KISSsoft Release 03/2015 F

KISSsoft evaluation

File

Name : CylGearPair 6 (Helical DIN3990)
Description: KISSsoft example
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CALCULATION OF A HELICAL GEAR PAIR

Drawing or article number:
Gear 1: 0.000.0
Gear 2: 0.000.0

Calculation method DIN 3990:1987 Method B

		------- GEAR 1	-------- GEAR 2 --
Power (kW)	[P]	12.500	
Speed (1/min)	[n]	2950.0	765.9
Torque (Nm)	[T]	40.5	155.9
Application factor	[KA]	1.25	
Required service life (h)	[H]	20000.00	
Gear driving (+) / driven (-)		+	-

Working flank gear 1: Right flank

1. TOOTH GEOMETRY AND MATERIAL

(geometry calculation according to DIN 3960:1987)

		------- GEAR 1	-------- GEAR 2 --
Center distance (mm)	[a]	101.845	
Centre distance tolerance	ISO 286:2010 Measure js7		
Normal module (mm)	[mn]	1.5000	
Pressure angle at normal section (°)	[alfn]	20.0000	
Helix angle at reference circle (°)	[beta]	14.0000	
Number of teeth	[z]	27	104
Facewidth (mm)	[b]	21.00	20.00
Hand of gear		left	right
Accuracy grade	[Q-DIN 3961:1978]	6	6
Inner diameter (mm)	[di]	0.00	146.39
Inner diameter of gear rim (mm)	[dbi]	0.00	0.00

Material

Gear 1:	31 CrMoV9, Nitriding steel, gas-nitrided		
	ISO 6336-5 Figure 13b/14b (MQ)		
Gear 2:	42 CrMo 4 (3), Through hardened steel, nitrided		
	ISO 6336-5 Figure 13a/14a (MQ)		

		------- GEAR 1	-------- GEAR 2 --
Surface hardness		HV 800	HV 550
Fatigue strength. tooth root stress (N/mm²)	[sigFlim]	425.00	370.00
Fatigue strength for Hertzian pressure (N/mm²)	[sigHlim]	1250.00	1000.00
Tensile strength (N/mm²)	[Rm]	1100.00	1100.00
Yield point (N/mm²)	[Rp]	900.00	900.00
Young's modulus (N/mm²)	[E]	206000	206000
Poisson's ratio	[ny]	0.300	0.300
Roughness average value DS, flank (µm)	[RAH]	3.00	3.00
Roughness average value DS, root (µm)	[RAF]	3.00	3.00
Mean roughness height, Rz, flank (µm)	[RZH]	20.00	20.00
Mean roughness height, Rz, root (µm)	[RZF]	20.00	20.00

Gear reference profile	1 :		
Reference profile	1.25 / 0.38 / 1.0 ISO 53.2:1997 Profil A		
Dedendum coefficient		[hfP*]	1.250
Root radius factor		[rhofP*]	0.380 (rhofPmax*= 0.472)
Addendum coefficient		[haP*]	1.000
Tip radius factor		[rhoaP*]	0.000
Protuberance height factor		[hprP*]	0.000
Protuberance angle		[alfprP]	0.000
Tip form height coefficient		[hFaP*]	0.000
Ramp angle		[alfKP]	0.000
		not topping	

Gear reference profile	2 :		
Reference profile	1.25 / 0.38 / 1.0 ISO 53.2:1997 Profil A		
Dedendum coefficient		[hfP*]	1.250
Root radius factor		[rhofP*]	0.380 (rhofPmax*= 0.472)
Addendum coefficient		[haP*]	1.000
Tip radius factor		[rhoaP*]	0.000
Protuberance height factor		[hprP*]	0.000
Protuberance angle		[alfprP]	0.000
Tip form height coefficient		[hFaP*]	0.000
Ramp angle		[alfKP]	0.000
		not topping	

Summary of reference profile gears:

Dedendum reference profile	[hfP*]	1.250	1.250
Tooth root radius Refer. profile	[rofP*]	0.380	0.380
Addendum Reference profile	[haP*]	1.000	1.000
Protuberance height factor	[hprP*]	0.000	0.000
Protuberance angle (°)	[alfprP]	0.000	0.000
Tip form height coefficient	[hFaP*]	0.000	0.000
Ramp angle (°)	[alfKP]	0.000	0.000
Type of profile modification:			
for high load capacity gearboxe			
Tip relief (µm)	[Ca]	5.0	5.0

