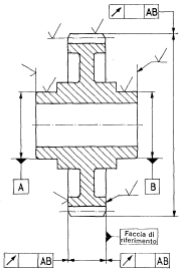
Cylindrical Gears: Basic Module

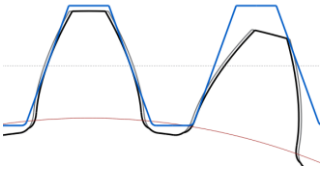
"Design and verification of spur gears with KISSsoft"

Introduction



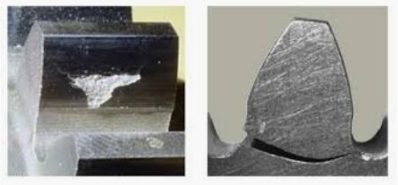
- UNI, DIN, ISO and AGMA Standards
- Vocabulary (Italian and English) of gears
- 3D and 2D representation of gears: how to do drafting
- Gear tables on drawings: what to put in and what to omit
- How to read a gear drawing (and stay calm)

Theory of gear geometry



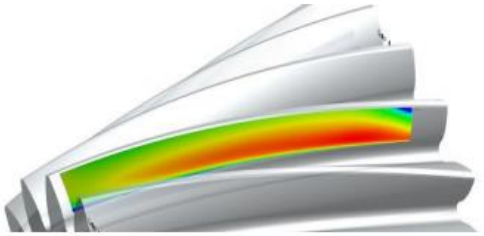
- Spur gears.
- Straight, helical, internal and external gears
- The profile shift factor (x) and the center distance
- Backlash at assembly and in operation
- Standard, lowered, HCR reference profiles
- Quality and tolerances: how to define them and how to control them
- Machining: hobs, power-skiving, grinding and shaving
- Simulation of the actual tooth shape produced by different machining operations

Load capacity (Resistance)



- Strength and durability calculation according to ISO 6336: bending, pitting, and other failure modes
- Influence of other machine elements on the operation of gears (shafts, bearings, housing) on service life and operation
- Gear materials and their heat treatments
- Load spectra, accumulated damage, duration
- Pulsating and alternating bending
- Static calculation

Design



- Safety factors.
- Design of a spur gear pair
- Optimization of macro geometry

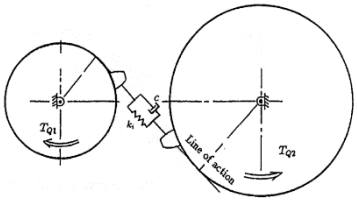
Hints of advanced topics

- Gear noise, NVH
- Contact analysis, transmission error
- How to consider shaft deformations
- Microgeometry: crowning and tip-relief: what they are for, how to make them, how to optimize them

Cylindrical Gears: NVH Analysis and Optimization

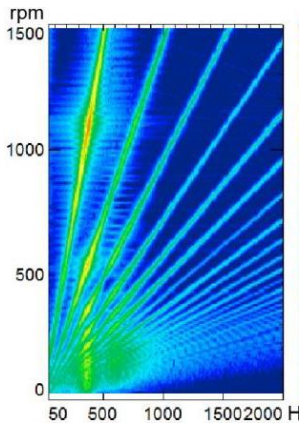
"Optimization of gear noise with KISSsoft"

Cylindrical gears with an involute rim profile



- Spur gears: straight, helical, internal, external gears
- Conjugate profiles and the law of meshing
- The circle involute profile: genesis and main properties
- Profile displacement factor and center distance
- Backlash at assembly and in operation
- Standard, lowered, HCR reference profiles
- Profile contact ratio εα, Transverse contact ratio εb : mathematical definition and physical meaning
- The quality of gears and influence on noise
- Microgeometries of gears according to ISO 21771
    - Profile modifications (Head/foot strips; Pressure angle modification; Bombing)
    - Band modifications (End strips; Helix angle modification, Bombing)
- Decibel and weighting scale dB(A)
- Noise, Vibration and Harshness (NVH): Basic Concepts.
- Noise analysis according to the formulations of Kato and Masuda

