

KISSsoft-Hirnware LZ0
 File name :
 Z:/JohnDeere_S/2009_07_20_2Synchro_Gearbox/Analysis/KISS/synchro-djh-5sat-ET_ContactBend.Z14
 Project :
 Date : 25.01.2011/07:13:44 User : example
 Description : No.:

Important hint: At least one warning has occurred during the calculation:

1-> Mesh gear 1 - 2 :
 The face load coefficient is very high.
 The rough calculation according DIN 3990 results sometimes in too high values. An accurate calculation of the bending should be made with the KISSsoft shaft module.

CYLINDRICAL GEAR CALCULATION (Planetary gears)

Drawing or article number:
 Gear 1: 0.000.0
 Gear 2: 0.000.0
 Gear 3: 0.000.0

Calculation-method ISO 6336 Method B (YF Method C)

		----- Gear 1 -----	Gear 2 -----	Gear 3 ---
Number of planets/intermediate wheels	[No.wheel]	(1)	5	(1)
Nominal power (kW)	[P]		218.74	
Speed (UpM)	[n]	1299.7	-1474.7	0.0
Speed Pl.-Carrier (1/min)	[nSteg]		404.4	
Torque (Nm)	[T]	1607.2	0.0	3558.7
Torque Pl.-Carrier (Nm)	[TSteg]		5165.840	
Application factor	[KA]		1.20	
Power distribution factor	[Kgam]		1.00	
Service life in hours	[H]		75.00	
Gear driving (+) / driven (-)		+	-/+	-

1. TOOTH GEOMETRY AND MATERIAL

(Geometry calculation according DIN 3960)

		----- Gear 1 -----	Gear 2 -----	Gear 3 ---
Centre distance (mm)	[a]		89.500	
Centre distance tolerances			ISO 286 Measure js7	
Normal module (mm)	[mn]		4.0000	
Pressure angle at normal section (°)	[alfn]		20.0000	
Helix angle at Pitch diameter (°)	[beta]		0.0000	
Number of teeth	[z]	28	17	-62
Facewidth (mm)	[b]	76.00	75.00	74.60
Chamfer Facewidth (mm)	[Faseb]	2.00	2.00	2.00
Accuracy grade	[Q-ISO1328]	8	8	8
Inner diameter of ring (mm)	[dRing]	0.00	0.00	
Outer diameter ring (mm)	[dRing]			0.00
Internal diameter gearbody di (mm)	[di]	0.00	0.00	
Outer diameter gearbody di (mm)	[di]			270.00

Material

Gear 1: 18CrNiMo7-6 (1) (>=28HRC core), Case-hardening steel, case-hardened
 DIN 3990-5 Figure 4a/4b (MQ), core strength >=28HRC
 Gear 2: 18CrNiMo7-6 (1) (>=28HRC core), Case-hardening steel, case-hardened
 DIN 3990-5 Figure 4a/4b (MQ), core strength >=28HRC
 Gear 3: 31 CrMoV9, Nitriding steel, gas-nitrided
 DIN 3990-5 Figure 5a/5b (MQ)

		----- Gear 1 -----	Gear 2 -----	Gear 3 ---
Surface hardness		HRC 61	HRC 61	HV 800
Material treatment according to ISO 6336: ML (normal)				
Fatigue str. tooth root tension (N/mm ²)	[sigFlim]	430.00	430.00	
425.00				
Fatigue str. Hertzian stress (N/mm ²)	[sigHlim]	1500.00	1500.00	
1250.00				
Yield point (N/mm ²)	[sigs]	850.00	850.00	

