Bevel and hypoid gears

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classifications

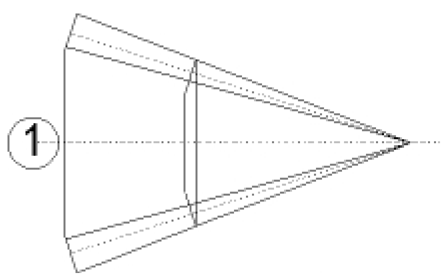
Bevel gears

- Straight bevel gears
- helical bevel gears
- spiral bevel gears
  - without offset (Bevel gears)
  - with offset (Hypoid gears)

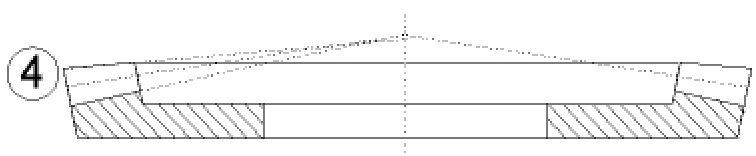
Systemdata „Standard“

The type Standard is recommended to be used for straight or helical bevel gears (non-offset) only.

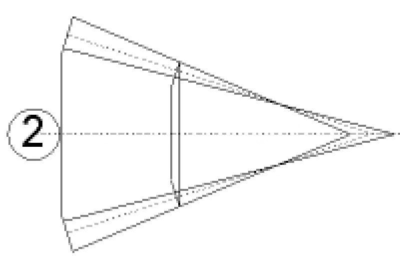
There are different types of bevel gears regarding the position of the apex related to the crossing point of the axes



All apex coincide



Root apex coincide with pitch apex, face cone is tilted



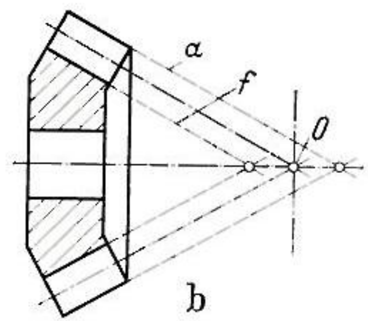
Root and face apex do not coincide

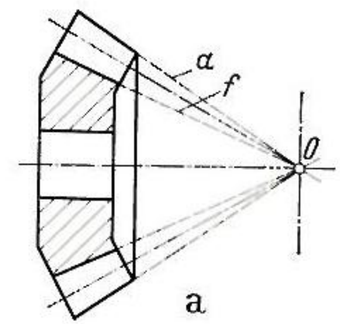
Strength

For rolling gears the methods ISO, DIN, AGMA can be selected

For static application as i.e. differential bevel gears, the static calculation is recommended:

- Static load with criterias rupture or yielding
- Several strands possible





Face Hobbing
(continuous indexing)
constant tooth height

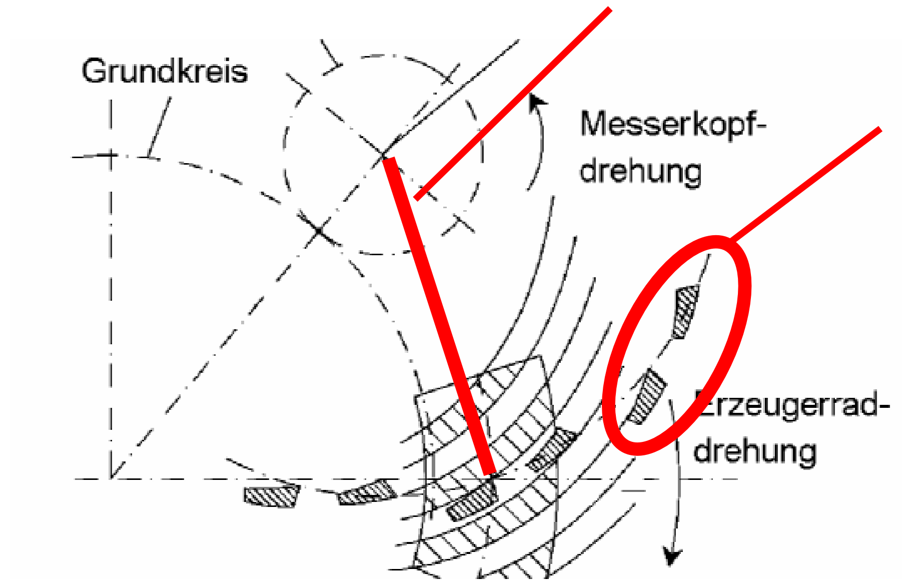
Face Milling
(single indexing)
modified tooth height