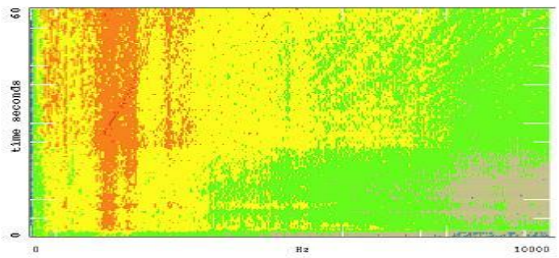
Contact Analysis and Transmission Error



- Contact analysis (LTCA): basic concepts
- Profile and band overlay analysis under load
- The genesis of noise: transmission error (LTE)
- The propagation of noise
    - Structure borne (structural propagation)
    - Air borne (airborne propagation)
- Analysis of the transmission error spectrum
- Harris Maps
- Microgeometry optimization for noise.
    - The stripping of short/long head (Linear/Arcuate/Progressive)

Analysis of the excitation frequencies of a transmission

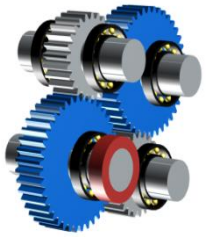
- Time and frequency domain
- Nyquist-Shannon theorem (of sampling)
- Fourier analysis: basic concepts
- Campbell diagram
- Gearing Frequency: Spur and Planetary Gears
- The characteristic frequencies of the bearings
- The broadband noise: gear rattle
- The tonal noise: gear whine



Cylindrical Gears: Metrological Control

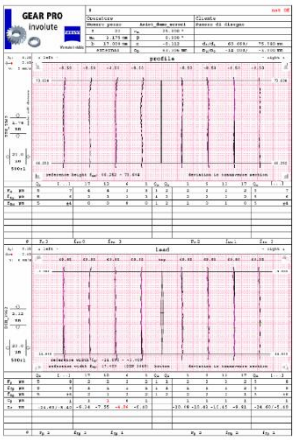
"Gear metrology and functional interpretation of control diagrams"

Involute Gears: Basic Concepts



- Involute cylindrical gears: straight, helical, internal, external gears
- Basic concepts (module, pressure angle, helix angle, profile shift)
- The roller (or ball) dimension: Calculation and measurement
- The Wildhaber: Calculation and measurement
- Measuring instruments
    - Evolventimeter
    - Gauge: Single and double-sided control
    - CMM machines
    - Laser Measurement (Gleason)
- Profile and Lead: ISO 21771 and DIN 3960 definitions
- The most common profile and lead corrections
- Tolerances according to ISO and DIN
- Tolerance diagrams of the profile (K profile) and lead

The control report

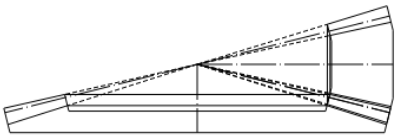


- Profile errors according to DIN 3960
- Lead errors according to DIN 3960
- Division errors according to DIN 3960
- Concentricity errors according to DIN 3960
- Compound single flank rolling deviations according to DIN 3960
- Double-sided compound rolling errors according to DIN 3960
- "Critical" reading of an audit report

Bevel Gears: Basic Module

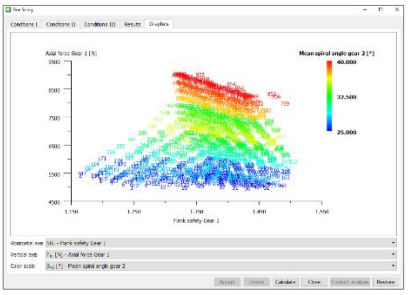
"Verification and design of bevel gears with KISSsoft"

