Shaft, Standard

This program allows to prove the bearing ability for shafts and axles. The calculation base is provided by DIN 743, edition of December 2012 .

The proof of the bearing ability for shafts an axles is produced by defining a calculated safety. This safety is divided in the safety against fatigue fracture and the residual deformation (and flaw or forced break).

When calculating the avoidance of fatigue fracture, constant stress amplitudes being equivalent to damaging loads are taken as a basis. These ones are resulting from the predetermined loads. When proving against the residual deformation or forced break, designated as a safety against yielding, only the maximum occurring load is determinant. This one is resulting from the predetermined loads, too.

The calculation of factors of safety is related only to the point of a clear notch effect. For it, 9 calculable notches are at your disposal due to the graphical selection, principally.

The scope is limited to steels. Welded members should be calculated separately. But the utilized standard or the present program is ineffective for this purpose!

The calculation base for the module Shaft Calculation is provided by DIN 743, edition of December 2012, part 1-4 " Tragfähigkeitsberechnung von Wellen and Achsen" ("Calculation of bearing capacity of shafts and axles").

Input data:

Shaft calculation in accordance with DIN 743 - standard version

Geometry scheme — General shaft geometry

Calculation process — Dynamic and static strength proof

Geometry

Shaft geometry

Shaft geometry

Nr.	$D_{a\,l}$ mm	$D_{i\,l}$ mm	$D_{a\,r}$ mm	$D_{i\,r}$ mm	L mm	R_z µm	r mm	d: mm	t: mm	$\alpha_{\sigma\,zd}$:	$\alpha_{\sigma b}$:	$\alpha_{\tau t}$:	n_{zd}:	n_b:	n_t:	$\beta_{\sigma\,zddBK}$:	$\beta_{\sigma\,bdBK}$:	$\beta_{\tau\,dBK}$:	d_{BK}: mm
1	32	0	32	0	58	3.2	1	0	0	0	0	0	0	0	0	0	0	0	0
2	40	0	40	0	50	1.6	0.8	0	0	0	0	0	0	0	0	0	0	0	0
3	50	0	50	0	24.5	6.3	1	0	0	0	0	0	0	0	0	0	0	0	0
4	56.792	0	56.792	0	55	3.2	1	0	0	0	0	0	0	0	0	0	0	0	0
5	50	0	50	0	22.5	6.3	0.8	0	0	0	0	0	0	0	0	0	0	0	0
6	40	0	40	0	18.5	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0

Shaft, Standard

Predetermine the diameter determinant for the heat treatment ? no

Calculation of the deflection for point x = 160 mm

Shaft speed n : 1500 1/min

Considering weight - horizontal or vertical horizontal shaft

Width of bearing stiffness? No

Bearing

Nr.	Type =	Position x = mm	Radial bearing stiffness c_r = N/m	Torsional bearing stiffness c_α = N·m	Bending bearing stiffness c_β = N·m	Radial bearing stiffness c_r = N/m	Torsional bearing stiffness c_α = N·m	Bending bearing stiffness c_β = N·m	Bearing width = mm
1	Locating bearing ->	218.5	1e+015	0	0	1e+015	0	0	0
2	Locating bearing <-	99.5	1e+015	0	0	1e+015	0	0	0

Loading Data

Type of loading: tension-pressure Dynamically pure cyclic

Type of loading: bending Dynamically pure cyclic

Type of loading: torsion Dynamically pure cyclic

Factor for maximum loading (tension-pressure) 1

Factor for maximum loading (bending) 1

Factor for maximum loading (torsion) 1

Axial forces F_{ax}

Nr.	Position x = mm	Amount = N	Radius = mm	Angle α = °
1	160	-634.41	28.396	180

Radial forces F_r

Nr.	Position x = mm	Amount = N	Angle α = °
1	160	-1200.83	270

Torsion

Nr.	Position x = mm	Torsion moments M_t: N·mm	Power P: kW	Transition part =
1	29	114591.55	0	drive
2	160	114591.55	0	takeoff

Specifications about the load/loadings

Loading case	Constant mean stress (loading case 1)
Calculation of finite-life fatique strength ?	yes
Load cycles until fatique strength	N_D = 1000000
Required load cycles	N_L = 10000000
Slope exponent of S-N curve normal stress	q_σ : 5
Slope exponent of S-N curve shear stress	q_τ : 8
Minimum safety against fatigue fracture	S_{Dmin} = 1.2
Minimum safety against residual deformation	S_{Fmin} = 1.2
Minimum safety against incipient crack with hard surface	S_{Gmin} = 1.2

Material Data

Strength values according to	MDESIGN database

Shaft, Standard

Material designation	18CrNiMo7-6	
Material number	1.6587	
Gage diameter	d_B = 16	mm
For the gage diameter		
Tensile strength	$\sigma_{B'}$ (R_m) = 1200	N/mm²
Yield stress	$\sigma_{S'}$ (R_e) = 850	N/mm²
Cyclic fatigue strength under bending stress	$\sigma_{bW'}$ = 600	N/mm²
Cyclic tension and pressure fatigue strength	$\sigma_{zdW'}$ = 480	N/mm²
Cyclic torsional fatigue strength	$\tau_{tW'}$ = 360	N/mm²
Young's modulus	E = 215000	N/mm²
Shear modulus	G = 83000	N/mm²
Density	ρ = 7850	kg/m³
Apply surface hardening to	Total shaft	
Material group	Cemented steels	
Heat treatment	trial hardened (Cr-Ni-Mo-cemented steels)	
Surface hardening	cemented	

Results:

Calculation process: Dynamic and static strength proof

Geometry

Total shaft length	L	=	228.5	mm
Total shaft mass	m	=	2.86	kg
Mass moment of inertia of the shaft	J	=	0.00085	kg·m²
Geometrical moment of inertia of the shaft	I	=	142.704	cm⁴
Position of the centre of gravity in the X-axis	x_s	=	133.18	mm
Angle of torsion	φ	=	0.043	°

Additional shaft data:

Shaft fillet number	l mm	I_p cm⁴	W_t cm³	m kg	J kg·m²	I cm⁴	W_b cm³
1	58	10.294	6.434	0.366	0	5.147	3.217
2	50	25.133	12.566	0.493	0.0001	12.566	6.283
3	24.5	61.359	24.544	0.378	0.0001	30.68	12.272
4	55	102.129	35.966	1.094	0.0004	51.064	17.983
5	22.5	61.359	24.544	0.347	0.0001	30.68	12.272
6	18.5	25.133	12.566	0.182	0	12.566	6.283

Loading Data

Calculation results for point	**x**	=	160	mm
Trend of curve of the transverse force	Q_x	=	628.371	N
deflection	y_x	=	0.000426	mm
Angle of deflection	Θ	=	0.000106	°

Supporting forces:

No.	Type	Position x mm	Radial force in the Y-axis R_y N	Radial force in the Z-axis R_z N	Result. radial force R N	Axial force in the X-axis R_{ax} N	Tilting moment in the Y-axis N·m	Tilting moment in the Z-axis N·m	Result. tilting moment N·m
1	Locating bearing <-	99.5	-131.275	-590.324	604.744	0	0	0	0
2	Locating bearing ->	218.5	159.322	-610.506	630.953	634.41	0	0	0

Resulting maximum bending moment:				
Position	x	=	160	mm
Amount	M_{bmax}	=	36.833	N·m
Resulting maximum torsional moment:				
Position	x	=	29	mm
Amount	M_{tmax}	=	114.592	N·m
Resulting maximum tension-pressure-force:				
Position	x	=	160	mm

Amount	F_{zdmax}	=	634.41	N
Resulting maximum tension-pressure-stress:				
Position	x	=	210.546	mm
Amount	σ_{zdmax}	=	0.505	N/mm²
Resulting maximum bending stress:				
Position	x	=	160	mm
Amount	σ_{bmax}	=	2.048	N/mm²
Resulting maximum torsional stress:				
Position	x	=	29	mm
Amount	τ_{tmax}	=	17.81	N/mm²
Resulting maximum equivalent stress:				
Position	x	=	29	mm
Amount	σ_{vmax}	=	30.848	N/mm²
Resulting maximum deflection:				
Position	x	=	0	mm
Amount	y_{max}	=	0.001205	mm
Angle of the maximum deflection:				
Position	x	=	0.653	mm
Amount	Θ	=	0.000695	°
Minimum safety against yielding:				
Position	x	=	58	mm
Amount	S_F	=	24.703	
Minimum safety against fatigue fracture:				
Position	x	=	58	mm
Amount	S_D	=	12.693	
Minimum safety against incipient crack with hard surface:				
Position	x	=	58	mm
Amount	S_G	=	77.32	

Parameter of cross-sections:

Tension-pressure force F_{zd} and tension/pressure stress σ_{zd}

No.	Type	Position x mm	Result. F_{zdx} N	Amplitude F_{zda} N	Mean F_{zdm} N	Maximum F_{zdmax} N	Amplitude σ_{zda} N/mm²	Mean σ_{zdm} N/mm²	Maximum σ_{zdmax} N/mm²
1	Shaft fillet	58	0	0	0	0	0	0	0
2	Shaft fillet	108	0	0	0	0	0	0	0
3	Shaft fillet	132.5	0	0	0	0	0	0	0
4	Shaft fillet	187.5	634.41	634.41	0	634.41	0.323	0	0.323
5	Shaft fillet	210	634.41	634.41	0	634.41	0.505	0	0.505
6	Calculation results for point x	160	634.41	634.41	0	634.41	0.25	0	0.25

Bending moment M_b and bending stress σ_b

No.	Type	Position x mm	Result. M_{bx} N·m	Amplitude M_{ba} N·m	Mean M_{bm} N·m	Maximum M_{bmax} N·m	Amplitude σ_{ba} N/mm²	Mean σ_{bm} N/mm²	Maximum σ_{bmax} N/mm²
1	Shaft fillet	58	0.104	0.104	0	0.104	0.032	0	0.032
2	Shaft fillet	108	5.243	5.243	0	5.243	0.834	0	0.834
3	Shaft fillet	132.5	20.109	20.109	0	20.109	1.639	0	1.639
4	Shaft fillet	187.5	19.536	19.536	0	19.536	1.592	0	1.592
5	Shaft fillet	210	5.359	5.359	0	5.359	0.853	0	0.853
6	Calculation results for point x	160	36.833	36.833	0	36.833	2.048	0	2.048

