Fastening
- Non-permanent
  - Bolted
- Permanent
  - Bolted
  - Welded
  - Bonded

Outline - Bolted
- General Thread Nomenclature & Types
- Power Screws
- Stresses in Threads
- Preloading Fasteners/Joints
- Fasteners in Shear

Outline
- General Thread Nomenclature & Types
- Power Screws
  - Threads
  - Loads
  - Self-locking
  - Efficiency
- Stresses in Threads
- Preloading Fasteners/Joints
- Fasteners in Shear

Threads
- \( p \): pitch (in./thread)
- \( d \): diameter (major) (in.)
- \( d_p \): pitch diameter (in.)
- \( d_r \): minor diameter (in.)
- \( L \): lead (in.)

Screw Classifications
- Unified National Standard
- ISO (Metric)
  - UNC – coarse
  - UNF – fine
  - UNEF – extra fine

Tensile Stress
\[
\sigma_T = \frac{F}{A_t}
\]
\[
A_t = \frac{\pi}{4} \left( \frac{d}{2} + \frac{d_r}{2} \right)^2
\]
\( A_t \) also in Tables 14-1 and 14-2

Outline
- General Thread Nomenclature & Types
- Power Screws
  - Threads
  - Loads
  - Self-locking
  - Efficiency
- Stresses in Threads
- Preloading Fasteners/Joints
- Fasteners in Shear
Power Screw Applications

*Where have you seen power screws?*

- jacks for cars
- C-clamps
- vises
- Instron material testing machines
- machine tools (for positioning of table)

Power Screw Types

- Square
  - strongest
  - no radial load
  - hard to manufacture
- Acme
  - 29° included angle
  - easier to manufacture
  - common choice for loading in both directions
- Buttress
  - great strength
  - only unidirectional loading

Load Analysis

*What “simple machine” does a power screw utilize?*

\[
\tan \lambda = \frac{L}{md_P} \quad T_S = \frac{Pd_P (\mu md_P + L)}{2 (md_P - \mu d)}
\]

Friction Coefficients

- \( \mu_{oil \text{ lubricated}} = 0.15 \pm 0.05 \)
- \( \mu_{collar \text{ w/ bearing}} = 0.015 \pm 0.005 \)

Outline

- General Thread Nomenclature & Types
- Power Screws
- Stresses in Threads
  - Body Stresses
  - Axial
  - Torsion
  - Thread Stresses
    - Bearing
    - Bending
  - Buckling
- Preloading Fasteners/Joints
- Fasteners in Shear
Outline

- General Thread Nomenclature & Types
- Power Screws
- Stresses in Threads
- Preloading Fasteners/Joints
  - Proof Strength
  - Spring Behavior
  - Loading & Deflection
  - Separation of Joints
- Fasteners in Shear

Dynamic Loading of Fasteners

- Bolt only absorbs small % of P
- Stresses
  - Bolt is in tension
  - Material is in compression
- Fatigue is a tensile failure phenomenon
  - Preloading helps tremendously in fatigue

Preloading & Proof Strength

- $S_p$ → stress at which bolt begins to take a permanent set

Preloading

- static loading: preload at roughly 90% of $S_p$
- dynamic loading: preload at roughly 75% of $S_p$

Spring Behavior

BOOTH material being clamped and bolt behave as springs (up to yield/permanent set stresses)

$$ k = \frac{AE}{l} $$

for the bolt, threaded vs unthreaded have different spring constants:

$$ \frac{1}{k_b} = \frac{l_t}{A_t E_b} + \frac{l_s}{\pi l^2/4} E_b $$

applied load $P$

See Example 14-2, p. 906

Outline

- General Thread Nomenclature & Types
- Power Screws
- Stresses in Threads
- Preloading Fasteners/Joints
- Fasteners in Shear
  - What is Shear?
  - Straight Direct Shear

Direct Shear

$$ \tau = \frac{P}{A_{\text{rein}}} $$
Dowelled Joints

Shear can be handled by friction caused by bolts... but, better practice is to use dowels.

Bolts need clearances... at best 2 out of a 4 bolt pattern will bear all of load.

Dowels support shear, but not tensile loads.
Bolts support tensile loads, but not shear.

Norton

Direct Shear

\[ \tau = \frac{F}{A_{\text{shear}}} \]

\[ A_{\text{shear}} = 2a \times \text{cross sec of dowels} \]

\[ N = \frac{S_{Y}}{\tau} = \frac{0.577S_{Y}}{\tau} \]

Outline Revisited

- General Thread Nomenclature & Types
- Power Screws
- Stresses in Threads
- Preloading Fasteners/Joints
- Fasteners in Shear

Chapter 9
Welding, Brazing, Bending, and the Design of Permanent Joints

From Shigley & Mischke, Mechanical Engineering Design

Part 3
Design of Mechanical Elements

Welding Symbols

(a) 
(b)

Butt Welds

Reinforcement

Throat \( h \)
Fillet Welds

Welding Issues
- Requires
  - Careful Design
  - Skilled Welder
- Can Cause
  - Weakened adherends
  - Thermal distortion
  - Removal of heat treatment

Welding References
- AWS (American Welding Society)
- Lincoln Electric
- ASME Codes & Standards
  - Pressure Vessels & Piping
  - Nuclear Installations
  - Safety Codes
  - Performance Test Codes

Bonded Joints (thin members)

Bonded Joint Types
(a) Single-lap
(b) Double-lap
(c) Stiff
(d) Bevel

More Types
(e) Stop
(f) Butt-wrap
(g) Double butt-wrap
(h) Tubular lap
Peel Stresses

- Peel stresses can be a problem at ends of lap joints of all types

Good Practices

- Lighter joint
- Less costly joint
- Better sound absorption

Bonding Issues

- Can achieve
  - Lighter joint
  - Less costly joint
  - Better sound absorption
- Beware
  - Peel stresses
  - Environmental effects
  - Thermal mismatch

Bonding References

- SAMPE (Society for the Advancement of Material & Process Engineering)
- ASTM Committee D-14 on Adhesives