Lubrication type		oil bath lubrication
Type of oil		Oil: Mobilgear 600 XP 150
Lubricant base		Mineral-oil base
Kinem. viscosity oil at 40 °C (mm²/s)	[nu40]	150.00
Kinem. viscosity oil at 100 °C (mm²/s)	[nu100]	14.70
FZG test A/8.3/90 (ISO 14635-1:2006)	[FZGtestA]	12
Specific density at 15 °C (kg/dm³)	[roOil]	0.890
Oil temperature (°C)	[TS]	70.000

		------- GEAR 1 --------	GEAR 2 --
Overall transmission ratio	[itot]	-3.852	
Gear ratio	[u]	3.852	
Transverse module (mm)	[mt]	1.546	
Pressure angle at pitch circle (°)	[alft]	20.562	
Working transverse pressure angle (°)	[alfwt]	21.425	
	[alfwt.e/i]	21.450 / 21.400	
Working pressure angle at normal section (°)	[alfwn]	20.838	
Helix angle at operating pitch circle (°)	[betaw]	14.078	
Base helix angle (°)	[betab]	13.140	
Reference centre distance (mm)	[ad]	101.258	
Sum of profile shift coefficients	[Summexi]	0.3994	
Profile shift coefficient	[x]	0.3255	0.0739
Tooth thickness (Arc) (module) (module)	[sn*]	1.8077	1.6246
Tip alteration (mm)	[k*mn]	-0.012	-0.012
Reference diameter (mm)	[d]	41.740	160.776
Base diameter (mm)	[db]	39.081	150.533
Tip diameter (mm)	[da]	45.692	163.973
(mm)	[da.e/i]	45.692 / 45.682	163.973 / 163.963
Tip diameter allowances (mm)	[Ada.e/i]	0.000 / -0.010	0.000 / -0.010
Tip form diameter (mm)	[dFa]	45.692	163.973
(mm)	[dFa.e/i]	45.692 / 45.682	163.973 /

163.963			
Active tip diameter (mm)	[dNa]	45.692	163.973
Active tip diameter (mm)	[dNa.e/i]	45.692 / 45.682	163.973 / 163.963
Operating pitch diameter (mm)	[dw]	41.982	161.708
(mm)	[dw.e/i]	41.989 / 41.975	161.736 / 161.680
Root diameter (mm)	[df]	38.966	157.247
Generating Profile shift coefficient	[xE.e/i]	0.2852/ 0.2669	0.0006/ -0.0452
Manufactured root diameter with xE (mm)	[df.e/i]	38.845 / 38.791	157.028 / 156.890
Theoretical tip clearance (mm)	[c]	0.375	0.375
Effective tip clearance (mm)	[c.e/i]	0.576 / 0.468	0.486 / 0.418
Active root diameter (mm)	[dNf]	40.193	158.852
(mm)	[dNf.e/i]	40.221 / 40.171	158.888 / 158.821
Root form diameter (mm)	[dFf]	40.081	158.171
(mm)	[dFf.e/i]	40.006 / 39.973	157.980 / 157.862
Reserve (dNf-dFf)/2 (mm)	[cF.e/i]	0.124 / 0.082	0.513 / 0.421
Addendum (mm)	[ha=mn*(haP*+x)]	1.976	1
.599			
(mm)	[ha.e/i]	1.976 / 1.971	1.599 / 1.594
Dedendum (mm)	[hf=mn*(hfP*-x)]	1.387	1
.764			
(mm)	[hf.e/i]	1.447 / 1.475	1.874 / 1.943
Roll angle at dFa (°)	[xsi_dFa.e/i]	34.709 / 34.681	24.746 / 24.736
Roll angle to dNa (°)	[xsi_dNa.e/i]	34.709 / 34.681	24.746 / 24.736
Roll angle to dNf (°)	[xsi_dNf.e/i]	13.943 / 13.626	19.353 / 19.272
Roll angle at dFf (°)	[xsi_dFf.e/i]	12.542 / 12.312	18.243 / 18.095
Tooth height (mm)	[H]	3.363	3
.363			
Virtual gear no. of teeth	[zn]	29.343	113
.025			
Normal-tooth thickness at tip circle (mm)	[san]	0.973	1
.218			
(mm)	[san.e/i]	0.931 / 0.903	1.141 / 1.086