typical brand names are:

Klingelnberg Palloid
Klingelnberg Cyclopalloid
Oerlikon
Triac / Pentac FH

Gleason 5 cut
Gleason Duplex
Klingelnberg ARCON

cutting method

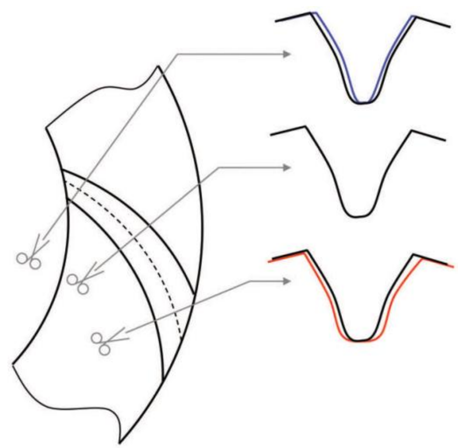


The workpiece rotates continuously while the cutting tool plunges. The effective curvature radius is influenced by the number of blade groups and cutter radius.

Face Hobbing

KISSsoft
Berechnungsprogramme für den Maschinenbau

Geometry details



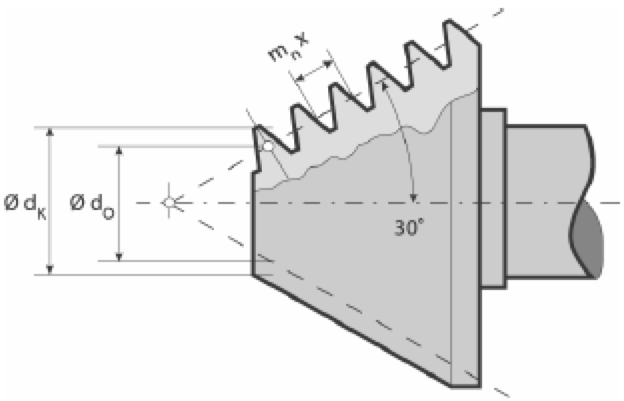
The tooth height is constant

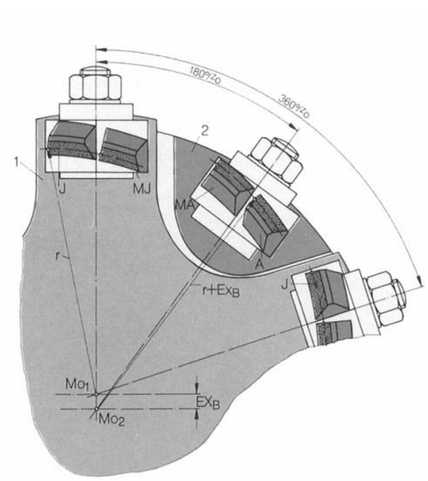
The slot width is varying

The lengthwise curvature is an elongated epicycloid
➔ grinding is not (directly) possible, lapped gearsets

