Autodesk Inventor Engineer s Handbook

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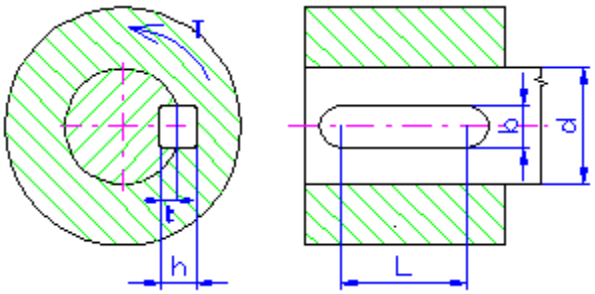
Joints / Movable Joints

Key Generator

[قابل توجه خوانندگان عزیز: کلیه مطالب این هندبوک از سایت شرکت Autodesk کپی برداری شده است.]

Key joint - formulas for metric calculation



Transferred torque

$$T = \frac{30 \cdot 10^3 \cdot P}{\pi \cdot n} \quad [Nm]$$

where:

Ppower [kW]

nspeed [rpm]

Calculation of Minimum Shaft Diameter

1. shaft inside diameter $d_h > 0$

a)
$$d_{min} = 3\sqrt{\frac{16 \cdot T \cdot K_a \cdot S_v}{\pi \cdot \tau_A \cdot K_f}} \quad [mm]$$

b) if $d_{min} \leq d_h$ -> $d_{min} = 1.1\, d_h$ [mm]

c) if $d_{min} \leq 1.5\, d_h$ -> $d_{min} = 1.5\, d_h$ [mm]

2. shaft inside diameter $d_h = 0$

$$d_{min} = 3\sqrt{\frac{16 \cdot T \cdot K_a \cdot S_v}{\pi \cdot \tau_A \cdot K_f}} \quad [mm]$$

where:

d_{min} minimal shaft diameter [mm]

d_h shaft inside diameter [mm]

T torque [Nm]

K_a application factor

K_f fatigue-life factor

S_v desired safety

τ_A Allowable Shear Stress

General calculation

$$h_s = \sqrt{\frac{d^2}{4} - \frac{b^2}{4}} + t - \frac{d}{2} - s \quad [mm]$$ the range of force activity on the shaft

$h_k = h - h_s - 2\,s$ [mm] the range of force activity on the hub

$$d_s = \sqrt{\left(\frac{d}{2} - t + s\right)^2 + \frac{b^2}{4}} + \frac{d}{2} \quad [mm]$$ shaft diameter of the range of the force activity

$$d_s = \sqrt{\left(\frac{d}{2} - h - t - s\right)^2 + \frac{b^2}{4}} + \frac{d}{2} \quad [mm]$$ hub diameter of the range of the force activity

$$F_s = 2 \cdot \frac{T \cdot 10^3}{d_s} \quad [N]$$ force on shaft

force on hub

$$F_h = 2 \cdot \frac{T \cdot 10^3}{d_h} \quad [N]$$

where:

T	torque [Nm]
F_s	force on shaft [N]
F_h	force on hub [N]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [mm]
d_s	shaft diameter where force F_s actuates [mm]
d_h	shaft diameter where force F_d actuates [mm]
N	number of grooves [-]
h	height of groove
h_s	height of force point of action on shaft [mm]
h_h	height of force point of action on hub [mm]
b	width of groove
t	groove depth in shaft [mm]
s	chamfer
p_{Dmins}	minimal allowable pressure (groove, shaft) [MPa]
p_{Dminh}	minimal allowable pressure (groove, hub) [MPa]

Minimum key length to transfer the torque

1. Fixed connection:

a) $$L_{min\,s} = \frac{F_s \cdot K_a \cdot S_v}{p_{Dmin\,s} \cdot h_s \cdot N \cdot K_m \cdot K_f} \quad [mm]$$

b) $$L_{min\,h} = \frac{F_h \cdot K_a \cdot S_v}{p_{Dmin\,h} \cdot h_h \cdot N \cdot K_m \cdot K_f} \quad [mm]$$

