7.07 Miscellaneous Shaft Components

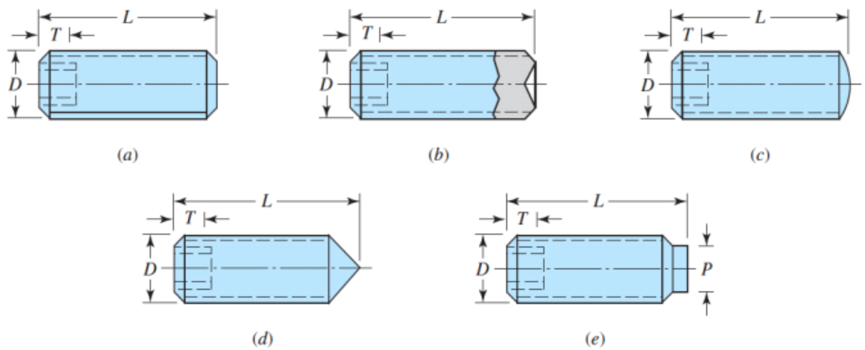
(I) Set-screws

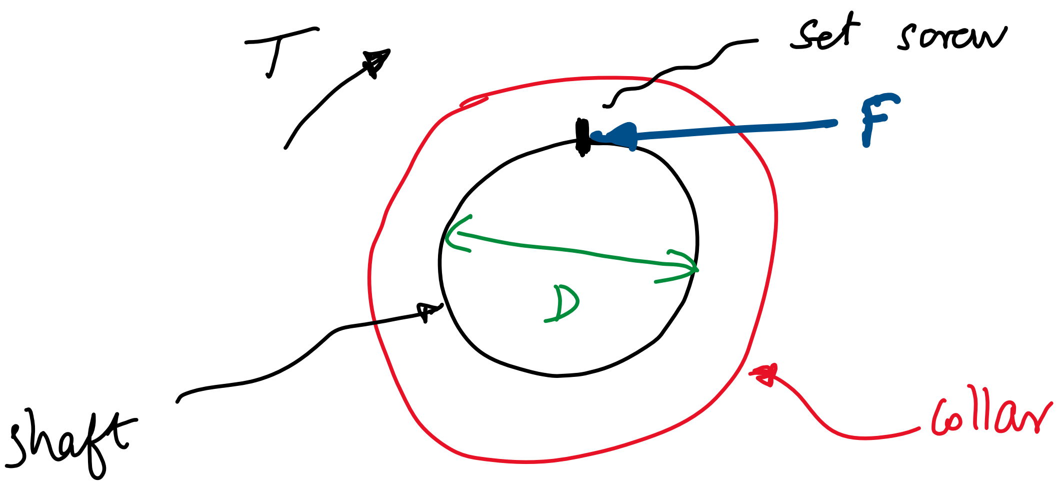
- rely on compression to clamp 2 surfaces
- set-screw between shaft and collar

transmits torques through force resistance between shaft and collar.

Figure 7–15

Socket setscrews: (*a*) flat point; (*b*) cup point; (*c*) oval point; (*d*) cone point; (*e*) half-dog point.





$$T = \frac{FD}{2}$$

T – torque

F – holding force

D – diameter

Table 7–4

Typical Holding Power (Force) for Socket Setscrews*

Source: Unbrako Division, SPS Technologies, Jenkintown, Pa.

Size, in	Seating Torque, lbf · in	Holding Power, lbf
#0	1.0	50
#1	1.8	65
#2	1.8	85
#3	5	120
#4	5	160
#5	10	200
#6	10	250
#8	20	385
#10	36	540
$\frac{1}{4}$	87	1000
$\frac{5}{16}$	165	1500
$\frac{3}{8}$	290	2000
$\frac{7}{16}$	430	2500
$\frac{1}{2}$	620	3000
$\frac{9}{16}$	620	3500
$\frac{5}{8}$	1325	4000
$\frac{3}{4}$	2400	5000
$\frac{7}{8}$	5200	6000
1	7200	7000

*Based on alloy-steel screw against steel shaft, class 3A coarse or fine threads in class 2B holes, and cup-point socket setscrews.