Torsional moment M_t und Torsional stress τ_t

No.	Type	Position x mm	Result. M_{tx} N·m	Amplitude M_{ta} N·m	Mean M_{tm} N·m	Maximum M_{tmax} N·m	Amplitude τ_{ta} N/mm²	Mean τ_{tm} N/mm²	Maximum τ_{tmax} N/mm²
1	Shaft fillet	58	114.592	114.592	0	114.592	17.81	0	17.81
2	Shaft fillet	108	114.592	114.592	0	114.592	9.119	0	9.119
3	Shaft fillet	132.5	114.592	114.592	0	114.592	4.669	0	4.669
4	Shaft fillet	187.5	0	0	0	0	0	0	0
5	Shaft fillet	210	0	0	0	0	0	0	0
6	Calculation results for point x	160	114.592	114.592	0	114.592	3.186	0	3.186

Critical shaft speed values:

Critical bending shaft speed values

No.	Critical shaft speed values n_b 1/min	Eigenfrequencies ω rad/s
1	147741.06	15471.41
2	406806.45	42600.67
3	672369.05	70410.32
4	1112230.23	116472.48
5	1521810.74	159363.65

Critical torsional shaft speed values

No.	Critical shaft speed values n_b 1/min	Eigenfrequencies ω rad/s
1	543907.45	56957.86
2	963052.13	100850.58
3	1266403.87	132617.5
4	1754193.61	183698.73
5	2231983.22	233732.74

Material Data

Material parameter for	d_{max}	=	56.792	mm
Material designation		18CrNiMo7-6		
Material number		1.6587		
Tensile strength	σ_B	=	1028.348	N/mm²
Yield stress	σ_S	=	728.413	N/mm²
Cyclic tension and pressure fatigue strength	σ_{zdW}	=	411.339	N/mm²
Cyclic fatigue strength under bending stress	σ_{bW}	=	514.174	N/mm²
Cyclic torsional fatigue strength	τ_{tW}	=	308.504	N/mm²
Technological dimension factor (tensile strength)	$K_{1B}(d_{max})$	=	0.857	
Technological dimension factor (yield stress)	$K_{1S}(d_{max})$	=	0.857	

Proof of Strength

$K_1(d)$ - Technological dimension factor
$K_2(d)$ - Geometrical dimension factor
K_F - Influence factor of surface roughness
$\alpha_{\sigma,\tau}$ - Form factors

No.	Type	Position x mm	$K_{1B}(d)$	$K_{1S}(d)$	Tension - pressure $K_2(d)$	Bending and torsion $K_2(d)$	Tension-pressure, bending $K_{F\sigma}$	Torsion $K_{F\tau}$	Tension - pressure $\alpha_{\sigma zd}$	Bending $\alpha_{\sigma b}$	Torsion α_τ
1	Shaft fillet	58	0.9	0.9	1	0.9	0.92	0.95	2.58	2.33	1.67
2	Shaft fillet	108	0.87	0.87	1	0.89	0.97	0.98	3	2.69	1.85
3	Shaft fillet	132.5	0.86	0.86	1	0.87	0.87	0.93	2.73	2.51	1.73
4	Shaft fillet	187.5	0.86	0.86	1	0.87	0.87	0.93	2.73	2.51	1.73
5	Shaft fillet	210	0.87	0.87	1	0.89	0.97	0.98	3	2.69	1.85
6	Calculation results for point x	160	0.86	0.86	1	0.86	0.92	0.95	-	-	-

G′ - Relative stress drop
$n_{\sigma,\tau}$ - Bearing factor

No.	Type	Position x mm	Tension-pressure G'_{zd} 1/mm	Bending G'_b 1/mm	Torsion G'_t 1/mm	Tension-pressure $n\sigma_{zd}$	Bending $n_{\sigma b}$	Torsion n_τ
1	Shaft fillet	58	2.53	2.53	1.15	1.32	1.32	1.21
2	Shaft fillet	108	3.11	3.11	1.44	1.35	1.35	1.24
3	Shaft fillet	132.5	2.55	2.55	1.15	1.32	1.32	1.21
4	Shaft fillet	187.5	2.55	2.55	1.15	1.32	1.32	1.21
5	Shaft fillet	210	3.11	3.11	1.44	1.35	1.35	1.24
6	Calculation results for point x	160	-	-	-	-	-	-

Shaft, Standard

$\beta_{\sigma zddBK}$, $\beta_{\sigma bdBK}$, $\beta_{\tau dBK}$ - Stress concentration factor at d_{BK}
$\beta_{\sigma zd}$, $\beta_{\sigma b}$, β_{τ} - Stress concentration factors
K_V - Influence factor of surface hardening

No.	Type	Position x mm	Tension-pressure $\beta_{\sigma zddBK}$	Bending $\beta_{\sigma bdBK}$	Torsion $\beta_{\tau dBK}$	Tension-pressure $\beta_{\sigma zd}$	Bending $\beta_{\sigma b}$	Torsion β_{τ}	Tension-pressure $K_{v\sigma zd}$	Bending $K_{v\sigma b}$	Torsion $K_{v\tau}$
1	Shaft fillet	58	-	-	-	1.96	1.77	1.37	1.1	1.1	1.1
2	Shaft fillet	108	-	-	-	2.22	1.99	1.49	1.1	1.1	1.1
3	Shaft fillet	132.5	-	-	-	2.07	1.9	1.42	1	1	1
4	Shaft fillet	187.5	-	-	-	2.07	1.9	1.42	1	1	1
5	Shaft fillet	210	-	-	-	2.22	1.99	1.49	1.1	1.1	1.1
6	Calculation results for point x	160	-	-	-	1	1	1	1	1	1

K_{σ}, K_{τ} - Total influence factor
σ_{zdWK}, σ_{bWK}, τ_{tWK} - Cyclic fatigue strength of the notched part
K_{2F} - Static bearing effect

No.	Type	Position x mm	Tension - pressure K_{σ}	Bending K_{σ}	Torsion K_{τ}	Tension - pressure σ_{zdWK} N/mm²	Bending σ_{bWK} N/mm²	Torsions τ_{tWK} N/mm²	Tension - pressure K_{2Fzd}	Bending K_{2Fb}	Torsion K_{2Ft}
1	Shaft fillet	58	1.86	1.86	1.43	231.5	289.29	226.07	1	1	1
2	Shaft fillet	108	2.05	2.07	1.54	204.45	253.14	203.1	1	1	1
3	Shaft fillet	132.5	2.21	2.32	1.71	185.79	221.26	180.94	1	1	1
4	Shaft fillet	187.5	2.21	2.32	1.71	185.79	221.26	180.94	1	1	1
5	Shaft fillet	210	2.05	2.07	1.54	204.45	253.14	203.1	1	1	1
6	Calculation results for point x	160	1.09	1.24	1.2	378.83	413.96	256.26	1	1	1

Shaft, Standard

γ_F - Yield point rise

σ_{zdFK}, σ_{bFK}, τ_{tFK} - Yield point of the part

No.	Type	Position x mm	Tension-pressure γ_{Fzd}	Bending γ_{Fb}	Torsion γ_{Ft}	Tension-pressure σ_{zdFK} N/mm²	Bending σ_{bFK} N/mm²	Torsion τ_{tFK} N/mm²
1	Shaft fillet	58	1.1	1.1	1	838.26	838.26	439.97
2	Shaft fillet	108	1.1	1.1	1	814.7	814.7	427.61
3	Shaft fillet	132.5	1.1	1.1	1	801.25	801.25	420.55
4	Shaft fillet	187.5	1.1	1.1	1	801.25	801.25	420.55
5	Shaft fillet	210	1.1	1.1	1	814.7	814.7	427.61
6	Calculation results for point x	160	1	1	1	728.41	728.41	420.55

Static safety

No.	Type	Position x mm	S_F	In Point1 S_{F1}	in Point2 S_{F2}
1	Shaft fillet	58	24.7	-	-
2	Shaft fillet	108	46.84	-	-
3	Shaft fillet	132.5	88.58	-	-
4	Shaft fillet	187.5	418.41	-	-
5	Shaft fillet	210	600.04	-	-
6	Calculation results for point x	160	121.85	-	-

ψ - Influence factor of the mean stress sensitivitz

σ_{mv}, τ_{mv} - Comparative mean stress

No.	Type	Position x mm	Tension-pressure $\psi_{zd\sigma K}$	Bending $\psi_{b\sigma K}$	Torsion $\psi_{\tau K}$	σ_{mv} N/mm²	τ_{mv} N/mm²	σ_{mv1} N/mm²	τ_{mv1} N/mm²	σ_{mv2} N/mm²	τ_{mv2} N/mm²
1	Shaft fillet	58	-	0.16	0.12	0	0	-	-	-	-
2	Shaft fillet	108	-	0.14	0.11	0	0	-	-	-	-
3	Shaft fillet	132.5	-	0.12	0.1	0	0	-	-	-	-
4	Shaft fillet	187.5	0.1	0.12	-	0	0	-	-	-	-
5	Shaft fillet	210	0.11	0.14	-	0	0	-	-	-	-
6	Calculation results for point x	160	0.23	0.25	0.14	0	0	-	-	-	-

Alternating fatigue strength of the part (rated fatigue limit)

No.	Type	Position x mm	Tension-pressure σ_{zdADK} N/mm²	Bending σ_{bADK} N/mm²	Torsion τ_{tADK} N/mm²	Tension-pressure in Point1 σ_{zdADK1} N/mm²	Bending in Point1 σ_{bADK1} N/mm²	Torsion in Point1 τ_{tADK1} N/mm²	Tension-pressure in Point2 σ_{zdADK2} N/mm²	Bending in Point2 σ_{bADK2} N/mm²	Torsion in Point2 τ_{tADK2} N/mm²
1	Shaft fillet	58	-	289.29	226.07	-	-	-	-	-	-
2	Shaft fillet	108	-	253.14	203.1	-	-	-	-	-	-
3	Shaft fillet	132.5	-	221.26	180.94	-	-	-	-	-	-
4	Shaft fillet	187.5	185.79	221.26	-	-	-	-	-	-	-
5	Shaft fillet	210	204.45	253.14	-	-	-	-	-	-	-
6	Calculation results for point x	160	378.83	413.96	256.26	-	-	-	-	-	-