Cutting method and geometry



- Cutting methods for straight and helical bevel gears
- Cutting methods Face Hobbing und Face Milling and its specialties
- Different cone types for bevel and hypoid gears
- Calculation of geometry, virtual cylindrical gear

Strength rating

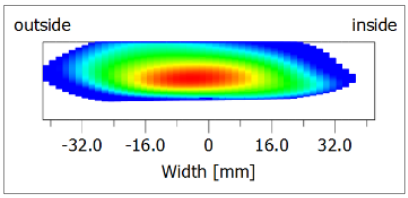


- Calculation of strength, different standards
- Scuffing according to ISO/DTS 10300-20
- Flank fracture according to ISO/DTR 19042

Design of bevel gears

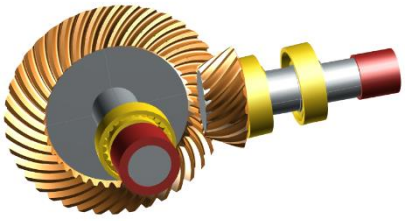
- Rough sizing, relevant parameters
- Fine sizing, optimization of bevel and hypoid gears
- Microgeometry

Contact analysis



- Determination of EPG displacement with KISSsys
- Contact analysis of bevel gears
- Contact pattern, transmission error
- Optimization using gear modifications
-
-

Processes



- Design processes with conventional manufacturing (GEMS®) and 5-Axis milling
- Generating 3D models, check of contact pattern (contact lines)
- Topological modification

Plastic Gears

Small Cylindrical and Crossed Helical Worm Gears in Plastic or Sinter Material

The use of plastic and sinter gears is often considered because of their advantages over metal gears. As they also have disadvantages like lower strength and lower manufacturing tolerances, it is important to evaluate ex- actly the strength and geometry of the gears before going into production.

During the 2-day training, the specific differences compared to steel gears and their calculation methods will be explained. An overview of the material properties with advantages and limitations as well as the measuring tech- niques will be given. The choice of the material and the calculation of the tooth profile special- ties will be discussed. The basic issues involved in the theory of worm wheels and crossed helical gears are summarized. The differences between worm wheels with and without globoid form are illustrated.

In addition, participants will carry out several exercises to see the problems and possible solutions in practical cases, using a full KISSsoft version.

This training is for design engineers who had already participated in a cylindrical gear training and do know how to use the KISSsoft user interface and the sizing functions in the gear calculation module. A knowledge of geometry and strength calculation is essential for properly understanding the contents of this course.



General Topics

- General properties of plastic and sinter materials
- Tribological properties of plastic and sinter materials
- Typical failure modes of cylindrical and crossed helical gears
- Overview of materials implemented in KISSsoft
- Sizing functions in KISSsoft: rough, fine sizing and sizing of modifications
- Overview of the VDI 2736 and old VDI 2545
- S-N curves (Wöhler lines) for plastics and sinters: their measurements and implementation into KISSsoft
- Safety factors: general recommendation, procedure to design plastic gears

Cylindrical Gear Calculation

- Strength calculation: static strength and lifetime calculations, load spectrum calculation, evaluation of results and reports
- Temperature calculation: theoretical background, measurement possibilities
- Wear calculation: theoretical background, methods in KISSsoft
- Contact analysis: background, general overview, result evaluation
- Noise optimization: main sources of noise, possible optimization procedures
  - Operating backlash optimization: general inputs, interpretation of the results
- Tooth form calculation: tolerances, special tooth profile modifications for small gears

Calculating the Injection Mold

The theoretical tooth profile, which has been optimized as described above, is calculated using the mean tooth thickness deviations. The result is the required tooth profile, which can be transferred to a CAD program via the DXF or IGES interface. In further calculations, you can also take into account the manufacturing processes:

- Modifying the injection mold to compensate for shrinkage/expansion
- Display the eroding wire / spark gap
- Monitoring the wire diameter during erosion process