$L_{min} = \min(L_{mins}, L_{minh})$

2. Flexible connection:

a) $$L_{min\,s} = \frac{F_s \cdot K_a \cdot S_v}{p_{Dmin\,s} \cdot h_s \cdot N \cdot K_m \cdot K_w} \quad [mm]$$

b) $$L_{min\,k} = \frac{F_k \cdot K_a \cdot S_v}{p_{Dmin\,k} \cdot h_k \cdot N \cdot K_m \cdot K_w} \quad [mm]$$

$L_{min} = \min(L_{mins}, L_{minh})$

where:

F_s	force on shaft [N]
F_h	force on hub [N]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [mm]
N	number of grooves [-]
h_s	height of force point of action on shaft [mm]
h_h	height of force point of action on hub [mm]
p_{Dmins}	minimal allowable pressure (groove, shaft) [MPa]
p_{Dminh}	minimal allowable pressure (groove, hub) [MPa]

Minimal Allowable pressure

1. Fixed connection:

a) $$p_{min\,s} = \frac{F_s \cdot K_a}{l_f \cdot h_s \cdot N \cdot K_m \cdot K_f} \quad [MPa]$$

b) $$p_{min\,k} = \frac{F_k \cdot K_a}{l_f \cdot h_k \cdot N \cdot K_m \cdot K_f} \quad [MPa]$$

2. Flexible connection:

a) $$L_{min\,k} = \frac{F_k \cdot K_a \cdot S_v}{p_{Dmin\,k} \cdot h_k \cdot N \cdot K_m \cdot K_w} \quad [mm]$$

b) $$p_{min\,k} = \frac{F_k \cdot K_a}{l_f \cdot h_k \cdot N \cdot K_m \cdot K_w} \quad [MPa]$$

where:

F_s	force on shaft [N]
F_h	force on hub [N]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	inside diameter of groove section [mm]
N	number of grooves [-]
h_s	height of force point of action on shaft [mm]
h_h	height of force point of action on hub [mm]
l_f	active key length [mm]

Strength Check

$p_{mins} \leq p_{Ds}$

$p_{minh} \leq p_{Dh}$

where:

p_{mins} minimal calculated shear pressure in shaft [MPa]

p_{minh} minimal calculated shear pressure in hub [MPa]

p_{Ds} allowable pressure in shaft [Mpa]

p_{Dh} allowable pressure in hub [Mpa]

Simplified calculation

Minimum key length to transfer the torque

1. Fixed connection:

$$L_{min} = \frac{T \cdot 10^3 \cdot K_a \cdot S_v}{\frac{d}{2} \cdot p_{Dmin} \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_f} \quad [mm]$$

2. Flexible connection: $$L_{min} = \frac{T \cdot 10^3 \cdot K_a \cdot S_v}{\frac{d}{2} \cdot p_{Dmin} \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_w} \quad [mm]$$

where:

T	torque [Nm]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [mm]
N	number of grooves [-]
h	height of groove
s	chamfer
h_{st}	connection height $h_{st} = h - 2\ s$ [mm]
p_{Dmin}	allowable pressure on supporting surface of shaft, groove, or hub [MPa]

Allowable pressure

1. Fixed connection: $$p_{min} = \frac{T \cdot 10^3 \cdot K_a}{\frac{d}{2} \cdot l_f \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_f} \quad [MPa]$$

2. Flexible connection: $$p_{min} = \frac{T \cdot 10^3 \cdot K_a}{\frac{d}{2} \cdot l_f \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_w} \quad [MPa]$$

where:

T	torque [Nm]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [mm]
N	number of grooves [-]
h	height of groove
s	chamfer
h_{st}	connection height $h_{st} = h - 2\ s$ [mm]
l_f	active key length [mm]