67.635	[dw.e/i]	111.400 / 111.356	67.635 / 67.609	67.609 /
Root diameter (mm)	[df]	100.043	58.979	
-258.000				
Manufacturing addendum modification	[xE.e/i]	-0.2738 / -0.3082	0.0931 / 0.0588	-0.0395 /
-0.0841				
Manufactured root diameter with xE (mm)	[df.e]	99.81	58.75	
-258.32				
Manufactured root diameter with xE (mm)	[df.i]	99.53	58.47	
-258.67				
Theoretical tip clearance (mm)	[c]	0.989	0.989/1.011	
1.811				
Tip clearance upper allowance (mm)	[c.e]	1.311	1.311/1.415	
2.132				
Tip clearance lower allowance (mm)	[c.i]	1.089	1.089/1.151	
1.910				
Active root diameter (mm)	[dNf]	106.456	64.141/64.171	
-254.045				
	[dNf.e]	106.500	64.170/64.218	
-253.931				
	[dNf.i]	106.440	64.132/64.162	
-254.088				
Root form circle (mm)	[dFf]	105.646	63.957	
-256.942				
	[dFf.e/i]	105.589 / 105.527	63.932 / 63.911	-257.332
/ -257.777				
Reserve (dNf-dFf)/2 (mm)	[rNf-rFf.e/i]	0.486 / 0.426	0.130 / 0.100	1.923 /
1.622				
Addendum (mm)	[ha]	3.021	4.489	
3.200				
(mm)	[ha.e/i]	3.021 / 2.971	4.489 / 4.439	3.200 /
3.150				
Dedendum (mm)	[hf]	5.979	4.511	
5.000				
(mm)	[hf.e/i]	6.095 / 6.233	4.627 / 4.765	5.158 /
5.337				
Profile angle to dFa (°)	[alf_dNa_t.e/i]	26.734 / 26.638	33.669 / 33.557	15.466 /
15.552				
Profile angle to dFf (°)	[alf_dNf0_t.e/i]	4.624 / 4.189	1.834 / 1.115	25.094 /
25.304				
Tooth depth (mm)	[H]	9.000	9.000	
8.200				
Virtual gear no. of teeth	[zn]	28.000	17.000	
-62.000				
Normal Tooth thickness at Tip cyl. (mm)	[san]	3.150	2.486	
4.097				
(mm)	[san.e/i]	3.109 / 2.956	2.454 / 2.277	4.014 /
3.858				
(without consideration of tip chamfer/ tip rounding)				
Normal Tooth space as Tip cylinder (mm)	[efn]	0.000	0.000	
2.241				
(mm)	[efn.e/i]	0.000 / 0.000	0.000 / 0.000	2.212 /
2.180				
Max. sliding speed at tip (m/s)	[vga]	2.056	2.536	
1.145				
Max. sliding speed at tip (m/s)	[vga]	2.056	2.536/1.145	0.909
Specific sliding at the tip	[zetaa]	0.827	0.772/0.348	0.666
Specific sliding at the root	[zetaf]	-3.379	-4.785/-1.994	-0.535
Sliding factor on tip	[Kga]	0.394	0.486	
0.219				
Sliding factor on root	[Kgf]	-0.486	-0.394	
-0.174				
Pitch (mm)	[pt]		12.566	
Base pitch (mm)	[pbt]		11.809	
Transverse pitch on contact-path (mm)	[pet]		11.809	
Axial pitch (mm)	[px]	0.000	0.000	
0.000				
Length of path of contact (mm)	[ga]		18.501	18.330
(mm)	[ga.e/i]	18.555 / 18.246	18.383 /	17.999
Length T1-A (mm)	[T1A]		8.005	2.953
Length T1-B (mm)	[T1B]		14.698	9.474
Length T1-C (mm)	[T1C]		18.223	11.064
Length T1-D (mm)	[T1D]		19.813	14.761
Length T1-E (mm)	[T1E]		26.506	21.283
Transverse contact ratio	[Eps.a]		1.567	1.552
Transverse contact ratio, effective	[Eps.aEffe/i]	1.571 / 1.545	1.557 /	1.524
Overlap ratio	[Eps.b]		0.000	0.000
Total contact ratio	[Eps.G]		1.567	1.552
Total contact ratio, effective	[Eps.gEffe/i]	1.571 / 1.545	1.557 /	1.524

