

File

Name : AA  
 Changed by : leo tsai on: 12.01.2013 at: 22:40:45

**Analysis of shafts, axle and beams**

**Input data**

Coordinate system shaft: see picture W-002

Label	Shaft 1
Drawing	
Initial position (mm)	0.000
Length (mm)	550.000
Speed (1/min)	100.00
Sense of rotation: clockwise	
Material	30 CrNiMo 8 (1)
Young's modulus (N/mm <sup>2</sup> )	206000.000
Poisson's ratio nu	0.300
Specific weight (kg/m <sup>3</sup> )	7830.000
Warmth elongation coefficient (10 <sup>-6</sup> /K)	11.500
Temperature (°C)	20.000
Weight of shaft (kg)	68.297
Mass moment of inertia (kgm <sup>2</sup> )	0.214
Momentum of mass GD <sup>2</sup> (Nm <sup>2</sup> )	8.409
Position in space (°)	0.000
Consider deformations due to shearing	
Shear correction coefficient	1.100
Roller bearing stiffness is calculated from inner bearing geometry	
Reference temperature (°C)	20.000

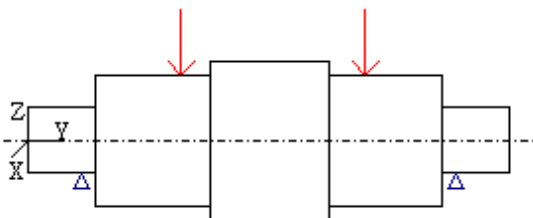
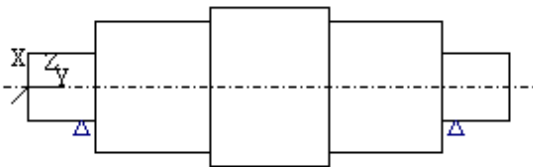


Figure: Load applications

**SHAFT GEOMETRY, BEARING AND FORCES**

**Shaft 'Shaft 1':**

Cylinder outside ('Cylinder') y= 0.00...77.50 (mm)  
 d=75.00 (mm), l=77.50 (mm), Rz= 8.0

Cylinder outside ('Cylinder') y= 77.50...207.00 (mm)  
 d=150.00 (mm), l=129.50 (mm), Rz= 8.0

Cylinder outside ('Cylinder') y= 207.00...343.00 (mm)  
 d=180.00 (mm), l=136.00 (mm), Rz= 8.0

Cylinder outside ('Cylinder') y= 343.00...472.50 (mm)  
 d=150.00 (mm), l=129.50 (mm), Rz= 8.0

Cylinder outside ('Cylinder') y= 472.50...550.00 (mm)  
 d=75.00 (mm), l=77.50 (mm), Rz= 8.0

Centric force ('Central load') y= 385.00 (mm)  
 Width of force input (mm) 0.0000

Torque (Nm)	0.0000
Axial force (N)	0.0000
Shearing force X (N)	0.0000
Shearing force Z (N)	-64285.0000
Bending moment X (Nm)	0.0000
Bending moment Z (Nm)	0.0000

Centric force ('Central load') y= 175.00 (mm)  
 Width of force input (mm) 0.0000

Torque (Nm)	0.0000
Axial force (N)	0.0000
Shearing force X (N)	0.0000
Shearing force Z (N)	-185714.0000
Bending moment X (Nm)	0.0000
Bending moment Z (Nm)	0.0000

Own Input ('Bearing (in general)') y= 61.00 (mm)  
 Degrees of freedom

X: fixed  
 Y: fixed  
 Z: fixed  
 Rx: free  
 Ry: fixed  
 Rz: fixed

Own Input ('Bearing (in general)') y= 489.00 (mm)  
 Degrees of freedom

X: fixed  
 Y: fixed  
 Z: fixed  
 Rx: free  
 Ry: fixed  
 Rz: fixed

max. deflection 0.05699 mm (Shaft 1, 241.00 (mm))

**Center of mass**  
 Shaft 1 275.0 mm

Roller bearing service life according to ISO/TS 16281

**Shaft 'Shaft 1' Bearing 'Bearing (in general)'**

Position (Y-coordinate) [y]	61.00	mm
Bearing reaction force [Fx]	0.000	kN
Bearing reaction force [Fy]	0.000	kN
Bearing reaction force [Fz]	152.204	kN

