KISSsoft Release 03/2015 F

KISSsoft evaluation

File

Name : WormGear 1 (DIN3996, Example 1)
Description: KISSsoft example
Changed by: kspl on: 07.03.2016 at: 10:50:47

WORM GEAR ANALYSIS

Drawing or article number:
Worm: 0.000.0
Gear: 0.000.0

Calculation method DIN 3996:2012
(Geometry: DIN 3975:2002)
Geometry calculation from axial module

		------- WORM	---------- WHEEL ----
Power (kW)	[P]	4.500	
Worm driving			
Power (kW)	[P]	5.302	4.500
Speed (1/min)	[n]	1500.0	73.2
Torque (Nm)	[T]	33.754	587.282
Application factor	[KA]	1.00	
Required service life	[H]	25000.00	
Number of starts (1/h)	[Ns]	0.00	

1. TOOTH GEOMETRY AND MATERIAL

Shape of flank: ZI (ISO/DTR 10828.2:2011)

		------- WORM	---------- WHEEL ----
Center distance (mm)	[a]	100.000	
Centre distance tolerance		ISO 286:2010 Measure js7	
Shaft angle (°)	[Sigma]	90.0000	
Transverse module (mm)	[mt]		4.0000
Normal module (mm)	[mn]	3.9047	
Axial module (mm)	[mx]	4.0000	
Pressure angle at normal section (°)	[alfn]	20.0000	
Mean lead angle (°)	[gamma]	12.5288	
Hand of gear		left	left
Number of teeth	[z]	2	41

Facewidth (mm)	[b1]	60.00	
Wheel rim width b2R (mm)	[b2R]		31.00
Wheel width b2H (mm)	[b2H]		31.00
Facewidth for calculation (mm)	[b1, b2]	60.00	30.83
Accuracy grade (manufacturing)	[Vqual]	6	7
Internal diameter gearbody (mm)	[di]	0.00	134.40

Material

Worm: 16 MnCr 5 (1), Case-carburized steel, case-hardened
ISO 6336-5 Figure 9/10 (MQ), core strength >=25HRC Jominy
J=12mm<HRC28

Gear 2: CuSn12Ni2-C-GZ, Bronze, untreated
DIN 3996:2005

		------- WORM	---------- WHEEL ----
Surface hardness		HRC 59	HBW 95
Pulsating shear strength (N/mm²)	[tauFlim]	430.00	90.00
Fatigue strength for Hertzian pressure (N/mm²)	[sigHlim]	1500.00	520.00
Material Coefficient YW	[YW]		0.95
Material lubrication coefficient	[WML_PolyG]		1.75
Tensile strength (N/mm²)	[Rm]	1000.00	300.00
Yield point (N/mm²)	[Rp]	695.00	180.00
Young's modulus (N/mm²)	[E]	206000	98100
Poisson's ratio	[ny]	0.300	0.350
Roughness average value DS, flank (µm)	[RAH]	0.50	2.00
Roughness average value DS, root (µm)	[RAF]	0.50	2.00
Mean roughness height, Rz, flank (µm)	[RZH]	3.00	8.00
Mean roughness height, Rz, root (µm)	[RZF]	3.00	8.00

Gear reference profile	1 :		
Reference profile	1.20 / 0.20 / 1.0 DIN 867:1986		
Dedendum coefficient		[hfP*]	1.200
Root radius factor		[rhofP*]	0.200 (rhofPmax*= 0.498)
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	1.20 / 0.20 / 1.0 DIN 867:1986		
Dedendum coefficient		[hfP*]	1.200

Root radius factor	[rhofP*]	0.200 (rhofPmax*= 0.498)
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*]	1.200	1.200
Tooth root radius Refer. profile	[rofP*]	0.200	0.200
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:

none (only running-in)

Tip relief (µm)	[Ca]	0.0	0.0

Lubrication type	oil bath lubrication	
Type of oil (Own input)	ÖI: ISO-VG 220	
Lubricant base	Synthetic oil based on Polyglycol	
Kinem. viscosity oil at 40 °C (mm²/s)	[nu40]	220.00
Kinem. viscosity oil at 100 °C (mm²/s)	[nu100]	37.00
FZG test A/8.3/90 (ISO 14635-1:2006)	[FZGtestA] 13	
Specific density at 15 °C (kg/dm³)	[roOil]	1.020
Oil temperature (°C)	[TS]	73.226
Ambient temperature (°C)	[TU]	20.000

		------- WORM---------- WHEEL ----
Generating angle (°)	[alfa0]	20.000
Pressure angle at normal section (°)	[alfn]	20.000

Indications for the manufacture of the worm wheel according to ISO 14521:
(Only valid for worm wheels which are manufactured with a hob similar to the worm.)