2. FACTORS OF GENERAL INFLUENCE

----- Gear 1 ----- Gear 2 ----- Gear

Nominal circum. force at pitch circle (N)	[Ft]	5739.822	5739.822
Axial force (N)	[Fa]	0.0	0.0
0.0			
Axial force (total) (N)	[Fa_ges]	0.0	
0.0			
Radial force (N)	[Fr]	2089.1	2089.1
2089.1			
Normal force (N)	[Fnorm]	6108.2	6108.2
6108.2			
Tangent.load at p.c.d.per mm (N/mm) (N/mm)	[w]	80.84	81.30
Circumferential speed pitch d.. (m/sec)	[v]		5.25
Running in value y.a (µm)	[ya]	1.6	1.7
Gear body coefficient CR	[CR]	1.00	1.00
Correction coefficient CM	[CM]	0.80	0.80
Reference profile coefficient CBS	[CBS]	0.98	0.98
Singular tooth stiffness (N/mm/µm)	[c']	11.598	14.135
Meshing spring stiffness (N/mm/µm)	[cg]	16.528	19.990
Reduced mass (kg/mm)	[mRed]	0.0053	0.0134
Resonance speed (min-1)	[nE1]	19091	21694
Nominal speed (-)	[N]	0.068	0.068
Subcritical range			
Planets are on a bearing on a fixed restraint bolt			
Tooth trace deviation (active) (µm)	[Fby]	20.88	17.85
from deformation of shaft (µm)	[fsh]	4.57	0.00
Tooth trace		0	0
(0:without, 1:crowned, 2:Tip relief, 3:full modification)			
from production tolerances (µm)	[fma]	20.00	21.00
Running in value y.b (µm)	[yb]	3.68	3.15
Dynamic coefficient	[KV]	1.11	1.14
Face coefficient - flank	[KHb]	2.53	2.53
- Tooth root	[KFb]	2.25	2.25
- Scuffing	[KBb]	2.53	2.53
Transverse coefficient - flank	[KHα]	1.07	1.17
- Tooth root	[KFα]	1.07	1.17
- Scuffing	[KBα]	1.07	1.17
Helix angle coefficient scuffing	[Kbg]	1.00	1.00
No of load changes (in mio.)	[NL]	20.1	6.6
9.1			

3. TOOTH ROOT STRENGTH

		----- Gear 1 -----	Gear 2 -----	Gear
3 ---				
Calculation of Tooth form coefficients according method: C				
(Tooth shape coefficients are calculated using the manufacturing addendum modification xE.e for				
measures > 0.05*mn)				
Tooth form factor	[YF]	2.95	2.78/2.78	1.79
Stress correction factor	[YS]	1.49	1.57/1.57	2.87
Bending lever arm (mm)	[hF]	7.49	7.74/7.74	6.61
working angle (°)	[alfen]	25.20	31.79/31.79	20.00
Tooth thickness at root (mm)	[sFn]	7.66	7.78	9.42
Tooth root radius (mm)	[roF]	2.61	2.19	0.60
Contact ratio factor	[Yeps]		0.73	0.73
Helix angle factor	[Ybet]		1.00	1.00
Effective facewidth (mm)	[beff]	76.00	75.00/75.00	
74.60				
Local Tooth root stress (N/mm ²)	[sigF0]	60.50	60.75/61.12	
72.45				
(Effective)Tooth root stress (N/mm ²)	[sigF]	195.15	195.94/220.26	
261.07				
Permissible bending stress at root of Test-gear				
Support factor	[Ydrel]	0.99	0.993/0.993	
1.172				
Surface-factor	[YRrelT]	0.947	0.947	
0.988				
Size coefficient (Tooth root)	[YX]	1.000	1.000	
1.000				
Limited-life factor	[YNT]	0.963	0.984	
0.978				
Alternating bending coefficient	[Kwb]	1.000	0.700	
1.000				
Stress correction factor	[Yst]		2.00	
Permissible Tooth root stress (N/mm ²)	[sigFG]	775.59	557.06/557.06	

962.62				
([sigFP] = [sigFG] / [SFmin]) (N/mm ²)	[sigFP]	553.99	397.90/397.90	
687.58				
Nominal safety	[SFmin]	1.40	1.40/1.40	1.40
Transmittable power (kW)	[kWRating]	620.98	444.20/395.16	
576.11				
Safety for Tooth root stress	[SF=sigFG/sigF]	3.97	2.84/2.53	3.69

