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STRENGTH AND DURABILITY OF GEARS

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- PRODUCT CATEGORY**
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- SPUR GEARS

 - HELICAL GEARS

 - INTERNAL GEARS

 - GEAR RACK

 - CP RACKS & PINIONS

 - MITER GEARS

 - BEVEL GEARS

 - SCREW GEARS

 - WORM GEAR

 - BEVEL GEARBOX

 - OTHER PRODUCTS

7. Strength and Durability of Gears / The tooth is the most crucial element of gears. Strength of gears depends on the breakage durability or friction durability.

Gear designers decide specifications in accordance with factors like torque, rotation and expected lifetime. In this section, we briefly introduce the bending strength and the surface durability.

Bending Strength of Spur Gears and Helical Gears JGMA401-01

As shown in the Figure.7.1, the tooth fillet breakage occurs at the root when applied force exceeds the limit. The following is the equation for bending stress :

$$\text{Allowable Tangential Force } (F_{\text{lim}}) = \sigma_{\text{Flim}} \frac{m_n b}{Y_F Y_\epsilon Y_\beta} \left(\frac{K_L K_{\text{FX}}}{K_V K_O} \right) \frac{1}{S_F} \quad (7.1)$$

Allowable Tangential Force (7.1)

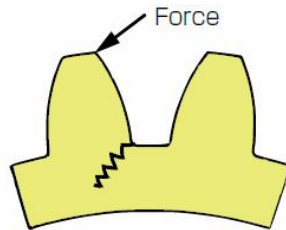


Fig. 7.1 Lack of bending stress at root

ADVANTAGES OF KHK STOCK GEARS



View this video to witness first hand KHK's strengths as a gear manufacturer.

KHK GEAR MANUFACTURING PROCESS

Symbol	Name	Affected Factors and other Specifications
σ_{Flim}	Allowable bending stress at root	Material / Heat treatment
m_n	Normal Module	Tooth size
b	Face Width	Gear size
Y_F	Tooth Profile Factor	Pressure angle/ Profile shift coefficient / Tooth wic
Y_ϵ	Load Sharing Factor	Contact ratio
Y_β	Helix Angle Factor	Helix angle of helical gear
K_L	Life Factor	Expected lifetime
K_{FX}	Size Factor of Root Stress	1.00 at the moment (unknown)
K_V	Dynamic Load Factor	Circumferential speed / Gear accuracy
K_O	Overload Factor	Motor / Impact from load
S_F	Safety Factor	It should be set to more than 1.2 for safety consid



View this video to learn about KHK's advanced gear manufacturing process.

How to encourage bending strength

To encourage bending strength, values in the equation for allowable tangential force (7.1) should be set to; The value of denominator should be small & The numerator should be large

- Use durable materials (Increase allowable bending stress at root)
- Enlarge the gear size (For large module / wide tooth width)
- Strengthen tooth profile (Decrease tooth profile factor)
 - Large pressure angle
 - Positive correction
- Increase contact ratio (Decrease load distribution factor)
 - Small pressure angle
 - Large tooth depth
- Improve accuracy

Surface Durability of Spur and Helical Gears JGMA402-01

Tooth surface durability is calculated in accordance with the contact stress, to figure out the strength against the tooth surface damage (Pitting).

The allowable tangential force F_{lim} for surface durability is;

$$\text{Allowable Tangential Force } (F_{lim}) = \sigma_{Hlim}^2 d_{01} b_H \frac{i}{i \pm 1} \left(\frac{K_{HL} Z_L Z_R Z_V Z_W K_{HX}}{Z_H Z_M Z_\epsilon Z_\beta} \right)^2 \frac{1}{K_{H\beta} K_V K_O} \frac{1}{S_H^2} \quad (7.2)$$

Allowable Tangential Force (F_{lim})

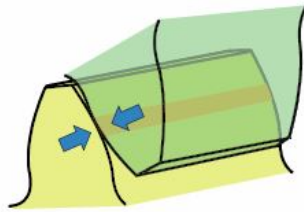


Fig. 7.2 Contact Stress

Symbol	Name	Affected Factors and other Specificat
σ_{Hlim}	Allowable Hertz Stress	Material / Heat treatment
d_{01}	Pitch Diameter of Pinion	Pinion size (Diameter)
b_H	Effective Facewidth	Gear size
i	Gear Ratio (z_2 / z_1)	Ratio of the number of teeth
Z_H	Zone Factor	Helix angle / Profile shift coefficient
Z_M	Material Factor	Material combination
Z_ϵ	Contact Ratio Factor	Transverse / Overlap contact ratio
Z_β	Helix Angle Factor	1.00 (Assumed)
Z_{HL}	Life Factor	Expected lifetime
Z_L	Lubricant Factor	Lubricants and Viscosity
Z_R	Surface Roughness Factor	Surface roughness
Z_V	Lubrication Speed Factor	Circumferential speed / Surface hard
Z_W	Hardness Ratio Factor	Hardness of wheels
K_{HX}	Size Factor	1.00 assumed
$K_{H\beta}$	Longitudinal Load Distribution Factor	Gear Support / Stiffness etc.
K_V	Dynamic Load Factor	Circumferential speed / Gear accur
K_O	Overload Factor	Motor / Impact from load
S_H	Safety Factor	Set to more than 1.15 for safety consid

How to increase surface durability

- Use hard material treated by quenching (Increase allowable hertz stress)
- Enlarge gear size (Large pitch diameter / Wide effective tooth width)
- Increase contact ratio (Decrease contact ratio factor)
- Improve accuracy

The strength calculator on KHK web site

The calculation of gear strength tends to be rather complicated. On our web site, we offer a strength calculator for KHK stock gears, which enables you to calculate gear strength automatically, by inputting values in accordance with your usage condition. For gear strength calculation, there are

several formulas. The gear strength formula used in our calculator is based on JGMA (Japanese Gear Manufacturers Association) specifications.

Related links:

[Gear Strength and Gear Durability](#) – A page of Gear Technical Reference

[Bending Strength of Spur and Helical Gears](#) – A page of Gear Technical Reference

[Surface Durability of Spur and Helical Gears](#) – A page of Gear Technical Reference

[Bending Strength of Bevel Gears](#) – A page of Gear Technical Reference

[Surface Durability of Bevel Gear](#) – A page of Gear Technical Reference

[Surface Durability of Worm Gear](#) – A page of Gear Technical Reference

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