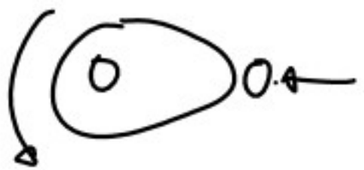
Shaft Design

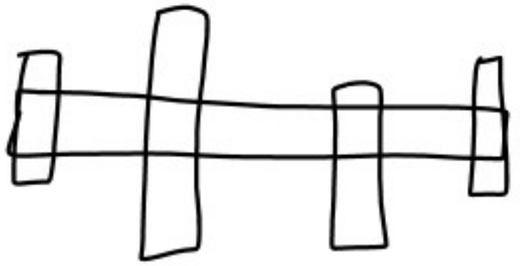

Transmission Shaft
Input Shaft
Line Shaft
Machine Shaft
Spindle Shaft
Crank Shaft
Counter Shaft
Output Shaft

Components

- Gears
- Splines
- Bearings
- Pullys
- Sproket
- Threads
- Cams
- Levers



Shaft Layout



Shaft Materials

- Stiffness
- Strength

Design for Stress

for infinite life

$$\sigma = \frac{Mc}{I} \qquad J = \frac{\pi d^4}{64}$$

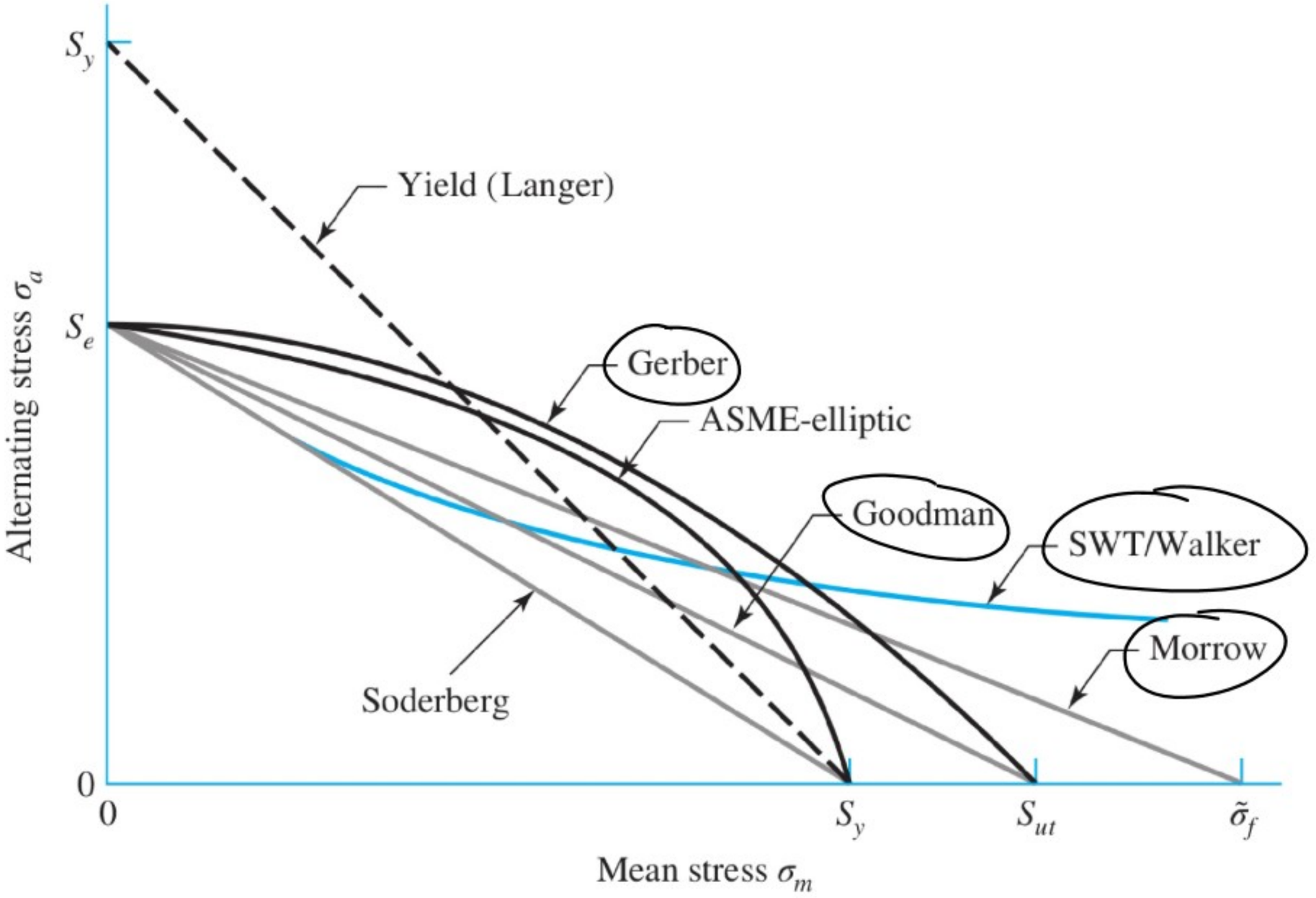
Check for yield

$$\sigma_a = K_f \frac{32 M_a}{\pi d^3} \qquad \sigma_m = K_f \frac{32 M_m}{\pi d^3}$$