4. SAFETY AGAINST PITTING (TOOTH FLANK)

		----- Gear 1 -----	Gear 2 -----	Gear
3 ---				
Zone factor	[ZH]	2.56	2.56	
Elasticity coefficient (N ^{.5} /mm)	[ZE]	189.81	189.81	
Contact ratio factor	[Zeps]	0.90	0.90	
Helix angle factor	[Zbet]	1.00	1.00	
Effective facewidth (mm)	[beff]	71.00	70.60	
Nominal value Surface pressure (N/mm ²)	[sigH0]	604.29	408.46	
Surface pressure at Operating pitch diameter (N/mm ²)	[sigH]	1150.14	821.70	
Lubrication factor	[ZL]	0.954	0.963/0.963	0.946
Speed factor	[ZV]	0.986	0.989/0.989	0.983
Roughness-factor	[ZR]	0.943	0.954/0.925	0.891
Material mating factor	[ZW]	1.000	1.000/1.000	1.000
Limited-life factor	[ZNT]	1.071	1.165	
0.972				
Minimal no. of pittings permissible:	no			
Size coefficient (flank)	[ZX]	1.000	1.000	
1.000				
Permissible surface pressure (N/mm ²)	[sigHG]	1423.49	1587.94/1539.06	
1006.08				
([sigHP] = [sigHG] / [SHmin]) (N/mm ²)	[sigHP]	1423.49	1587.94/1539.06	
1006.08				
Safety for surface pressure at pitch diameter	[SHw]	1.24	1.38/1.87	1.22
Single tooth contact factor	[ZBD]	1.00	1.04/1.10	1.00
Surface pressure single tooth con. (N/mm ²)	[sigHBD]	1150.14	1191.99/905.99	
821.70				
Nominal safety	[SHmin]	1.00	1.00/1.00	1.00
Transmittable power (kW)	[kWRating]	335.07	388.20/631.23	
327.92				
Safety for stress at single tooth contact	[SH=sigHG/sigHBD]	1.24	1.33/1.70	1.22

5. STRENGTH AGAINST SCUFFING

Calculation method according DIN3990				
Lubrication coefficient (Scoring)	[XS]	1.000		
Relative structure coefficient (Scoring)	[XWrelT]	1.000	1.000	
Angle factor	[Xalfbet]	0.964	0.964	
(eps1: 0.701/0.865, eps2: 0.865/0.687)				
Therm. contact factor (N/mm/s ^{.5} /K)	[BM]	13.795	13.795	
13.795				
Average roughness, Ra, tooth flank (µm)	[RAH]	0.80	0.80	
3.60				
Applicable circumferential force/tooth width	[wbt]	292.850	329.022	
Flashtemperature-criteria				
Tooth mass temperature (°C)	[them]	120.757	105.887	
theM-B = theoil + XS*0.47*theflamax	[theflamax]	107.99	76.36	
Scuffing temperature (°C)	[thes]	444.866	444.866	
Coordinate gamma (point of highest temp.)	[Gamma]	-0.749	-0.733	
Highest contact temp. (°C)	[theB]	228.751	182.242	
Flash factor	[XM]	50.002	50.002	
Geometry-factor	[XB]	0.664	0.333	
Distribution factor	[XGam]	0.333	0.333	
Coefficient of friction	[mymy]	0.192	0.248	
Nominal safety	[SBmin]	2.000		
Safety coefficient for scuffing (flash-temp)	[SB]	2.361	3.340	
Integraltemperature-criteria				
Tooth mass temperature (°C)	[theMC]	95.789	77.156	
theM-C = theoil + XS*0.70*theflaint	[theflaint]	36.84	10.22	
Scuffing temperature (°C)	[theSint]	444.866	444.866	
Flash factor	[XM]	50.002	50.002	
Contact ratio factor	[XE]	0.251	0.252	
Mean coefficient of friction	[mym]	0.104	0.114	
Geometry-factor	[XBE]	0.553	0.129	
Meshing factor	[XQ]	1.000	1.000	

Tip relief-factor	[XCa]	1.000	1.000
Integral-tooth flank temperature (°C)	[theint]	151.051	92.491
Nominal safety	[SSmin]	1.80	
Safety coefficient for scuffing (intg.-temp.)	[SSint]	2.95	4.81
Safety referring to transfered torque	[SSL]	4.63	16.67