Mean lead angle of the worm (°)	[gamma]	12.5288
Transverse module (mm)	[mt]	4.0000
Reference diameter (mm)	[d]	164.000
Reference operating diameter (mm)	[dm]	164.000
Throat radius (mm)	[rk]	14.000
Throat center distance (mm)	[a_rk]	100.000

Facewidth chamfer angle (mm)	[theta]		0.000
Chamfering center distance (mm)	[a_theta]		100.000
External diameter (mm)	[de]		181.410
Tip diameter (mm)	[da]		172.000
Profile shift coefficient	[x-worm]		0.0000
Pitch on reference circle (mm)	[p2]		12.566

Indications for the manufacture of the worm wheel as a cylindrical gear
(This specification is only a suggestion. It is necessary to do a calculation of the exact geometry using the crossed-helical calculation!)

Pressure angle at Transverse section (°)	[alft]	(59.205)	20.448
Pressure angle at axial section (°)	[alfx]	(20.448)	59.205
Helix angle at reference circle (°)	[beta]	(77.471)	12.529
Lead angle at reference diameter (°)	[gamma]	(12.529)	77.471
Transverse module (mm)	[mt]	(18.000)	4.000
Axial module (mm)	[mx]	(4.000)	18.000
Helix angle at operating pitch circle (°)	[betas]	(77.471)	12.529
Operating pitch diameter (mm)	[dw]	(36.000)	164.000
Profile shift coefficient	[x-DIN3960]	(0.0000)	0.0000

Overall transmission ratio	[itot]	-20.500	
Gear ratio	[u]	20.500	
Base helix angle (°)	[betab]		11.762
Reference centre distance (mm)	[ad]	100.000	
Diametral factor q	[q]	9.000	
Sum of profile shift coefficients	[Summexi]	0.0000	
Profile shift coefficient	[x-worm]	0.0000	0.0000
Profile shift (x*m) (mm)	[x*mx]	0.0000	0.0000

(The profile shift is related to the axial module of the worm subject to ISO TR 14521:2010/DIN 3975:2002.)

Tip alteration (mm)	[k*mn]	0.000	0.000
Theoretical tip clearance (mm)	[c]	0.800	0.800
Effective tip clearance (mm)	[c.e/i]	1.059/ 0.963	0.877/ 0.782
Reference operating diameter (mm)	[dm]	36.000	164.000
Reference diameter (mm)	[d]		164.000
Base diameter (mm)	[db]		153.666
Tip diameter (mm)	[da]	44.000	172.000
Tip form diameter (mm)	[dFa]	44.000	172.000
(mm)	[dFa.e/i]	44.000/ 43.990	172.000/ 171.990
Tip diameter allowances (mm)	[Ada.e/i]	0.000/ -0.010	0.000/ -0.010
Root diameter (mm)	[df]	26.400	154.400
Generating Profile shift coefficient	[xE.e/i]		-0.0450/ -0.0591
Manufactured root diameter with xE (mm)	[df.e/i]	26.400/ 26.290	154.040/ 153.927

Lead height (mm)	[pz]	25.133	

Axial pitch (mm)	[px]	12.566
Transverse contact ratio (approximate value following Thomas-Charchut)	[eps_a]	1.911
For ZI-worms:		
Base diameter (mm)	[db]	18.431
Base lead angle (°)	[gamb]	23.463
Base pitch (mm)	[pb]	11.527

2. FACTORS OF GENERAL INFLUENCE

		------- WORM	---------- WHEEL ----
Nominal circum. force at pitch circle (N)	[Ft]	1875.2	7162.0
Axial force (N)	[Fa]	-7162.0	-1875.2
Radial force (N)	[Fr]	2847.3	-2847.3
Normal force (N)	[Fn]	8343.7	
Circumferential speed reference circle (m/s)	[v]	2.827	0.628
Sliding velocity an mean circle (m/s)	[vgm]	2.896	
Number of load cycles (in mio.)	[NL]	2249.999	109.756
Data of reference gearbox:			
Equivalent Young's modulus (N/mm²)	[EredT]	150622.00	
Surface roughness of worm (µm)	[RaT]	0.500	
Center distance (mm)	[aT]	100.000	
Transmission ratio	[uT]	20.500	
Reference operating diameter (mm)	[dm1T]	36.000	164.000
Characteristic value for mean Hertzian pressure	[pmT*]	0.962	
Characteristic value for mean lubricant gap thickness	[hT*]	0.070	
Characteristic value for mean sliding path	[sT*]	30.800	
Physical characteristic values:			
Characteristic value for mean lubrication Space width	[h*]	0.0692	
Characteristic value for mean Hertzian pressure	[pm*]	0.9470	
Characteristic value for mean sliding path	[s*]	30.2850	
Efficiency according method C:			
Rolling bearing with set support			
Bearing loss-power (kW)	[PVLP]	0.126	
Number of sealings (worm-shaft)	[nVD]	2	
Sealing power loss (kW)	[PVD]	0.046	
Idle power loss (kW)	[PV0]	0.153	
Base friction number	[muOT]	0.0245	
Size factor	[YS]	1.000	
Geometry factor	[YG]	1.006	
Roughness factor	[YR]	1.000	

