

KISSsoft evaluation

File

Name : Unnamed

Changed by: jirri on: 01.08.2019 at: 13:28:32

Analysis of shafts, axle and beams

Input data

Coordinate system shaft: see picture W-002

Label	Shaft4
Drawing	
Initial position (mm)	0.000
Length (mm)	243.000
Speed (1/min)	6246.81
Sense of rotation: clockwise	
Material	31 CrMoV9
Young's modulus (N/mm ²)	206000.000
Poisson's ratio nu	0.300
Density (kg/m ³)	7830.000
Coefficient of thermal expansion (10 ⁻⁶ /K)	11.500
Temperature (°C)	20.000
Temperature for load spectrum	
No.	Temperature (°C)
1	70.000
2	65.000
3	50.000
4	50.000
5	50.000
6	50.000
7	50.000
8	50.000
9	50.000
10	50.000
Weight of shaft (kg)	3.033
(Notice: Weight stands for the shaft only without considering the gears)	
Weight of shaft, including additional masses (kg)	23.597
Mass moment of inertia (kg*m ²)	0.282
Momentum of mass GD2 (Nm ²)	11.078
Weight towards	(0.000, 0.000, -1.000)
Regard gears as masses and stiffness	
Consider deformations due to shearing	
Shear correction coefficient	1.100
Contact angle of rolling bearings is considered	
Tolerance field: Mean value	
Reference temperature (°C)	20.000

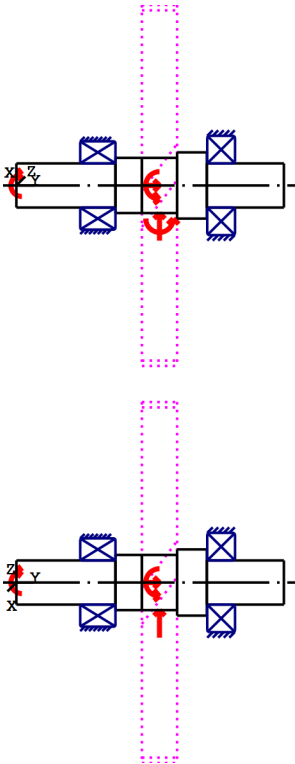


Figure: Load applications

Shaft definition (Shaft4)

Outer contour

Cylinder (Cylinder)			0.000mm ...	90.000mm
Diameter (mm)	[d]	40.0000		
Length (mm)	[l]	90.0000		
Surface roughness (µm)	[Rz]	8.0000		

Radius right (Radius right)
r=2.00 (mm), Rz=8.0, Turned (Ra=3.2µm/125µin)

Cylinder (Cylinder)			90.000mm ...	146.000mm
Diameter (mm)	[d]	50.0000		
Length (mm)	[l]	56.0000		
Surface roughness (µm)	[Rz]	8.0000		

Radius right (Radius right)
r=2.00 (mm), Rz=8.0, Turned (Ra=3.2µm/125µin)

Cylinder (Cylinder)			146.000mm ...	173.000mm
Diameter (mm)	[d]	60.0000		
Length (mm)	[l]	27.0000		
Surface roughness (µm)	[Rz]	8.0000		

Cylinder (Cylinder)			173.000mm ...	243.000mm
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Diameter (mm)	[d]	40.0000
Length (mm)	[l]	70.0000
Surface roughness (µm)	[Rz]	8.0000

Radius left (Radius left)

r=2.00 (mm), Rz=8.0, Turned (Ra=3.2µm/125µin)

Forces

Type of force element		Coupling		
Label in the model		Coupling4(Out)		
Position on shaft (mm)	[ylocal]	5.0000		
Position in global system (mm)	[yglobal]	5.0000		
Effective diameter (mm)		30.0000		
Radial force factor (-)		0.0000		
Direction of the radial force (°)		0.0000		
Axial force factor (-)		0.0000		
Length of load application (mm)		10.0000		
Power (kW)		756.2500		
Torque (Nm)		-1156.0553		
Axial force (load spectrum) (N)		0.0000 /	0.0000 /	0.0000
Shearing force X (load spectrum) (N)		-0.0000 /	-0.0000 /	-0.0000
Shearing force Z (Load spectrum) (N)		-0.0000 /	-0.0000 /	-0.0000
Mass (kg)		0.0000		
Mass moment of inertia Jp (kg*m ²)		0.0000		
Mass moment of inertia Jxx (kg*m ²)		0.0000		
Mass moment of inertia Jzz (kg*m ²)		0.0000		
Eccentricity (mm)		0.0000		

Load spectrum, driving (output)

Example with file (with factors)

No.	Frequency (%)	Speed (1/min)	Power (kW)	Torque (Nm)
1	1.0000e+001	6246.808	-756.250	-1156.055
2	1.0000e+001	6246.808	-680.625	-1040.450
3	1.0000e+001	6871.489	-665.500	-924.844
4	1.0000e+001	6871.489	-582.312	-809.239
5	1.0000e+001	7496.170	-544.500	-693.633
6	1.0000e+001	7496.170	-453.750	-578.028
7	1.0000e+001	8745.531	-423.500	-462.422
8	1.0000e+001	8745.531	-317.625	-346.817
9	1.0000e+001	8745.531	-211.750	-231.211
10	1.0000e+001	8745.531	-105.875	-115.606

Type of force element		Cylindrical gear		
Label in the model		z4		
Position on shaft (mm)	[ylocal]	130.0000		
Position in global system (mm)	[yglobal]	130.0000		
Operating pitch diameter (mm)		327.1028		
Helix angle (°)		15.0435 left		
Working pressure angle at normal section (°)		20.4402		
Position of contact (°)		180.0000		
Length of load application (mm)		32.0000		
Power (kW)		756.2500		
Torque (Nm)		1156.0553		
Axial force (load spectrum) (N)		1899.7405 /	1709.7664 /	1519.7924
Shearing force X (load spectrum) (N)		2727.8676 /	2455.0808 /	2182.2941

Shearing force Z (Load spectrum) (N)	7068.4521 /	6361.6069 /	5654.7617
Bending moment X (Load spectrum) (Nm)	-0.0000 /	-0.0000 /	-0.0000
Bending moment Z (Load spectrum) (Nm)	-310.7052 /	-279.6347 /	-248.5642

Load spectrum, driven (input)

Example with file (with factors)

No.	Frequency (%)	Speed (1/min)	Power (kW)	Torque (Nm)
1	1.0000e+001	6246.808	756.250	1156.055
2	1.0000e+001	6246.808	680.625	1040.450
3	1.0000e+001	6871.489	665.500	924.844
4	1.0000e+001	6871.489	582.312	809.239
5	1.0000e+001	7496.170	544.500	693.633
6	1.0000e+001	7496.170	453.750	578.028
7	1.0000e+001	8745.531	423.500	462.422
8	1.0000e+001	8745.531	317.625	346.817
9	1.0000e+001	8745.531	211.750	231.211
10	1.0000e+001	8745.531	105.875	115.606

