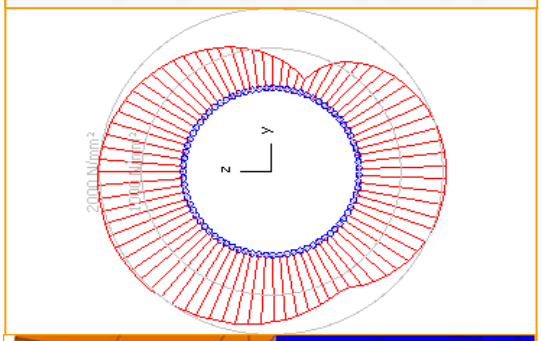
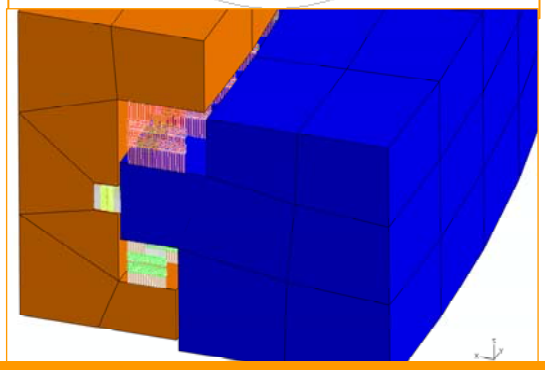
Slewing Bearing Analysis

Stiffness
Static rating
Life rating

For ball, cross roller and roller bearings

www.EES-Gear.ch





EES GEAR

Engineering | Education | Software

Recent projects

- ✓ Analysis of a >5m slewing bearing for mining application, Korea
- ✓ Re-calculation for certification, wind turbine pitch/yaw bearing, India/Italy
- ✓ Analysis review and certification assistance, pitch/yaw bearing, India/Korea
- ✓ Comparative analysis for wind turbine pitch and yaw bearings, Germany
- ✓ Analysis methodology study for slewing rings, Spain
- ✓ Various calculations for slewing ring gearboxes, Japan, Italy, India, Germany

Your benefit

- ✓ CAE software for bearing rating (basic, modified, reference and modified reference rating) taking into account lubrication, shaft misalignment, housing stiffness and internal bearing geometry
- ✓ Strength and life calculation of large, flexible bearings considering adjacent structures and bolt pre-tensioning
- ✓ Certification assistance e.g. for wind turbine bearing certification
- ✓ Bearing rating using application load spectra, analysis for certification
- ✓ Training on bearing rating theory and software

Our approach

We use KISSsoft software, calculations along DIN and ISO standards (implemented in Excel and MathCad) and FEM analysis (ABAQUS).

Combining different calculation methods, we can handle simple and complex problems alike.

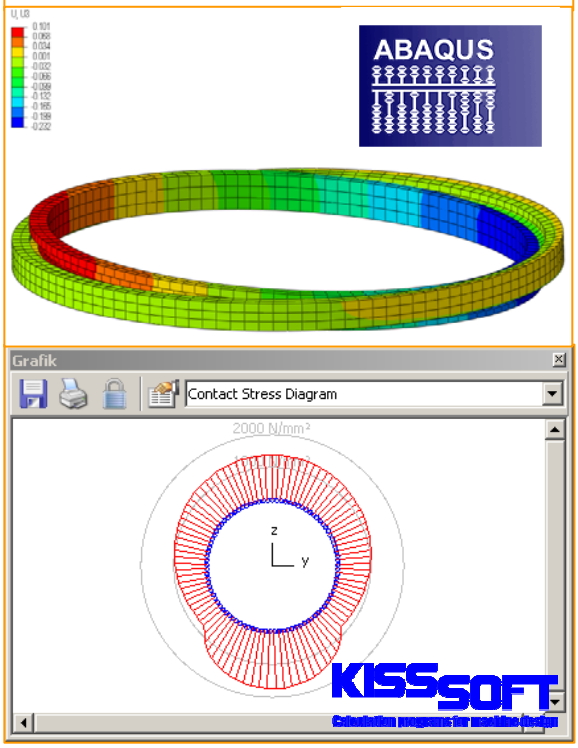
FEM calculations are only used to determine rolling element loads and to account for the elasticity of adjacent structures. Non linear spring stiffness of rolling elements is taken into account.

