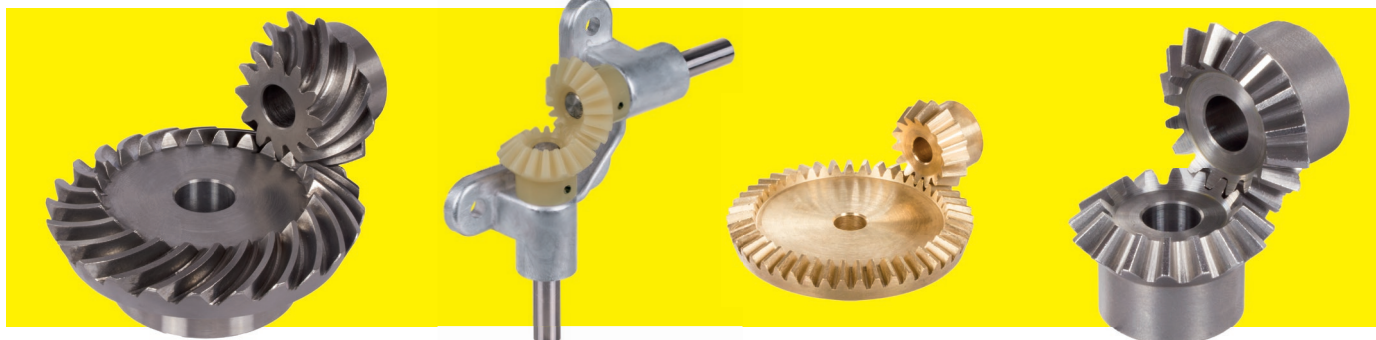


## Bevel Gears Overview



### Contents

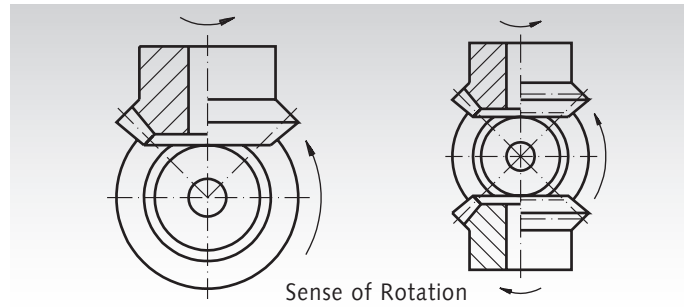
Material	Tooth System	Ratio	Module	perm. Output Torque	Page	
Plastic resin	straight teeth	1:1	0,5 - 3,5	0,009 - 4,4 Nm	275	
		as ready-to-install angular gear drive				276
		2:1	1 - 3	0,012 - 7,4 Nm	275	
		3:1	1 - 2,5	0,083 - 1,8 Nm	275	
		4:1	1 - 2	0,045 - 1,6 Nm	275	
		5:1	1	0,6 Nm	275	
Zinc die-cast	straight teeth	1:1	1 - 3,5	0,14 - 5,8 Nm	276	
Brass	straight teeth	1:1	0,5 - 1	0,009 - 1,97 Nm	277	
		1,5:1	0,5 - 1	0,036 - 0,27 Nm	277	
		2:1	0,5 - 1	0,027 - 0,41 Nm	277	
		2,5:1	0,5	0,075 Nm	277	
		3:1	0,5 - 1	0,045 - 0,33 Nm	277	
		4:1	1	0,49 Nm	277	
Steel	straight teeth	1:1	0,5 - 8	0,011 - 181,6 Nm	278	
		1,25:1	3 - 5	6,5 - 31,8 Nm	279	
		1,5:1	0,5 - 5	0,021 - 90,9 Nm	279	
		2:1	0,5 - 6	0,034 - 260 Nm	280	
		2,5:1	0,5 - 5	0,018 - 152,5 Nm	281	
		3:1	0,5 - 6	0,027 - 212 Nm	281	
		3,5:1	1 - 4	0,445 - 86,5 Nm	282	
		4:1	1 - 4	0,468 - 86,8 Nm	282	
Stainless steel	straight teeth	1:1	1 - 4	0,06 - 4,8 Nm	283	
		2:1	1 - 4	0,16 - 12 Nm	283	
		3:1	1 - 4	0,30 - 28,2 Nm	283	
		4:1	1 - 4	0,56 - 35,6 Nm	283	
Steel hardened	spiral teeth	1:1	0,6 - 3,5	2,1 - 238 Nm	284	
		1,24:1	1,5	17,1 Nm	285	
		1,39:1	1,5	15,7 Nm	285	
		1,5:1	0,6 - 3	3,3 - 215 Nm	285	
		1,62:1	1	3,9 Nm	285	
		2:1	0,6 - 3,5	4,6 - 394 Nm	286	
		2,07:1	1	7,4 Nm	286	
		2,5:1	0,6 - 3,5	6,5 - 315 Nm	286	
		3:1	0,6 - 3,5	6,3 - 396 Nm	287	
		4:1	1 - 1,5	31,2 - 45,2 Nm	287	