Normal-tooth thickness on tip form circle (mm)	[sFan]	0.973		1.218
(mm)	[sFan.e/i]	0.931 /	0.903	1.141 / 1.086
Normal space width at root circle (mm)	[efn]	0.000		1.077
(mm)	[efn.e/i]	0.000 /	0.000	1.090 / 1.099
Max. sliding velocity at tip (m/s)	[vga]	1.622		1.157
Specific sliding at the tip	[zetaa]	0.444		0.444
Specific sliding at the root	[zetaf]	-0.798		-0.798
Mean specific sliding	[zetam]		0.444	
Sliding factor on tip	[Kga]	0.250		0.178
Sliding factor on root	[Kgf]	-0.178		-0.250
Pitch on reference circle (mm)	[pt]		4.857	
Base pitch (mm)	[pbt]		4.547	
Transverse pitch on contact-path (mm)	[pet]		4.547	
Lead height (mm)	[pz]	525.932		2025.813
Axial pitch (mm)	[px]		19.479	
Length of path of contact (mm)	[ga, e/i]	7.142 (	7.190 /	7.072)
Length T1-A, T2-A (mm)	[T1A, T2A]	4.695(4.647/	4.755)	32.508(32.508/ 32.495)
Length T1-B (mm)	[T1B, T2B]	7.290(7.290/	7.280)	29.912(29.864/ 29.970)
Length T1-C (mm)	[T1C, T2C]	7.668(7.658/	7.678)	29.535(29.497/ 29.573)
Length T1-D (mm)	[T1D, T2D]	9.242(9.194/	9.303)	27.960(27.960/ 27.948)
Length T1-E (mm)	[T1E, T2E]	11.837(11.837/	11.828)	25.365(25.317/ 25.423)
Length T1-T2 (mm)	[T1T2]	37.202 (	37.154 /	37.250)
Diameter of single contact point B (mm)	[d-B]	41.712(41.712/	41.705)	161.986(161.950/ 162.028)
Diameter of single contact point D (mm)	[d-D]	43.232(43.191/	43.283)	160.585(160.585/ 160.576)
Addendum contact ratio	[eps]	0.917(0.919/	0.913)	0.654(0.662/ 0.643)
Minimal length of contact line (mm)	[Lmin]		31.954	
Transverse contact ratio	[eps_a]		1.571	

Transverse contact ratio with allowances	[eps_a.e/m/i]	1.581 / 1.568 / 1.555
Overlap ratio	[eps_b]	1.027
Total contact ratio	[eps_g]	2.597
Total contact ratio with allowances	[eps_g.e/m/i]	2.608 / 2.595 / 2.582

2. FACTORS OF GENERAL INFLUENCE

		------- GEAR 1 -------- GEAR 2 --
Nominal circum. force at pitch circle (N)	[Ft]	1938.8
Axial force (N)	[Fa]	483.4
Radial force (N)	[Fr]	727.3
Normal force (N)	[Fnorm]	2126.4
Nominal circumferential force per mm (N/mm)	[w]	96.94
Only as information: Forces at operating pitch circle:		
Nominal circumferential force (N)	[Ftw]	1927.6
Axial force (N)	[Faw]	483.4
Radial force (N)	[Frw]	756.4
Circumferential speed reference circle (m/s)	[v]	6.45
Circumferential speed operating pitch circle (m/s)	[v(dw)]	6.48
Running-in value (µm)	[yp]	0.6
Running-in value (µm)	[yf]	0.4
Correction coefficient	[CM]	0.800
Gear body coefficient	[CR, bs/b, sr/mn]	0.933 (0.500, 3.619)
Reference profile coefficient	[CBS]	0.975
Material coefficient	[E/Est]	1.000
Singular tooth stiffness (N/mm/µm)	[c']	13.649
Meshing stiffness (N/mm/µm)	[cg]	19.491
Reduced mass (kg/mm)	[mRed]	0.00525
Resonance speed (min-1)	[nE1]	21549
Resonance ratio (-)	[N]	0.137
Subcritical range		
Running-in value (µm)	[ya]	0.6
Bearing distance l of pinion shaft (mm)	[l]	42.000
Distance s of pinion shaft (mm)	[s]	4.200
Outside diameter of pinion shaft (mm)	[dsh]	21.000
Load according to Figure 6.8, DIN 3990-1:1987 (0:6.8a, 1:6.8b, 2:6.8c, 3:6.8d, 4:6.8e)	[-]	4
Coefficient K' according to Figure 6.8, DIN 3990-1:1987	[K']	-1.00
Without support effect		
Tooth trace deviation (active) (µm)	[Fby]	4.65
from deformation of shaft (µm)	[fsh*B1]	0.40
(fsh (µm) = 0.80, B1= 0.50, fHb5 (µm) = 6.00)		