6. TOOTH THICKNESS DIMENSIONS

		----- Gear 1 -----	----- Gear 2 -----	----- Gear
3 ---				
Tooth thickness tolerance		DIN3967 c27	DIN3967 c27	
DIN3967 c27				
Tooth thickness allowance (normal section) (mm)	[As.e/i]	-0.085/-0.185	-0.085/-0.185	
-0.115/-0.245				
No of teeth over which to measure	[k]	3.000	3.000	
-7.000				
Diameter of contact point (mm)	[dMWk]	109.554	70.938	
-246.467				
Base tangent length ('span') (no backlash) (mm)	[Wk]	30.421	30.808	
-80.229				
Effective base tangent length ('span') (mm)	[Wk.e/i]	30.341/30.247	30.729/30.635	
-80.337/-80.459				
Theor. ball/roller diameter (mm)	[dm]	6.628	7.192	
6.627				
Eff. ball/roller diameter (mm)	[DMeff]	7.000	7.500	
7.000				
Diameter of contact point (mm)	[dMMr]	110.813	69.399	
-246.830				
Theor. dim. centre to ball (mm)	[MrK]	60.100	40.077	
-118.806				
Real dimension centre to ball (mm)	[MrK.e/i]	59.991/59.861	39.993/39.893	
-118.983/-119.180				
Theor. dimension over two balls (mm)	[MdK]	120.200	79.844	
-237.612				
Real dimension over balls (mm)	[MdK.e/i]	119.981/119.721	79.676/79.477	
-237.966/-238.359				
True dimension over rolls (mm)	[MdR.e/i]	119.981/119.721	79.676/79.477	
-237.966/-238.359				
Effective dimensions over 3 rolls (mm)	[Md3K.e/i]	0.000/0.000	79.368/79.170	
0.000/0.000				
Chordal tooth thickness without play (mm)	[smn]	5.569	6.629	
6.283				
Effective chordal tooth thickness (mm)	[smn.e/i]	5.484/5.384	6.544/6.444	
6.168/6.038				
Reference chordal height (mm)	[ha]	3.091	4.651	
3.160				
Axial Distance Without Backlash (mm)	[aControl.e/i]	89.255/88.966	-89.789/-90.121	
Centre distance deviation (mm)	[Aa.e/i]	0.018/-0.018	0.018/-0.018	
Circumferential backlash (mm)	[jt]	0.382/0.158	0.442/0.188	
Normal backlash (mm)	[jn]	0.359/0.148	0.415/0.177	
entire torsion angle (°)	[j.tSys]	0.1178/0.2546		
(j.tSys: Torsion angle of planet carrier for blocked shaft)				

7. TOLERANCES

		----- Gear 1 -----	----- Gear 2 -----	----- Gear
3 ---				
According ISO 1328:				
Accuracy grade	[Q-ISO1328]	8	8	
8				
Single pitch deviation (µm)	[fpb]	17.0	17.0	
19.0				
Profile deviation (µm)	[ffa]	21.0	21.0	
23.0				
Profile angular deviation (µm)	[fHa]	17.0	17.0	
19.0				
Profile total deviation (µm)	[Fa]	27.0	27.0	
30.0				
Helix form deviation (µm)	[ffb]	20.0	20.0	
21.0				
Helix slope deviation (µm)	[fHb]	20.0	20.0	
21.0				
Tooth helix deviation (µm)	[Fb]	28.0	28.0	
29.0				

Total cumulative pitch deviation (μm)	[Fp]	55.0	55.0
72.0			
Runout tolerance (μm)	[Fr]	44.0	44.0
58.0			
Total radial composite tolerance (μm)	[Fi"]	72.0	72.0
86.0			
Tooth-to-tooth radial composite tolerance (μm)	[fi"]	29.0	29.0
29.0			
Total tangential composite deviation (μm)	[Fi']	97.0	97.0
117.0			
Tooth-to-tooth tangential composite deviation (μm)	[fi']	42.0	42.0
45.0			

8. ADDITIONAL DATA

Medium coef. of friction (acc. Niemann)	[mum]	0.073	0.081
Wear sliding coef. by Niemann	[zetw]	1.257	0.759
Meshpower (kW)		150.688	150.688
Power loss from gear load (kW)		0.442	0.218
Total power loss (kW)		3.299	
Total efficiency		0.985	
Inertia (System referenced to wheel 1): calculation without consideration of the exact tooth shape single gears ((da+df)/2...di) (kgm^2)	[TraeghMom]	0.00820	0.00122
0.08049			
System ((da+df)/2...di) (kgm^2)	[TraeghMom]	0.01602	

Remarks:

- Specifications with [.e/i] imply: Maximum [e] and Minimal value [i] with consideration of all tolerances
- For the flank backlash the center-distance tolerances and the tooth thickness deviation are taken into account. Shown is the maximal and the minimal backlash corresponding to the largest resp. smallest measure.
- Details of calculation method:
cg according to method B
KV according to method B
KHb, KFb according to method C1
KHa, KFa according to method B

End report lines : 414