Bearing

Label in the model		RollerBearing3
Bearing type		SKF 33208
Bearing type		Taper roller bearing (single row)
		SKF EXPLORER
Bearing position (mm)	[ylocal]	74.000
Bearing position (mm)	[yglobal]	74.000
Attachment of external ring		Set fixed bearing left
Inner diameter (mm)	[d]	40.000
External diameter (mm)	[D]	80.000
Width (mm)	[b]	32.000
Corner radius (mm)	[r]	1.500
The bearing pressure angle will be considered in the calculation		
Position (center of pressure)		(mm)
78.5570		
Basic static load rating (kN)	[C ₀]	132.000
Basic dynamic load rating (kN)	[C]	128.000
Fatigue load rating (kN)	[C _u]	15.000
Values for approximated geometry:		
Basic dynamic load rating (kN)	[C _{theo}]	0.000
Basic static load rating (kN)	[C _{0theo}]	0.000
Correction factor Basic dynamic load rating	[f _C]	1.000
Correction factor Basic static load rating	[f _{C0}]	1.000

Label in the model		RollerBearing4
Bearing type		Koyo 30308DJR
Bearing type		Taper roller bearing (single row)
Bearing position (mm)	[ylocal]	186.000
Bearing position (mm)	[yglobal]	186.000
Attachment of external ring		Set fixed bearing right
Inner diameter (mm)	[d]	40.000
External diameter (mm)	[D]	90.000
Width (mm)	[b]	25.250
Corner radius (mm)	[r]	2.000

The bearing pressure angle will be considered in the calculation

Position (center of pressure)		(mm)
168.7250		
Basic static load rating (kN)	[C ₀]	90.200
Basic dynamic load rating (kN)	[C]	100.000
Fatigue load rating (kN)	[C _u]	13.100
Values for approximated geometry:		
Basic dynamic load rating (kN)	[C _{theo}]	0.000
Basic static load rating (kN)	[C _{0theo}]	0.000
Correction factor Basic dynamic load rating	[f _C]	1.000
Correction factor Basic static load rating	[f _{C0}]	1.000

Shaft 'Shaft4': Cylindrical gear 'z4' (y= 130.0000 (mm)) is taken into account as component of the shaft.
 EI (y= 114.0000 (mm)): 63200.0085 (Nm²), EI (y= 146.0000 (mm)): 63200.0085 (Nm²), m (yS= 130.0000 (mm)): 20.5638 (kg)
 Jp: 0.2815 (kg*m²), Jxx: 0.1425 (kg*m²), Jzz: 0.1425 (kg*m²)

Results

Note: the maximum deflection and torsion of the shaft under torque, the life modification factor also, and the bearing's thinnest lubricant film thickness EHL, are predefined for the first load bin.

Shaft

Maximum deflection (μm)	2.582
Position of the maximum (mm)	243.000
Mass center of gravity (mm)	125.303
Total axial load (N)	1899.740
Torsion under torque (°)	0.315

Bearing

Probability of failure	[n]	1.00	%
Axial clearance	[u _A]	10.00	μm
Lubricant	Mobil Jet Oil II		
Lubricant - service temperature	[T _B]	70.00	°C

Rolling bearings, classical calculation (contact angle considered)

Shaft 'Shaft4' Rolling bearing 'RollerBearing3'

Position (Y-coordinate)	[y]	74.00	mm
Life modification factor for reliability[a ₁]		0.248	
Nominal bearing service life	[L _{nh}]	0.11	h
Operating viscosity	[v]	9.77	mm ² /s
Static safety factor	[S ₀]	0.72	

Bearing reaction force

Bearing reaction moment

	Fx (kN)	Fy (kN)	Fz (kN)	Fr (kN)	Mx (Nm)	My (Nm)	Mz (Nm)	Mr (Nm)
1	2.274	201.373	-2.935	3.713	-13.374	0.000	-10.364	16.919

2	2.047	172.127	-2.631	3.334	-11.990	0.000	-9.327	15.191
3	1.819	84.220	-2.328	2.954	-10.607	0.000	-8.291	13.463
4	1.592	84.304	-2.024	2.575	-9.224	0.000	-7.255	11.735
5	1.365	84.388	-1.720	2.196	-7.840	0.000	-6.218	10.007
6	1.137	84.473	-1.417	1.817	-6.457	0.000	-5.182	8.279
7	0.910	84.557	-1.113	1.438	-5.073	0.000	-4.146	6.552
8	0.682	84.642	-0.810	1.059	-3.690	0.000	-3.109	4.825
9	0.455	84.726	-0.506	0.681	-2.307	0.000	-2.073	3.101
10	0.227	84.810	-0.203	0.305	-0.923	0.000	-1.036	1.388

Displacement of bearing

Misalignment of bearing

	ux (µm)	uy (µm)	uz (µm)	rr (µm)	rx (mrad)	ry (mrad)	rz (mrad)	rr (mrad)
1	0.0000	-10.0000	0.0000	0.0000	0.027	4.006	-0.002	0.027
2	0.0000	-10.0000	0.0000	0.0000	0.024	3.605	-0.002	0.024
3	0.0000	-10.0000	0.0000	0.0000	0.021	3.205	-0.002	0.021
4	0.0000	-10.0000	-0.0000	0.0000	0.019	2.804	-0.001	0.019
5	0.0000	-10.0000	-0.0000	0.0000	0.016	2.404	-0.001	0.016
6	0.0000	-10.0000	-0.0000	0.0000	0.013	2.003	-0.001	0.013
7	0.0000	-10.0000	-0.0000	0.0000	0.010	1.602	-0.001	0.010
8	0.0000	-10.0000	-0.0000	0.0000	0.008	1.202	-0.001	0.008
9	0.0000	-10.0000	-0.0000	0.0000	0.005	0.801	-0.000	0.005
10	0.0000	-10.0000	0.0000	0.0000	0.002	0.401	-0.000	0.002

Shaft 'Shaft4' Rolling bearing 'RollerBearing4'

Position (Y-coordinate)	[y]	186.00	mm
Life modification factor for reliability[a ₁]		0.248	
Nominal bearing service life	[L _{nh}]	0.78	h
Operating viscosity	[v]	9.77	mm ² /s
Static safety factor	[S ₀]	1.07	