Stress calculations are then done more accurately using formulas based on Hertzian theory including modifications for edge stresses. These stresses are then the basis for a static or life rating.

Our calculations are in line with

- ✓ ISO76, ISO281
- ✓ DIN ISO 281-4 / ISO TS 16281
- ✓ ISO81400
- ✓ NREL DG 03
- ✓ Harris/Kotzalas, “Essential Concepts of Bearing Technology” and “Advanced Concepts of Bearing Technology”

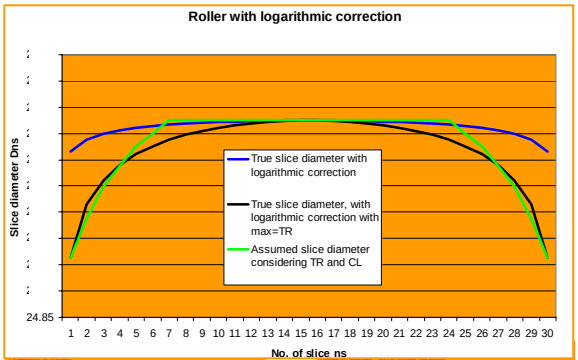
$$Ca := \begin{cases} \left[fcm \cdot \left(\cos\left(\alpha \cdot \frac{\pi}{180} \right) \right)^{0.7} \cdot Z^{\frac{2}{3}} \cdot d^{1.8} \cdot \tan\left(\alpha \cdot \frac{\pi}{180} \right) \right] & \text{if } d \le 25.4 \\ \left[fcm \cdot \left(\cos\left(\alpha \cdot \frac{\pi}{180} \right) \right)^{0.7} \cdot Z^{\frac{2}{3}} \cdot d^{1.4} \cdot \tan\left(\alpha \cdot \frac{\pi}{180} \right) \right] & \text{if } d > 25.4 \end{cases}$$



Clearance and profile modifications

For the roller load, any assembly clearance and any kind of roller profile modifications may be considered due to our combined spring-gap modelling approach using various initial gap opening

Initial clearance or pre-tension may be considered as well



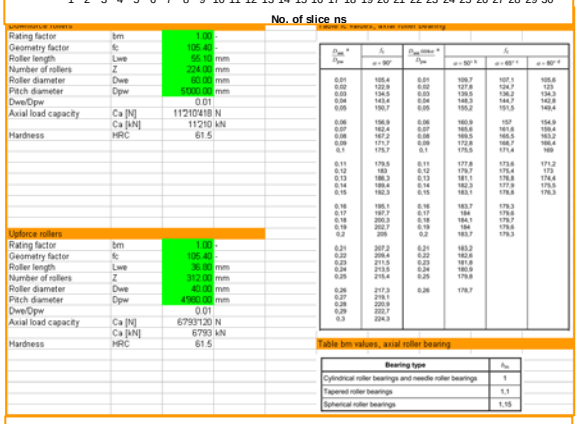
Static rating

Using load capacity numbers calculated along ISO76 and static equivalent load

Using true contact stresses, calculated from FEM load distribution and Hertzian contact stress with stress correction function to account for edge stresses

Using permissible values for different types of bearings, considering true hardness compared to reference hardness

Considering ring and structure elasticity or assuming stiff support only



$$C_a = b_m f_c L_{we}^{7/9} Z^{3/4} D_{we}^{29/27}$$

$$f_i[k] = f_0[k] = \left(1 - \frac{0{,}01}{\ln\left(1{,}985 \times \left|\frac{2 \times k - n_s - 1}{2 \times n_s - 2}\right|\right)}\right)$$

$$q_{ei,k} = \left(\frac{1}{Z}\sum_{j=1}^{Z}\left(f_i[j,k] \times q_{j,k}\right)^4\right)^{\frac{1}{4}}$$