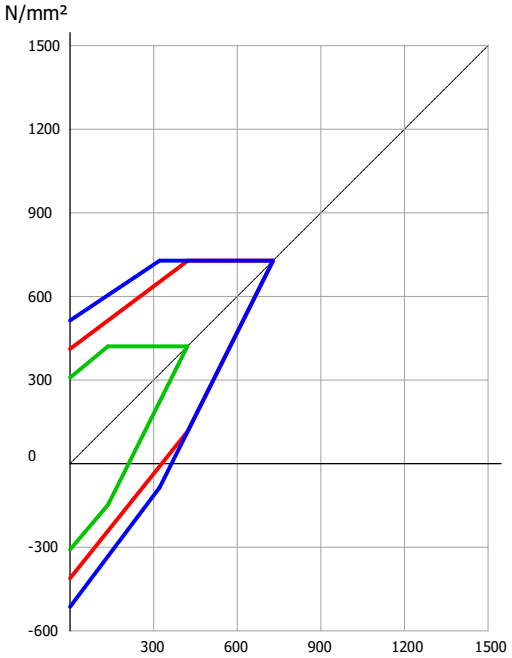
Dynamic safety

No.	Type	Position x mm	S_D	in Point1 S_{D1}	in Point2 S_{D2}
1	Shaft fillet	58	12.69	-	-
2	Shaft fillet	108	22.21	-	-
3	Shaft fillet	132.5	37.25	-	-
4	Shaft fillet	187.5	111.93	-	-
5	Shaft fillet	210	171.28	-	-
6	Calculation results for point x	160	73.31	-	-

Safety against incipient crack with hard surface

No.	Type	Position x mm	S_G	In Point1 S_{G1}	in Point2 S_{G2}
1	Shaft fillet	58	77.32	-	-
2	Shaft fillet	108	127.62	-	-
3	Shaft fillet	132.5	221.74	-	-
4	Shaft fillet	187.5	471.36	-	-
5	Shaft fillet	210	604.27	-	-
6	Calculation results for point x	160	507.01	-	-

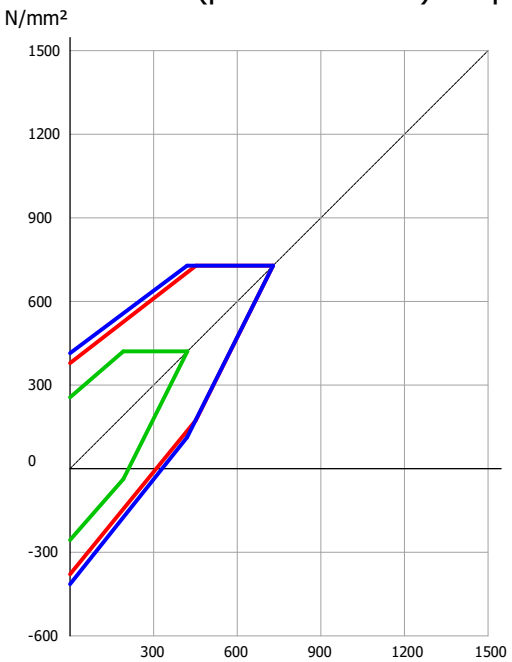
Unnotched (part dimension) for point x



Material	= 18CrNiMo7-6
Number	= 1.6587
$\sigma_B(d_{eff})$	= 1028 N/mm²
σ_{zdF}	= 728 N/mm²
σ_{bF}	= 728 N/mm²
τ_{tF}	= 421 N/mm²
σ_{zdW}	= 411 N/mm²
σ_{bW}	= 514 N/mm²
τ_{tW}	= 309 N/mm²

Tension-pressure
Bending
Torsion

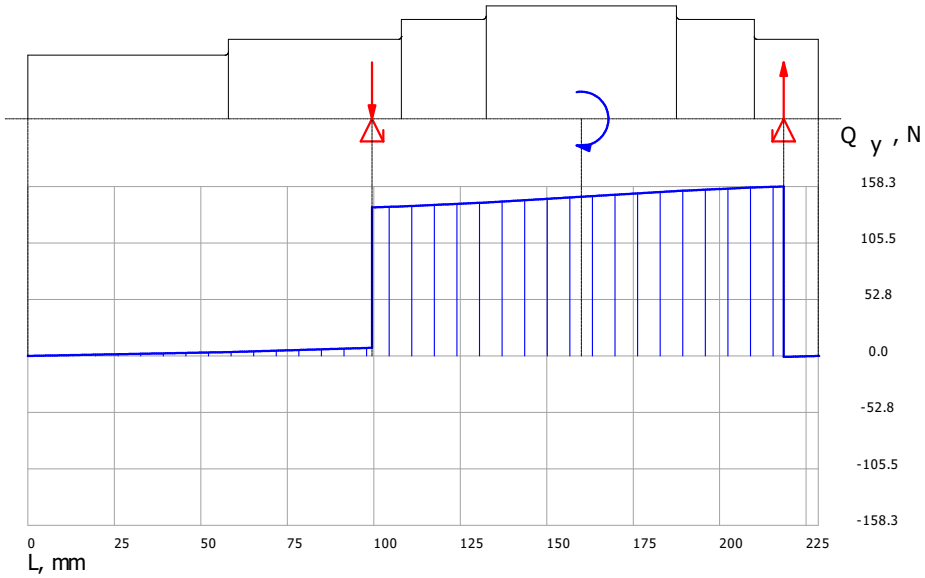
Notched (part dimension) for point x



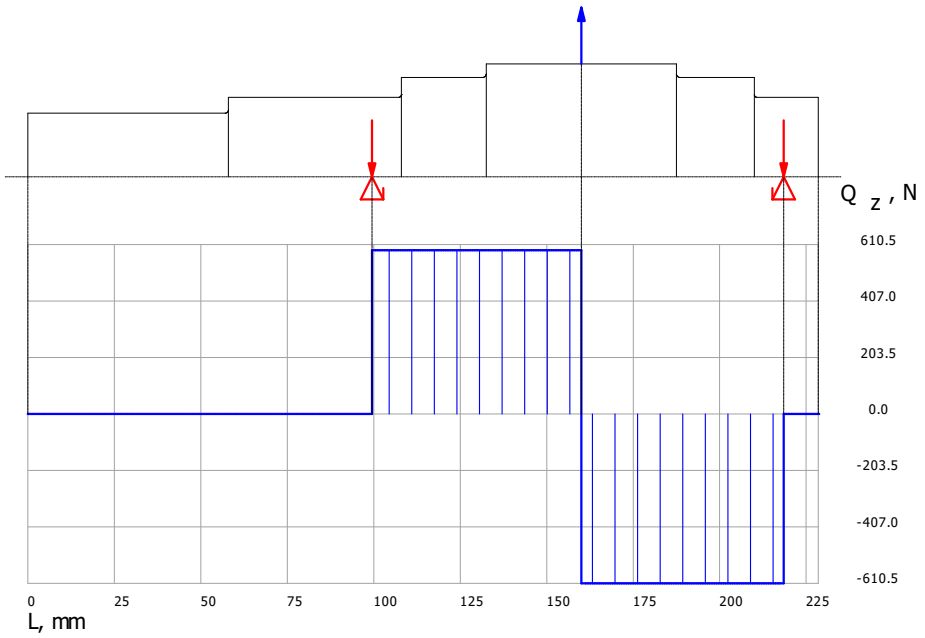
Material	= 18CrNiMo7-6
Number	= 1.6587
$\sigma_B(d_{eff})$	= 1028 N/mm²
σ_{zdFK}	= 728 N/mm²
σ_{bFK}	= 728 N/mm²
τ_{tFK}	= 421 N/mm²
σ_{zdWK}	= 379 N/mm²
σ_{bWK}	= 414 N/mm²
τ_{tWK}	= 256 N/mm²

Tension-pressure
Bending
Torsion

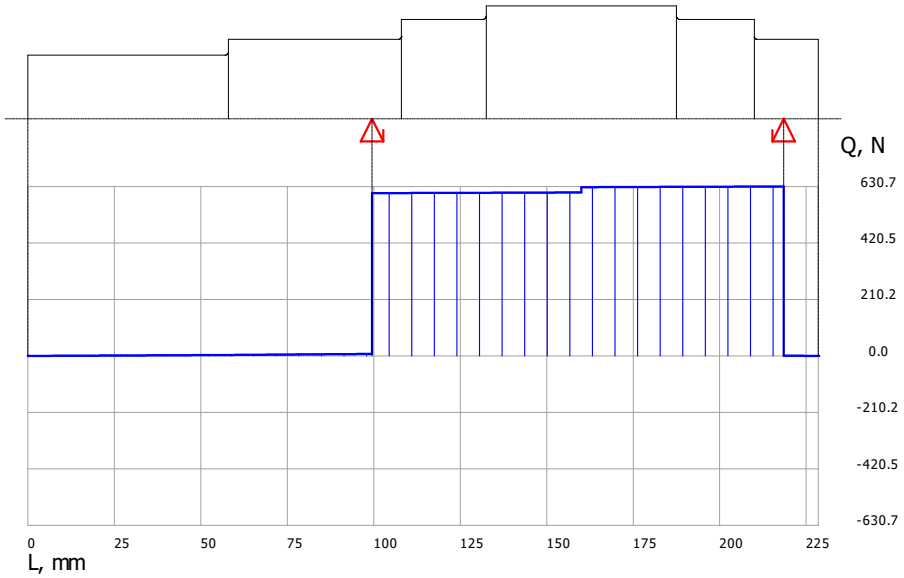
Trend of curve of the transverse force in the Y-X-plane