Bearing reaction force

Bearing reaction moment

	Fx (kN)	Fy (kN)	Fz (kN)	Fr (kN)	Mx (Nm)	My (Nm)	Mz (Nm)	Mr (Nm)
1	-5.002	-203.273	-3.902	6.344	67.411	0.000	-86.412	109.596
2	-4.502	-173.837	-3.499	5.702	60.445	0.000	-77.771	98.498
3	-4.002	-85.740	-3.096	5.059	53.478	0.000	-69.129	87.400
4	-3.501	-85.634	-2.692	4.417	46.512	0.000	-60.488	76.303
5	-3.001	-85.528	-2.289	3.775	39.545	0.000	-51.847	65.207
6	-2.501	-85.423	-1.886	3.132	32.579	0.000	-43.206	54.112
7	-2.001	-85.317	-1.483	2.490	25.612	0.000	-34.565	43.020
8	-1.501	-85.211	-1.079	1.848	18.645	0.000	-25.924	31.932
9	-1.000	-85.106	-0.676	1.207	11.679	0.000	-17.282	20.858
10	-0.500	-85.000	-0.273	0.570	4.712	0.000	-8.641	9.843

Displacement of bearing

Misalignment of bearing

	ux (µm)	uy (µm)	uz (µm)	rr (µm)	rx (mrad)	ry (mrad)	rz (mrad)	rr (mrad)
1	0.0000	10.0000	0.0000	0.0000	0.007	5.506	-0.045	0.045
2	0.0000	10.0000	0.0000	0.0000	0.007	4.955	-0.040	0.041
3	0.0000	10.0000	0.0000	0.0000	0.006	4.405	-0.036	0.036
4	0.0000	10.0000	0.0000	0.0000	0.005	3.854	-0.031	0.032
5	0.0000	10.0000	0.0000	0.0000	0.004	3.303	-0.027	0.027
6	0.0000	10.0000	0.0000	0.0000	0.003	2.753	-0.022	0.023
7	0.0000	10.0000	0.0000	0.0000	0.003	2.202	-0.018	0.018
8	0.0000	10.0000	0.0000	0.0000	0.002	1.652	-0.013	0.014
9	0.0000	10.0000	0.0000	0.0000	0.001	1.101	-0.009	0.009
10	0.0000	10.0000	0.0000	0.0000	0.000	0.551	-0.004	0.004

Damage (%) [Lreq] (7200.000)

Bin no	B1	B2
1	9999.99	9999.99
2	9999.99	9999.99
3	9999.99	9999.99
4	9999.99	9999.99
5	9999.99	9999.99
6	9999.99	9999.99
7	9999.99	9999.99
8	9999.99	9999.99
9	9999.99	9999.99
10	9999.99	9999.99
Σ	9999.99	9999.99

Utilization (%) [Lreq] (7200.000)

B1	B2
2755.31	1548.83

Note: Utilization = (Lreq/Lh)^(1/k)
 Ball bearing: k = 3, roller bearing: k = 10/3

B1: RollerBearing3
 B2: RollerBearing4

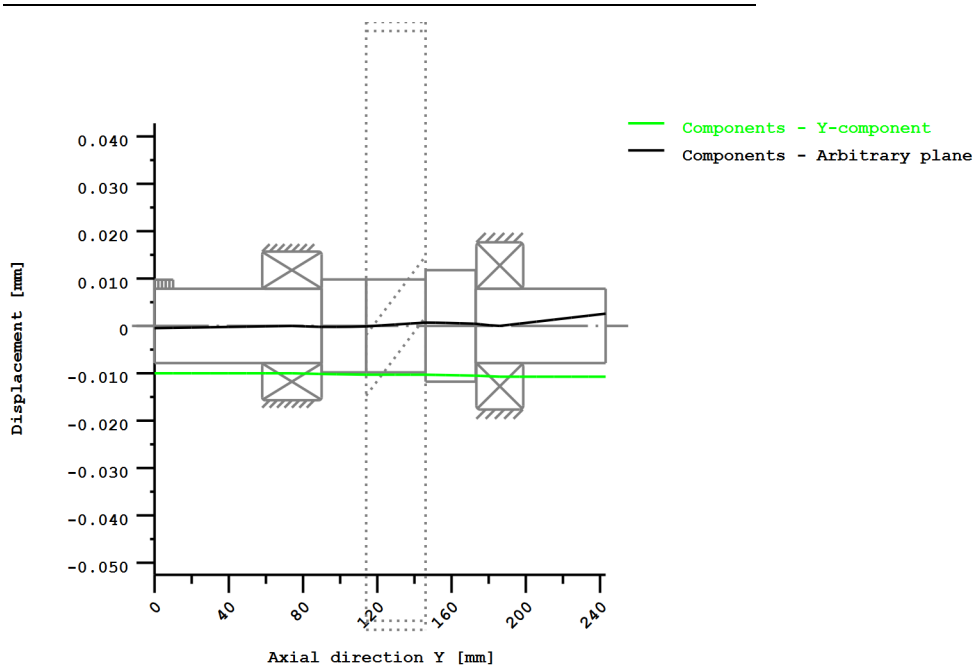
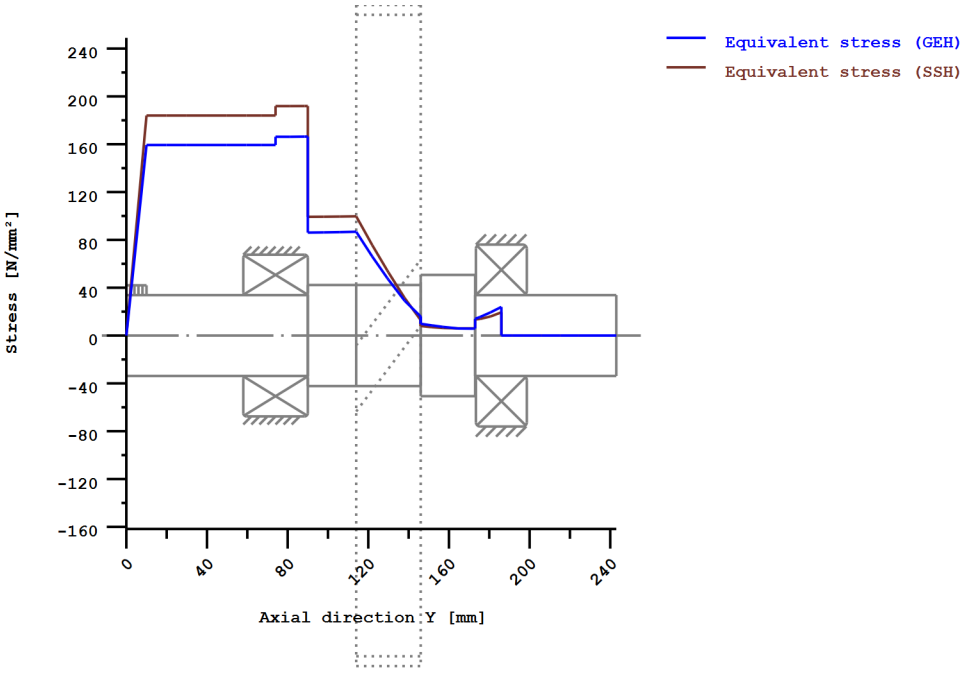