Face Hobbing

Cutting tools & manufacturing data





Palloid

Defined by cutting length SF and diameter dk

➔ Warning in KISSsoft if the cutter size doesn‘t fit

Cyclopalloid

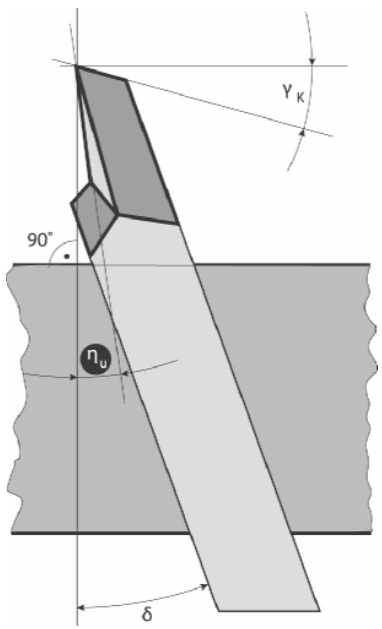
Defined by blade groups and cutter radius, or Klingelnberg machine type

➔ Sizing of cutter radius in KISSsoft possible

Face Hobbing

Berechnungsprogramme für den Maschinenbau

Cutting tools & manufacturing data



Klingelnberg SPIRON
Oerlikon FS
Gleason TRIAC
Gleason PENTAC FH

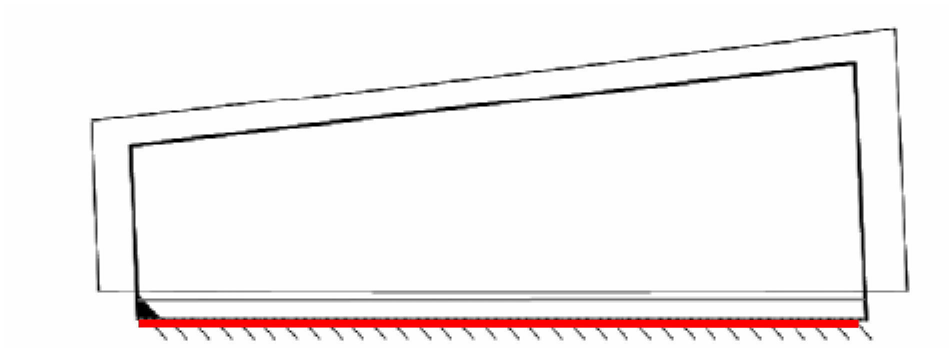
Defined by:
blade groups and cutter radius

➔ Sizing of cutter radius in KISSsoft possible

Face Hobbing

KISSsoft
Berechnungsprogramme für den Maschinenbau

Reference profile



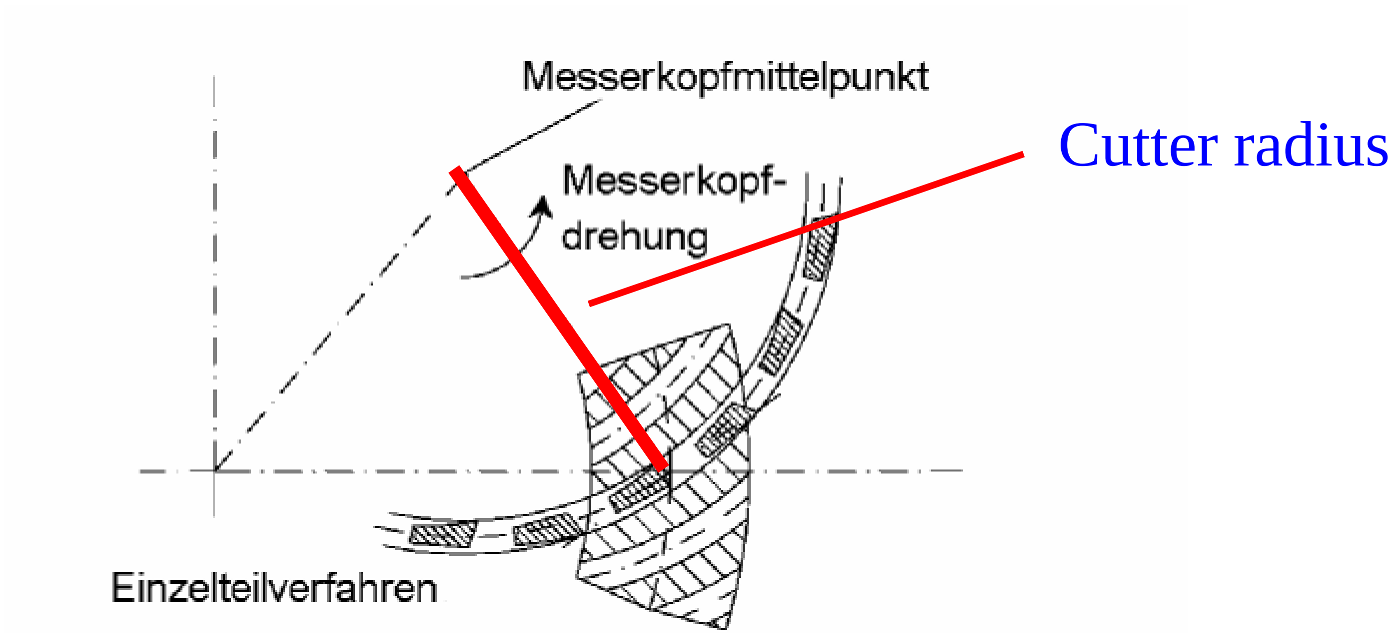
Face hobbing requires only little tilting of the cutterhead in order to create the required lengthwise crowning. Cyclopalloid doesn‘t apply tilt at all.