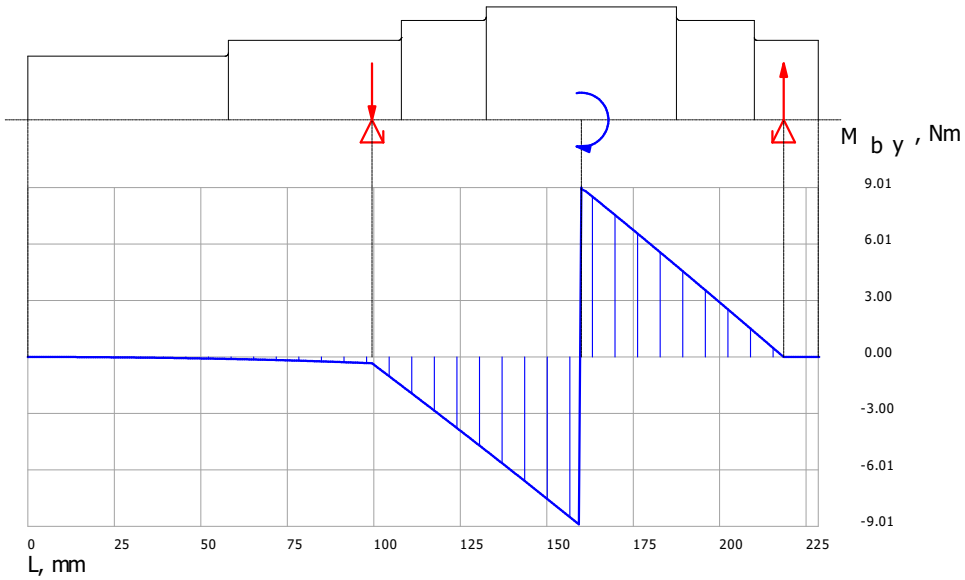
Trend of curve of the transverse force in the Z-X-plane



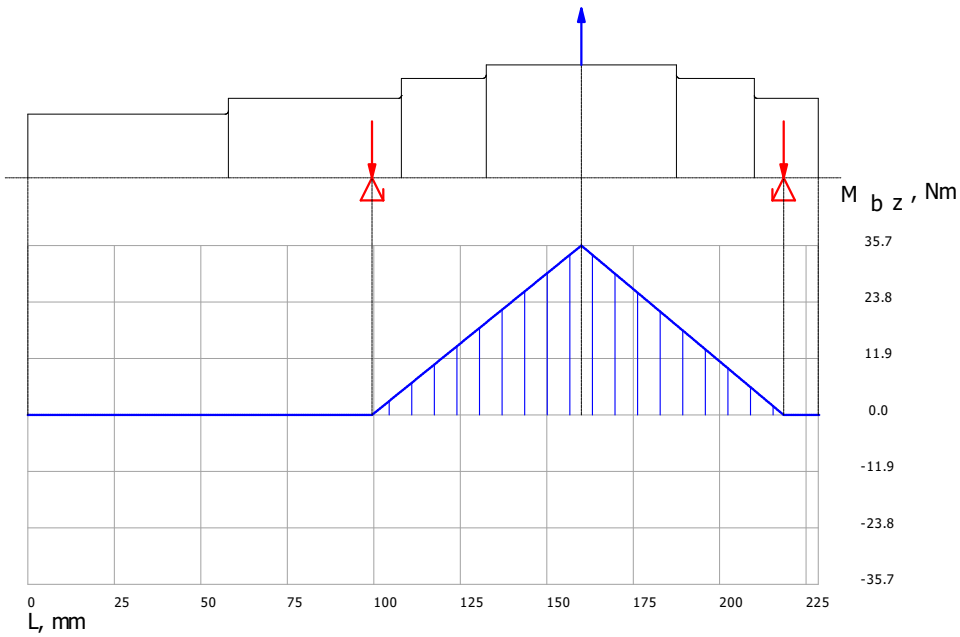
Trend of curve of the transverse force (combined characteristic)



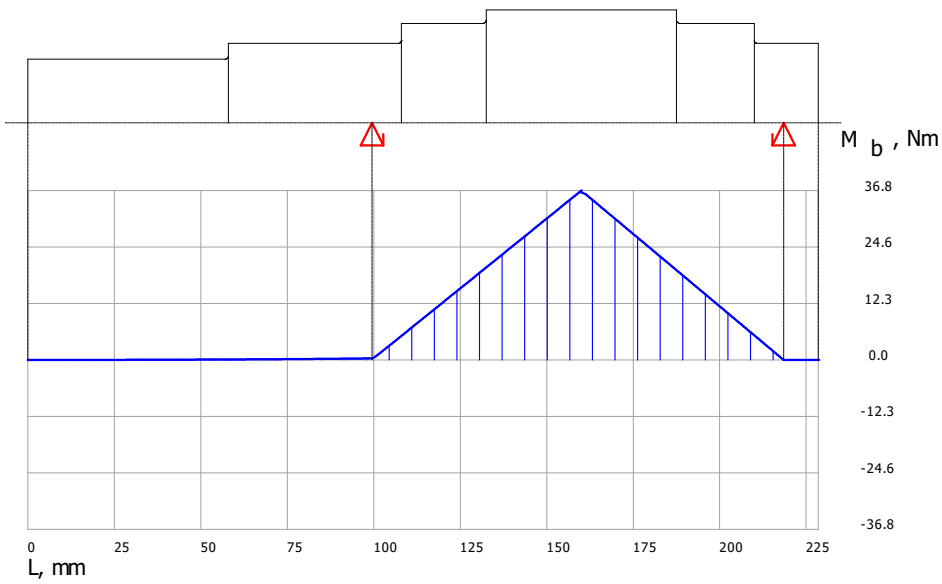
Bending moment in the Y-X-plane



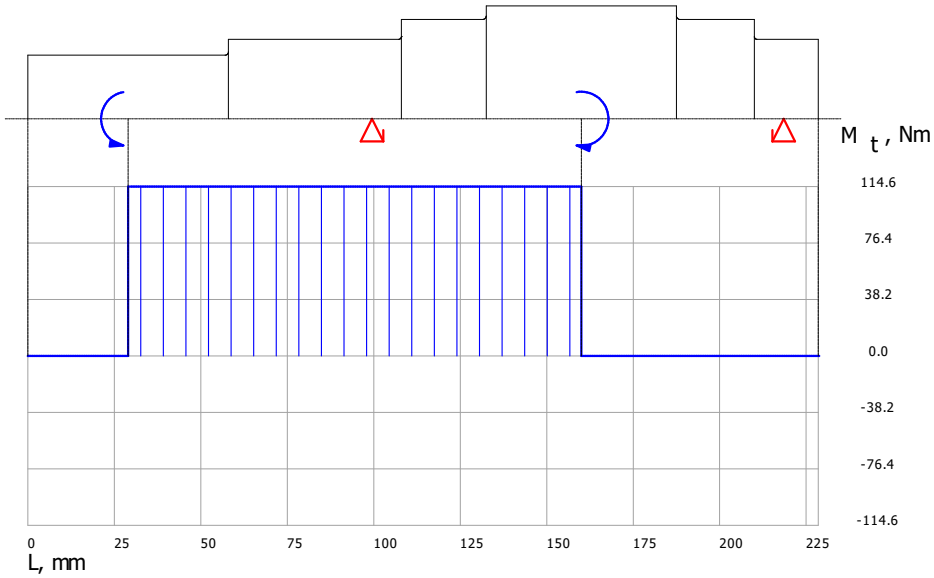
Trend of curve of the bending moment curve in the Z-X plane



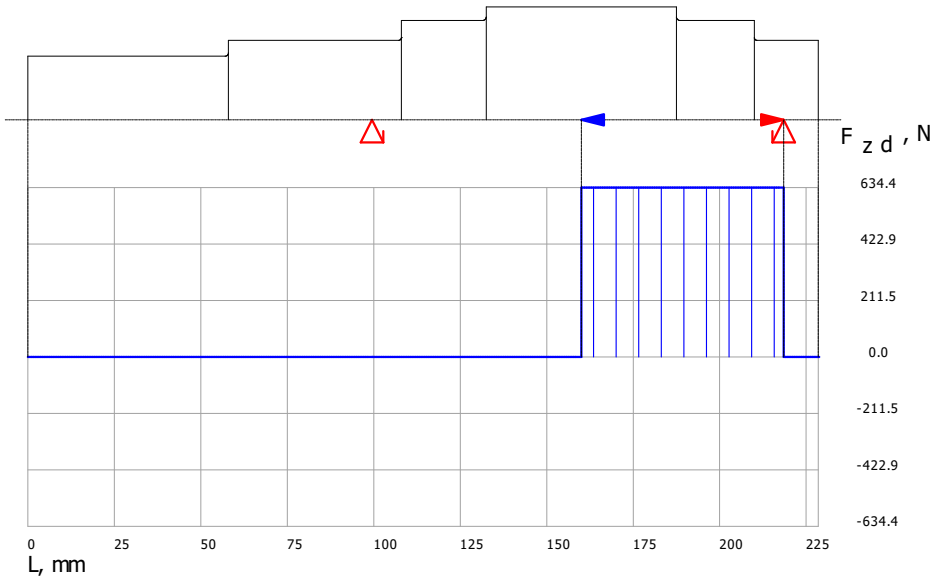
Trend of curve of the bending moment (combined characteristic)