Figure: Deformation (bending etc.) (Arbitrary plane 9.305095299 121)



Nominal stresses, without taking into account stress concentrations

GEH(von Mises): $\text{sigV} = ((\text{sigB} + \text{sigZ}, D)^2 + 3 * (\text{tauT} + \text{tauS})^2)^{1/2}$

SSH(Tresca): $\text{sigV} = ((\text{sigB} - \text{sigZ}, D)^2 + 4 * (\text{tauT} + \text{tauS})^2)^{1/2}$

Figure: Equivalent stress

**Strength calculation according to DIN 743:2012
with finite life fatigue strength according to FKM standard and FVA draft**

Summary

Shaft4

Material	31 CrMoV9
Material type	Nitriding steel
Material treatment	gas-nitrided
Surface treatment	No

Calculation of service strength and static strength
S-N curve (Woehler line) according Miner elementary

Calculation for load case 2 ($\sigma_{av}/\sigma_{mv} = \text{const}$)

Cross section	Position (Y-Coord) (mm)	
A-A	74.00	Own Input
B-B	90.00	Own Input
C-C	130.00	Smooth shaft
D-D	146.00	Own Input
E-E	157.00	Own Input
F-F	172.00	Own Input
E-E	186.00	Own Input

Results:

Cross section	Kfb	Kfs	K2d	SZ	SS	SA
A-A	1.00	0.86	0.89	3.30	2.10	31.96
B-B	1.00	0.86	0.89	3.26	2.13	31.41
C-C	1.00	0.86	0.87	4.97	4.65	239.80
D-D	1.00	0.86	0.87	4.79	5.13	9999.99
E-E	1.00	0.86	0.86	7.18	6.88	9999.99
F-F	1.00	0.86	0.86	7.35	6.64	9999.99
E-E	1.00	0.86	0.89	3.08	3.26	9999.99

Required safeties: 1.40 1.40 1.40

Abbreviations:

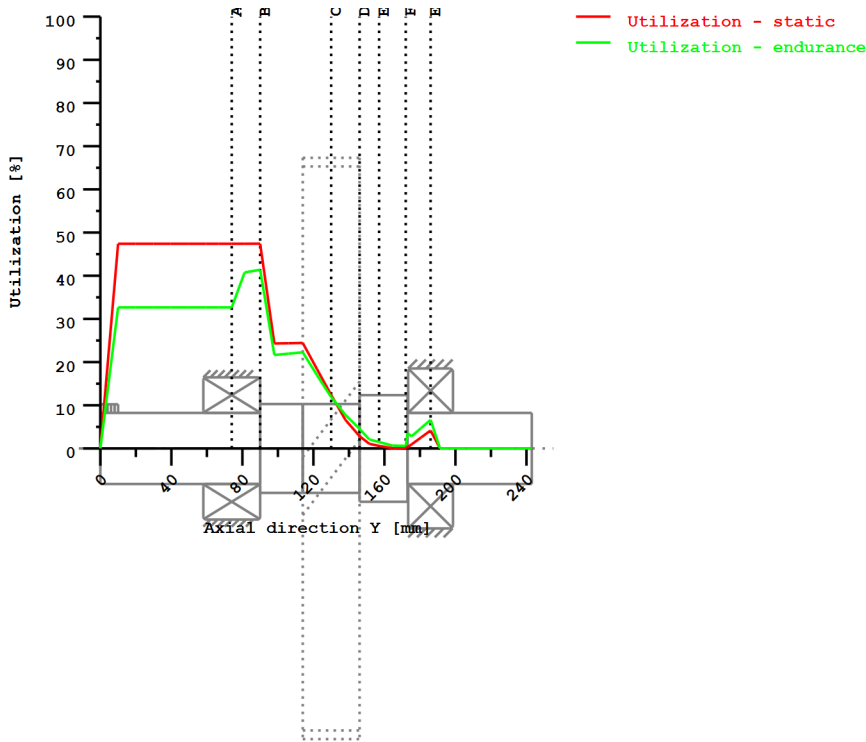
- Kfb: Notch factor bending
- Kfs: Surface factor
- K2d: size factor bending
- SZ: Safety fatigue strength
- SS: Safety against yield point
- SA: Safety against incipient crack

Service life and damage

System service life (h)	[Hatt]	1000000.00
Damage to system (%)	[D]	0.00

Utilization (%) [Smin/S]

Cross section	Static	Endurance
A-A	66.672	42.403
B-B	65.809	42.984
C-C	30.120	28.189
D-D	27.296	29.236
E-E	20.341	19.488
F-F	21.099	19.042
E-E	42.939	45.512
Maximum utilization (%)	[A]	66.672



Utilization = S_{min}/S (%)

Figure: Strength

Calculation details

General statements

Label	Shaft4		
Drawing			
Length (mm)	[l]	243.00	
Speed (1/min)	[n]	6246.81	

Material	31 CrMoV9
Material type	Nitriding steel
Material treatment	gas-nitrided
Surface treatment	No

	Tension/Compression	Bending	Torsion	Shearing
Load factor static calculation	1.700	1.700	1.700	1.700
Load factor endurance limit	1.000	1.000	1.000	1.000

Reference diameter material (mm)	[dB]	100.00
σ_B according to DIN 743 (at dB) (N/mm ²)	[σ_B]	1000.00
σ_S according to DIN 743 (at dB) (N/mm ²)	[σ_S]	800.00
[σ_{zdW}] (bei dB) (N/mm ²)		400.00
[σ_{bW}] (bei dB) (N/mm ²)		500.00
[τ_{tW}] (bei dB) (N/mm ²)		300.00
Thickness of raw material (mm)	[dWerkst]	65.00

Material data calculated according DIN743/3 with K1(d)

Material strength calculated from size of raw material

Geometric size factor K1d calculated from raw material diameter

[σBeff] (N/mm ²)	1000.00
[σSeff] (N/mm ²)	800.00
[σbF] (N/mm ²)	800.00
[τtF] (N/mm ²)	461.88
[σBRand] (N/mm ²)	2300.00
[σzdW] (N/mm ²)	400.00
[σbW] (N/mm ²)	500.00
[τtW] (N/mm ²)	300.00

Service strength for a load spectrum

S-N curve (Woehler lines) according to Miner elementary according to FKM guideline

Required life time	[H]	18000.00
Number of load cycles (Mio)	[NL]	8230.794

Data of S-N curve (Woehler line) analog to FKM standard:

[κσ, κτ]	15	25
[κDσ, κDτ]	0	0
[NDσ, NDτ]	1e+006	1e+006
[NDσII, NDτII]	0	0

Calculation for load case 2 (σ.av/σ.mv = const)

Cross section 'A-A' Own Input

Comment

Position (Y-Coordinate) (mm)	[y]	74.000
External diameter (mm)	[da]	40.000
Inner diameter (mm)	[di]	0.000
Notch effect		Own Input
Mean roughness (μm)	[Rz]	8.000