$$T = \frac{FD}{2}$$

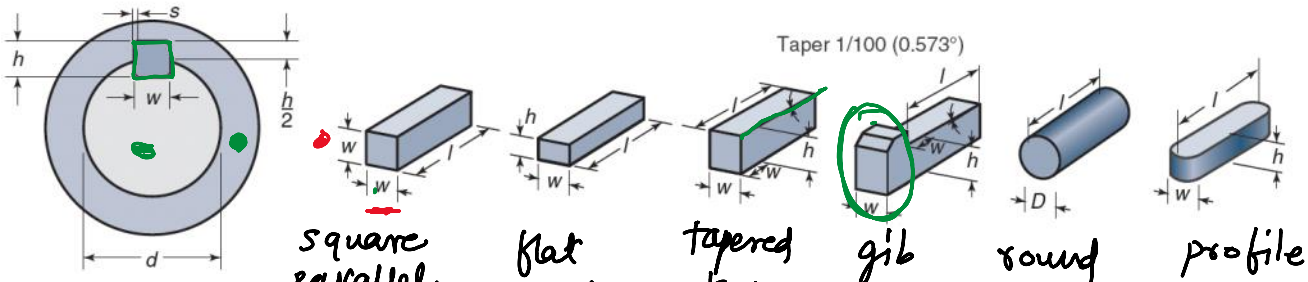
Force

225

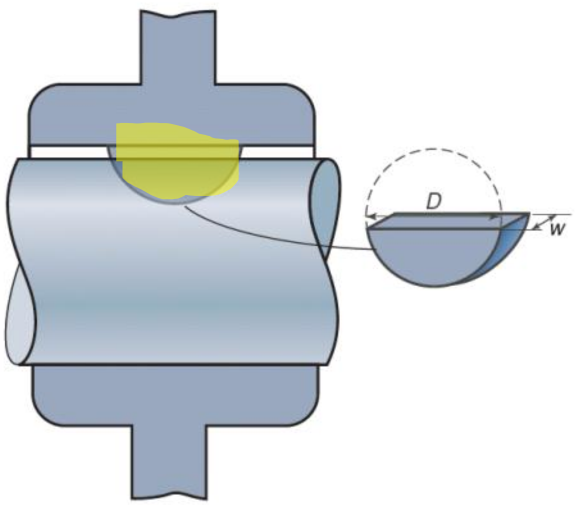
Bigger

(II) Keys :

— transmit torque from shafts to other shaft elements



square parallel key | flat parallel key | tapered key | gib head key (head assist removal) | round key | profile key



woodruff key

— adjusts to any taper in the hub of mating piece
— extra depth prevents overturning in tapering shafts

— depth of keyway weakens the shaft.

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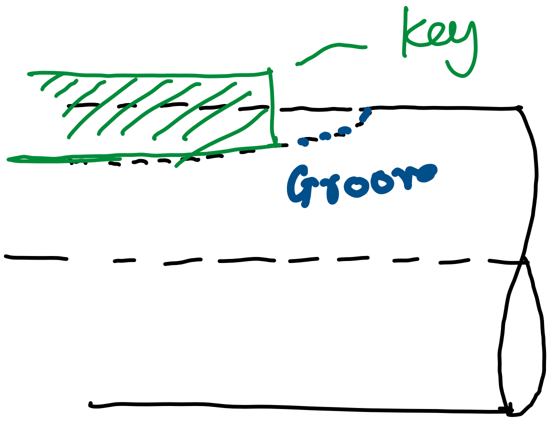
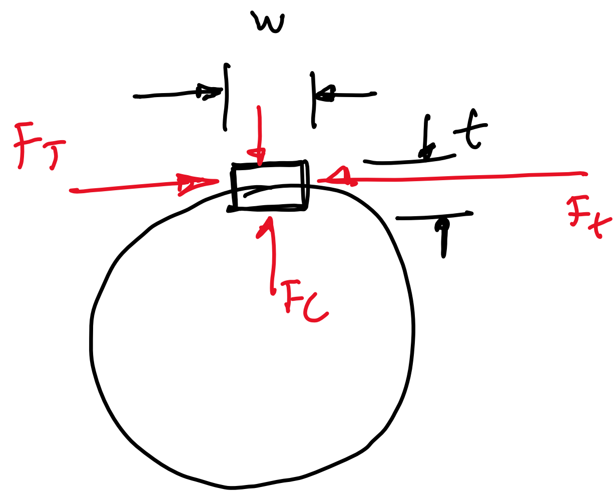
Analysis of Keys

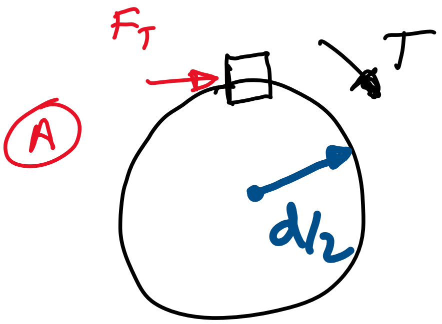


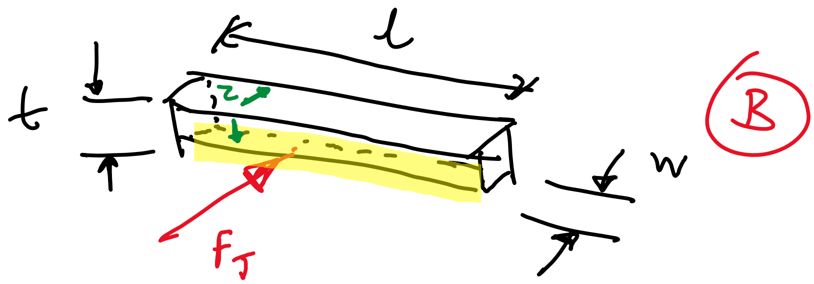


F_T – Force due to transmission torque
- compressive force
- can be computed from external torque T.