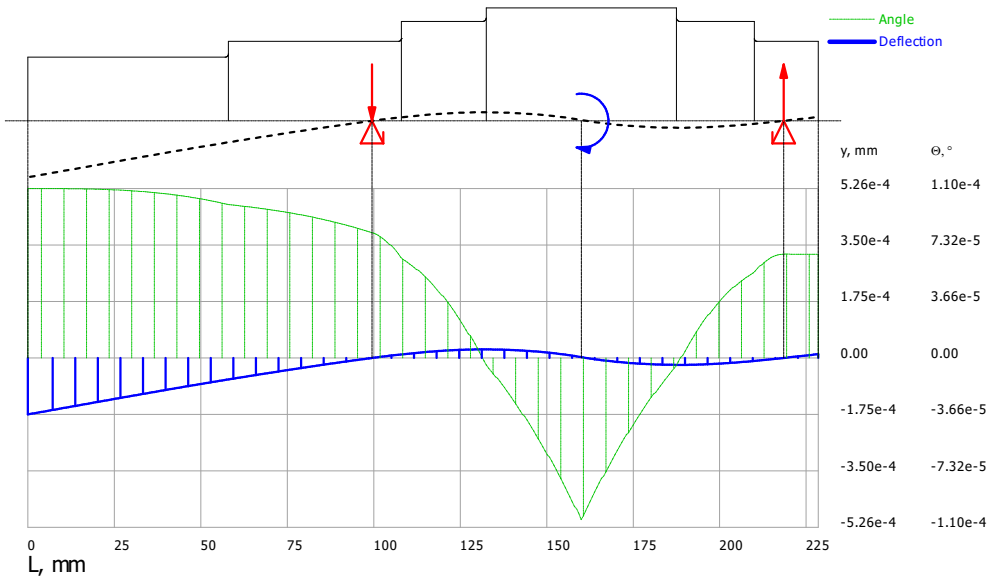
Trend of curve of the torsional moment



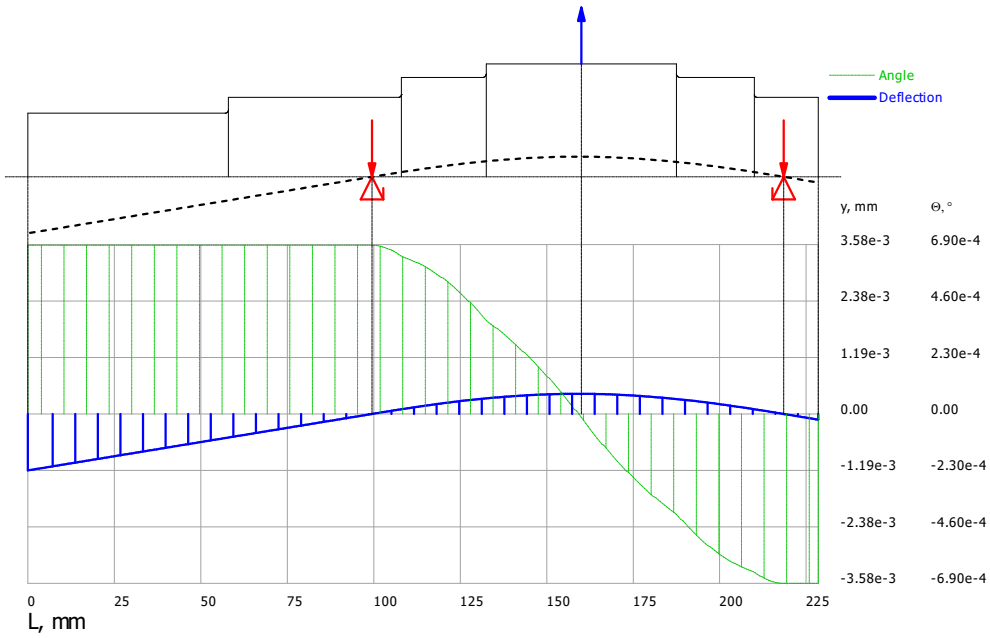
Trend of curve of the tension-pressure forces



Deflection and angle of deflection in the Y-X-plane

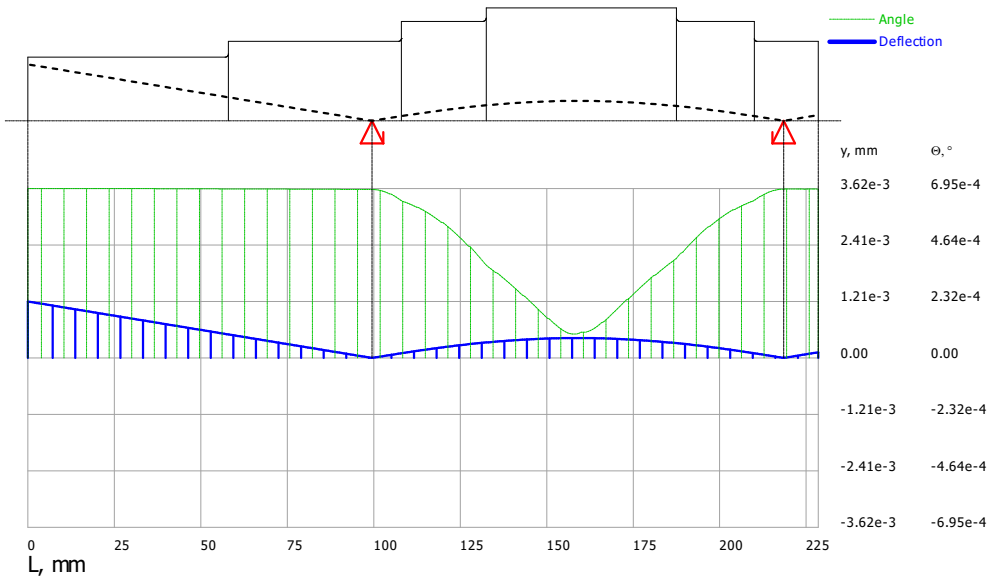


Deflection and angle of deflection in the Z-X-plane

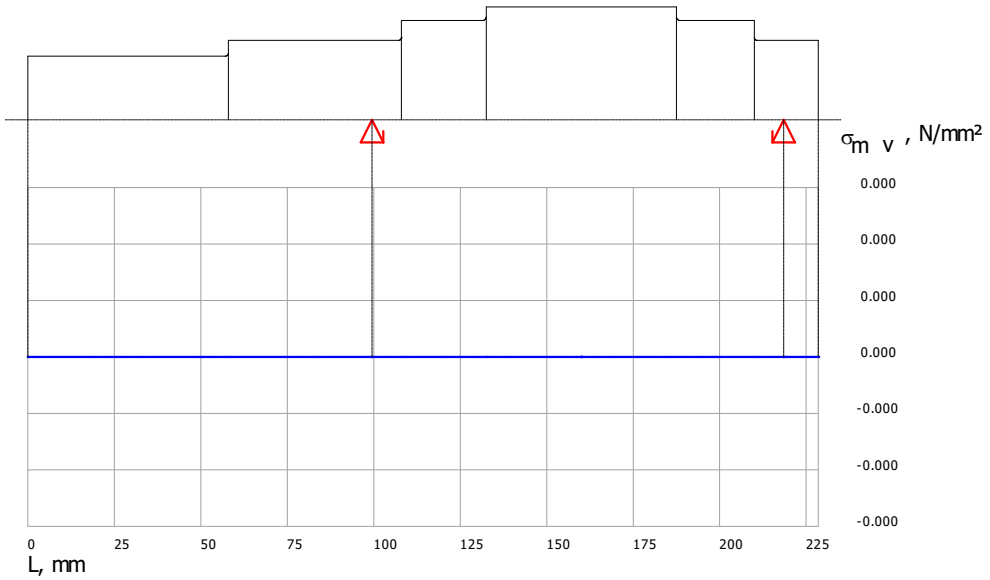


Shaft, Standard

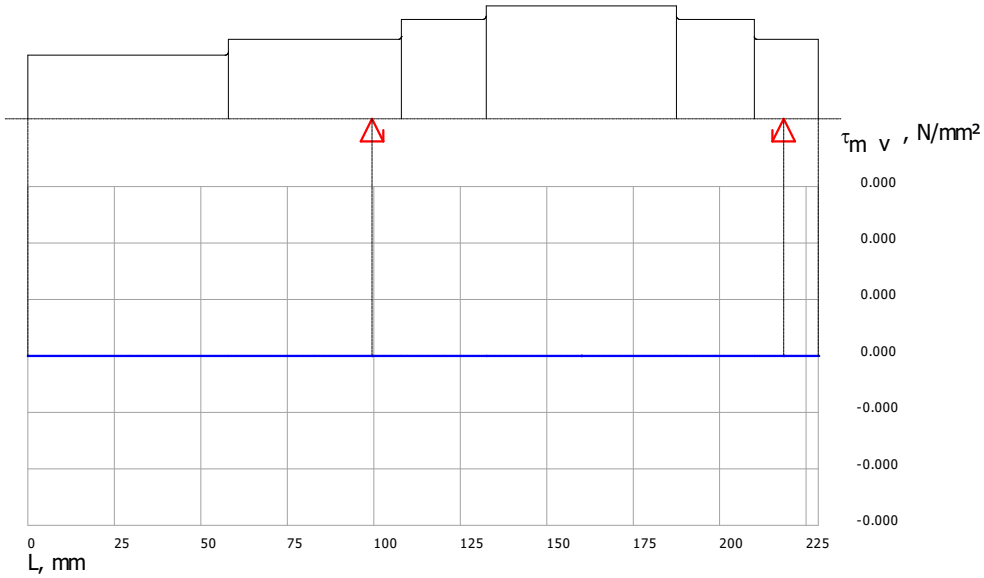
Deflection and angle of deflection (combined characteristic)



