Articulated trunnion in the rod

The trunnion is used to pivot the machine parts that transmit forces perpendicular to the trunnion axis. The trunnions can also be used for short axes such as wheels, pulleys, etc. They are usually mounted with clearance, allowing relative movement. The connecting Trunnions must be secured against axial displacement.

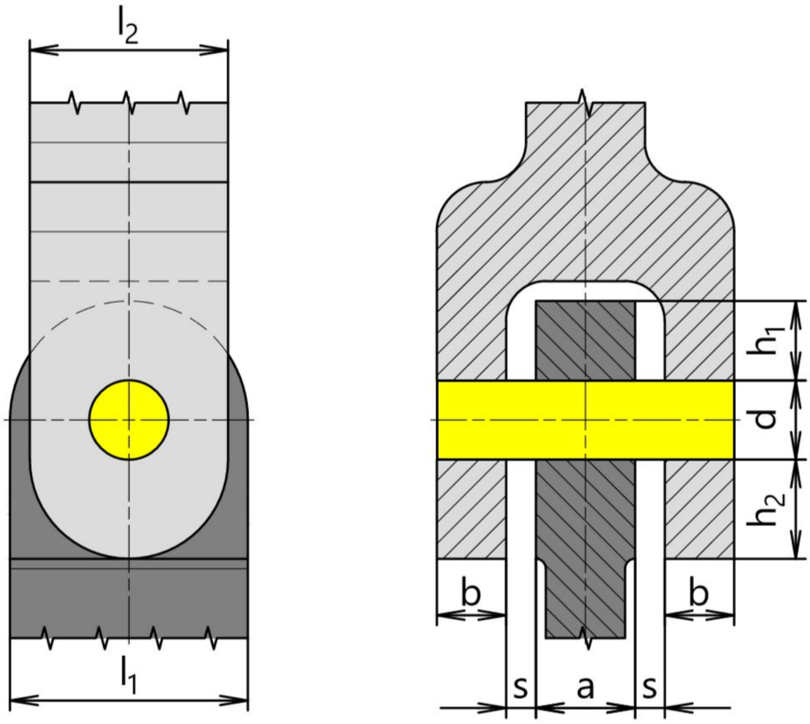

Fig. 1 Articulated trunnion in the rod

Shear stress in the trunnion:

$$\tau_{s(t)} = \frac{2F}{\pi d^2} \leq \tau_{all}$$

$\tau_{s(t)}$	shear stress in the trunnion	[MPa]
F	force	[N]
d	trunnion diameter	[mm]
τ_{all}	allowable shear stress	[MPa]

Allowable shear stress:

$$\tau_{all} = \frac{0{,}4 R_{p0,2T}}{S_F} * C_c$$

τ_{all}	allowable shear stress	[MPa]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
S_F	safety factor	[]
C_c	coefficient according to load	[]

Coefficient according to load:

load	[]
Unidirectional load, non-impact load	0,8
Unidirectional load, with a small impact load	0,7
Unidirectional load, with a big impact load	0,6
Alternating load, with a small impact load	0,45
Alternating load, with a big impact load	0,25

Bending stress in the trunnion:

$$\sigma_B = \frac{4F(b + 2a + 4s)}{\pi d^3} \leq \sigma_{Ball}$$

σ_B bending stress in the trunnion [MPa]
F force [N]
d trunnion diameter [mm]
a thickness the rod [mm]
b thickness the clevis [mm]
s gap [mm]
σ_{Ball} allowable bending stress [MPa]

Allowable bending stress:

$$\sigma_{Ball} = \frac{0{,}6R_{p0,2T}}{S_F} * C_c$$

σ_{Ball} allowable bending stress [MPa]
$R_{p0,2T}$ the minimum yield strength or 0,2% proof strength at calculation temperature [MPa]
S_F safety factor []
C_c coefficient according to load []

Combined stress in the trunnion:

$$\sigma_{tresca} = \sqrt{\sigma_B^2 + 4\tau_{s(t)}^2} \leq \sigma_{Call}$$

σ_{tresca} combined stress in the trunnion [MPa]
σ_B bending stress in the trunnion [MPa]
$\tau_{s(t)}$ shear stress in the trunnion [MPa]
σ_{Call} allowable combined stress [MPa]