Bearing reaction force	[Fr]	152.204	kN (90°)
Displacement of bearing	[ux]	0.000	mm
Displacement of bearing	[uy]	0.000	mm
Displacement of bearing	[uz]	-0.000	mm
Displacement of bearing	[ur]	0.000	mm
Misalignment of bearing	[rx]	-0.419	mrاد (-1.44')
Misalignment of bearing	[ry]	0.000	mrاد (0')
Misalignment of bearing	[rz]	0.000	mrاد (0')
Misalignment of bearing	[rr]	0.419	mrاد (1.44')

**Shaft 'Shaft 1' Bearing 'Bearing (in general)'**

Position (Y-coordinate)	[y]	489.00	mm
Bearing reaction force	[Fx]	0.000	kN
Bearing reaction force	[Fy]	0.000	kN
Bearing reaction force	[Fz]	98.465	kN
Bearing reaction force	[Fr]	98.465	kN (90°)
Displacement of bearing	[ux]	0.000	mm
Displacement of bearing	[uy]	0.000	mm
Displacement of bearing	[uz]	-0.000	mm
Displacement of bearing	[ur]	0.000	mm
Misalignment of bearing	[rx]	0.352	mrاد (1.21')
Misalignment of bearing	[ry]	0.000	mrاد (0')
Misalignment of bearing	[rz]	0.000	mrاد (0')
Misalignment of bearing	[rr]	0.352	mrاد (1.21')

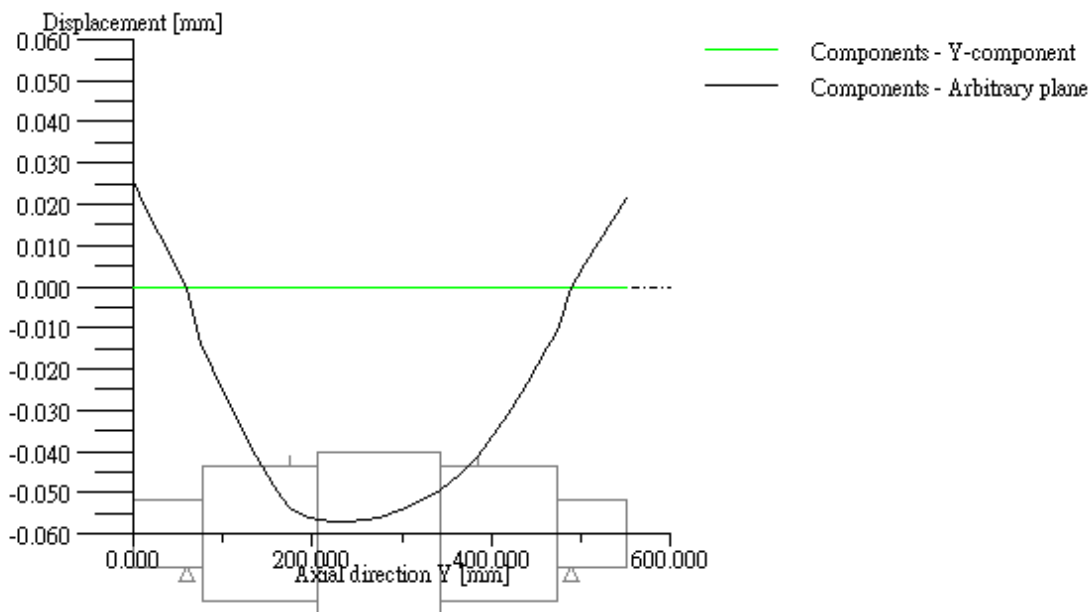
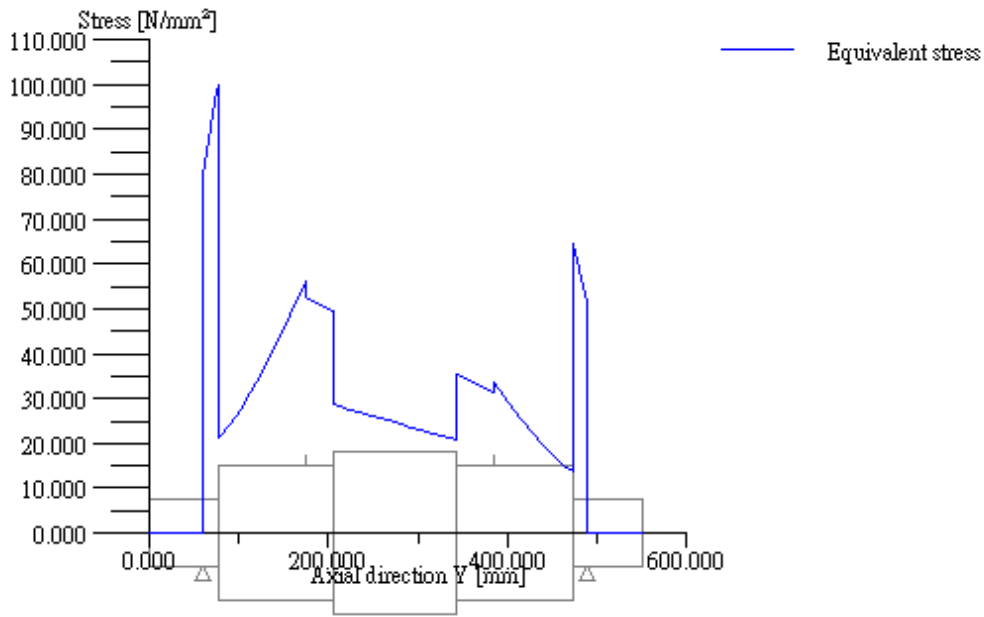
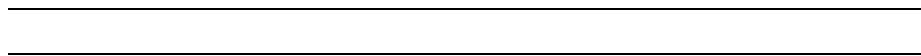