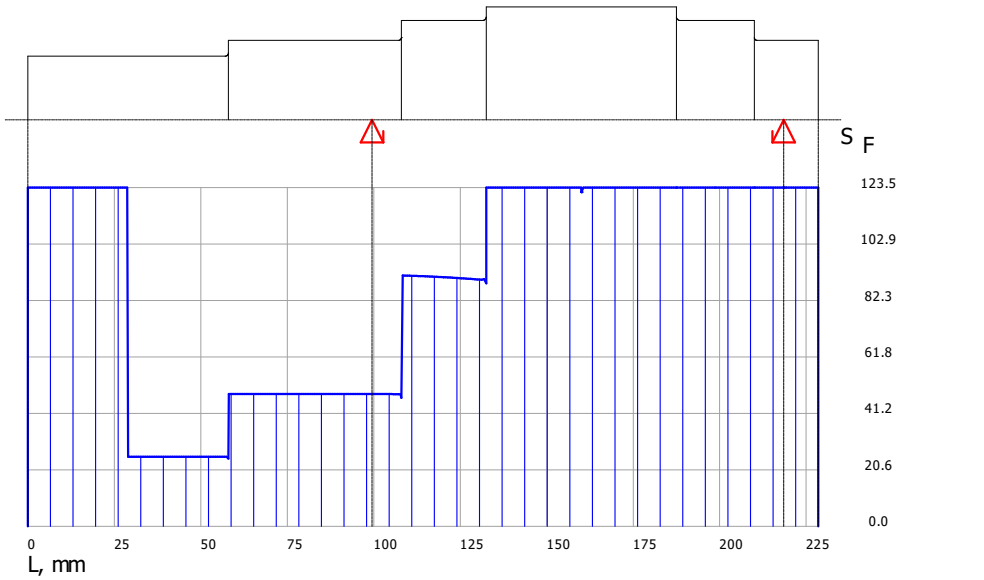
Equivalent mean stress (normal stress)



Equivalent mean stress (shear stress)

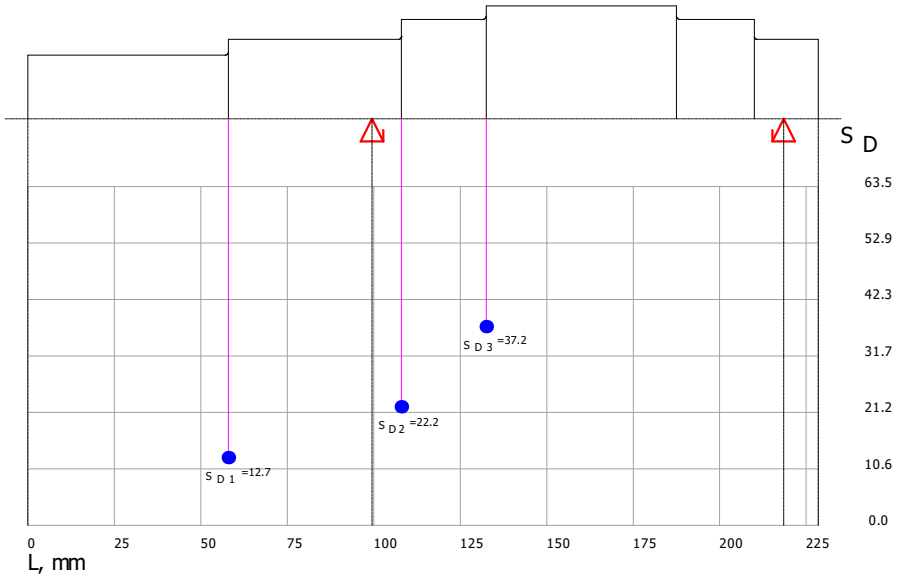


Safety factor against yielding
(diagram section up to 5*minimum safety)

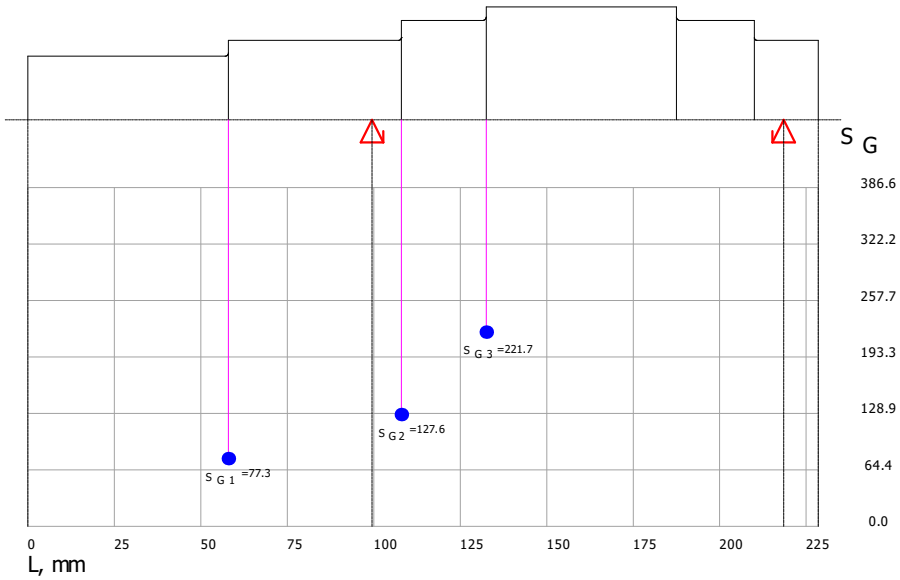


Shaft, Standard

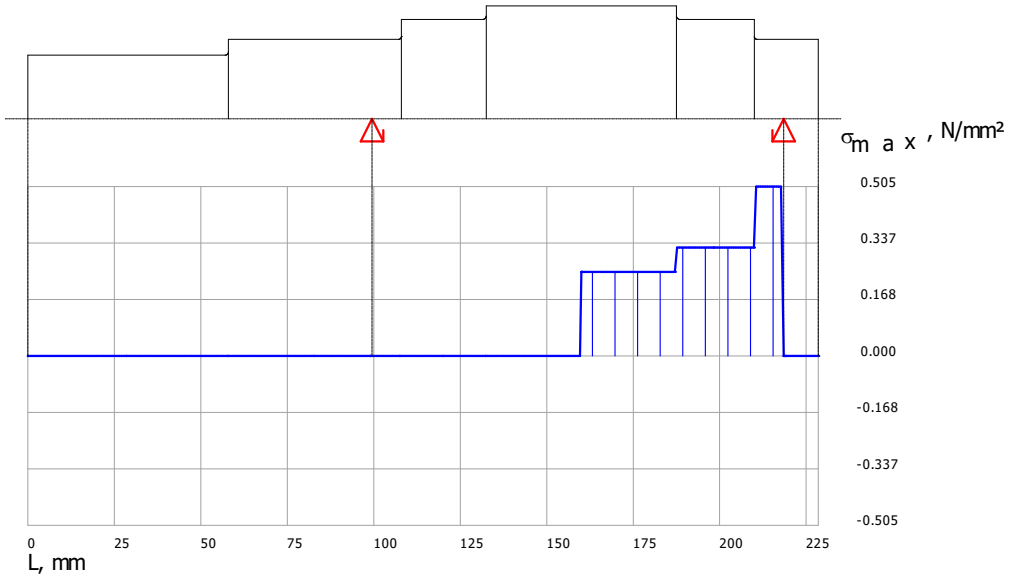
Safety against fatigue fracture
(diagram section up to 5*minimum safety)



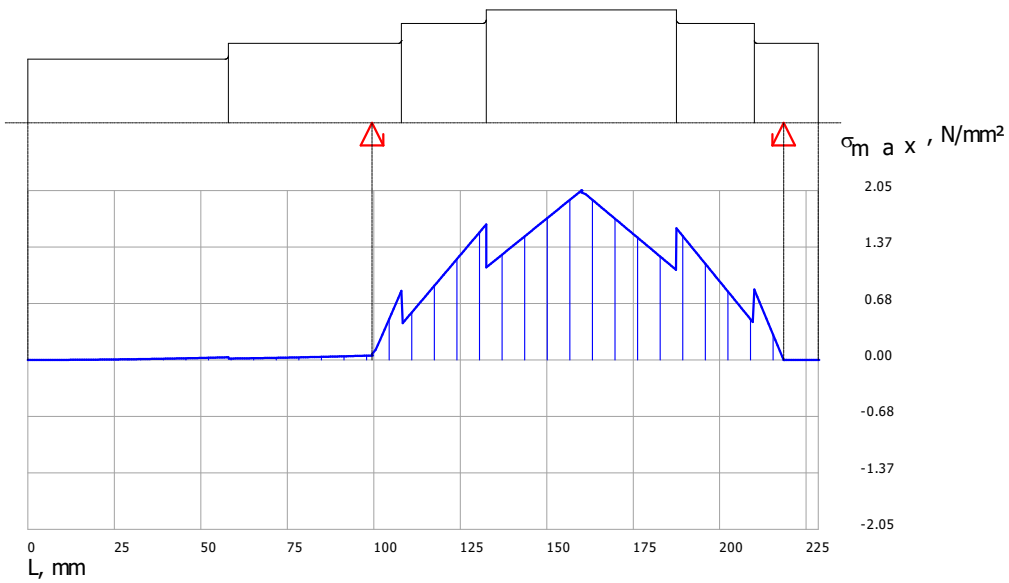
Safety against incipient crack with hard surface
(Cross-section: SG=5*SGmin)



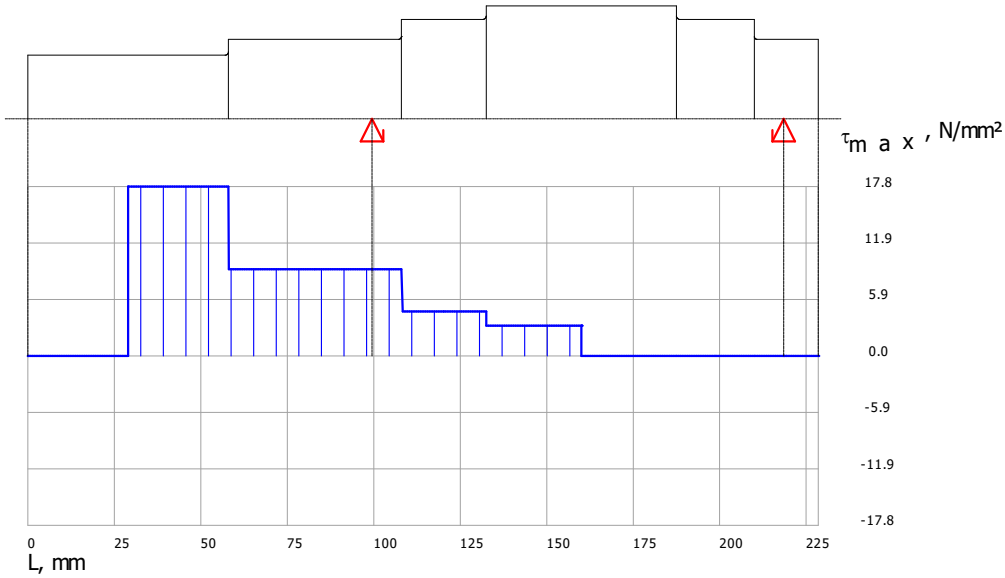
Maximum value of the tension-pressure stress (combined characteristic)