Hence also the root land is flat. There is no risk at the toe or heel side to get interference with the counterpart. The recommended tip clearance c* is:

Face Hobbing :	0.25
Cyclopalloid :	0.25
Palloid :	0.30

Face Milling

cutting method

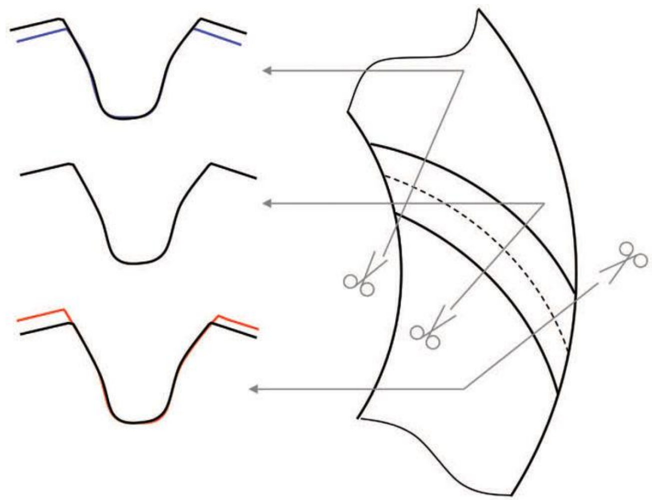


The workpiece has no rotation while the cutting tool plunges.

The effective curvature radius is only determined by cutter radius.

Face Milling

Geometry details



The tooth height is not constant

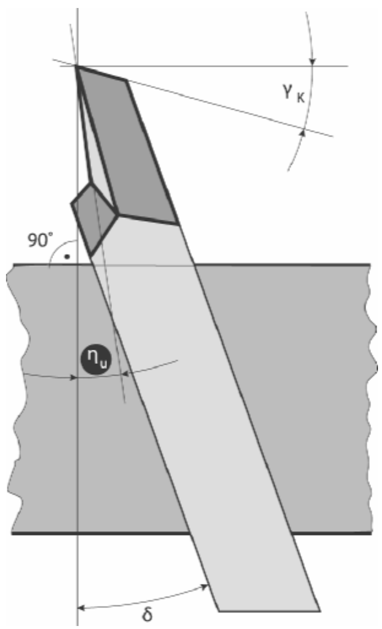
The slot width is constant (DUPLEX, COMPLETING) or modified (5-CUT, FIXED SETTINGS)

The lengthwise curvature is an elongated epicycloid
➔ grinding or lapping is possible