Material Coefficient YW	[YW]	0.950
Mean tooth friction number	[muzm]	0.0234
Tooth friction angle (°)	[roz]	1.341
Meshing efficiency (%)	[etaz]	90.002
Meshing power loss (kW)	[PVZ]	0.477
Total power loss (kW)	[PV]	0.802
Total efficiency (%)	[etaGes]	84.872

Wheel bulk temperature:		
Lubrication type	oil bath lubrication	
Worm submerges into lubricant		
Cooling area of wheel-pair (cm²)	[AR]	50.840
Heat-transfer coefficient wheels (W/m²/K)	[alfL]	24439.990
Wheel bulk temperature (°C)	[theM]	77.1
Oil sump temperature (°C)	[theS]	73.2

3. WEAR SUPPORT CAPABILITY ACCORDING METHOD B,C

Mean lubricant gap thickness (µm)	[hminm]	0.2480
(hminm calculated with etaOM= 0.0642 Ns/m2 theM=77.1°)		
Pressure factor	[WH]	1.0000
Factor for lubricant structure	[WS]	2.6140
Factor for start	[WNS]	1.0000
Characteristic value	[Kw]	0.6484
Wear intensity	[JOT]	5.10181e-010
Wear intensity	[Jw]	8.92817e-010
Wear path (m)	[sWm]	815829
Wear removal (mm)	[delWn]	0.728
Permissible tooth thickness reduction (coefficient in module)	[DeltaS]	0.300
Permissible mass decrease (kg)		
Normal-tooth thickness at tip circle (mm)	[san]	2.907
(mm) [san.e/i]		2.778/ 2.731
Permissible wear on flanc (mm)	[delWlimn]	1.171
Limited by: Permissible tooth thickness decrease		
Safety against wear	[SW]	1.608
Required safety	[SWmin]	1.100
As information:		
Achievable service life (with SW = 1.100) (h)	[Lh]	36551.07

4.PITTING SUPPORT CAPABILITY ACCORDING METHOD B,C

		------- WORM---------- WHEEL ----
Equivalent Young's modulus (N/mm²)	[Ered]	149673.38

Mean flank pressure (N/mm²)	[sigHm]	367.36	
Life coefficient	[Zh]		1.000
Speed factor	[ZV]		0.851
Size factor	[ZS]		1.000
Lubrication factor	[Zoil]		1.000
Ratio factor	[Zu]		1.000
Boundary value of average flank pressure (N/mm²)	[sigHG]		442.766
Safety for surface pressure on flank	[SH]		1.205
Required safety	[SHmin]		1.000
As information:			
Achievable service life (with SHmin = 1.000) (h)	[Lh]	76640.67	

5. BENDING SAFETY

Bearing distance l1 (mm)	[l1]	150.000
Distance l11 (mm)	[l11]	75.000
Deflection (mm)	[delm]	0.030
Boundary value bending (mm)	[dellim]	0.080
Safety for bending	[Sdel]	2.632
Required safety	[Sdelmin]	1.000

6. TOOTH ROOT SUPPORT CAPABILITY ACCORDING METHOD C

		------- WORM---------- WHEEL ----
Calculation taking into account the decrease of the tooth thickness due to wear (with minimum (delWn, delWlimn))		
Tooth thickness at root (mm)	[sft2]	9.663
Tooth form factor	[YF2]	1.200
Contact ratio factor	[Yeps]	0.500
Lead coefficient	[Ygam]	1.024
Rim thickness (mm)	[sk2]	10.000
Rim thickness coefficient	[YK2]	1.000
Nominal shear stress at tooth root (N/mm²)	[tauF2]	35.51
No Quality reduction by small plastic deformation is accepted.		
Life coefficient	[YNL]	1.000
Boundary value of shear stress at tooth root (N/mm²)	[tauFG]	90.00
Safety for Tooth root stress	[SF]	2.534
Required safety	[SFmin]	1.100

7. TEMPERATURE SAFETY ACCORDING METHOD C

Housing with cooler		
Ambient temperature (°C)	[TU]	20.0

Oil temperature (°C)	[theOil]	73.2
Boundary value oil temperature (°C)	[theSlim]	100.0
Temperature safety	[ST=theSlim/theOil]	1.366
Required safety	[STmin]	1.100
Oil sump temperature (°C)	[theS]	73.2
(Safety	[theSlim/theS]	1.366)