Figure: Displacement (bending etc.) (Arbitrary plane 90 °)



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

Figure: Equivalent stress



**Strength calculation according to Draft DIN 743 (Edition 2008-10)  
with finite life fatigue strength according to FKM standard and FVA draft**

**Summary**

Label	Shaft 1
Drawing	
Material	30 CrNiMo 8 (1)
Material type	Through hardened steel
Material treatment	alloyed, through hardened
Surface treatment	No

Calculation of finite life fatigue strength and static strength  
Calculation for load case 2 (sig.av/sig.mv = const)

Cross section	Position (Y-Coord) (mm)				
Limited cross section	77.00	Smooth shaft			
<b>Results:</b>					
Cross section	Kfb	Kfsig	K2d	SD	SS
Limited cross section	1.00	0.87	0.85	5.76	8.00
Nominal safety:				1.20	1.20

Abbreviations:  
 Kfb: Notch factor bending  
 Kfsig: Surface factor  
 K2d: Size coefficient bending  
 SD: Safety endurance limit  
 SS: Safety against yield point

The requirements of the safety proof of the shaft are:

satisfied [x] not satisfied [ ]

Design engineer:..... Date:..... Signature:.....

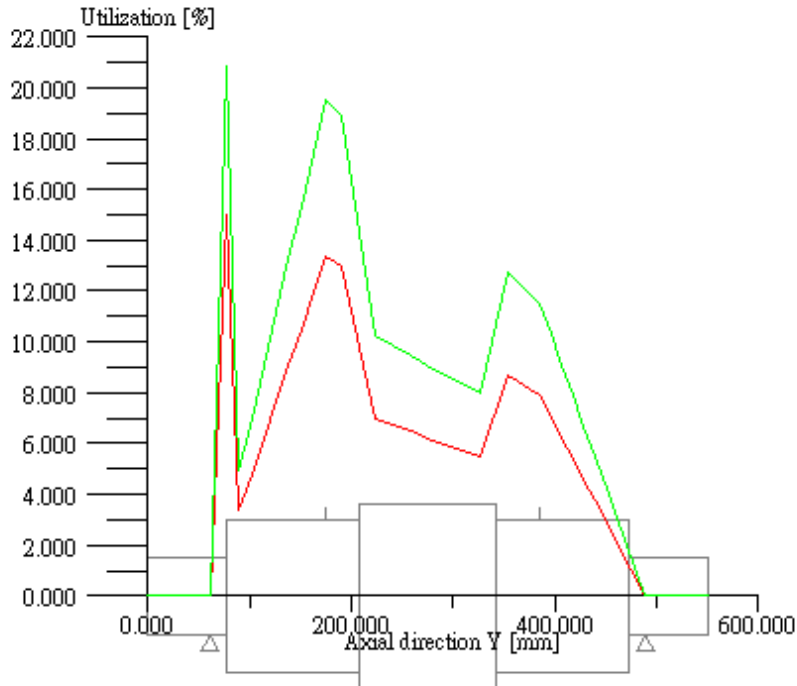


Figure: Strength

**Calculation details:**

General statements

Label Shaft 1  
 Drawing  
 Length (mm) [l] 550.00  
 Speed (1/min) [n] 100.00  
 Material 30 CrNiMo 8 (1)  
 Material type Through hardened steel  
 Material treatment alloyed, through hardened  
 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]	16.00
sigB according DIN 743 (at dB) (N/mm <sup>2</sup> )	[sigB]	1250.00
sigS according DIN 743 (at dB) (N/mm <sup>2</sup> )	[sigS]	1050.00
[sigzdW] (bei dB) (N/mm <sup>2</sup> )		500.00
[sigbW] (bei dB) (N/mm <sup>2</sup> )		625.00
[tautW] (bei dB) (N/mm <sup>2</sup> )		375.00
Thickness of raw material (mm)	[dWerkst]	190.00
Material data calculated according DIN743/3 with K1(d)		
Material strength calculated from size of raw material		
Geometric size coefficient K1d calculated from raw material diameter		
[sigBeff] (N/mm <sup>2</sup> )		900.74
[sigSeff] (N/mm <sup>2</sup> )		666.36
[sigbF] (N/mm <sup>2</sup> )		799.63
[tautF] (N/mm <sup>2</sup> )		461.66
[sigBRand] (N/mm <sup>2</sup> )		900.00
[sigzdW] (N/mm <sup>2</sup> )		360.30
[sigbW] (N/mm <sup>2</sup> )		450.37
[tautW] (N/mm <sup>2</sup> )		270.22

Fatigue strength for single stage use  
 Required life time [h] 2000.00  
 Number of load cycles (Mio) [NL] 12.000  
 Data of Woehler line (S-N curve) analog to FKM standard:  
 [ksigma, ktau] 5 8

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[kDsigma, kDtau]          0      0
[NDSigma, NDTau]        1e+006  1e+006
[NDSigmaII, NDTauII]    0      0
[DM]                     0.3

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

**Cross section 'Limited cross section' Smooth shaft**

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Comment