Face Milling

KISSsoft
Berechnungsprogramme für den Maschinenbau

Cutting tools & manufacturing data



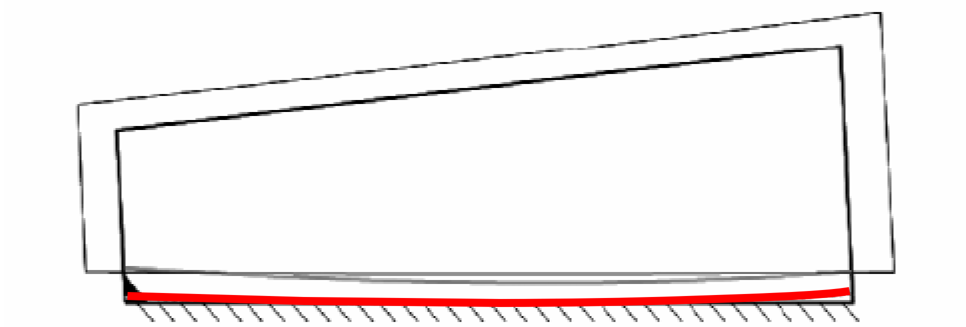
Gleason PENTAC FM
Gleason RSR
Klingelnberg ARCON

Defined by:
cutter radius

➔ Sizing of cutter radius in KISSsoft possible

Face Milling

Reference profile



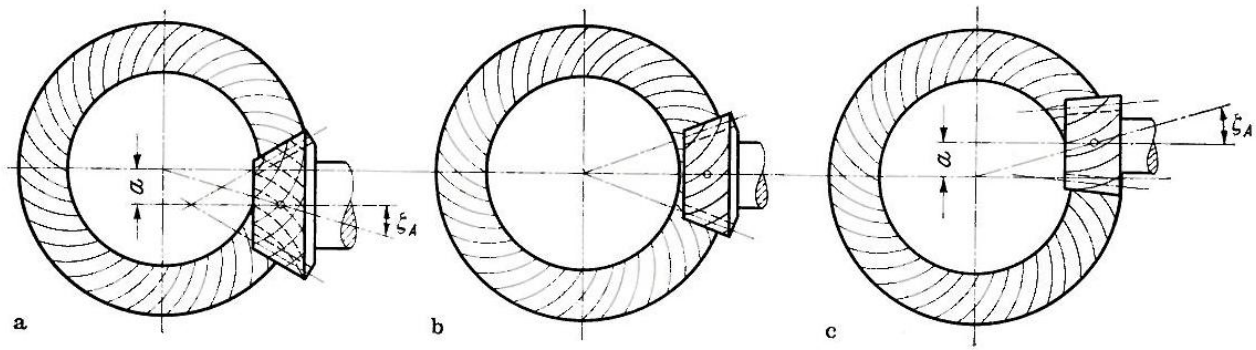
Face Milling requires bigger tilting of the cutterhead in order to create the required lengthwise crowning.

Hence the root land is not flat and there is a higher risk at the toe or heel side to get interference with the counterpart. The recommended tip clearance c* is:

Face Milling (Duplex):	0.35
Face Milling (5 cut):	0.3

Hypoid gears

KISSsoft
Berechnungsprogramme für den Maschinenbau



Hypoid gears have an offset between the axes.
The offset leads to a bigger pinion diameter (positive offset) and therefore higher strength. Also the overlap is higher and the gears are quieter.
The offset creates horizontal sliding and therefore higher losses and a higher risk of scuffing.