## General Basics about Bevel Gears

Bevel gears enable a non-slip power transmission between two shafts mounted at 90 degrees.

Available from stock are transmission ratios of 1:1 up to max. 1:5 (depending on the material used). Other than for spur gears, the module is not standardized, but is chosen with view to technical considerations. The module of the bevel gear is not a constant value, but it changes with the diameter.



Sense of Rotation

### Bevel Gears with Straight-Tooth System

to be calculated	given unit	formula	
Module = m	Pitch	$\frac{t}{\pi}$	
	Pitch $\varnothing$ and No. of Teeth	$\frac{d}{z}$	
Pitch $\varnothing$ = d	No. of Teeth and Module	$z \cdot m$	
Pitch (Cone) Angle Gear 1 = $\delta_{01}$	No. of Teeth Gear 1 and Gear 2	$\frac{z_2}{z_1} = \tan \delta_{01}$	
Pitch (Cone) Angle Gear 2 = $\delta_{02}$	Angle of Axles and Pitch (Cone) Angle, Gear 1	$\delta_a - \delta_{01}$	
Addendum Angle = $\chi_k$	Pitch (Cone) Angle and No. of Teeth	$\frac{2 \cdot \sin \delta_0}{z} = \tan \chi_k$	
	Module and Outer Cone Distance $R_a$	$\frac{m}{R_a} = \tan \chi_k$	
Tip $\varnothing$ = $d_a$	Pitch $\varnothing$ , Pitch (Cone) Angle and Module	$d + (2m \cdot \cos \delta_0)$	
	No. of Teeth, Pitch (Cone) Angle and Module	$z \cdot m + (2m \cdot \cos \delta_0)$	
Tip (Cone) Angle = $\delta_k$	Pitch (Cone) Angle and Addendum Angle	$\delta_0 + \chi_k$	
Outer Cone Distance Cone Distance = $R_a$	Pitch (Cone) Diameter $\varnothing$ and Pitch (Cone) Angle	$\frac{d}{2 \cdot \sin \delta_0}$	
Gear 1 = big gear, Gear 2 = small gear			
Torque = Md in Nm	Power and Speed	Gear 1	Gear 2
		$9550 \frac{P}{n_1}$	$9550 \frac{P}{n_2}$
Tooth Width maximum 0.4 x Outer Cone Distance $R_a$ . For Bevel Gears with a Shaft Angle larger or smaller than 90°, the following formula applies for the calculation of the Pitch (Cone) Angle			
$\frac{z_2}{z_1 \cdot \sin \delta_a} + \cot \delta_a = \cot \delta_{01}$			

Note: if  $\delta_{01}$  is given, then  $\delta_{k2} = \delta_a - (\delta_{01} - \chi_k)$   
Addendum Angle is the same for both gears:  $\chi_k = \chi_{k1} = \chi_{k2}$   
Tangent = tan, Cotangent = cot