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)					
Mean value [Fzdm, Mbm, Tm, Fqm]	-100686.6	0.0	578.0	0.0	
Amplitude [Fzda, Mba, Ta, Fqa]	100686.6	16.7	578.0	3718.5	
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]	-342334.5	28.4	1965.3	6321.4	
Cross section, moment of resistance: (mm ²)					
[A, Wb, Wt, A]	1256.6	6283.2	12566.4	1256.6	

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compres. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-201373.239	16.707	1156.055	3718.466
2	1.0000e+001	-172127.049	14.980	1040.450	3339.202
3	1.0000e+001	-84219.763	13.252	924.844	2959.951
4	1.0000e+001	-84304.122	11.525	809.239	2580.718
5	1.0000e+001	-84388.480	9.799	693.633	2201.512
6	1.0000e+001	-84472.838	8.073	578.028	1822.350
7	1.0000e+001	-84557.197	6.348	462.422	1443.266
8	1.0000e+001	-84641.555	4.625	346.817	1064.345
9	1.0000e+001	-84725.913	2.909	231.211	685.857
10	1.0000e+001	-84810.272	1.228	115.606	309.390

Stresses: (N/mm ²)					
[σzdm, σbm, τm, τqm] (N/mm ²)		-80.124	0.000	45.998	0.000
[σzda, σba, τa, τqa] (N/mm ²)		80.124	2.659	45.998	3.945
[σzdmax, σbmax, τmax, τqmax] (N/mm ²)		-272.421	4.520	156.393	6.707

Technological size influence	[K1(σB)]	1.000		
	[K1(σS)]	1.000		

Tension/Compression Bending Torsion

Notch effect coefficient	[β(dB)]	0.000	0.000	0.000
[dB] (mm) = 0.0				
Geometrical size influence	[K3(d)]	0.000	0.000	0.000
Geometrical size influence	[K3(dB)]	0.000	0.000	0.000
Notch effect coefficient	[β]	1.000	1.000	1.000
Geometrical size influence	[K2(d)]	1.000	0.888	0.888
Influence coefficient surface roughness	[KF]	0.861	0.861	0.920
Surface stabilization factor	[KV]	1.000	1.017	1.017
Total influence coefficient	[K]	1.161	1.266	1.193

Present safety for endurance limit:

Equivalent mean stress (N/mm ²)	[σmV]		-8.508	
Equivalent mean stress (N/mm ²)	[τmV]		0.000	

Fatigue limit of part (N/mm ²)	[σWK]	344.452	394.949	251.526
Influence coefficient of mean stress sensitivity.				
	[ψσK]	0.208	0.246	0.144
Permissible amplitude (N/mm ²)	[σADK]	352.234	190.486	251.526
Permissible amplitude (N/mm ²)	[σANK]	352.234	190.486	251.526
Effective Miner sum	[DM]	1.000	1.000	1.000
Load spectrum factor	[fKoll]	1.000	1.000	1.000
Safety against fatigue	[S]		3.302	
Required safety against fatigue	[Smin]		1.400	
Result (%)	[S/Smin]		235.8	

Present safety

for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[γF]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σFK]	800.000	800.000	461.880
Safety yield stress	[S]		2.100	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		150.0	

Present safety

for proof of avoiding incipient crack on hard surface layers:

Safety against incipient crack	[S]		31.960	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		2282.8	

Cross section 'B-B' Own Input

Comment

Position (Y-Coordinate) (mm)	[y]	90.000
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External diameter (mm)	[da]	50.000
Inner diameter (mm)	[di]	0.000
Notch effect	Own Input	
Mean roughness (μm)	[Rz]	8.000

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)				
Mean value [Fzdm, Mbm, Tm, Fqm]	-100686.6	0.0	578.0	0.0
Amplitude [Fzda, Mba, Ta, Fqa]	100686.6	42.8	578.0	3719.7
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]	-342334.5	72.8	1965.3	6323.5
Cross section, moment of resistance: (mm^2)				
[A, Wb, Wt, A]	1256.6	6283.2	12566.4	1256.6

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compres. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-201373.239	42.799	1156.055	3719.688
2	1.0000e+001	-172127.049	38.459	1040.450	3340.423
3	1.0000e+001	-84219.763	34.118	924.844	2961.170
4	1.0000e+001	-84304.122	29.778	809.239	2581.934
5	1.0000e+001	-84388.480	25.438	693.633	2202.724
6	1.0000e+001	-84472.838	21.098	578.028	1823.557
7	1.0000e+001	-84557.197	16.758	462.422	1444.465
8	1.0000e+001	-84641.555	12.419	346.817	1065.531
9	1.0000e+001	-84725.913	8.083	231.211	687.013
10	1.0000e+001	-84810.272	3.757	115.606	310.439

Stresses: (N/mm^2)

[σ_{zdm} , σ_{bm} , τ_m , τ_{qm}] (N/mm^2)	-80.124	0.000	45.998	0.000
[σ_{zda} , σ_{ba} , τ_a , τ_{qa}] (N/mm^2)	80.124	6.812	45.998	3.947
[σ_{zdmax} , σ_{bmax} , τ_{max} , τ_{qmax}] (N/mm^2)	-272.421	11.580	156.393	6.709

Technological size influence	[K1(σ_B)]	1.000
	[K1(σ_S)]	1.000

Tension/Compression Bending Torsion

Notch effect coefficient	[β (dB)]	0.000	0.000	0.000
[dB] (mm) =		0.0		
Geometrical size influence	[K3(d)]	0.000	0.000	0.000
Geometrical size influence	[K3(dB)]	0.000	0.000	0.000
Notch effect coefficient	[β]	1.000	1.000	1.000
Geometrical size influence	[K2(d)]	1.000	0.888	0.888
Influence coefficient surface roughness	[KF]	0.861	0.861	0.920
Surface stabilization factor	[KV]	1.000	1.017	1.017
Total influence coefficient	[K]	1.161	1.266	1.193

Present safety for endurance limit:

Equivalent mean stress (N/mm^2)	[σ_mV]	-8.508
Equivalent mean stress (N/mm^2)	[τ_mV]	0.000

Fatigue limit of part (N/mm^2)	[σ_{WK}]	344.452	394.949	251.526
Influence coefficient of mean stress sensitivity.	[$\psi\sigma_K$]	0.208	0.246	0.144
Permissible amplitude (N/mm^2)	[σ_{ADK}]	352.234	355.702	251.526

Permissible amplitude (N/mm ²)	[σANK]	352.234	355.702	251.526
Effective Miner sum	[DM]	1.000	1.000	1.000
Load spectrum factor	[fKoll]	1.000	1.000	1.000
Safety against fatigue	[S]		3.257	
Required safety against fatigue	[Smin]		1.400	
Result (%)	[S/Smin]		232.6	