Strength Check

$p_{min} \leq p_{Ds}$

$p_{min} \leq p_{Dh}$

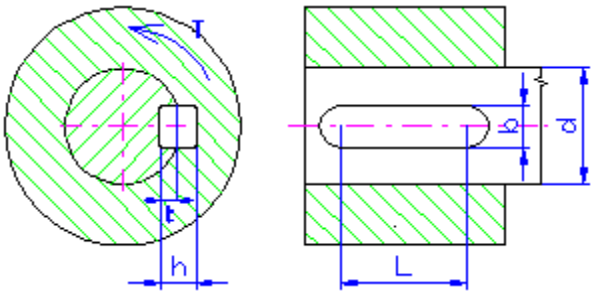
where:

p_{min} minimal calculated h/2 pressure [MPa]

p_{Ds} allowable pressure in shaft [Mpa]

p_{Dh} allowable pressure in hub [Mpa]

Key joints - formulas for English calculations



Transferred torque

$$T = \frac{30 \cdot 550 \cdot P}{\pi \cdot n} \quad [\text{lb ft}]$$

where:

P power [lb ft]

n speed [rpm]

Calculation of Minimum Shaft Diameter

1. shaft inside diameter $d_h > 0$

a)
$$d_{min} = 3\sqrt{\frac{16 \cdot T \cdot K_a \cdot S_y}{\pi \cdot \tau_A \cdot K_f}} \quad [in]$$

b) if $d_{min} \leq d_h$ -> $d_{min} = 1.1\, d_h$ [mm]

c) if $d_{min} \leq 1.5\, d_h$ -> $d_{min} = 1.5\, d_h$ [mm]

2. shaft inside diameter $d_h = 0$

$$d_{min} = 3\sqrt{\frac{16 \cdot T \cdot K_a \cdot S_y}{\pi \cdot \tau_A \cdot K_f}} \quad [in]$$

where:

d_{min}	minimal shaft diameter [in]
d_h	shaft inside diameter [in]
T	torque [Nm]
K_a	application factor
K_f	fatigue-life factor
S_v	desired safety
τ_A	Allowable Shear Stress
s	chamfer
p_{Dmins}	minimal allowable pressure (groove, shaft) [MPa]
p_{Dminh}	minimal allowable pressure (groove, hub) [MPa]

General calculation

$$h_s = \sqrt{\frac{d^2}{4} - \frac{b^2}{4}} + t - \frac{d}{2} - s \quad [in]$$ the range of force activity on the shaft

$h_k = h - h_s - 2\,s$ [in] the range of force activity on the hub

$$d_s = \sqrt{\left(\frac{d}{2} - t + s\right)^2 + \frac{b^2}{4}} + \frac{d}{2} \quad [in]$$ shaft diameter of the range of the force activity

$$d_s = \sqrt{\left(\frac{d}{2} - h - t - s\right)^2 + \frac{b^2}{4}} + \frac{d}{2} \quad [in]$$ hub diameter of the range of the force activity

$$F_s = 2 \cdot \frac{T \cdot 12}{d_s} \quad [lb]$$ force on shaft

force on hub

$$F_k = 2 \cdot \frac{T \cdot 12}{d_k} \quad [lb]$$

where:

T	torque [lbft]
F_s	force on shaft [lb]
F_h	force on hub [lb]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [in]
d_s	shaft diameter where force F_s actuates [in]
d_h	shaft diameter where force F_d actuates [in]
N	number of grooves [-]
h	height of groove [in]
h_s	height of force point of action on shaft [in]
h_h	height of force point of action on hub [in]
b	width of groove [in]
t	groove depth in shaft [in]
s	chamfer
p_{Dmins}	minimal allowable pressure (groove, shaft) [psi]
p_{Dminh}	minimal allowable pressure (groove, hub) [psi]

Minimum key length to transfer the torque

1. Fixed connection:

a) $$L_{\min s} = \frac{F_s \cdot K_a \cdot S_v}{p_{D\min s} \cdot h_s \cdot N \cdot K_m \cdot K_f} \quad [in]$$

b) $$L_{\min k} = \frac{F_k \cdot K_a \cdot S_v}{p_{D\min k} \cdot h_k \cdot N \cdot K_m \cdot K_f} \quad [in]$$

