Mechanical fasteners

Basic, important components

For example: an airplane may have several million rivets, bolts, and screws, these should be carefully designed with safety factors.

Threaded fasteners

- See 8.1 for standard size and nomenclature
- Pitch \( p \), \( \frac{1}{p} \) = number of threads per inch
- Lead \( e \) = axial advance per revolution = \( n \cdot p \)
- Thread angle \( \alpha \)
- Major & minor diameter, mean diameter
- Tensile stress area

Analysis of bolted joint

- \( F_i \) = "preload" produced by tightening

Power screw

- Raising a load \( F \)

Square thread

Torsion required to raise the load?
extend one cycle (this represents the whole system)

\[ \begin{align*}
F_{\text{MN}} &= P - N \sin \alpha - N \cos \alpha = 0 \\
F_{\text{N}} &= F + \mu N \sin \alpha - N \cos \alpha = 0
\end{align*} \]

we are not interested in \( N \)
eliminate \( P \)

\[ P = \frac{F (\sin \alpha - \mu \sin \alpha)}{\cos \alpha - \mu \sin \alpha} \] raise

Same way for lower.

\[ P = \frac{F (\mu \cos \alpha - \sin \alpha)}{\cos \alpha + (\mu \sin \alpha)} \] lower

also we have \( \tan \alpha = \frac{\rho}{\text{adm}} \)

\[ \begin{align*}
\{ & P = \frac{F [\frac{\rho}{\text{adm}} + \mu]}{1 - \mu \text{adm}} \text{ raise} \\
& P = \frac{\text{Torque}}{P \frac{\text{dm}}{2}} \text{ lower}
\end{align*} \]

Torque = \( P \frac{\text{dm}}{2} \)

\[ \begin{align*}
\text{same way for lower.} \\
\text{Torque} &= \frac{F \text{dm}}{2} \left( \frac{\mu \text{dm} - \rho}{\text{dm} - \mu \rho} \right) \text{ raise} \\
\text{Torque} &= \frac{F \text{dm}}{2} \left( \frac{\mu \text{dm} - \rho}{\text{dm} - \mu \rho} \right) \text{ lower}
\end{align*} \]

if \( \text{Torque lower} < 0 \rightarrow \text{lower automatically} \)

\( \text{Torque lower} > 0 \rightarrow \text{self-locking} \)

for self-locking \( \rightarrow \frac{\text{adm} \mu > \rho}{\text{adm} - \mu \rho} \)

\[ \mu > \frac{\rho}{\text{adm} - \tan \alpha} \]

friction coefficient thread and angle.
non-square thread

\[ T_{\text{raise}} = \frac{Fdm}{2} \left( \frac{E + \mu \cdot dm \cdot \sec \alpha}{\pi \cdot dm - \mu \cdot E \cdot \sec \alpha} \right) + \frac{F \cdot \mu d}{\pi} \]

(collar diameter)

(neglect the lead angle effect)

since it is small

in most cases

efficiency of gear

if \( \mu = 0 \) (no friction)

\[ T_0 = \frac{F \cdot l}{2 \pi} \]

\[ \eta = \frac{T_0}{T} = \frac{F \cdot l}{2 \pi \cdot T} \]

square \& ACME threaded

lead \( F_{\ell} \)

Table 8-43 (prefered thread)