Tooth trace: width-crowned [Cbeta = 0.5*(fma+fsh)]			
Position of Contact pattern: favorable			
from production tolerances (µm) (B2= 0.50)	[fma*B2]		4.50
Tooth trace deviation, theoretical (µm)	[Fbx]		5.47
Running-in value (µm)	[yb]		0.82
Dynamic factor	[KV]		1.063
Face load factor - flank	[KHb]		1.351
- Tooth root	[KFb]		1.284
- Scuffing	[KBb]		1.351
Transverse load factor - flank	[KHa]		1.069
- Tooth root	[KFa]		1.069
- Scuffing	[KBa]		1.069
Helical load factor scuffing	[Kbg]		1.240
Number of load cycles (in mio.)	[NL]	3540.000	919.038

3. TOOTH ROOT STRENGTH

Calculation of Tooth form coefficients according method: B

		------- GEAR 1 --------	GEAR 2 --
Calculated with manufacturing profile shift	[xE.e]	0.29	0.00
Tooth form factor	[YF]	1.20	1.35
Stress correction factor	[YS]	2.19	2.12
Working angle (°)	[alfFen]	21.30	20.27
Bending lever arm (mm)	[hF]	1.43	1.74
Tooth thickness at root (mm)	[sFn]	3.27	3.40
Tooth root radius (mm)	[roF]	0.70	0.69

(hF* = 0.953/ 1.162 sFn* = 2.177/ 2.268 roF* = 0.466/ 0.459 dsFn = 39.393/ 157.625 alfsFn = 30.00/ 30.00)

Contact ratio factor	[Yeps]		1.000
Helix angle factor	[Ybet]		0.883
Effective facewidth (mm)	[beff]	21.00	20.00
Nominal stress at tooth root (N/mm²)	[sigF0]	142.75	163.89
Tooth root stress (N/mm²)	[sigF]	260.31	298.87
Permissible bending stress at root of Test-gear			
Notch sensitivity factor	[YdrelT]	0.993	0.999
Surface factor	[YRrelT]	0.990	0.990

size factor (Tooth root)	[YX]	1.000		1.000
Finite life factor	[YNT]	1.000		1.000
	[YdrelT*YRrelT*YX*YNT]	0.983		0.989
Alternating bending factor (mean stress influence coefficient)				
	[YM]	1.000		1.000
Stress correction factor	[Yst]		2.00	
Yst*sigFlim (N/mm²)	[sigFE]	850.00		740.00
Permissible tooth root stress (N/mm²)	[sigFP=sigFG/SFmin]	642.62		562.78
Limit strength tooth root (N/mm²)	[sigFG]	835.41		731.62
Required safety	[SFmin]	1.30		1.30
Safety for Tooth root stress	[SF=sigFG/sigF]	3.21		2.45
Transmittable power (kW)	[kWRating]	30.86		23.54

4. SAFETY AGAINST PITTING (TOOTH FLANK)

		------- GEAR 1	-------- GEAR 2 --	
Zone factor	[ZH]		2.379	
Elasticity coefficient (√N/mm)	[ZE]		189.812	
Contact ratio factor	[Zeps]		0.798	
Helix angle factor	[Zbet]		0.985	
Effective facewidth (mm)	[beff]		20.00	
Nominal flank pressure (N/mm²)	[sigH0]		607.16	
Surface pressure at operating pitch circle (N/mm²)				
	[sigHw]		841.26	
Single tooth contact factor	[ZB,ZD]	1.00		1.00
Flank pressure (N/mm²)	[sigHB, sigHD]	841.26		841.26
Lubrication coefficient at NL	[ZL]	0.988		0.988
Speed coefficient at NL	[ZV]	0.981		0.981
Roughness coefficient at NL	[ZR]	0.797		0.797
Work hardening factor at NL	[ZW]	1.000		1.000
Finite life factor	[ZNT]	1.000		1.000
	[ZL*ZV*ZR*ZNT]	0.772		0.772
Small no. of pittings permissible:	no			
Size factor (flank)	[ZX]	1.000		1.000
Permissible surface pressure (N/mm²)	[sigHP=sigHG/SHmin]	1016.23		812.99
Limit strength pitting (N/mm²)	[sigHG]	965.42		772.34
Required safety	[SHmin]	0.95		0.95
Safety for surface pressure at operating pitch circle				
	[SHw]	1.15		0.92
Safety for stress at single tooth contact	[SHBD=sigHG/sigHBD]	1.15		0.92
(Safety regarding transmittable torque)	[(SHBD)^2]	1.32		0.84
Transmittable power (kW)	[kWRating]	18.24		11.67