Crossed Helical Gear Calculation

- Basic geometry and forces
- Differences between globoidal and cylindrical worm wheel
- Efficiency calculations, self-locking gear pairs
- Strength calculation: static and lifetime calculations, differences between VDI 2545 and VDI 2736
- Wear calculation: method according to Pech
- Tooth thickness optimization
- Graphical contact analysis: visualization with 3D surface model

Plastics Manager

- General overview
- How to measure gear fatigue data on a test rig
- Statistical evaluation of measured data

Various

- Asymmetric gears: design possibilities, advantages and limitations
- Non-circular gears: design possibilities, advantages and limitations
- Importing tooth profile as a .dxf

Worm Gears - 1 days

"Verification and design of worm-worm gears with KISSsoft"

Worm Gears



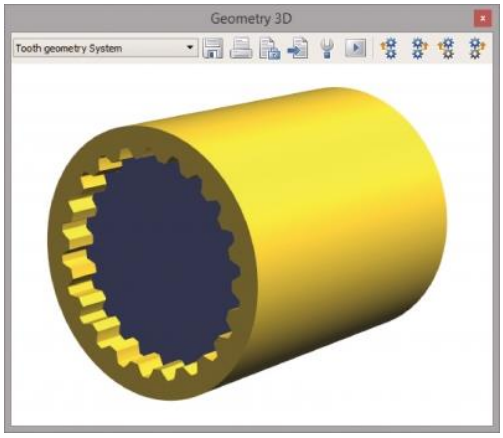
- Types of cutting (ZI, ZA, ZK, etc.)
- Strength calculation methods (ISO, AGMA, BS)
- Yields
- 3D model generation
- Plastic-Metal Couplings
    - Resistance
    - Tooth shape optimization
- Calculation exercises in KISSsoft

Splines: Geometry, Strength, Corrections
1 day

"Design of splines in the state of the art."

Grooved Joints

- International Standards: (DIN 5480, ISO 4156, ANSI B92.1)
- The technical document AGMA 945-A18: Design and Application of Grooved Joints.
    - The strength calculation of splined shafts: examination of the main calculation methodologies
- The microgeometries of splined connections.
- 3D export
- Surface model generation

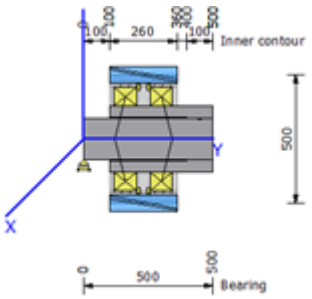


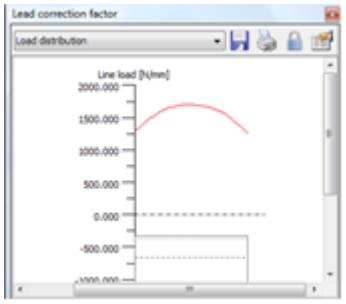
Shafts and Bearings: Basic Module (2 days)

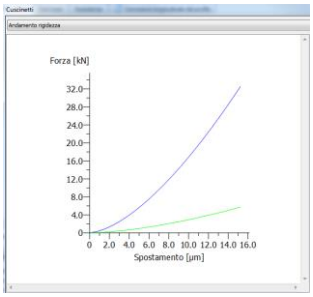
"Verification and design of shafts and bearings with KISSsoft"

Modeling of Shafts and Bearings - Basic

- Shaft modeling;
- Calculation of deformations and stresses
- Calculation of static and fatigue strength
- Bearing life (with/without oil contamination) ISO 281
- Influence of stiffness and preloads
- Overview of vibration analysis
- KISSsoft Exercises