Allowable combined stress:

$$\sigma_{Call} = \frac{R_{p0,2T}}{S_F} * C_c$$

σ_{Call} allowable combined stress [MPa]
$R_{p0,2T}$ the minimum yield strength or 0,2% proof strength at calculation temperature [MPa]
S_F safety factor []
C_c coefficient according to load []

Bearing stress in the rod:

$$p_r = \frac{F}{d * a} \leq \sigma_{all}$$

p_r	bearing stress in the rod	[MPa]
F	force	[N]
d	trunnion diameter	[mm]
a	thickness the rod	[mm]
σ_{all}	allowable bearing stress	[MPa]

Allowable bearing stress:

$$\sigma_{all} = \frac{0{,}9R_{p0,2T}}{S_F} * C_c * C_b$$

σ_{all}	allowable bearing stress	[MPa]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
S_F	safety factor	[]
C_c	coefficient according to load	[]
C_b	coefficient of use of joints according to trunnion support	[]

Coefficient of use of joints according to trunnion support:

Trunnion support	[]
fixed fit	1
running fit	0,25

Bearing stress in the clevis:

$$p_c = \frac{F}{2d * b} \leq \sigma_{all}$$

p_c	bearing stress in the clevis	[MPa]
F	force	[N]
d	trunnion diameter	[mm]
b	thickness the clevis	[mm]
σ_{all}	allowable bearing stress	[MPa]

Axial stress in the rod:

$$\sigma_r = \frac{K_{tr} * F}{(l_1 - d)a} \leq \sigma_{Aall}$$

σ_r	axial stress in the rod	[MPa]
K_{tr}	concentration factor in the rod	[]
F	force	[N]
d	trunnion diameter	[mm]
a	thickness the rod	[mm]
l_1	width the rod	[mm]
σ_{Aall}	allowable axial stress	[MPa]

Allowable axial stress:

$$\sigma_{Aall} = \frac{0,45 R_{p0,2T}}{S_F} * C_c$$

σ_{Aall}	allowable axial stress	[MPa]
$R_{p0,2T}$	the minimum yield strength or 0,2% proof strength at calculation temperature	[MPa]
S_F	safety factor	[]
C_c	coefficient according to load	[]

Concentration factor in the rod:

$$K_{tr} = 12,882 - 52,714\left(\frac{d}{l_1}\right) + 89,762\left(\frac{d}{l_1}\right)^2 - 51,667\left(\frac{d}{l_1}\right)^3$$

K_{tr}	concentration factor in the rod	[]
d	trunnion diameter	[mm]
l_1	width the rod	[mm]

Axial stress in the clevis:

$$\sigma_c = \frac{K_{tc} * F}{(l_2 - d)2b} \leq \sigma_{Aall}$$

σ_c	axial stress in the clevis	[MPa]
K_{tc}	concentration factor in the clevis	[]
F	force	[N]
d	trunnion diameter	[mm]
b	thickness the clevis	[mm]
l_2	width the clevis	[mm]
σ_{Aall}	allowable axial stress	[MPa]

Concentration factor in the clevis:

$$K_{tc} = 12,882 - 52,714\left(\frac{d}{l_2}\right) + 89,762\left(\frac{d}{l_2}\right)^2 - 51,667\left(\frac{d}{l_2}\right)^3$$

K_{tc}	concentration factor in the clevis	[]
d	trunnion diameter	[mm]
l_2	width the clevis	[mm]

Shear stress in the rod:

$$\tau_{s(r)} = \frac{F}{h_1 * a} \leq \tau_{all}$$

$\tau_{s(r)}$	shear stress in the rod	[MPa]
F	force	[N]
a	thickness the rod	[mm]
h_1	length the rod	[mm]
τ_{all}	allowable shear stress	[MPa]

Shear stress in the clevis:

$$\tau_{s(c)} = \frac{F}{h_2 * 2b} \leq \tau_{all}$$

$\tau_{s(c)}$	shear stress in the clevis	[MPa]
F	force	[N]
b	thickness the clevis	[mm]
h_2	length the clevis	[mm]
τ_{all}	allowable shear stress	[MPa]

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