4b. MICROPITTING ACCORDING TO ISO/TR 15144-1:2014

Calculation of permissible specific film thickness

Lubricant load according to FVA Info sheet 54/7		10	(Oil: Mobilgear 600 XP 150)
Reference data FZG-C Test:			
Torque (Nm)	[T1Ref]	265.1	
Line load at contact point A (N/mm)	[FbbRef,A]	236.3	
Oil temperature (°C)	[theOilRef]	90.0	
Tooth mass temperature (°C)	[theMRef]	128.0	
Contact temperature (°C)	[theBRef,A]	253.8	
Lubrication gap thickness (µm)	[hRef,A]	0.043	
Specific film thickness in test (µm)	[lamGFT]	0.085	
Material coefficient	[WW]	1.00	
Permissible specific film thickness (µm)	[lamGFP]	0.120	

Interim results in accordance with ISO/TR 15144:2014

Coefficient of friction	[mym]	0.106	
Lubricant factor	[XL]	1.000	
Roughness factor	[XR]	1.831	
Tooth mass temperature (°C)	[theM]	73.3	
Tip relief factor	[XCa (A)]	1.817	
Loss factor	[HV]	0.105	
Equivalent Young's modulus (N/mm²)	[Er]	226374	
Compressed viscosity index (m2/N)	[alf38]	0.02052	
Dynamic viscosity (Ns/m2)	[etatM]	28.6	
Roughness average value (µm)	[Ra]	3.0	
Calculation of speeds, load distribution and flank curvature according to method B following ISO/TR 15144-1:2014			
Ca taken as optimal in the calculation (0=no, 1=yes)		1	1
Calculation at point (0:A, 1:AB, 2:B, 3:C, 4:D, 5:DE, 6:E, -1:No Point)		1	
Diameter (mm)	[dy]	40.877	162.962
Relative radius of curvature (mm)	[pred]	5.162	
Flank pressure (N/mm²)	[pH]	759.796	
Flank pressure (N/mm²)	[pdyn]	1052.759	
Minimal specific film thickness (µm)	[lamGFY]	0.067	(hY=0.200 µm)
Safety against micropitting	[Slam(B)]	0.557	

(For intermediate results refer to file: Micropitting_12.tmp)

5. STRENGTH AGAINST SCUFFING

Calculation method according to

DIN 3990:1987

Lubrication coefficient (for lubrication type)	[XS]	1.000	
Relative structure coefficient (Scuffing)	[XWrelT]	1.500	
Thermal contact factor (N/mm/s^.5/K)	[BM]	13.780	13.780
Relevant tip relief (µm)	[Ca]	5.00	5.00
Optimal tip relief (µm)	[Ceff]	6.22	
Ca taken as optimal in the calculation (0=no, 1=yes)		1	1
Effective facewidth (mm)	[beff]	20.000	
Applicable circumferential force/facewidth (N/mm)	[wBt]	230.707	
Angle factor (ε1:0.917, ε2:0.654)	[Xalfbet]	0.993	

Flash temperature-criteria		
Tooth mass temperature (°C)	[theM-B]	83.48
theM-B = theoil + XS*0.47*theflamax	[theflamax]	28.68
Scuffing temperature (°C)	[theS]	522.88
Coordinate gamma (point of highest temp.) [Gamma.A]=-0.388 [Gamma.E]=0.544	[Gamma]	0.277
Highest contact temp. (°C)	[theB]	112.16
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.058
Geometry factor	[XB]	0.128
Load sharing factor	[XGam]	0.819
Dynamic viscosity (mPa*s)	[etaM]	20.37 (83.5 °C)
Coefficient of friction	[mym]	0.116
Required safety	[SBmin]	2.000
Safety factor for scuffing (flash temperature)	[SB]	10.740