Present safety

for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[γF]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σFK]	800.000	800.000	461.880
Safety yield stress	[S]		2.127	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		152.0	

Present safety

for proof of avoiding incipient crack on hard surface layers:

Safety against incipient crack	[S]		31.413	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		2243.8	

Cross section 'C-C' Smooth shaft

Comment

Position (Y-Coordinate) (mm)	[y]		130.000
External diameter (mm)	[da]		50.000
Inner diameter (mm)	[di]		0.000
Notch effect		Smooth shaft	
Mean roughness (μm)	[Rz]		8.000

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)					
Mean value [Fzdm, Mbm, Tm, Fqm]		-101161.6	0.0	289.0	0.0
Amplitude [Fzda, Mba, Ta, Fqa]		101161.6	127.4	289.0	3670.2
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]		-343949.3	216.5	982.6	6239.4
Cross section, moment of resistance: (mm ²)					
[A, Wb, Wt, A]		1963.5	12271.8	24543.7	1963.5

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compress. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-202323.109	127.359	578.028	3670.235
2	1.0000e+001	-172981.933	114.279	520.225	3303.019
3	1.0000e+001	-84979.659	101.198	462.422	2935.804
4	1.0000e+001	-84969.031	88.118	404.619	2568.590
5	1.0000e+001	-84958.402	75.038	346.817	2201.378
6	1.0000e+001	-84947.773	61.958	289.014	1834.168
7	1.0000e+001	-84937.145	48.879	231.211	1466.963
8	1.0000e+001	-84926.516	35.800	173.408	1099.768
9	1.0000e+001	-84915.887	22.724	115.606	732.597
10	1.0000e+001	-84905.259	9.660	57.803	365.522

Stresses: (N/mm²)

[σzdm, σbm, τm, τqm] (N/mm ²)	-51.521	0.000	11.775	0.000
[σzda, σba, τa, τqa] (N/mm ²)	51.521	10.378	11.775	2.492
[σzdmax, σbmax, τmax, τqmax] (N/mm ²)	-175.172	17.643	40.037	4.237

Technological size influence	[K1(σB)]	1.000		
	[K1(σS)]	1.000		

Tension/Compression Bending Torsion

Notch effect coefficient	[β]	1.000	1.000	1.000
Geometrical size influence	[K2(d)]	1.000	0.873	0.873
Influence coefficient surface roughness	[KF]	0.861	0.861	0.920
Surface stabilization factor	[KV]	1.000	1.017	1.017
Total influence coefficient	[K]	1.161	1.285	1.212

Present safety for endurance limit:

Equivalent mean stress (N/mm ²)	[σmV]		-47.312	
Equivalent mean stress (N/mm ²)	[τmV]		0.000	

Fatigue limit of part (N/mm ²)	[σWK]	344.452	389.143	247.605
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Influence coefficient of mean stress sensitivity.

	[ψσK]	0.208	0.242	0.141
Permissible amplitude (N/mm ²)	[σADK]	417.035	143.915	247.605
Permissible amplitude (N/mm ²)	[σANK]	417.035	143.915	247.605
Effective Miner sum	[DM]	1.000	1.000	1.000
Load spectrum factor	[fKoll]	1.000	1.000	1.000
Safety against fatigue	[S]		4.966	
Required safety against fatigue	[Smin]		1.400	
Result (%)	[S/Smin]		354.7	

Present safety

for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[γF]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σFK]	800.000	800.000	461.880
Safety yield stress	[S]		4.648	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		332.0	

Present safety

for proof of avoiding incipient crack on hard surface layers:

Safety against incipient crack	[S]		239.796	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		17128.3	

Cross section 'D-D' Own Input

Comment			
Position (Y-Coordinate) (mm)	[y]		146.000
External diameter (mm)	[da]		60.000
Inner diameter (mm)	[di]		0.000
Notch effect		Own Input	
Mean roughness (μm)	[Rz]		8.000

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)					
Mean value [Fzdm, Mbm, Tm, Fqm]		-101636.5	0.0	-0.0	0.0
Amplitude [Fzda, Mba, Ta, Fqa]		101636.5	144.5	0.0	6352.0
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]		-345564.1	245.6	0.0	10798.3
Cross section, moment of resistance: (mm ²)					
[A, Wb, Wt, A]		1963.5	12271.8	24543.7	1963.5

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compres. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-203272.980	144.479	-0.000	6351.969
2	1.0000e+001	-173836.816	129.879	-0.000	5709.514
3	1.0000e+001	-85739.556	115.279	-0.000	5067.079
4	1.0000e+001	-85633.940	100.680	0.000	4424.670
5	1.0000e+001	-85528.324	86.082	-0.000	3782.303
6	1.0000e+001	-85422.709	71.484	-0.000	3140.001
7	1.0000e+001	-85317.093	56.890	-0.000	2497.817
8	1.0000e+001	-85211.477	42.299	-0.000	1855.872
9	1.0000e+001	-85105.861	27.721	-0.000	1214.545
10	1.0000e+001	-85000.246	13.193	-0.000	575.902

Stresses: (N/mm²)

[σzdm, σbm, τm, τqm] (N/mm ²)	-51.763	0.000	-0.000	0.000
[σzda, σba, τa, τqa] (N/mm ²)	51.763	11.773	0.000	4.313
[σzdmax, σbmax, τmax, τqmax] (N/mm ²)	-175.994	20.014	0.000	7.333

Technological size influence	[K1(σB)]	1.000
	[K1(σS)]	1.000

Tension/Compression Bending Torsion

Notch effect coefficient	[β(dB)]	0.000	0.000	0.000
[dB] (mm) =		0.0		
Geometrical size influence	[K3(d)]	0.000	0.000	0.000
Geometrical size influence	[K3(dB)]	0.000	0.000	0.000
Notch effect coefficient	[β]	1.000	1.000	1.000
Geometrical size influence	[K2(d)]	1.000	0.873	0.873
Influence coefficient surface roughness	[KF]	0.861	0.861	0.920
Surface stabilization factor	[KV]	1.000	1.017	1.017
Total influence coefficient	[K]	1.161	1.285	1.212

Present safety for endurance limit:

Equivalent mean stress (N/mm ²)	[σmV]	-51.763
Equivalent mean stress (N/mm ²)	[τmV]	0.000

Fatigue limit of part (N/mm ²)	[σWK]	344.452	389.143	247.605
Influence coefficient of mean stress sensitivity.	[ψσK]	0.208	0.242	0.141
Permissible amplitude (N/mm ²)	[σADK]	400.000	148.239	247.605
Permissible amplitude (N/mm ²)	[σANK]	400.000	148.239	247.605
Effective Miner sum	[DM]	1.000	1.000	1.000
Load spectrum factor	[fKoll]	1.000	1.000	1.000
Safety against fatigue	[S]		4.789	
Required safety against fatigue	[Smin]		1.400	