Life rating

Life rating along NREL DG 03 for Wind Turbine pitch and yaw bearings

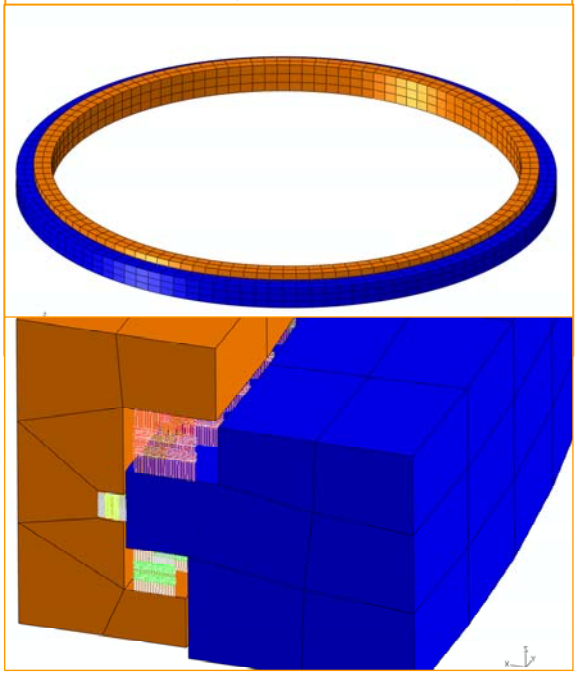
Using rolling element forces from FEM calculation or standard formulas

Life rating along ISO281 for basic or reference life

FEM analysis of slewing rings

Calculation of rolling element load considering Rolling element stiffness, ring elasticity, adjacent Structure, pre-tension from bolting

Calculation of tilting stiffness and axial, considering assembly clearance, rolling element and ring stiffness



Gearing and bolting analysis

Gear rating can be done along ISO6336, DIN3990, AGMA2001 and AGMA6004

For fatigue rating, including load spectra, or static rating. Rating against pitting and root fracture

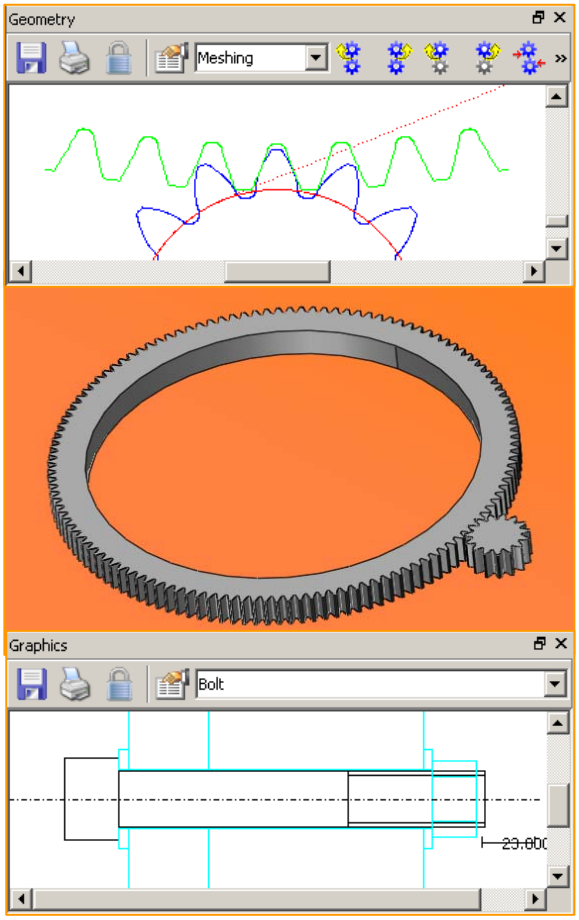
Geometric analysis for clearance and assembly tolerances

Calculation of pinion lead and profile corrections

Bolt rating is done along VDI2230, considering Pretension, bolt tightening procedure and settling

Calculations are done using KISSsoft software, ensuring that results are readily acceptable to customers and certification agencies

Calculations are documented such that they are suitable for submission to certification societies like Germanische Lloyd, TüV, DEWI, KR, C-WET and others