F_C – Force due to the key fitting inside the keyway

- compressive / crushing force
- difficult to determine.





$$\tau = \frac{F_T}{lw} \quad \text{from (B)}$$

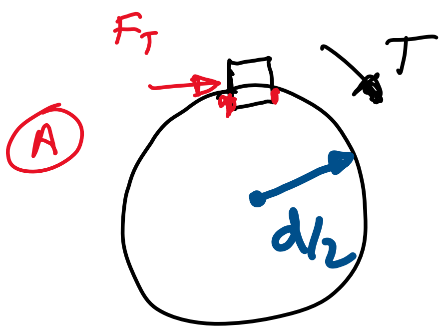
$$T = F_T \frac{d}{2} \quad \text{from (A)}$$

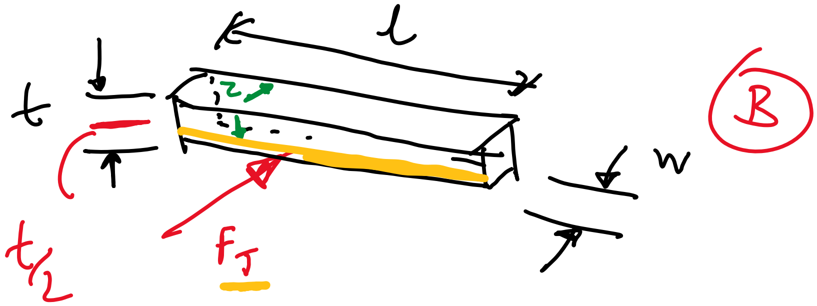
} (*)

Eliminate F_T in (*)

$$l w \tau = \frac{2T}{d}$$

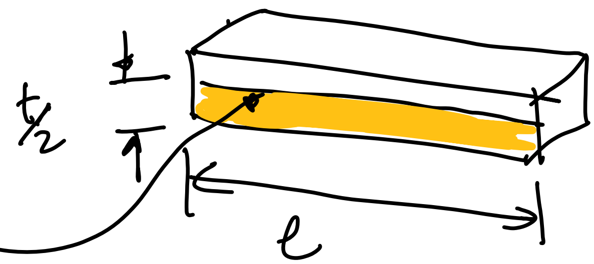
$$\boxed{\tau = \frac{2T}{dwl}} \quad (1)$$





σ_c – compressive (crushing stress

(2) $\left\{ \sigma_c = \dfrac{F_t}{\left(l\,t/2\right)} \right.$



From (B)

$T = F_T \, d/2$ From (A)

Eliminate F_T from (2)

$$\sigma_c \left(\frac{l t}{2}\right) = 2T/d$$

$$\boxed{\sigma_c = \frac{4T}{d l t}} \quad \text{— (2)}$$

From (1) and (2) $$\boxed{\frac{\sigma_c}{\tau} = 2 \, \frac{w}{t}}$$

Design factor

1. Crushing

$$n = \frac{S_y}{\sigma_c} = \frac{S_y}{\frac{4T}{dtl}}$$

$$\boxed{n = \frac{S_y\, d t l}{4T}}$$

2. Shear strength

$$n = \frac{S_{sy}}{\tau} = \frac{S_{sy}}{\frac{2T}{dwl}}$$

$$\boxed{n = \frac{S_{sy}\, d w l}{2T}}$$

NOTE: From distortion energy theory

$$\boxed{S_{sy} = 0.577\, S_y}$$

Q1

A shaft of diameter 1 (7/16) in = 1.4375 in will have a (3/8) in square key. Compute a suitable length for the key. Assume that the yield strength of the material of the key is 54 kpsi, the torque transmitted is 4200 lbf.in, and design factor of 1.5

$l = ?$

$w = t = 3/8$ (square key)

$S_y = 54$ kpsi

$d = 1.4375$

$T = 4200$ lbf.in

$n = 1.5$

Design based on crushing strength

$$n = \frac{S_y\, d\, t\, l}{4T} \Rightarrow l = \frac{4Tn}{S_y\, d\, t}$$

$$l = \frac{4\,(4200)(1.5)}{54(10^3)(1.4375)(3/8)}$$

$l = 0.866$ in —— (I)

Design based on shear strength

$$n = \frac{S_{sy}\, d\, W\, l}{2T} \qquad S_{sy} = 0.577\, S_y$$

$$l = \frac{2Tn}{(0.577\, S_y)\, d\, W}$$

$$l = \frac{2\,(4200)\,(1.5)}{(0.577)(54)(10^3)(1.4375)(3/8)}$$

$$l = 0.75 \text{ in} \quad \text{— (II)}$$

Summary

1. Design based on crushing strength; $l = 0.866$ in
2. Design based on shear strength; $l = 0.75$ in

Choose larger of the two.

$$\boxed{l = 0.866 \text{ in}}$$ ANSWER