Integral temperature-criteria		
Tooth mass temperature (°C)	[theM-C]	79.83
theM-C = theoil + XS*0.70*theflaint	[theflaint]	14.04
Integral scuffing temperature (°C)	[theSint]	522.88
Flash factor (°K*N^-.75*s^.5*m^-.5*mm)	[XM]	50.058
Contact ratio factor	[Xeps]	0.244
Dynamic viscosity (mPa*s)	[etaOil]	32.33 (70.0 °C)
Mean coefficient of friction	[mym]	0.111
Geometry factor	[XBE]	0.236
Meshing factor	[XQ]	1.000
Tip relief factor	[XCa]	1.068
Integral tooth flank temperature (°C)	[theint]	100.88
Required safety	[SSmin]	1.800
Safety factor for scuffing (intg.-temp.)	[SSint]	5.183
Safety referring to transferred torque	[SSL]	14.665

6. MEASUREMENTS FOR TOOTH THICKNESS

		------- GEAR 1 --------	GEAR 2 --
Tooth thickness deviation		DIN 3967 d24	DIN 3967 d25
Tooth thickness allowance (normal section) (mm)	[As.e/i]	-0.044 / -0.064	-0.080 / -0.130
Number of teeth spanned	[k]	4.000	13.000
Base tangent length (no backlash) (mm)	[Wk]	16.451	57.809
Actual base tangent length ('span') (mm)	[Wk.e/i]	16.410 / 16.391	57.734 / 57.687
(mm)	[ΔWk.e/i]	-0.041 / -0.060	-0.075 / -0.122
Diameter of contact point (mm)	[dMWk.m]	42.218	160.682
Theoretical diameter of ball/pin (mm)	[DM]	2.713	2.527
Eff. Diameter of ball/pin (mm)	[DMeff]	2.750	2.750
Theor. dim. centre to ball (mm)	[MrK]	23.341	82.625
Actual dimension centre to ball (mm)	[MrK.e/i]	23.294 / 23.273	82.522 / 82.458
Diameter of contact point (mm)	[dMMr.m]	42.672	161.251
Diametral measurement over two balls without clearance (mm)	[MdK]	46.607	165.251
Actual dimension over balls (mm)	[MdK.e/i]	46.514 / 46.471	165.045 / 164.916
Diametral measurement over rolls without clearance (mm)	[MdR]	46.681	165.251
Actual dimension over rolls (mm)	[MdR.e/i]	46.588 / 46.545	165.045 / 164.916
Chordal tooth thickness (no backlash) (mm)	['sn]	2.710	2.437
Actual chordal tooth thickness (mm)	['sn.e/i]	2.666 / 2.646	2.357 / 2.307
Reference chordal height from da.m (mm)	[ha]	2.015	1.605
Tooth thickness (Arc) (mm)	[sn]	2.712	2.437
(mm)	[sn.e/i]	2.668 / 2.648	2.357 / 2.307
Backlash free center distance (mm)	[aControl.e/i]	101.680 / 101.587	
Backlash free center distance, allowances (mm)	[jta]	-0.165 / -0.258	
dNf.i with aControl (mm)	[dNf0.i]	39.884	158.402
Reserve (dNf0.i-dFf.e)/2 (mm)	[cF0.i]	-0.061	0.211
Tip clearance	[c0.i(aControl)]	0.227	0.177
Centre distance allowances (mm)	[Aa.e/i]	0.018 / -0.018	
Circumferential backlash from Aa (mm)	[jtw_Aa.e/i]	0.014 / -0.014	
Radial clearance (mm)	[jrw]	0.276 / 0.147	
Circumferential backlash (transverse section) (mm)	[jtw]	0.215 / 0.115	
Rotation angle when gear 1 is fixed (°)		0.1522 / 0.0814	
Normal backlash (mm)	[jnw]	0.196 / 0.105	