Limit pressure angle

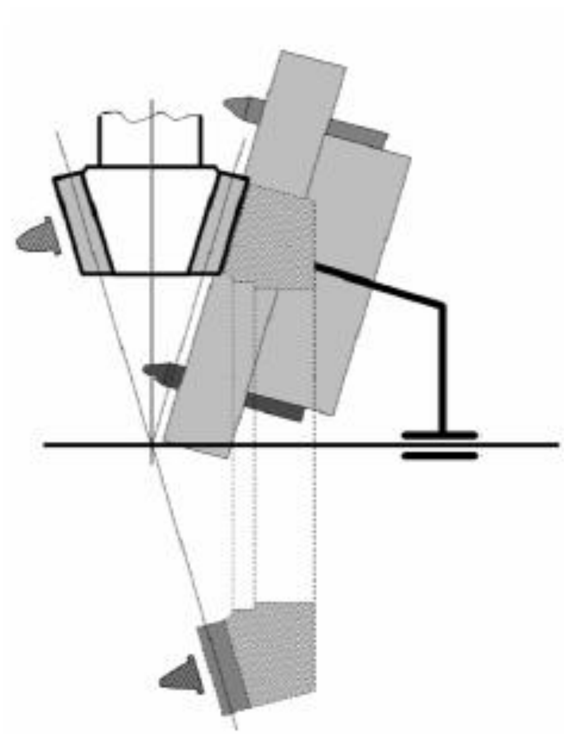
The limit pressure angle modifies the pressure angle and is required in order to balance the meshing conditions for drive and coast side of hypoid gears.

The limit pressure angle is considered differently with an influence factor for each cutting method:

Face Hobbing:	1
Face Milling (Duplex):	0.5
Zyklopalloid:	0

→ in KISSsoft, the factor can be entered under „additional data“

Generating or form cut gears



Bevel gears with ratio > 2.5, the ring gear usually is form cut (FORMATE, NON-GENERATED)

The pinion is always generated.

The cutting process is considered in the strength calculation also.

➔ in KISSsoft, the manufacturing process can be entered under „strength“

Basic formulae

Basic formulae for Sigma = 90°
bevel gear (non-offset)

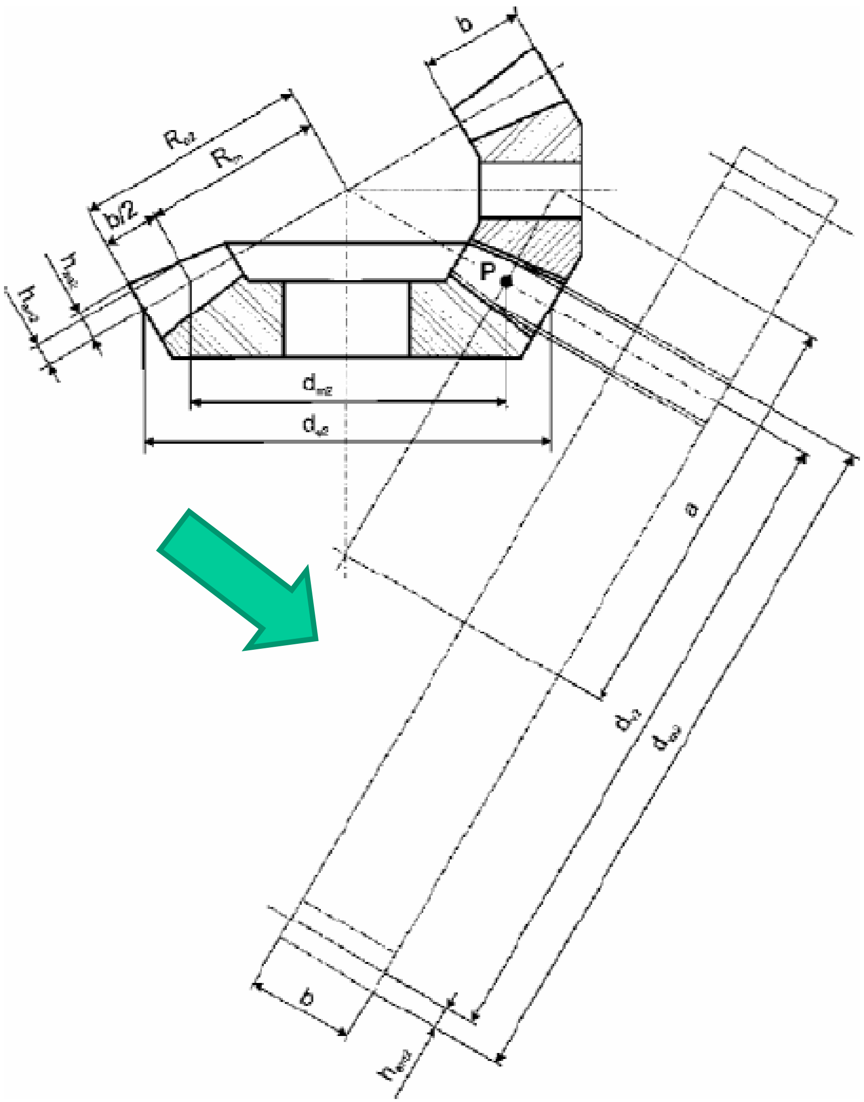
Ratio u = z2/z1
Pinion pitch cone delta 1 = arctan(1/u)
Wheel pitch angle delta 2 = 90° - Delta1
Outer cone distance Re = d2/(2*sinDelta2)
Mean cone distance Rm = Re-b2/2
Spiral angle beta1 = beta2