$$\tau_a = K_{fs} \frac{16 T_a}{\pi d^3} \qquad \tau_m = K_{fs} \frac{16 T_m}{\pi d^3}$$

$$A = \sqrt{4(K_f M_a)^2 + 3(K_{fs} T_a)^2}$$

$$B = \sqrt{4(K_f M_m)^2 + 3(K_{fs} T_a)^2}$$


S_y
S_e
0
0
S_y
S_{ut}
$\tilde{\sigma}_f$
Alternating stress σ_a
Mean stress σ_m
Yield (Langer)
Gerber
ASME-elliptic
Goodman
SWT/Walker
Morrow
Soderberg

Goodman

$$n = \frac{\pi d^3}{16}\left(\frac{A}{S_e} + \frac{B}{S_{ut}}\right)^{-1} \qquad d = \sqrt[3]{\frac{16}{\pi}\left(\frac{A}{S_e} + \frac{B}{S_{ut}}\right)}$$

Morrow

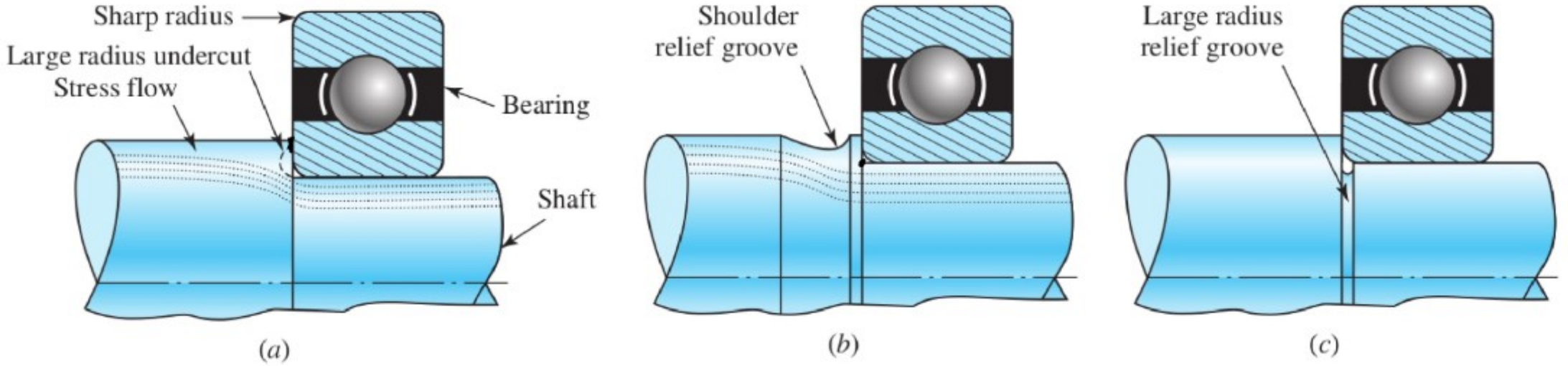
$$n = \frac{\pi d^3}{16}\left(\frac{A}{S_e} + \frac{B}{\sigma_f}\right)^{-1} \qquad d = \sqrt[3]{\frac{16}{\pi}\left(\frac{A}{S_e} + \frac{B}{\sigma_f}\right)}$$

Gerber

$$\frac{1}{n} = \frac{8A}{\pi d^3 S_e}\left(1 + \sqrt{1 + \left(\frac{2BS_e}{AS_{ut}}\right)^2}\right) \qquad d = \sqrt[3]{\frac{8nA}{\pi S_e}\left(1 + \sqrt{1 + \left(\frac{2BS_e}{AS_{ut}}\right)^2}\right)}$$

SWT

$$n = \frac{\pi d^3}{16}\frac{S_e}{\sqrt{A^2 + AB}} \qquad d = \sqrt[3]{\frac{16n}{\pi S_e}\sqrt{A^2 + AB}}$$



Stress concentrations

Deflection

Table 7-2

Slopes	
Tapered roller	0.0005–0.0012 rad
Cylindrical roller	0.0008–0.0012 rad
Deep-groove ball	0.001–0.003 rad
Spherical ball	0.026–0.052 rad
Self-align ball	0.026–0.052 rad
Uncrowned spur gear	<0.0005 rad

Transverse Deflections	
Spur gears with $P < 10$ teeth/in	0.010 in
Spur gears with $11 < P < 19$	0.005 in
Spur gears with $20 < P < 50$	0.003 in

P: gear pitch

$$d_{new} = d_{old} \left| \frac{n_d \; y_{old}}{y_{all}} \right|^{1/4}$$

$$d_{new} = d_{old} \left| \frac{n_d \left(dy/dx \right)_{old}}{(slope)_{all}} \right|^{1/4}$$