$L_{min} = \min(L_{mins}, L_{minh})$

2. Flexible connection:

a) $$L_{min\,s} = \frac{F_s \cdot K_a \cdot S_v}{p_{Dmin\,s} \cdot h_s \cdot N \cdot K_m \cdot K_w} \quad [in]$$

b) $$L_{min\,k} = \frac{F_k \cdot K_a \cdot S_v}{p_{Dmin\,k} \cdot h_k \cdot N \cdot K_m \cdot K_w} \quad [in]$$

$L_{min} = \min(L_{mins}, L_{minh})$

where:

F_s	force on shaft [lb]
F_h	force on hub [lb]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [in]
N	number of grooves [-]
h_s	height of force point of action on shaft [in]
h_h	height of force point of action on hub [in]
p_{Dmins}	minimal allowable pressure (groove, shaft) [psi]
p_{Dminh}	minimal allowable pressure (groove, hub) [psi]

Minimal Allowable pressure

1. Fixed connection:

a) $$p_{min\,s} = \frac{F_s \cdot K_a}{l_f \cdot h_s \cdot N \cdot K_m \cdot K_f} \quad [psi]$$

b) $$p_{min\,k} = \frac{F_k \cdot K_a}{l_f \cdot h_k \cdot N \cdot K_m \cdot K_f} \quad [psi]$$

2. Flexible connection:

a) $$L_{min\,k} = \frac{F_k \cdot K_a \cdot S_v}{p_{Dmin\,k} \cdot h_k \cdot N \cdot K_m \cdot K_w} \quad [in]$$

b) $$p_{min\,k} = \frac{F_k \cdot K_a}{l_f \cdot h_k \cdot N \cdot K_m \cdot K_w} \quad [psi]$$

where:

F_s	force on shaft [lb]
F_h	force on hub [lb]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	inside diameter of groove section [in]
N	number of grooves [-]
h_s	height of force point of action on shaft [in]
h_h	height of force point of action on hub [in]
l_f	active key length [in]

Strength Check

$p_{mins} \leq p_{Ds}$

$p_{minh} \leq p_{Dh}$

where:

p_{mins} minimal calculated shear pressure in shaft [psi]

p_{minh} minimal calculated shear pressure in hub [psi]

p_{Ds} allowable pressure in shaft [psi]

p_{Dh} allowable pressure in hub [psi]

Simplified calculation

Minimum key length to transfer the torque

1. Fixed connection:

$$L_{min} = \frac{T \cdot 12 \cdot K_a \cdot S_v}{\frac{d}{2} \cdot p_D \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_f} \quad [in]$$

2. Flexible connection: $$L_{min} = \frac{T \cdot 12 \cdot K_a \cdot S_v}{\frac{d}{2} \cdot p_D \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_w} \quad [in]$$

where:

T	torque [lbft]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [in]
N	number of grooves [-]
h	height of groove [in]
s	chamfer
h_{st}	connection height $h_{st} = h - 2\ s$ [in]
p_{Dmin}	allowable pressure on supporting surface of shaft, groove, or hub [psi]

Allowable pressure

1. Fixed connection: $$p_{min} = \frac{T \cdot 12 \cdot K_a}{\frac{d}{2} \cdot l \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_f} \quad [psi]$$

2. Flexible connection: $$L_{min} = \frac{T \cdot 12 \cdot K_a}{\frac{d}{2} \cdot p_D \cdot \frac{h_{st}}{2} \cdot N \cdot K_m \cdot K_w} \quad [psi]$$

where:

T	torque [lbft]
K_a	application factor
K_f	wear-life factor
K_w	application factor
K_m	load distribution factor
S_v	desired safety
d	shaft diameter [in]
N	number of grooves [-]
h	height of groove [in]
s	chamfer [in]
h_{st}	connection height $h_{st} = h - 2\ s$ [inm]
l_f	active key length [in]

Strength Check

$p_{min} \leq p_{Ds}$

$p_{min} \leq p_{Dh}$

where:

p_{min} minimal calculated h/2 pressure [psi]

p_{Ds} allowable pressure in shaft [psi]

p_{Dh} allowable pressure in hub [psi]