Position (Y-Coordinate) (mm) [y] 77.00
External diameter (mm) [da] 75.000
Inner diameter (mm) [di] 0.000
Notch effect Smooth shaft
Mean roughness (µm) [Rz] 8.000

Tension/Compression Bending Torsion Shearing
Stress: (N) (Nm)
Mean value -0.0 0.0 0.0 0.0
Amplitude 0.0 2434.3 0.0 152180.3
Maximum value -0.0 4138.2 0.0 258706.5
Cross section, moment of resistance: (mm²)
[A, Wb, Wt, A] 4417.9 41417 82835 4417.9

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Stresses: (N/mm²)
[sigzdm, sigbm, taum, tauqm] (N/mm²) -0.000 0.000 0.000 0.000
[sigzda, sigba, taua, tauqa] (N/mm²) 0.000 58.774 0.000 45.929
[sigzdmax, sigbmax, taumax, tauqmax] (N/mm²) -0.000 99.915 0.000 78.079

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Technological size influence [K1 (sigB)] 0.721
[K1 (sigS)] 0.635

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Tension/Compression Bending Torsion
Notch effect coefficient [beta (dB)] 0.000 0.000 0.000
[ dB] (mm) = 0.0
Geometrical size influence [K3 (d)] 0.000 0.000 0.000
[K3 (dB)] 0.000 0.000 0.000
Notch effect coefficient [beta] 1.000 1.000 1.000
Geometrical size influence [K2 (d)] 1.000 0.846 0.846
Influence coefficient surface roughness [KF] 0.870 0.870 0.925
Influence coefficient surface strengthening [KV] 1.000 1.000 1.000
Total influence coefficient [K] 1.149 1.331 1.262

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Present margin of safety for endurance limit:
Equivalent mean stress (N/mm²) [sigmV] 0.000
Equivalent mean stress (N/mm²) [taumV] 0.000
Fatigue limit of part (N/mm²) [sigWK] 313.512 338.402 214.066
Influence coeff. mean stress sensitivity. [PsisigK] 0.211 0.231 0.135
Permissible amplitude (N/mm²) [sigADK] 313.512 338.402 214.066
Permissible amplitude (N/mm²) [sigANK] 313.512 338.402 214.066
Load spectrum factor [fKoll] 1.000 1.000 1.000
Margin of safety endurance limit [S] 5.758
Required safety [Smin] 1.200
Result (%) [S/Smin] 479.8

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Present margin of safety for proof against exceed of yield point:
Static support number [K2F] 1.000 1.200 1.200
Increase coefficient [gammaF] 1.000 1.000 1.000
Yield stress of part (N/mm²) [sigFK] 666.356 799.627 461.665
Margin of safety yield stress [S] 8.003
Required safety [Smin] 1.200
Result (%) [S/Smin] 666.9

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Remarks:

- The shearing force is not considered in the analysis according to DIN 743..
- Cross section with square groove:  
The reference diameter for the notch number is not defined.  
Therefore the shaft diameter is taken as reference diameter..
- 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..

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End report lines: 359

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