8. ALLOWANCES FOR TOOTH THICKNESS

Tooth thickness deviation

Worm:	Own Input
Gear:	Own Input

		------- WORM	---------- WHEEL ----
Tooth thickness allowance (normal section) (mm)	[As.e/i]	0.000/ -0.040	-0.128/ -0.168
Backlash free center distance (mm)	[aControl]	99.820/ 99.707	
Backlash free center distance, allowances (mm)	[jta]	-0.180/ -0.293	
Number of teeth spanned	[k]		5.000
Base tangent length (mm)	[Wk]		54.275
Actual base tangent length ('span') (mm)	[Wk.e/i]		54.155/ 54.117
Diameter of contact point (mm)	[dMWk.m]		162.549

Base tangent length (span): Can only be measured, if the worm-wheel is manufactured like a cylindrical gear!

Theoretical diameter of ball/pin (mm)	[dm]	6.545		6.615
Eff. Diameter of ball/pin (mm)	[DMeff]	7.000		7.000
Radial one ball mass (mm)	[MrK]			87.190
Actual dimension centre to ball (mm)	[MrK.e/i]			87.034/ 86.985
Diameter of contact point (mm)	[dMMr.m]	37.166		164.455
Diametral two ball measure (mm)	[MdK]			174.257
Actual dimension over balls (mm)	[MdK.e/i]			173.946/ 173.848
Theoretical dim. over 3 wires (mm)	[Md3R]	46.559		
Actual diametral dimensions over 3 rolls (mm)	[Md3R.e/i]	46.559/ 46.452		
Normal tooth thickness (chord) in the reference circle (mm)				
	['sn]	6.133		6.132
(mm)	['sn.e/i]	6.133/ 6.093		6.004/ 5.964
Tooth thickness in the transverse section (chord) in the reference circle (mm)				
	['st]			6.282
(mm)	['st.e/i]			6.151/ 6.110
Tooth thickness in the transverse section (Arc) (mm)	[st]			6.283
(mm)	[st.e/i]			6.152/ 6.111
Tooth thickness on axial cut (mm)	[smx]	6.283		

(mm)	[smx.e/i]	6.283/ 6.242		
Tooth space in axial cut (mm)	[emx]	6.283		
(mm)	[emx.e/i]	6.283/ 6.324		
Reference chordal height from da.m (mm)	[ham1, ha2]	3.997		4.052

Centre distance allowances (mm)	[Aa.e/i]	0.018/ -0.018
Circumferential backlash (transverse section) (mm)	[jt]	0.226/ 0.118
Normal backlash (mm)	[jn]	0.207/ 0.108

9. GEAR ACCURACY

		------- WORM	---------- WHEEL ----
According to DIN 3974:1995:			
Accuracy grade	[Vqual]	6	7
Single pitch deviation (µm)	[fpx, fp2]	8.50	13.00
Adjacent pitch difference (µm)	[fux, fu2]	11.00	16.00
Total deviation of the slope (µm)	[Fpz]	11.00	
Total cumulative pitch deviation (µm)	[Fp2]		51.00
Profile slope deviation (µm)	[fHa]	7.50	11.00
Profile form deviation (µm)	[ffa]	11.00	15.00
Total profile deviation (µm)	[Fa]	13.00	19.00
Runout (µm)	[Fr]	18.00	35.00
Single flank composite, total (µm)	[Fi']	29.00	56.00
Single flank composite, tooth-to-tooth (µm)	[fi']	15.00	22.00

10. ADDITIONAL DATA

Weight - calculated with da (kg)	[Mass]	0.714	2.455
Start under load:			
Tooth friction number (acc. Niemann)	[muzm_S]	0.140	
Torque (Nm)	[T1_S]	48.195	587.282

11. SERVICE LIFE, DAMAGE

Required safety for tooth root	[SFmin]	1.10
Required safety for tooth flank	[SHmin]	1.00

Service life (calculated with required safeties):

System service life (h)	[Hatt]	36551

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

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

Damage calculated on basis of required service life

[H] (25000.0 h)

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

Damage calculated on basis of system service life

[Hatt] (36551.1 h)

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

REMARKS:

- Specifications with [.e/i] imply: Maximum [e] and Minimal value [i] with consideration of all tolerances
- The specification of circumferential backlash (as well as the backlash-free distance for the tooth thickness check) is not yet fully checked, and serves only as a guide.
- The details of the chordal tooth thickness are imprecise and merely an indication (The calculation is done according to ISO TR 14521:2010/DIN 3975:2002, without taking into account the exact shape of flank.).
- In ISO14521 and DIN3996, the necessary data for each material are not always complete. In such a case you get the message: "Not calculated (material data missing)'

End of Report lines: 425