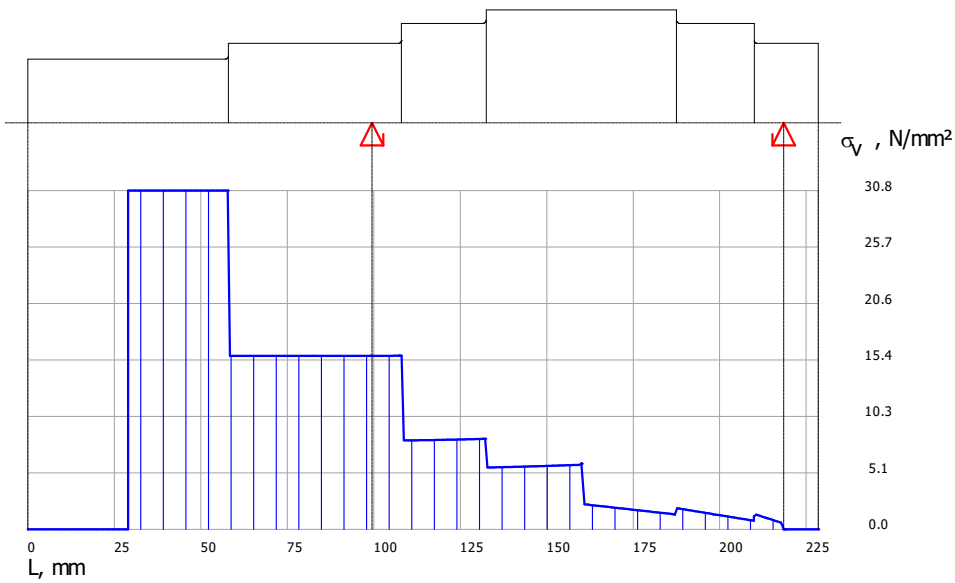
Maximum value of the bending stress (combined characteristic)



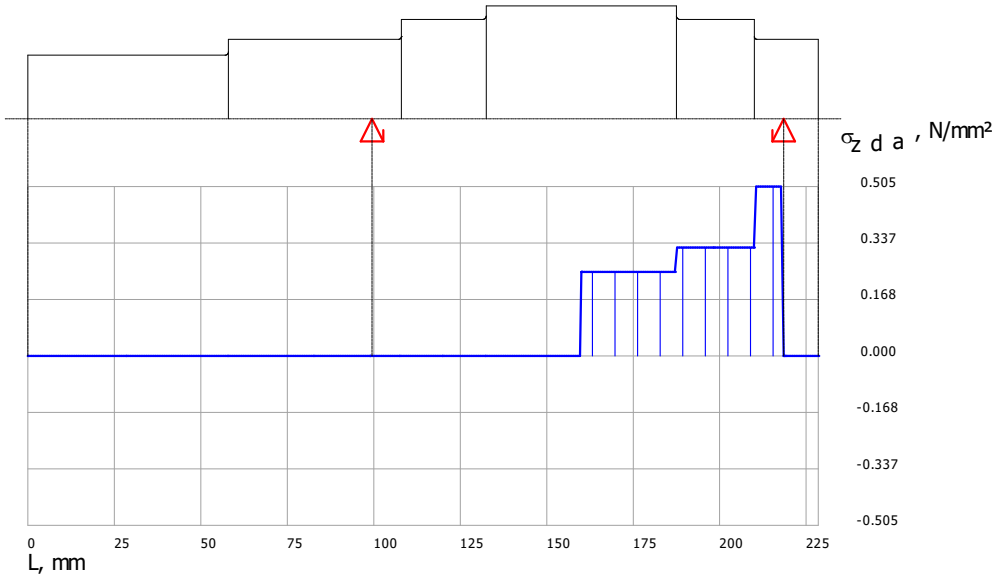
Maximum value of the torsional stress (combined characteristic)



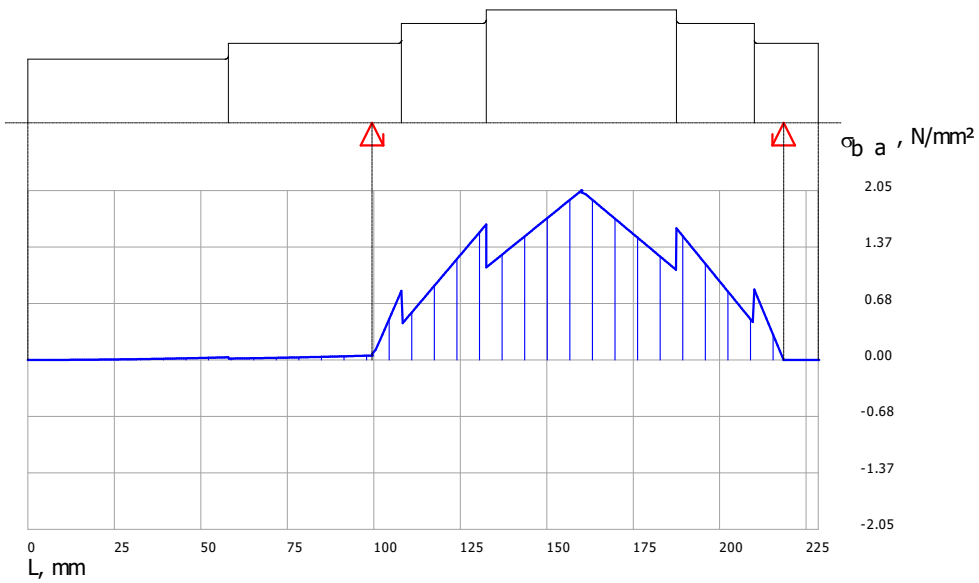
Equivalent stress development (resultant)



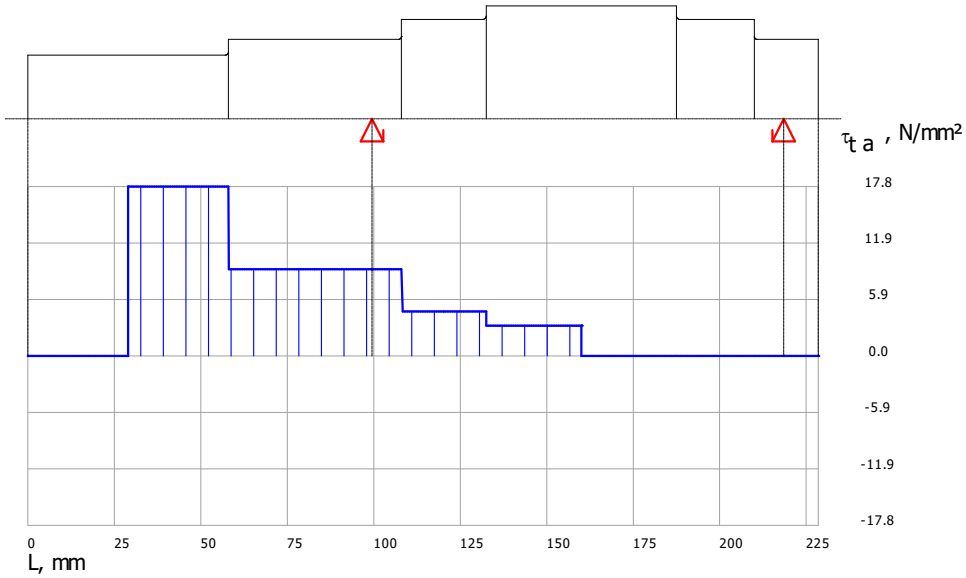
Amplitude value of the tension-pressure stress (combined characteristic)



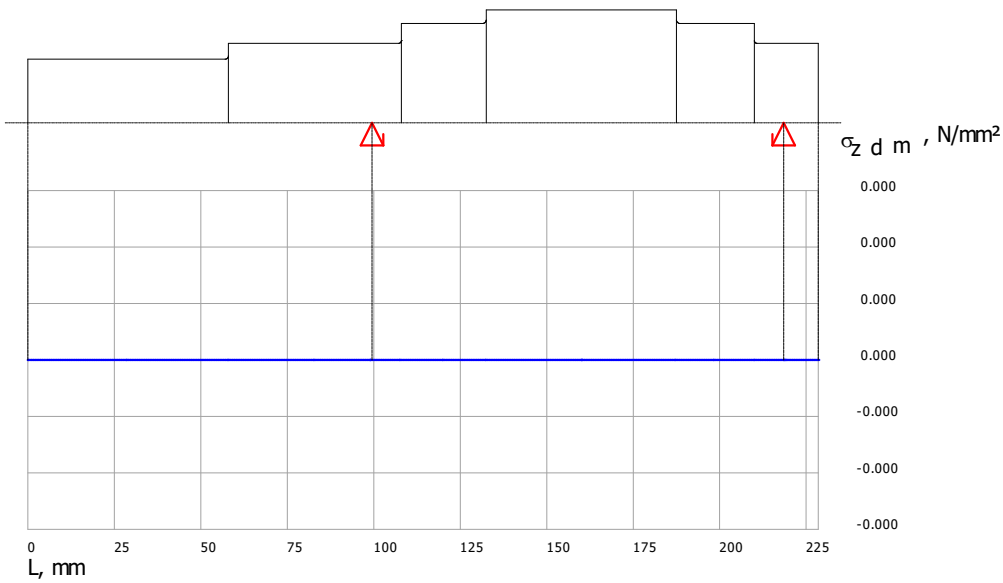
Amplitude value of the bending stress (combined characteristic)