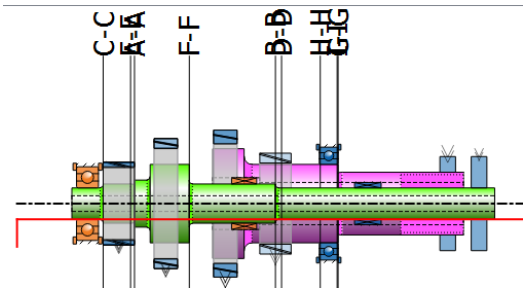






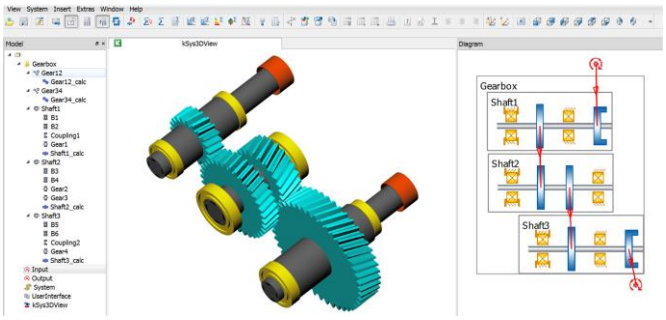
Modeling of Shafts and Bearings - Advanced

- Coaxial shafts
- Analysis of bearings according to ISO 16281
- Forced analysis
- KISSsoft Exercises



KISSsys: Modeling of Gearboxes (2 days)

"Gearbox modeling in KISSsys: basics, application cases and hands-on session"



Introduction to KISSsys

- Key benefits
- Important settings
- User and administrator mode
- User Interface and functionalities
- Terminology
- Using existing models
- Communication with KISSsoft modules for strength analysis

Introduction to Modeling

- Plan the model
- Calculation of kinematics / power flow
- System based calculations regarding safeties, lifetime, weight and cost
- Generate user defined tables

Modeling with Single Shafts

Examples of modeling a two-stage industrial gearbox and a bevel gear stage gearbox

- Creating a proper sketch
- Building the model with different methods
- Calculating and defining the kinematics
- Geometry definition of machine elements in KISSsoft Interfaces
- Sizing of gears, positioning of shafts and bearings according to the requirements
- Generating a User Interface table with variables for system information (operating data, safeties, lifetimes)

Exercise to build a simple industrial gearbox and use the sizing functionalities

Special Kinematic Conditions

Models with One Input Two Outputs

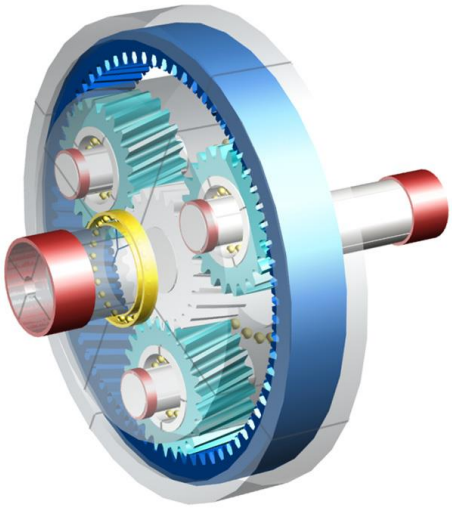
- Definition of boundary conditions
- Controlling power distribution

