Comparison AGMA 6123:C16 with KISSsoft

The first example of the standard AGMA 6123:C16 Annex C check the spline fretting capacity, which is a part of the spline calculation.

Example:

The small differences in the results are because of the rounded intermediate values in the calculation of the standard (KISSsoft calculates with not rounded values).

Results:	**AGMA 6123, Annex C**	**Calculated with KISSsoft**
Fatigue Safety SF (in KISSsoft SR)	**1.6**	**1.59**

On the right side are the diffent values in bold characters from the standard to KISSsoft.

KISSsoft Release 03/2017 β

KISSsoft-Entwicklungs-Version KISSsoft AG CH-8608 BUBIKON

File

Name : Splines 4 (AGMA 6123)
Description: KISSsoft example
Changed by: mschaerer on: 16.03.2017 at: 10:06:43

SPLINED JOINTS DIN 5480:2006

Shaft W - 104.00*6.00*16*6b*20
Hub N - 104.00*6.00*16*7H*20

Drawing or article number:
Shaft: 0.000.0
Hub: 0.000.0

1. TOOTH GEOMETRY AND MATERIAL

Normal module (mm)	[mn]	6.0000		
Nominal diameter DIN (mm)	[dB]	104.00		
Pressure angle at normal section (°)	[alfn]	20.000		
		------- SHAFT ---------	HUB --------	
Number of teeth	[z]	16		-16
Helix angle at reference circle (°)	[beta]	0.0000		
Facewidth (mm)	[b]	26.00	26.00	
Hand of gear	Spur gear			

Material

Gear 1: (Eigene Eingabe)	example AGMA, Through hardened steel, flame/ind. hardened ISO 6336-5 Bild 11/12 (MQ)		
Gear 2: (Eigene Eingabe)	example AGMA, Through hardened steel, flame/ind. hardened ISO 6336-5 Bild 11/12 (MQ)		
		------- SHAFT ---------	HUB ----
Surface hardness		HRC 45	HBW 424
Tensile strength (N/mm²)	[σB]	700.00	700.00
Yield point (N/mm²)	[σS]	490.00	490.00
Young's modulus (N/mm²)	[E]	206000	206000
Poisson's ratio	[v]	0.300	0.300
Roughness average value DS, flank (µm)	[RAH]	0.60	1.05
Roughness average value DS, root (µm)	[RAF]	3.00	3.00
Mean roughness height, Rz, flank (µm)	[RZH]	4.80	8.00
Mean roughness height, Rz, root (µm)	[RZF]	20.00	20.00

Gear reference profile 1 :
Reference profile (Own input)

Dedendum coefficient	[hfP*]	1.117
Root radius factor	[rhofP*]	0.010 (rhofPmax*= 0.541)
Addendum coefficient	[haP*]	0.300
Tip radius factor	[rhoaP*]	0.000
Protuberance height coefficient	[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 (Own input)

Dedendum coefficient	[hfP*]	0.400
Root radius factor	[rhofP*]	0.160 (rhofPmax*= 0.914)
Addendum coefficient	[haP*]	1.117
Tip radius factor	[rhoaP*]	0.000
Protuberance height coefficient	[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*]	1.117	0.400
Tooth root radius Refer. profile	[rofP*]	0.010	0.160
Addendum Reference profile	[haP*]	0.300	1.117
Protuberance height coefficient	[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

Transverse module (mm)	[mt]	6.000
Pressure angle at pitch circle (°)	[alft]	20.000
Base helix angle (°)	[betab]	0.000
Sum of profile shift coefficients	[Summexi]	0.0000