7. GEAR ACCURACY

		------- GEAR 1 --------	GEAR 2 --

According to DIN 3961:1978			
Accuracy grade	[Q-DIN3961]	6	6
Profile form deviation (µm)	[ff]	6.00	6.00
Profile slope deviation (µm)	[fHa]	5.00	5.00
Total profile deviation (µm)	[Ff]	8.00	8.00
Helix form deviation (µm)	[fbf]	5.50	4.00
Helix slope deviation (µm)	[fHb]	9.00	8.00
Total helix deviation (µm)	[Fb]	10.00	9.00
Normal base pitch deviation (µm)	[fpe]	7.00	8.00
Single pitch deviation (µm)	[fp]	7.00	8.00
Adjacent pitch difference (µm)	[fu]	8.00	10.00
Total cumulative pitch deviation (µm)	[Fp]	19.00	29.00
Sector pitch deviation over z/8 pitches (µm)	[Fpz/8]	12.00	18.00
Runout (µm)	[Fr]	14.00	19.00
Tooth Thickness Variation (µm)	[Rs]	8.00	11.00
Single flank composite, total (µm)	[Fi']	22.00	30.00
Single flank composite, tooth-to-tooth (µm)	[fi']	10.00	11.00
Radial composite, total (µm)	[Fi"]	17.00	24.00
Radial composite, tooth-to-tooth (µm)	[fi"]	6.00	10.00

According to DIN 58405:1972 (Feinwerktechnik):		
Tooth-to-tooth composite error (µm)	[fi"]	7.00	9.00
Composite error (µm)	[Fi"]	20.00	25.00
Axis alignment error (µm)	[fp]	17.31	17.31
Flank direction error (µm)	[fbeta]	5.00	5.00
Runout (µm)	[Trk, Fr]	21.00	28.00

Axis alignment tolerances (recommendation acc. ISO TR 10064:1992, Quality 6)		
Maximum value for deviation error of axis (µm)	[fSigbet]	11.55 (Fb= 11.00)
Maximum value for inclination error of axes (µm)	[fSigdel]	23.10

8. ADDITIONAL DATA

Maximal possible centre distance (eps_a=1.0)	[aMAX]	102.821	
Weight - calculated with da (kg)	[Mass]	0.270	0.671
Total weight (kg)	[Mass]	0.941	

Moment of inertia (System referenced to wheel 1):			
calculation without consideration of the exact tooth shape			
single gears ((da+df)/2...di) (kg*m²)	[TraeghMom]	5.145e-005	0.003132
System ((da+df)/2...di) (kg*m²)	[TraeghMom]	0.0002626	
Torsional stiffness (MNm/rad)	[cr]	0.1	2.2
Mean coeff. of friction (acc. Niemann)	[mum]	0.108	
Wear sliding coef. by Niemann	[zetw]	0.697	
Gear power loss (kW)	[PVZ]	0.141	

(Meshing efficiency (%) [etaz] 98.869)

Indications for the manufacturing by wire cutting:

Deviation from theoretical tooth trace (µm)	[WireErr]	148.8	38.7
Permissible deviation (µm)	[Fb/2]	5.0	4.5

9. DETERMINATION OF TOOTH FORM

Profile and tooth trace modifications for gear 1

Symmetric (both flanks)

- Tip relief, linear Caa = 5.000µm LCa = 0.865*mn dCa = 44.408mm

Profile and tooth trace modifications for gear 2

Symmetric (both flanks)

- Tip relief, linear Caa = 5.000µm LCa = 0.865*mn dCa = 162.966mm

Data for the tooth form calculation :
Data not available.

10. SERVICE LIFE, DAMAGE

Required safety for tooth root	[SFmin]	1.30	
Required safety for tooth flank	[SHmin]	0.95	

Service life (calculated with required safeties):

System service life (h)	[Hatt]	35.754	
Tooth root service life (h)	[HFatt]	1e+006	1e+006
Tooth flank service life (h)	[HHatt]	1e+006	35.75

Note: The entry 1e+006 h means that the Service life > 1,000,000 h.

Damage calculated on basis of required service life

[H] (20000.0 h)

F1%	F2%	H1%	H2%
0.00	0.00	0.00	9999.99

Damage calculated on basis of system service life

[Hatt] (35.8 h)

F1%	F2%	H1%	H2%
0.00	0.00	0.00	100.00

REMARKS:

- Specifications with [.e/i] imply: Maximum [e] and Minimal value [i] with consideration of all tolerances
  Specifications with [.m] imply: Mean value within tolerance
- For the backlash tolerance, the center distance tolerances and the tooth thickness deviation are taken into account. Shown is the maximal and the minimal backlash corresponding the largest resp. the smallest allowances
  The calculation is done for the Operating pitch circle..
- Details of calculation method:
  cg according to method B
  KV according to method B
  KHb, KFb according method C
  KHa, KFa according to method B

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