Slewing ring gearboxes

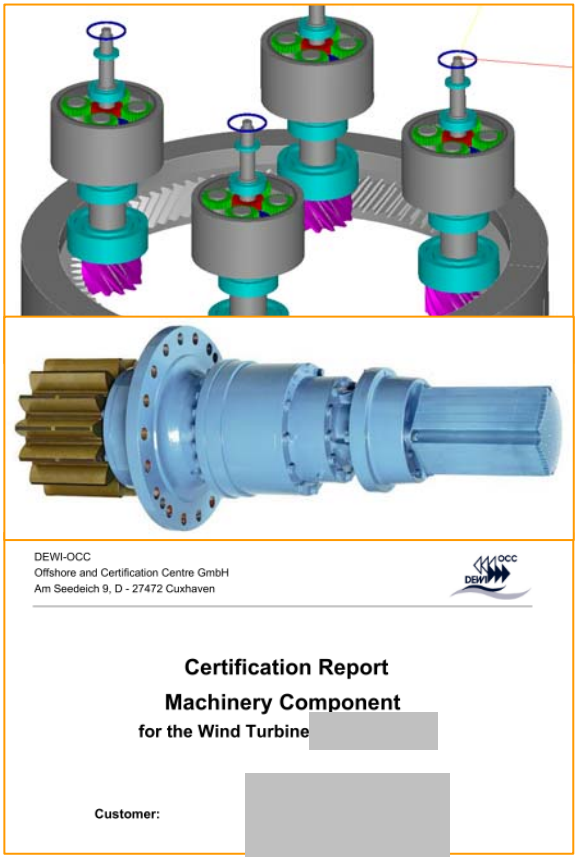
Slewing ring gearboxes
Wind turbine pitch and yaw gearboxes

Supplier calculation review
Analysis for certification
Certification assistance

Fatigue / static testing procedures definition

Gearbox design including gear sizing, shaft dimensioning, bearing selection and manufacturing drawings

FEM analysis of housings and planetary carriers



Staff

Dipl. Ing. ETH H. Dinner, Director
- FEM analyst, project manager with Helbling Technik AG, 4 years
- Project engineer and head of sales, with KISSsoft AG, 5 years
- Consultancy, 1.5 years

Dipl. Ing. FH T. Uvermann, Director
- Gearbox designer, 6 years
- Bearing application engineer, 2 years
- Head of heavy duty gearbox design, mining equipment company, 3 years

Dip. Ing ETH R. Stebler, FEM analysis
- FEM analyst and calculation project manager, 10 years with various companies
- Consultancy, 5 years

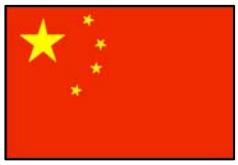
Dipl. Ing. FH A. Thuswaldner, Design
- Gearbox designer and head of marine / turbo gear department with MAAG, 13 years
- Head of technical sales with MAAG
- Consultancy, 3 years

Partners

STech&H Pvt Ltd, Seoul, Korea
- Dr. Young Il Kwon, Director
- Engineering partner
- KISSsoft software sales partner

Kadkraft Systems Pvt Ltd, Chandigarh, India, www.kadkraft.com
- Mr. Raman Gupta, Director
- CAD services partner, KISSsoft software sales partner

Estudio Pina, Bahia Blanca, Argentina, www.estudiopina.co.ar
- Mr. Jose Luis Pina, Director
- Engineering partner



Unique Technologies Pty Ltd, Shanghai, China
- Mr. Zhilin Ye, Director
- KISSsoft software sales partner

Memberships

EES Gear GmbH / EES KISSsoft GmbH is member of the following associations

Partnership with KISSsoft AG

EES Gear GmbH and it's sister company EES KISSsoft GmbH maintain a close partnership with KISSsoft AG. EES KISSsoft GmbH is sales partner to KISSsoft AG, responsible for the Asian Market (India, Japan, Taiwan, China, Korea, Southeast Asia).

Contact details

EES Gear GmbH is a sister company to EES KISSsoft GmbH. Both companies are under the same management and located in Switzerland near Zurich. All business related to the sale of KISSsoft & KISSsys software in Asia is conducted through EES KISSsoft GmbH. Engineering services are offered through EES Gear GmbH.

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