Result (%)	[S/Smin]		342.0	
Present safety				
for proof against exceed of yield point:				
Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[yF]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σFK]	800.000	800.000	461.880
Safety yield stress	[S]		5.129	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		366.3	

Present safety				
for proof of avoiding incipient crack on hard surface layers:				
Safety against incipient crack	[S]		9999.990	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		714285.0	

Cross section 'E-E' Own Input

Comment				
Position (Y-Coordinate) (mm)	[y]		157.000	
External diameter (mm)	[da]		60.000	
Inner diameter (mm)	[di]		0.000	
Notch effect		Own Input		
Mean roughness (μm)	[Rz]		8.000	

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)					
Mean value [Fzdm, Mbm, Tm, Fqm]		-101636.5	0.0	-0.0	0.0
Amplitude [Fzda, Mba, Ta, Fqa]		101636.5	74.6	0.0	6350.5
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]		-345564.1	126.8	0.0	10795.8
Cross section, moment of resistance: (mm ²)					
[A, Wb, Wt, A]		2827.4	21205.8	42411.5	2827.4

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compress. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-203272.980	74.615	-0.000	6350.497
2	1.0000e+001	-173836.816	67.082	-0.000	5708.045
3	1.0000e+001	-85739.556	59.549	0.000	5065.614
4	1.0000e+001	-85633.940	52.017	0.000	4423.210
5	1.0000e+001	-85528.324	44.484	-0.000	3780.850
6	1.0000e+001	-85422.709	36.953	-0.000	3138.558
7	1.0000e+001	-85317.093	29.422	0.000	2496.388
8	1.0000e+001	-85211.477	21.893	-0.000	1854.468
9	1.0000e+001	-85105.861	14.369	0.000	1213.192
10	1.0000e+001	-85000.246	6.866	-0.000	574.722

Stresses: (N/mm ²)					
[σzdm, σbm, τm, τqm] (N/mm ²)		-35.947	0.000	-0.000	0.000
[σzda, σba, τa, τqa] (N/mm ²)		35.947	3.519	0.000	2.995
[σzdmax, σbmax, τmax, τqmax] (N/mm ²)		-122.218	5.982	0.000	5.091

Technological size influence	[K1(σB)]	1.000		
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[K1(σ S)] 1.000

Tension/Compression Bending Torsion

Notch effect coefficient [dB] (mm) = 0.0	[β (dB)]	0.000	0.000	0.000
Geometrical size influence	[K3(d)]	0.000	0.000	0.000
Geometrical size influence	[K3(dB)]	0.000	0.000	0.000
Notch effect coefficient	[β]	1.000	1.000	1.000
Geometrical size influence	[K2(d)]	1.000	0.861	0.861
Influence coefficient surface roughness	[KF]	0.861	0.861	0.920
Surface stabilization factor	[KV]	1.000	1.017	1.017
Total influence coefficient	[K]	1.161	1.301	1.228

Present safety for endurance limit:

Equivalent mean stress (N/mm ²)	[σ mV]	-35.947
Equivalent mean stress (N/mm ²)	[τ mV]	0.000

Fatigue limit of part (N/mm ²)	[σ WK]	344.452	384.381	244.394
Influence coefficient of mean stress sensitivity.	[ψ σ K]	0.208	0.238	0.139
Permissible amplitude (N/mm ²)	[σ ADK]	400.000	71.326	244.394
Permissible amplitude (N/mm ²)	[σ ANK]	400.000	71.326	244.394
Effective Miner sum	[DM]	1.000	1.000	1.000
Load spectrum factor	[fKoll]	1.000	1.000	1.000
Safety against fatigue	[S]	7.184		
Required safety against fatigue	[Smin]	1.400		
Result (%)	[S/Smin]	513.1		

Present safety

for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[γ F]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σ FK]	800.000	800.000	461.880
Safety yield stress	[S]	6.883		
Required safety	[Smin]	1.400		
Result (%)	[S/Smin]	491.6		

Present safety

for proof of avoiding incipient crack on hard surface layers:

Safety against incipient crack	[S]	9999.990
Required safety	[Smin]	1.400
Result (%)	[S/Smin]	714285.0

Cross section 'F-F' Own Input

Comment

Position (Y-Coordinate) (mm)	[y]	172.000
External diameter (mm)	[da]	60.000
Inner diameter (mm)	[di]	0.000
Notch effect		Own Input
Mean roughness (μ m)	[Rz]	8.000

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)

Mean value [Fzdm, Mbm, Tm, Fqm]	-101636.5	0.0	-0.0	0.0
Amplitude [Fzda, Mba, Ta, Fqa]	101636.5	20.6	0.0	6348.5
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]	-345564.1	35.1	0.0	10792.4
Cross section, moment of resistance: (mm ²)				
[A, Wb, Wt, A]	2827.4	21205.8	42411.5	2827.4

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compress. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-203272.980	20.628	-0.000	6348.491
2	1.0000e+001	-173836.816	18.525	-0.000	5706.043
3	1.0000e+001	-85739.556	16.422	0.000	5063.617
4	1.0000e+001	-85633.940	14.319	0.000	4421.221
5	1.0000e+001	-85528.324	12.216	-0.000	3778.869
6	1.0000e+001	-85422.709	10.114	-0.000	3136.591
7	1.0000e+001	-85317.093	8.013	0.000	2494.442
8	1.0000e+001	-85211.477	5.915	-0.000	1852.556
9	1.0000e+001	-85105.861	3.823	0.000	1211.352
10	1.0000e+001	-85000.246	1.762	-0.000	573.125

Stresses: (N/mm²)

[σzdm, σbm, τm, τqm] (N/mm ²)	-35.947	0.000	-0.000	0.000
[σzda, σba, τa, τqa] (N/mm ²)	35.947	0.973	0.000	2.994
[σzdmax, σbmax, τmax, τqmax] (N/mm ²)	-122.218	1.654	0.000	5.089

Technological size influence

[K1(σB)]	1.000
[K1(σS)]	1.000

Tension/Compression Bending Torsion

Notch effect coefficient [β(dB)]	0.000	0.000	0.000
[dB] (mm) = 0.0			
Geometrical size influence [K3(d)]	0.000	0.000	0.000
Geometrical size influence [K3(dB)]	0.000	0.000	0.000
Notch effect coefficient [β]	1.000	1.000	1.000
Geometrical size influence [K2(d)]	1.000	0.861	0.861
Influence coefficient surface roughness [KF]	0.861	0.861	0.920
Surface stabilization factor [KV]	1.000	1.017	1.017
Total influence coefficient [K]	1.161	1.301	1.228

Present safety for endurance limit:

Equivalent mean stress (N/mm ²) [σmV]	-35.947
Equivalent mean stress (N/mm ²) [τmV]	0.000