„First aid" for bevel gear data:

Check for pitch data:
Outer Transverse pitch pte = de / z

Check for Non-Offset:
beta 1 = beta 2, or Delta 1+ Delta 2 = 90°

Strength calculation



Principle of strength calculation:

The bevel gear geometry is transferred into a virtual spur gear.

The dimension of middle of face width are used.

For the virtual spur gear the (modified) formulae of spur gear strength are applied.

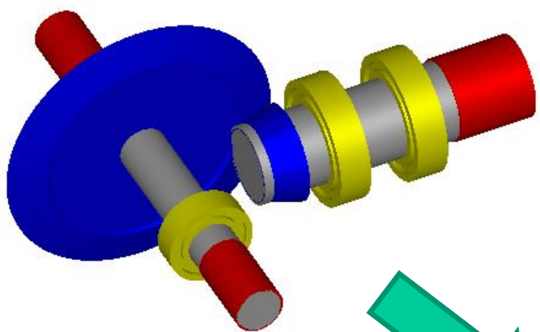
Strength calculation

Method	Bevel gears	Hypoid gears	Bending	Pitting	Scuffing	Wear	KISSsoft
DIN3991	✓	✗	✓	✓	✓	✗	✓
ISO10300	✓	✗	✓	✓	✗	✗	✓
FVA411	✓	✓	✓	✓	✗	✗	✓
Niemann/Winter	✓	✓	✓	✓	✓	✓	(✓)
ISO/TR13989	✓	✓	✗	✗	✓	✗	(✓)
AGMA2003	✓	✗	✓	✓	✗	✗	✓
Niemann (1965)	✓	✓	✓	✓	✓	✗	(✓)
KN3029 / 28 KN3030	✓	✓	✓	✓	✓	✗	✓
KN3025 / 26 KN3030	✓	✓	✓	✓	✓	✗	✓

Further strength calculation

KISSsoft
Berechnungsprogramme für den Maschinenbau

Loaded contact analyses

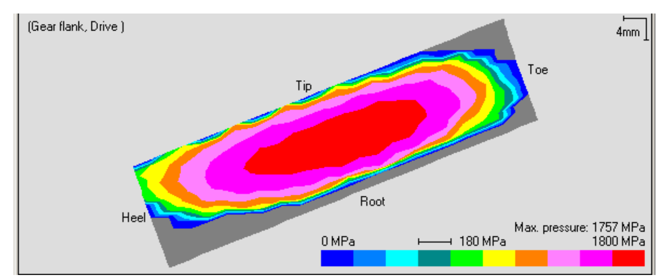


Step 1:
In KISSsys the shafts, bearings and forces are entered.

Step 2:
The deviations are calculated:

dH (dP)
dV (dE)
dJ (dG)
dΣ

Step 3:
With an appropriate software the tooth contact analyses under load is performed



Thank you for your attention

Sources:

Niemann / Winter: „Maschinenelemente, Band II“
ISO 10300 and ISO 23509
Klingelnberg , Jan: „Kegelräder“