Longitudinal pin for shaft-hub connection

The easiest and oldest way joints. It is a joint with a shape contact. The pin serves primarily to ensure the mutual positioning of the two parts. They are cylindrical or conical. The pins are dimensioned under simplified assumptions without will and without the pressing effect. When calculating the pin, the length of the pin should not be considered, which is different from the nominal cross-section see, for example, the thread in the pin etc.
When calculating, see below, the hub is simplified to transfer only torsion moments. In practice, it may not be true. If the hub is carrying another load e.g. axial the charge must be assessed on the individual stress components plus the combined stress.

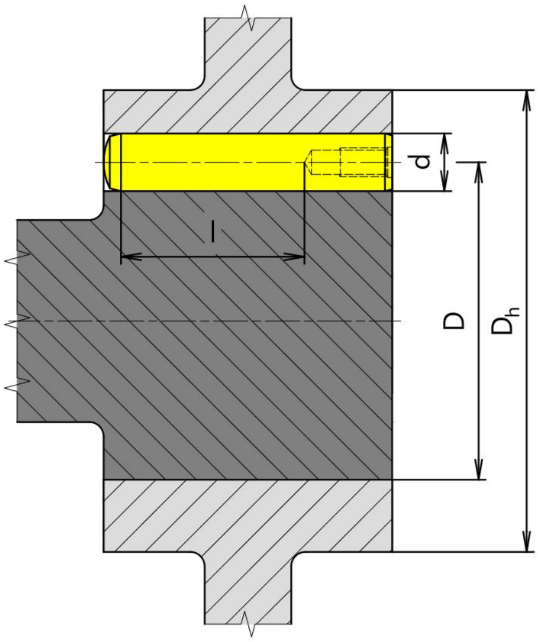

Fig. 1 Longitudinal pin for shaft-hub connection

Torsion stress in the shaft:

$$\tau_s = \frac{16M_T}{\pi(D-d)^3} \leq \tau_{all}$$

τ_s	torsion stress in the shaft	[MPa]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
d	diameter of the pin	[mm]
τ_{all}	allowable shear stress	[MPa]

Allowable shear stress:

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

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

Shear stress in the pin:

$$\tau_p = \frac{2M_T}{D * d * l * i} \leq \tau_{all}$$

τ_p shear stress in the pin [MPa]
M_T torque [Nm]
D diameter of the shaft [mm]
d diameter of the pin [mm]
l length pin (without threads, etc.) [mm]
i number of pins []
τ_{all} allowable shear stress [MPa]

Bearing stress in the pin, shaft and hub:

$$p = \frac{4M_T}{D * d * l * i} \leq \sigma_{all}$$

p bearing stress in the pin, shaft and hub [MPa]
M_T torque [Nm]
D diameter of the shaft [mm]
d diameter of the pin [mm]
l length pin (without threads, etc.) [mm]
i number of pins []
σ_{all} allowable bearing stress [MPa]

Allowable bearing stress:

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

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 []

Torsion stress in the hub:

$$\tau_h = K_t \frac{16M_T}{\pi\left((D_h^4 - (D+d)^4)/D_h\right)} \leq \tau_{all}$$

τ_h	torsion stress in the hub	[MPa]
K_t	concentration factor	[]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
D_h	diameter of the hub	[mm]
d	diameter of the pin	[mm]
τ_{all}	allowable shear stress	[MPa]

Concentration factor:

$$K_t = 1{,}953 + 0{,}1434\left(\frac{0{,}2}{d/D}\right) - 0{,}0021\left(\frac{0{,}2}{d/D}\right)^2$$

K_t	concentration factor	[]
D	diameter of the shaft	[mm]
d	diameter of the pin	[mm]

If the shaft is loaded with the bending moment in the joint, the bending stress must be checked. If the shaft is loaded with a shear force in the joint, the shear stress must be checked. The shaft may be load in the joint by axial force. The shaft must be checked for axial stresses. When calculating the different load types, it is necessary to calculate the combined stress.