		------- SHAFT ---------	HUB --------
Profile shift coefficient	[x]	0.1167	-0.1167
Profile shift (x*m) (mm)	[x*m]	0.7002	-0.7002
Reference diameter (mm)	[d]	96.000	-96.000
Base diameter (mm)	[db]	90.210	-90.210
Tip diameter (mm)	[da]	101.000	-83.996
Effective tip diameter (mm)	[da.e/i]	101.000 / 101.000	-83.996 / -83.996
Tip diameter allowances (mm)	[Ada.e/i]	0.000 / 0.000	0.000 / 0.000
Chamfer (1) / tip rounding (2)		0	2
Tip rounding (mm)	[rK]	2.500	
Tip form diameter (mm)	[dFa.e/i]	101.000 / 101.000	-90.736 / -90.736
Root diameter (mm)	[df]	83.996	-102.200
Effective root diameter (mm)	[df.e/i]	83.606 / 83.546	-102.250 / -102.338
Root diameter allowances (mm)	[Adf.e/i]	-0.390 / -0.451	-0.049 / -0.137
Generating Profile shift coefficient	[xE.e/i]	0.0842 / 0.0792	-0.1208 / -0.1281
Root form diameter (mm)	[dFf.e/i]	90.210 / 90.210	-98.368 / -98.368
(dFf2 calculated with virtual pinion type cutter (circa): z=		14 x= 0.300 rhoaP0*=0.1)	
Tooth height (mm)	[h]	8.502	9.102
Theoretical tip clearance (mm)	[c]	0.600	-0.000
Effective tip clearance (mm)	[c.e/i]	0.669 / 0.625	0.225 / 0.195
Normal tooth thickness at tip circle (mm)	[san]	8.214	0.000
(mm)	[san.e/i]	8.065 / 8.042	0.000 / 0.000
(without consideration of tip chamfer/ tip rounding)			
Normal space width at root circle (mm)	[efn]	0.000	7.687
(mm)	[efn.e/i]	0.000 / 0.000	7.683 / 7.677
Pitch on reference circle (mm)	[pt]	18.850	
Base pitch (mm)	[pbt]	17.713	
Transverse pitch on contact-path (mm)	[pet]	17.713	

2. MEASUREMENTS FOR TOOTH THICKNESS

		------- SHAFT ---------	HUB --------
Accuracy grade		6	7
Tooth thickness deviation		DIN 5480 b	DIN 5480 H
Number of teeth spanned	[k]	2.0000	-2.0000
Base tangent length (no backlash) (mm)	[Wk]	28.3927	-28.3927
Diameter of contact point (mm)	[dMWk.m]	94.5351	-94.5757
Theoretical diameter of ball/pin (mm)	[dm]	10.8225	9.9310
Effective diameter of ball/pin (mm)	[DMeff]	11.0000	10.0000
Theor. dimension over two balls (mm)	[MRe/Mri-ball]	113.3534	-83.8603
Diametral measurement over pins without clearance (mm)	[MRe/Mri-pin]	113.3534	-83.8603

Data for Actual Dimensions (DIN 5480:2006)

Tooth thickness / Spacewidth (mm)	[Smax/Smin, Emax/Emin]	9.7925 / 9.7705	9.9845 / 9.9525

Tooth thickness tolerance, normal section (mm)	[Tol.Smax/min]	-0.1420 / -0.1640	
Tooth space tolerance, normal section (mm)	[Tol.Emax/min]	0.0500 / 0.0180	
Base tangent length (mm)	[Wk.Smax/Smin]	28.2592 / 28.2386	-28.4397 / -28.4096
Diametral two ball measure (mm)	[MRe/Mri-ball]	113.0695 / 113.0253	-84.0286 / -83.9213
Diametral measurement over pins (mm)	[MRe/Mri-pin]	113.0695 / 113.0253	-84.0286 / -83.9213

Data for Effective Dimensions (DIN 5480:2006)

Tooth thickness / Spacewidth (mm)	[Svmax/min, Evmax/min]	9.8065 / 9.7925	9.9525 / 9.9345
Tooth thickness tolerance, normal section (mm)	[Tol.Svmax/min]	-0.1280 / -0.1420	
Tooth space tolerance, normal section (mm)	[Tol.Evmax/min]	0.0180 / 0.0000	
Base tangent length (mm)	[Wk.Svmax/min]	(28.2724 / 28.2592)	(-28.4096 / -28.3927)
Diametral two ball measure (mm)	[MRe/Mri-ball]	(113.0976 / 113.0695)	(-83.9213 / -83.8603)
Diametral measurement over pins (mm)	[MRe/Mri-pin]	(113.0976 / 113.0695)	(-83.9213 / -83.8603)

Tolerance data DIN 5480-1 (mm)	[TG]	0.0360	0.0500
(mm)	[Tact]	0.0220	0.0320
(mm)	[Teff]	0.0140	0.0180

Circumferential backlash (transverse section):

-Theoretical (without form errors) (mm)	[jt.th]	0.2140 /	0.1600
-Effective (with form errors) (mm)	[jt.eff]	0.1600 /	0.1280
Normal backlash theoretical (mm)	[jn.th]	0.2011 /	0.1504
Normal backlash (mm)	[jn.eff]	0.1504 /	0.1203
Theoretical radial clearance (mm)	[jr.th]	0.1926 /	0.1477
Radial clearance (mm)	[jr.eff]	0.1418 /	0.1177

Notice: When controlling splines with individual measurements (base tangent length/pin diameter) respect the values in 'Actual dimensions'.