Gear Chain with Three Gears

- Handling of KISSsoft calculations
- Setting alternating bending factors

Overdefined Kinematics

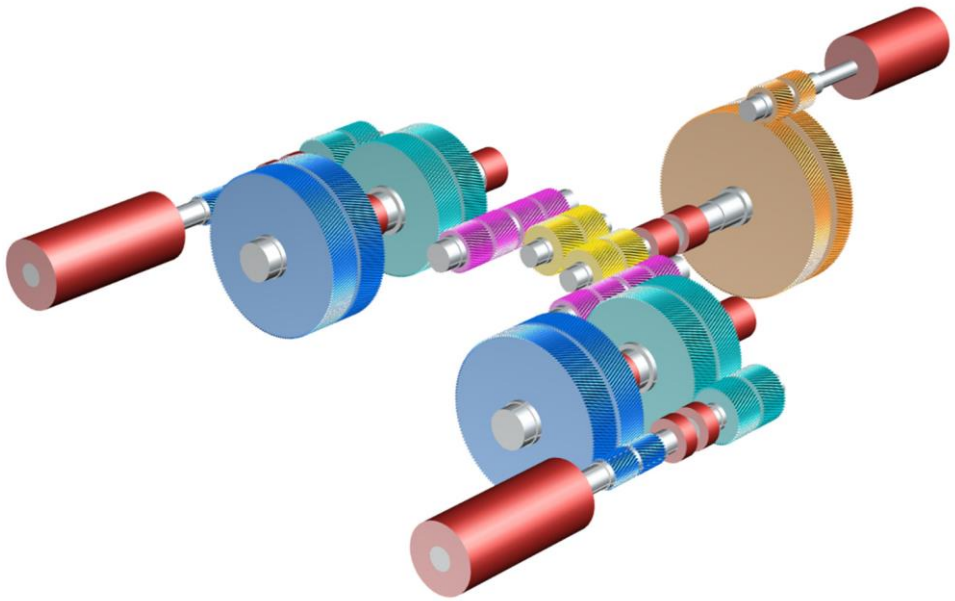
- Model with powersplits
- Using of torque split method



Coaxial Shaft Modeling

- Planetary Stage
- Important notes on the sketch
- Generation of the model, kinematics calculation
- Definition of the geometry in KISSsoft
- Modifying the positions of the groups
- Implementing of simple functions into a table
- Realization of multiple stages with spline connections
- Combination of single and coaxial shafts in one model

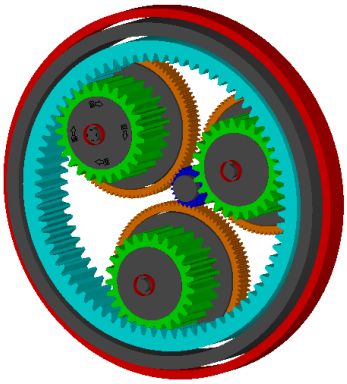
Summary of the first two days with a complete gearbox as an exercise.



KISSsys: Epicycloidal Gearboxes (1 day)

"Focus on KISSsys modeling of planetary gearboxes."

Different kinematics of planetary gearboxes

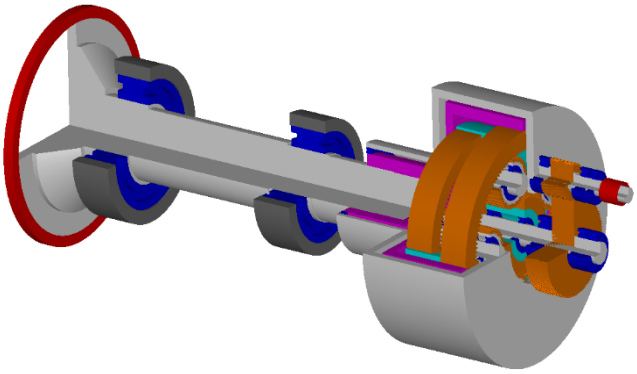


- Presentation of different epicyclic applications
- Conventional planetary stage
- Kinematics using epicyclics and gear pairs
- Compound planetary stage

Tooth contact analysis

- Influence of bearings, shafts and planetary carrier
- Basic gear flank modifications