Bending stress in the shaft:

$$\sigma_B = \frac{32M_B}{\pi(D-d)^3} \leq \sigma_{Ball}$$

σ_B	bending stress in the shaft	[MPa]
M_B	bending moment	[Nm]
D	diameter of the shaft	[mm]
d	diameter of the pin	[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	[]

Shear stress in the shaft:

$$\tau_{s(s)} = \frac{4F_R}{\pi(D-d)^2} \leq \tau_{all}$$

$\tau_{s(s)}$	shear stress in the shaft	[MPa]
F_R	shear force	[N]
D	diameter of the shaft	[mm]
d	diameter of the pin	[mm]
τ_{all}	allowable shear stress	[MPa]

Axial stress in the shaft:

$$\sigma_A = \frac{4F_A}{\pi(D-d)^2} \leq \sigma_{Aall}$$

σ_A	axial stress in the shaft	[MPa]
F_A	axial force	[N]
D	diameter of the shaft	[mm]
d	diameter of the pin	[mm]
σ_{Aall}	allowable axial stress	[MPa]

Allowable axial stress:

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

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	[]

Combined stress in the shaft:

$$\sigma_{tresca} = \sqrt{\sigma_B^2 + \sigma_A^2 + 4\left((K_t * \tau_s)^2 + \tau_{s(s)}^2\right)} \leq \sigma_{Call}$$

σ_{tresca}	combined stress in the shaft	[MPa]
σ_B	bending stress in the shaft	[MPa]
σ_A	axial stress in the shaft	[MPa]
K_t	concentration factor	[]
τ_s	torsion stress in the shaft	[MPa]
$\tau_{s(s)}$	shear stress in the shaft	[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	[]

When $i \geq 4$ the weakened part of the shaft and the hub must be seen see Fig. 2 to control the bending stress and the shear according to the Grashof formula.

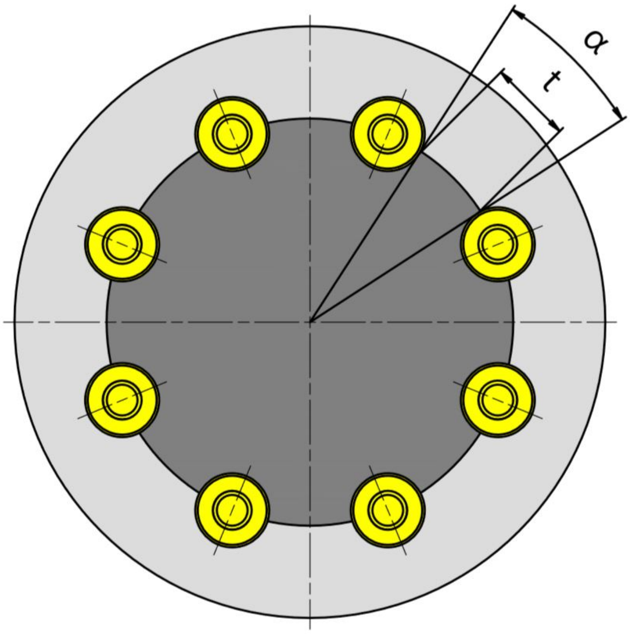

Fig. 2 weakened part of shaft and hub

Angle between pins:

$$\propto = \frac{2\pi - \left(2i * \sin^{-1}\frac{d}{D}\right)}{i}$$

α	angle between pins	[rad]
D	diameter of the shaft	[mm]
d	diameter of the pin	[mm]
i	number of pins	[]

Width between pins:

$$t = D * \cos\left(\sin^{-1}\frac{d}{D}\right) * \sin\frac{\propto}{2}$$

t	width between pins	[mm]
d	diameter of the pin	[mm]
D	diameter of the shaft	[mm]
α	angle between pins	[rad]

Bending stress in the weakened part of the shaft-hub:

$$\sigma_{B(s-h)} = \frac{3d * M_T}{D * l * t^2 * i} \leq \sigma_{Ball}$$

$\sigma_{B(s-h)}$	bending stress in the weakened part of the shaft-hub	[MPa]
d	diameter of the pin	[mm]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
l	length pin (without threads, etc.)	[mm]
t	width between pins	[mm]
i	number of pins	[]
σ_{Ball}	allowable bending stress	[MPa]

Shear stress in the weakened part of the shaft-hub

$$\tau_{s-h} = \frac{3M_T}{D * t * l * i} \leq \tau_{all}$$

τ_{s-h}	shear stress in the weakened part of the shaft-hub	[MPa]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
t	width between pins	[mm]
l	length pin (without threads, etc.)	[mm]
i	number of pins	[]
τ_{all}	allowable shear stress	[MPa]

Literature:

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