Fatigue limit of part (N/mm ²) [σWK]	344.452	384.381	244.394
Influence coefficient of mean stress sensitivity.			
[ψσK]	0.208	0.238	0.139
Permissible amplitude (N/mm ²) [σADK]	400.000	21.079	244.394
Permissible amplitude (N/mm ²) [σANK]	400.000	21.079	244.394
Effective Miner sum [DM]	1.000	1.000	1.000
Load spectrum factor [fKoll]	1.000	1.000	1.000
Safety against fatigue [S]		7.352	
Required safety against fatigue [Smin]		1.400	
Result (%) [S/Smin]		525.2	

Present safety

for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[yF]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σFK]	800.000	800.000	461.880
Safety yield stress	[S]		6.635	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		474.0	

Present safety

for proof of avoiding incipient crack on hard surface layers:

Safety against incipient crack	[S]		9999.990	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		714285.0	

Cross section 'E-E' Own Input

Comment

Position (Y-Coordinate) (mm)	[y]		186.000	
External diameter (mm)	[da]		40.000	
Inner diameter (mm)	[di]		0.000	
Notch effect		Own Input		
Mean roughness (μm)	[Rz]		8.000	

Tension/Compression Bending Torsion Shearing

Load: (N) (Nm)

Mean value [Fzdm, Mbm, Tm, Fqm]		-101636.5	0.0	0.0	0.0
Amplitude [Fzda, Mba, Ta, Fqa]		101636.5	109.5	0.0	6347.6
Maximum value [Fzdmax, Mbmax, Tmax, Fqmax]		-345564.1	186.1	0.0	10790.9
Cross section, moment of resistance: (mm ²)					
[A, Wb, Wt, A]		1256.6	6283.2	12566.4	1256.6

Load spectrum, load base values (Mean-value + Amplitude):

No.	Frequency (%)	Tens./Compress. (N)	Bending (Nm)	Torsion (Nm)	Shearing (N)
1	1.0000e+001	-203272.980	109.500	-0.000	6347.584
2	1.0000e+001	-173836.816	98.402	-0.000	5705.139
3	1.0000e+001	-85739.556	87.304	-0.000	5062.715
4	1.0000e+001	-85633.940	76.208	0.000	4420.322
5	1.0000e+001	-85528.324	65.112	-0.000	3777.975
6	1.0000e+001	-85422.709	54.018	-0.000	3135.703
7	1.0000e+001	-85317.093	42.927	-0.000	2493.563
8	1.0000e+001	-85211.477	31.841	-0.000	1851.693
9	1.0000e+001	-85105.861	20.771	-0.000	1210.523
10	1.0000e+001	-85000.246	9.768	0.000	572.409

Stresses: (N/mm²)

[σzdm, σbm, τm, τqm] (N/mm ²)		-80.880	0.000	0.000	0.000
[σzda, σba, τa, τqa] (N/mm ²)		80.880	17.427	0.000	6.735
[σzdmax, σbmax, τmax, τqmax] (N/mm ²)		-274.991	29.627	0.000	11.449

Technological size influence	[K1(σB)]	1.000
	[K1(σS)]	1.000

Tension/Compression Bending Torsion

Notch effect coefficient [dB] (mm) = 0.0	[β(dB)]	0.000	0.000	0.000
Geometrical size influence	[K3(d)]	0.000	0.000	0.000
Geometrical size influence	[K3(dB)]	0.000	0.000	0.000
Notch effect coefficient	[β]	1.000	1.000	1.000
Geometrical size influence	[K2(d)]	1.000	0.888	0.888
Influence coefficient surface roughness	[KF]	0.861	0.861	0.920
Surface stabilization factor	[KV]	1.000	1.017	1.017
Total influence coefficient	[K]	1.161	1.266	1.193

Present safety for endurance limit:

Equivalent mean stress (N/mm ²)	[σmV]	-80.880		
Equivalent mean stress (N/mm ²)	[τmV]	0.000		

Fatigue limit of part (N/mm ²)	[σWK]	344.452	394.949	251.526
Influence coefficient of mean stress sensitivity.				
	[ψσK]	0.208	0.246	0.144
Permissible amplitude (N/mm ²)	[σADK]	400.000	141.820	251.526
Permissible amplitude (N/mm ²)	[σANK]	400.000	141.820	251.526
Effective Miner sum	[DM]	1.000	1.000	1.000
Load spectrum factor	[fKoll]	1.000	1.000	1.000
Safety against fatigue	[S]		3.076	
Required safety against fatigue	[Smin]		1.400	
Result (%)	[S/Smin]		219.7	

Present safety

for proof against exceed of yield point:

Static notch sensitivity factor	[K2F]	1.000	1.000	1.000
Increase coefficient	[γF]	1.000	1.000	1.000
Yield stress of part (N/mm ²)	[σFK]	800.000	800.000	461.880
Safety yield stress	[S]		3.260	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		232.9	

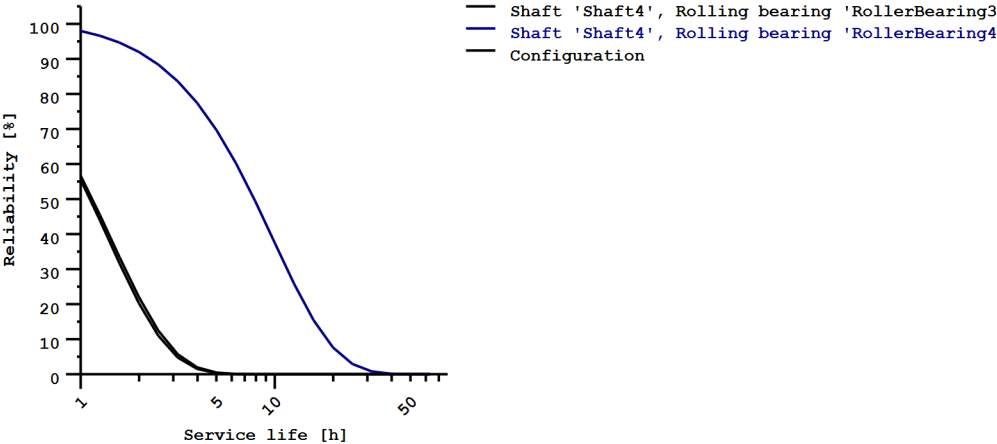
Present safety

for proof of avoiding incipient crack on hard surface layers:

Safety against incipient crack	[S]		9999.990	
Required safety	[Smin]		1.400	
Result (%)	[S/Smin]		714285.0	

Remarks:

- The shearing force is not considered in the analysis specified in DIN 743.
- Cross section with interference fit:
The notching factor for the light fit case is no longer defined in DIN 743.
The values are imported from the FKM-Guideline..



Reliability 99.0 % : Service life subsystem 0.038 h

Lmin: Bearing with the lowest attained lifetime of 0 h at 1 % failure probability.

Lmax: Bearing with the highest attained lifetime of 1 h at 1 % failure probability.

Figure: Reliability