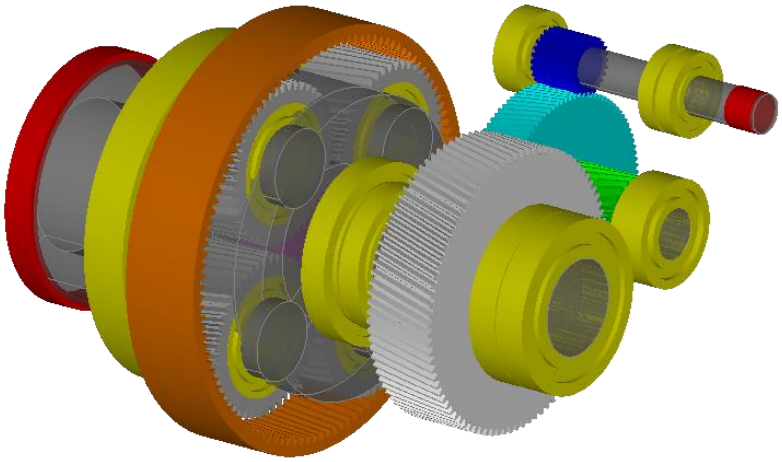
Load spectra calculation



- Gears
- Shafts and bearings

Efficiency calculation

- Power losses
- Thermal rating



Automotive: EV Drive
3 days

"KISSsys Modeling of Automotive Transmissions for Hybrid Drive."

Introduction to KISSsys modeling for E-Drive

- Relevant settings
- User and administrator mode
- User interface and functionality
- How to use predefined templates
- Planning a model
- Calculation of Kinematics/Power Flow.
- System Calculation of Mechanical Element Safeties, Durability, Weight, and Costs
- KISSsys examples of gearboxes for E-Drive

Exercise: Modeling a two-stage gearbox for electric traction.

- Creating a sketch
- Model realization
- Calculate and define kinematics
- Gear sizing, shaft and bearing positioning and sizing

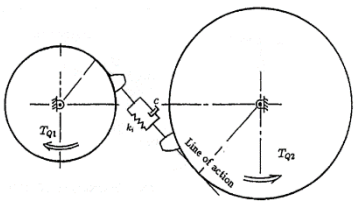
KISSsys: Contact Analysis

- Influence of bearings, shafts, and planetary carrier (in planetary gearboxes)
- Microgeometries in accordance with ISO 21771

KISSsys: System efficiency calculation (and battery sizing)

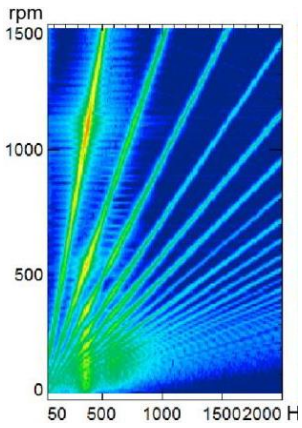
- Power Losses
- Thermal rating

NVH of Cylindrical Gears for E-Drive



- Spur gears: straight, helical, internal, external gears
- Conjugate profiles and the law of meshing
- The circle involute profile: genesis and main properties
- Profile displacement factor and center distance
- Backlash at assembly and in operation
- Standard, lowered, HCR reference profiles
- Profile coverage εα, Lead contact ratio εb : mathematical definition and physical meaning
- The quality of gears and influence on noise
- Microgeometries of gears according to ISO 21771
    - Profile modifications (Head/foot strips; Pressure angle modification; Bombing)
    - Band modifications (End strips; Helix angle modification, Bombing)
- Decibel and weighting scale dB(A)
- Noise, Vibration and Harshness (NVH): Basic Concepts.
- Noise analysis according to the formulations of Kato and Masuda

Contact Analysis and Transmission Error



- Contact analysis (LTCA): basic concepts
- Profile and band overlay analysis under load
- The genesis of noise: transmission error (LTE)
- The propagation of noise
    - Structure borne (structural propagation)
    - Air borne (airborne propagation)
- Analysis of the transmission error spectrum
- Harris Maps
- Microgeometry optimization for noise.
    - The stripping of short/long head (Linear/Arcuate/Progressive)

Analysis of the excitation frequencies of a transmission

- Time and frequency domain
- Nyquist-Shannon theorem (of sampling)
- Fourier analysis: basic concepts
- Campbell diagram
- Gearing Frequency: Spur and Planetary Gears
- The characteristic frequencies of the bearings
- The broadband noise: gear chatter
- The tonal noise: gear whistling

