Key(s) for shaft-hub connection

The feather key are used to transfer the torque between the shaft and the hub. The feather key are inserted into shaft and hub grooves. The torque is transmitted only by the flanks of the feather key. Therefore, the grooves of the grooves and the feather key must be parallel. The feather key are standardized most commonly used, which are listed in DIN 6885A.
The material is usually C45+C steel. For alternating or impact torque loads, the feather key is not suitable because changing the load direction and the impact of the wall, which can lead to loosening of the connection.

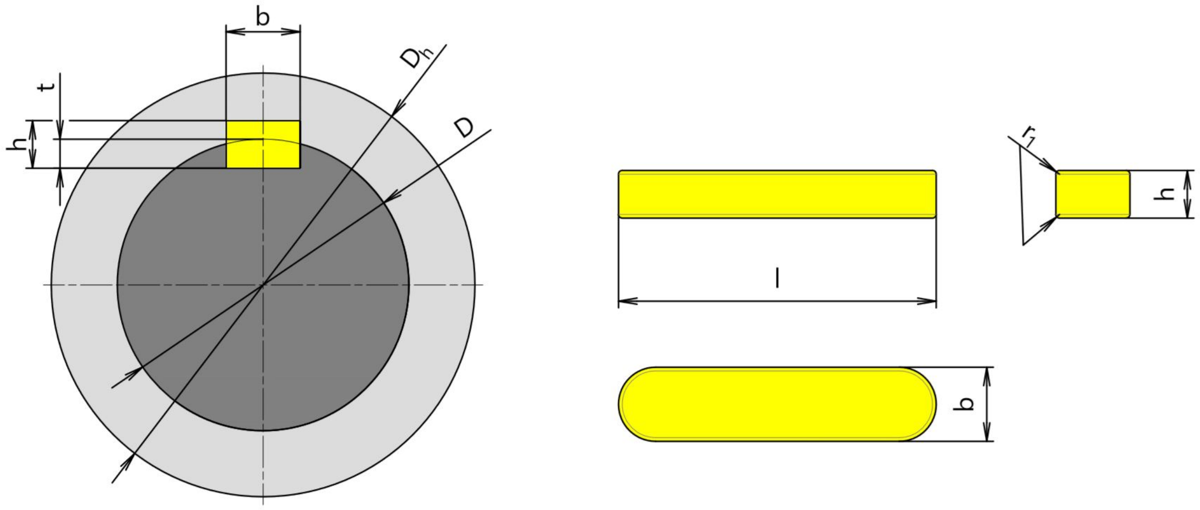

Fig. 1 Key(s) for shaft-hub connection

Torsion stress in the shaft:

$$\tau_s = \frac{16M_T}{\pi\left(\sqrt{(D-2t)^2+b^2}\right)^3} \leq \tau_{all}$$

τ_s	torsion stress in the shaft	[MPa]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
t	depth in the shaft	[mm]
b	key width	[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 of use of joints according to load	[]

Coefficient of use of joints 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

key under shear stress:

$$\tau_p = \frac{2M_T}{D * i * \left((l - b - l_t) * b + \frac{\pi b^2}{4}\right)} \leq \tau_{all}$$

τ_p	key under shear stress	[MPa]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
i	number of key	[]
l	key length	[mm]
b	key width	[mm]
l_t	tolerance of key length	[mm]
τ_{all}	allowable shear stress	[MPa]

Key/shaft under bearing stress:

$$p_s = \frac{2M_T}{D * i * \left((l - b - l_t) * (h_s - t_{1t} - (t + t_1 - h) - r_1)\right)} \leq \sigma_{all}$$

p_s	key/shaft under bearing stress	[MPa]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
i	number of key	[]
l	key length	[mm]
b	key width	[mm]
l_t	tolerance of key length	[mm]
h_s	the height of the key in the shaft	[mm]
t_{1t}	tolerance of the groove height in the hub	[mm]
t	depth in the shaft	[mm]
t_1	depth in the hub	[mm]
h	key height	[mm]
r_1	max. rounding the key	[mm]
σ_{all}	allowable bearing stress	[MPa]

The height of the key in the shaft:

$$h_s = t - \frac{D}{2} + \frac{D}{2}\cos\left(\sin^{-1}\frac{b}{D}\right)$$

h_s	the height of the key in the shaft	[mm]

t	depth in the shaft	[mm]
D	diameter of the shaft	[mm]
b	key width	[mm]

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 of use of joints according to load	[]

Key/hub under bearing stress:

$$p_h = \frac{2M_T}{D * i * \left((l - b - l_t) * (h_h - t_t - (t + t_1 - h) - r_1)\right)} \leq \sigma_{all}$$

P_h	key/hub under bearing stress	[MPa]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
i	number of key	[]
l	key length	[mm]
b	key width	[mm]
l_t	tolerance of key length	[mm]
h_h	the height of the key in the hub	[mm]
t_t	tolerance of the groove height in the shaft	[mm]
t	depth in the shaft	[mm]
t_1	depth in the hub	[mm]
h	key height	[mm]
r_1	max. rounding the key	[mm]
σ_{all}	allowable bearing stress	[MPa]

The height of the key in the hub:

$$h_h = t + t_1 - h_s$$

h_h	the height of the key in the hub	[mm]
t	depth in the shaft	[mm]
t_1	depth in the hub	[mm]
h_s	the height of the key in the shaft	[mm]

Torsion stress in the hub:

$$\tau_h = K_t \frac{16M_T}{\pi\left(\left(D_h^4 - \left(\sqrt{(D + 2t_1)^2 + b^2}\right)^4\right)/D_h\right)} \leq \tau_{all}$$

τ_h	torsion stress in the hub	[MPa]

K_t	concentration factor	[]
M_T	torque	[Nm]
D	diameter of the shaft	[mm]
t_1	depth in the hub	[mm]
b	key width	[mm]
D_h	diameter of the hub	[mm]
b	key width	[mm]
τ_{all}	allowable shear stress	[MPa]

Concentration factor:

$$K_t = 1{,}953 + 0{,}1434\left(\frac{0{,}1}{r_2/D}\right) - 0{,}0021\left(\frac{0{,}1}{r_2/D}\right)^2$$

K_t	concentration factor	[]
D	diameter of the shaft	[mm]
r_2	groove rounding	[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:

$$\sigma_B = \frac{32M_B}{\pi\left(\sqrt{(D-2t)^2+b^2}\right)^3} \le \sigma_{Ball}$$

σ_B	bending stress in the shaft	[MPa]
M_B	bending moment	[Nm]
D	diameter of the shaft	[mm]
t	depth in the shaft	[mm]
b	key width	[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 of use of joints according to load	[]

Shear stress in the shaft:

$$\tau_{s(s)} = \frac{4F_R}{\pi\left(\sqrt{(D-2t)^2+b^2}\right)^2} \leq \tau_{all}$$

$\tau_{s(s)}$	shear stress in the shaft	[MPa]
F_R	shear forces	[N]
D	diameter of the shaft	[mm]
t	depth in the shaft	[mm]
b	key width	[mm]
τ_{all}	allowable shear stress	[MPa]

Axial stress in the shaft:

$$\sigma_A = \frac{4F_A}{\pi\left(\sqrt{(D-2t)^2+b^2}\right)^2} \leq \sigma_{Aall}$$

σ_A	axial stress in the shaft	[MPa]
F_A	axial forces	[N]
D	diameter of the shaft	[mm]
t	depth in the shaft	[mm]
b	key width	[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 of use of joints 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 of use of joints according to load	[]

Literature:

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