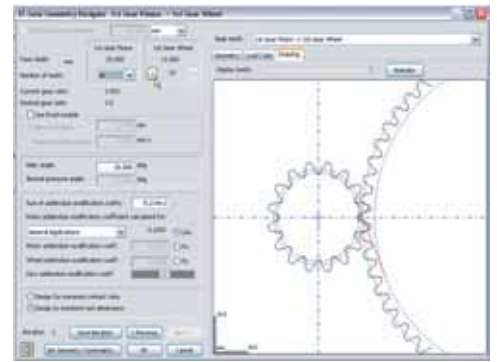
RomaxDurability includes design and rating modules for straight bevel gears, spiral bevel gears and hypoid gears.

Capabilities

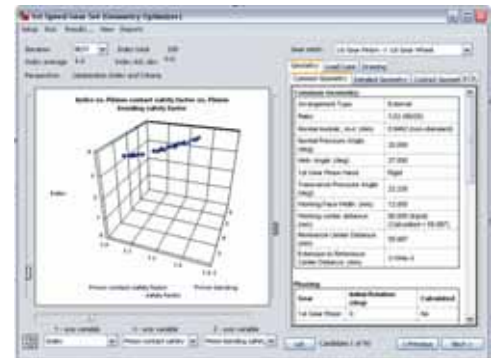
- Design of gears against numerous competing criteria
- Select designs with low transmission error
- Select designs based on minimised edge loading and maximum surface load
- Further design analysis for spur and helical gear meshes in one simple automated step
- A total integrated package solution for gear design, rating and optimisation

Benefits

- Reduce noise of spur and helical gear meshes
- Improve durability of gear meshes through effective automated analysis
- Confidence in selecting the best combination of multiple modifications through advanced technologies
- Robust and tailored gears for any environment
- Save time and cost through using a package which integrates fully with your overall design process
- Fast and accurate comparison of design iterations



Gear macro-geometry design study visualisation



Gear micro-geometry optimisation graphical interface

Unequal Load Sharing

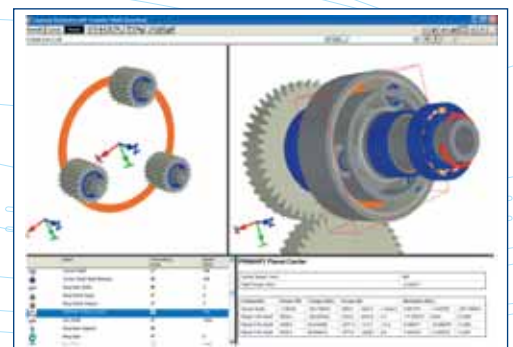
The unequal load sharing calculation within RomaxDurability offers you the unique capability of quickly and easily assessing the performance and efficiency of critical and sensitive components involved in planetary assemblies. This ultimately allows you to assess the sharing of loads between planet gears which leads to valuable time savings. This also enables you to best optimise the system, by quickly changing the macro- and micro-geometry of the gears, or the planetary system arrangement. For each arrangement, RomaxDurability accurately recalculates the deflections of every component along with the sharing of loads in a matter of seconds. Optimising a planetary system with the help of the unequal load sharing facility ensures an improved durability of gears and bearings.

Capabilities

- Use the detailed definition, tolerances and parameters specified in the power transmission model as well as the calculated full system flexibility
- Calculate the misalignment, power, torque, force and moment for each gear mesh
- Carry out detailed analysis of bearing performance, for example, assess the risk of premature failure due to planet bearing needle roller skewing
- Optimise the micro- and macro- geometry of planet gears to reduce the unequal load sharing

Benefits

- Improve the reliability of planetary systems at the design stage
- Understand the effect of manufacturing errors and tolerances on the planetary system
- Faster assessment leading to cost reductions



Unequal load sharing in a planetary system

Gear set	Mesh	Measurement	Output on Transfer Shaft
Planetary Gear Set	Planet 1 Gear -> Ring Gear	Misalignment (um)	38.72
Planetary Gear Set	Planet 2 Gear -> Ring Gear	Misalignment (um)	38.88
Planetary Gear Set	Planet 2 Gear -> Sun Gear	Misalignment (um)	18.88
Planetary Gear Set	Planet 3 Gear -> Ring Gear	Misalignment (um)	52.21
Planetary Gear Set	Planet 3 Gear -> Sun Gear	Misalignment (um)	58.87
Planetary Gear Set	Sun Gear -> Planet 1 Gear	Misalignment (um)	58.27
Transfer Gear Pair	Transfer Pinion -> Transfer Wheel	Misalignment (um)	4.18

Report giving gear mesh misalignment for each gear mesh due to unequal load sharing

Romax
TECHNOLOGY



RomaxDesigner is the complete simulation environment for transmission and driveline engineering. The software suite encompasses a variety of configurations focused on industries and applications, including:

- noise, vibration and harshness
- transmission design and durability
- design automation and optimisation
- advanced bearing simulation
- wind turbine solutions

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About Romax Technology

Romax Technology offers integrated solutions for noise, vibration, harshness [NVH] and bearings analysis through software tools, process, training and engineering services to major OEM and Tier 1 suppliers in the automotive, aerospace, wind energy, industrial equipment, rail and marine industries around the world.

Romax Technology's pioneering full-system flexibility and integrated software package encompasses 20 years of development and benchmarking in partnership with major OEMs and extensive research in conjunction with top academic establishments. Romax's customised and 'off-the-shelf' software provides customers with the tools for 'right-first-time' transmissions and driveline design and analysis.

Romax Technology's engineering teams are integrated with its advanced transmission software development which encompasses 20 years of expertise and benchmarking. Service offerings include benchmarking, concepts generation, issue investigation and resolution, analysis and detail design through to production. Romax offers agile issue resolution with a flexible team approach dedicated to individual projects with execution available remotely in the UK or locally with the customer. Local co-ordination of engineering programs is undertaken through offices in USA, Korea, Japan, China, India, Germany and the UK.

"PSA-Peugeot-Citroën and Romax Technology have combined their knowledge to develop a specific methodology for defining the life compliance of gearbox housings under internal mechanical forces."

PSA Engineering and Support Manager