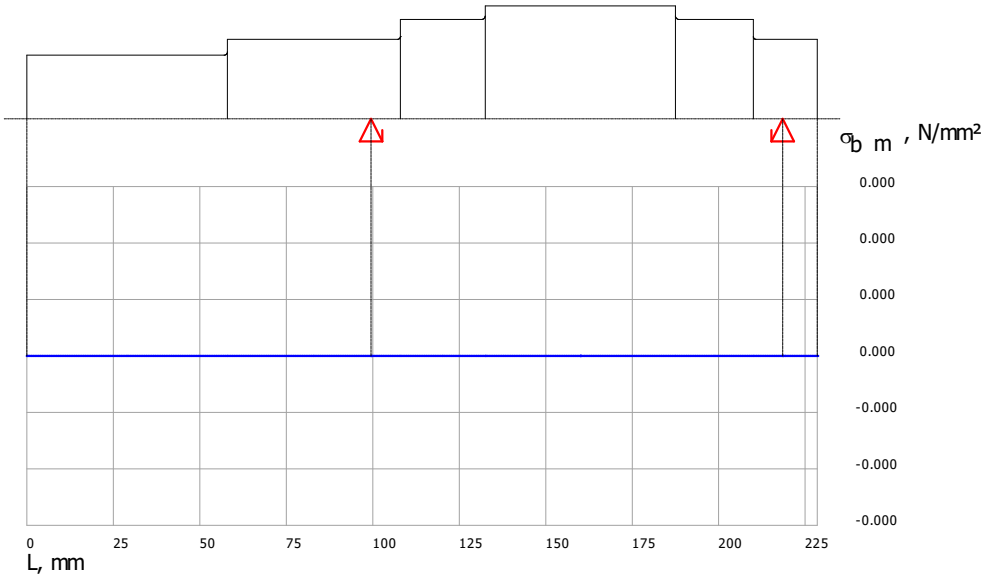
Amplitude value of the torsional stress (combined characteristic)



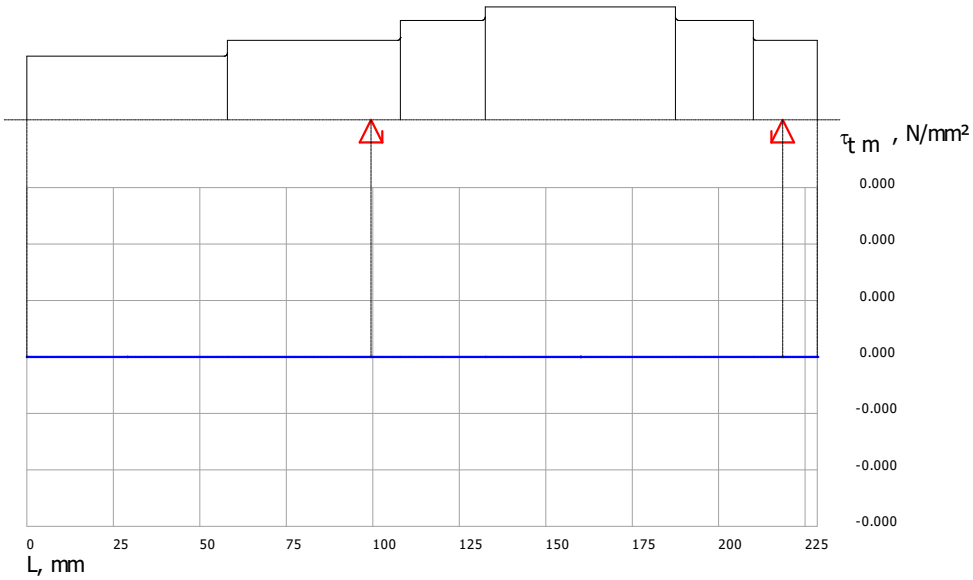
Mean value of the tension-pressure stress (combined characteristic)



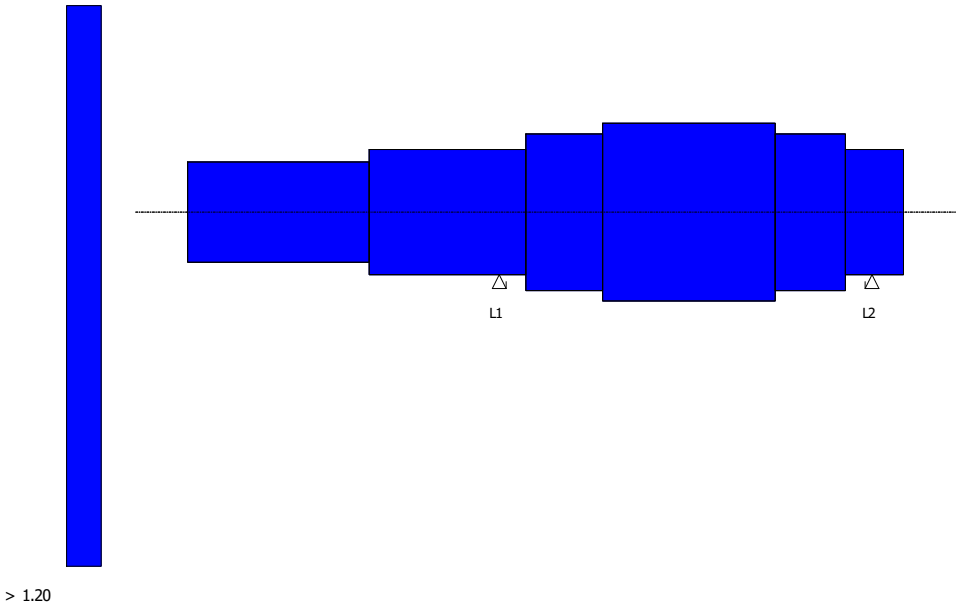
Mean value of the bending stress (combined characteristic)



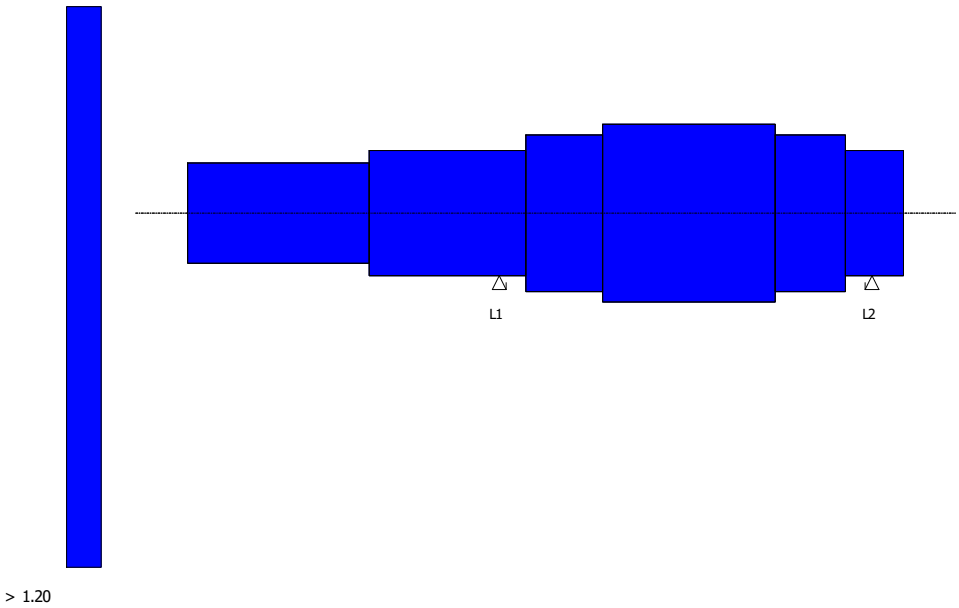
Mean value of the torsional stress (combined characteristic)



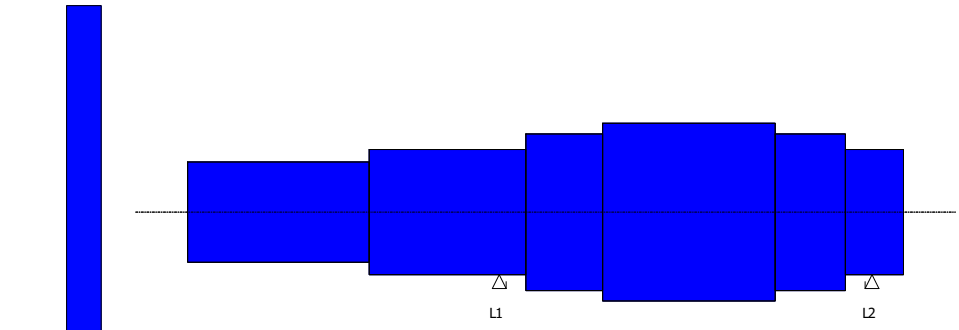
Safety factor against yielding



Safety against fatigue fracture

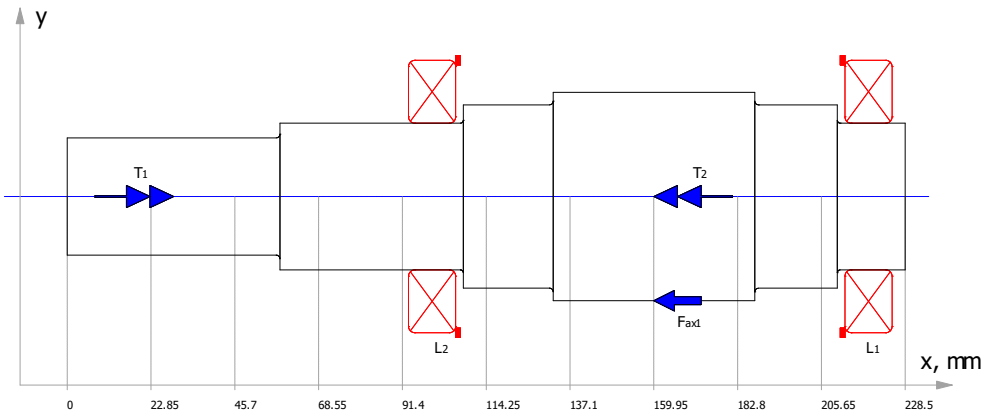


Safety against incipient crack with hard surface



> 1.20

Calculation graphic Y-X-plane



Calculation graphic Z-X-plane