**Material quality: information about the material quality can be found at each individual group of bevel gears.**

### Recommendations for the Lubrication of Bevel-Gear Sets

Peripheral speed	Lubrication	Lubricant
up to 1 m/s	Application of Lubricant	Adhesive Lubricant
up to 4 m/s	Splash Lubrication/Spray Lubrication	Grease or Adh. Lubricant
up to 15 m/s	Splash Lubrication	Oil
over 15 m/s	Pressure-Circulation or Spray Lubrication	Oil

## Notes Regarding the Torque Values Stated

The load bearing capacity calculations for the bevel gears are based on the basic principles regarding the pitting resistance of the tooth flanks and the occurring tooth root stress. The calculations are based on the DIN 3991. For the calculation, the following assumptions were made:

If the transmission ratio is not 1 : 1 the stated max. torque applies to the smaller gear.

Calc. Factor/Determining Factor	Abbreviation	Value	Note
Calculation Method	-	-	DIN 3991
Normal Pressure Angle	-	20° (17.5° for spiral tooth system module 0.6 to 1.5)	
Spiral Angle	-	0° (38° for spiral tooth system)	
DIN Quality	-	8	-
Flank Safety	$S_H$	1.0 (apart from zinc)	Endurance strength 10.000 h (for steel)
Tooth-Root Safety	$S_F$	1.5	Endurance strength 10.000 h (for steel)
Application Factor	$K_A$	1.25	Industrial gear mechanisms, uniform, light shocks
Dynamics Factor	$K_V$	1.0	Usually without great influence
Load Distribution over Width	$K_{H\beta}$	1.5 (1 for Polyacetal resin, Ms58 and ZnAl 4 Cu1)	Double-sided support
Lubricant/Surface Structure Speed Factor	$Z_L * Z_V * Z_R$	1	<ul style="list-style-type: none"> <li>• sufficient oil lubrication</li> <li>• relative surface roughness <math>R_{Z100} = 10</math></li> <li>• peripheral speed 8 m/s</li> </ul>
Lifetime Factor	$Z_N$	1	Endurance strength 10.000 h (for steel)
Operating temperature for plastic gears	$T_{Betr}$	up to 60°C	The material parameters of plastic gears highly depend on the temperature

The load bearing capacity of a bevel gear depends on various different factors. The torques stated are only reference values serving to facilitate the selection process. If necessary a specific calculation of strength and load bearing capacity must be carried out for each application.

Depending on the operating conditions the wear lifespan may be influenced by adequate grease/oil lubrication. Please also note that insufficient lubrication may lead to scuffing of the gear flanks.

## IMPORTANT

Please make sure you always check the permissible torque separately for the pinion and the gear side!

Plastic gears are, due to the higher elasticity, calculated with a  $K_{H\beta}$  of 1. Gears made from brass and zinc-die-cast are also calculated with a  $K_{H\beta}$  of 1, as a good running-in characteristic is assumed for these materials.

In the torque calculation of zinc-die-cast bevel gears only the root strength was considered. Due to the material properties these gears are only to a limited extent suitable for continuous operation.

## For the materials used, the following characteristic values were taken as basis:

Material	Perm. Pulsating Fatigue Strength under Bending Stress $s_{bW}$ in N/mm <sup>2</sup>	Perm. Flank Pressure $U_{Hlim}$ in N/mm <sup>2</sup>
Polyacetal resin	28 (VDI-2545)	40 (VDI-2545)
ZnAl4Cu1	60	150
Ms58 (2.0401)	100	250
11SMnPb30 (alt: 9SMn28K)	150	350
C45 normalized	200	590
42CrMo4 hardened	350	1360
16MnCr5 case hardened	400	1630
X10CrNiS18 9 (1.4305, stainless, austenitic)	200	400