3. GEAR ACCURACY

		------- SHAFT	--------- HUB --------
According to DIN 5480:2006:			
Accuracy grade	[Q-DIN5480]	6	7
Total profile deviation (µm)	[Fa]	12.0	17.0
Total helix deviation (µm)	[Fb]	8.0	10.0
Single pitch deviation (µm)	[fp]	10.0	13.0
Total cumulative pitch deviation (µm)	[Fp]	22.0	32.0
Runout (µm)	[Fr]	50.0	50.0

4. STRENGTH CALCULATION

Calculation method: AGMA 6123-C16		
Centering: flank centered		
Inner diameter (mm)	[dis]	-84.00
External diameter (mm)	[dos]	101.00
Nominal torque (Nm)	[T]	4391.11
Application factor	[KA]	1.44

Service torque (Nm)	[Tmax=T*KA]	6323.20	
Flank middle diameter (mm)	[dm]	92.50	
Alignment type: not justified, not crowned			
Alignment angle (°)	[fΣ]		
0.057			
Supporting length (mm)	[b']	26.000	
Load distribution coefficient	[Km]	1.250	
Required safety, shearing strength	[SminS]	1.000	
Required safety, wear resistance	[SminW]	1.000	
Required safety ring bursting	[SminR]	1.000	

Shaft

Width on shaft (mm)	[bs]	26.000	
Permitted shearing stress (N/mm²)	[ssA]	345.000	
Core hardness (HRC)	[HCore]	45.000	
Permitted shearing strength moment (Nm)	[TaS]	24110.752	
Permitted contact stress (N/mm²)	[scA]	76.950	
Surface hardness (HRC)	[HSurface]	45.000	
Permissible torque for fretting and wear resistance (Nm)	[TaR]	10069.717	
Safeties:			
Shearing strength moment	[SS]	3.81	
Fretting and wear resistance	[SR]	1.59	

HUB

Width on hub (mm)	[bs]	26.000	
Permitted shearing stress (N/mm²)	[ssA]	345.000	
Core hardness (HRC)	[HCore]	45.000	**45**
Permitted shearing strength moment (Nm)	[TaS]	24110.752	
Permitted contact stress (N/mm²)	[scA]	76.950	**77**
Surface hardness (HRC)	[HSurface]	45.000	**45**
Permissible torque for fretting and wear resistance (Nm)	[TaR]	10069.717	**10030**
Safeties:			
Shearing strength moment	[SS]	3.81	
Fretting and wear resistance	[SR]	1.59	**1.6**
Check resistance to ring bursting:			
Speed (1/min)	[n]	1000.000	
Wall thickness (mm)	[tw]	13.900	
Lewis factor	[Y]	1.5	
Outside diameter, Hub (mm)	[dso]	130.000	
Root diameter, internal toothing (mm)	[dri]	102.200	

Radial component (N/mm²)	[s1]	21.115
Tensile stress (N/mm²)	[s2]	70.370
Centrifugal ring stress (N/mm²)	[s3]	0.338
Total tensile stress (N/mm²)	[st]	114.696
Permissible stress (N/mm²)	[stA]	372.600
Safety ring bursting	[SRB]	3.25

5. ADDITIONAL DATA

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]	0	0
System	((da+df)/2...di) (kg*m²)	[TraeghMom]	0	

Remark regarding mounting with clamping using small helix angle on shaft
(Clamping at the latest at 0.66*b)

Helix angle difference (°)	[beta.max]	0.5342

6. MODIFICATIONS AND TOOTH FORM DEFINITION

Data for the tooth form calculation :
Data not available.

REMARKS:
- Permitted torque, shear:
  Ta = π*d^2*b'*ssA/(8000*Km)
  Assumption: the load is carried by 50% of the teeth.
- Permissible torque for fretting and wear resistance:
  Ta = z*b'*scA*(dos^2-dis^2)/(8000*Km)
  Assumption: the load is carried by 100% of the teeth.
- Rim fracture calculation:
  s1 = 1000*T*tan(αn)/(π*d*tw*b')
  s2 = 4000*T/(d*b'*Y)
  Y: The Lewis factor is fixed to 1.5 (value for a 30° spline)
  Assumption: the load is carried by 100% of the teeth.
  s3 = 8.85*10^-12*n^2*(2*dso^2+0.424*dri^2)
  st = Km*(s1+s2)+s3

End of Report lines: 273