



*The University of Tennessee at Martin*

**School of Engineering**

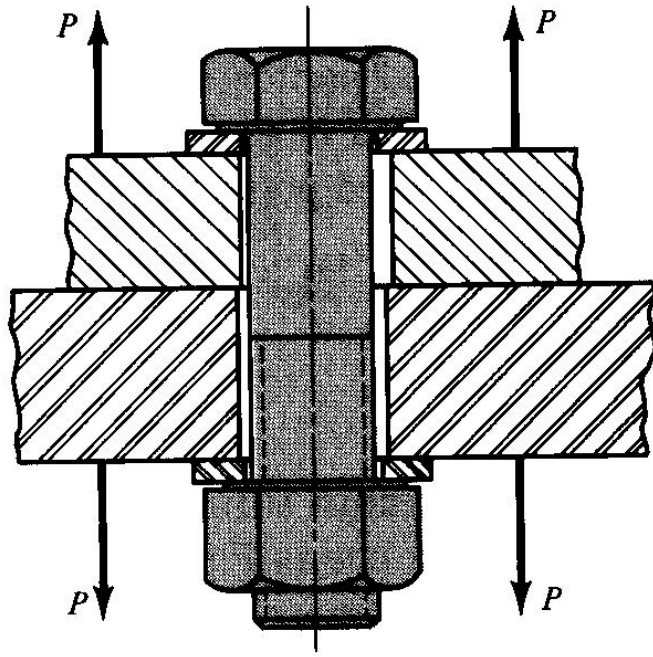
# **Mechanical Fasteners – Torque Vs Preload Relationship**

## **Lecture 30**

**Engineering 473  
Machine Design**

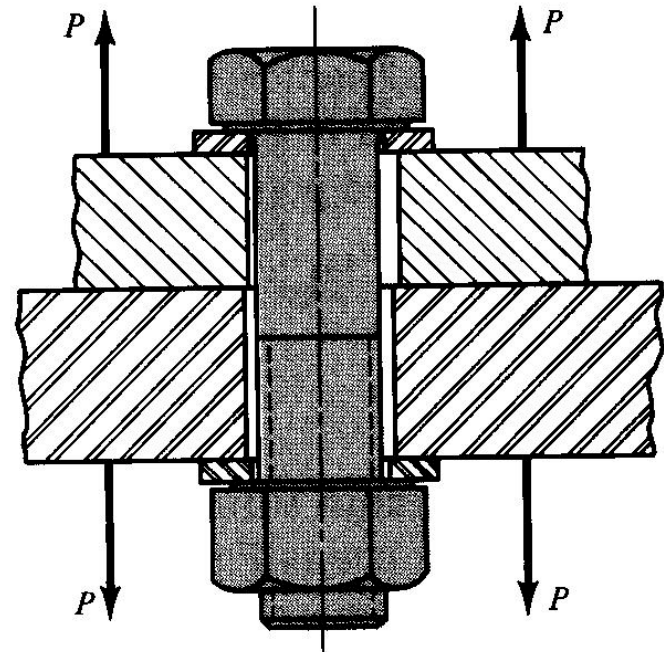
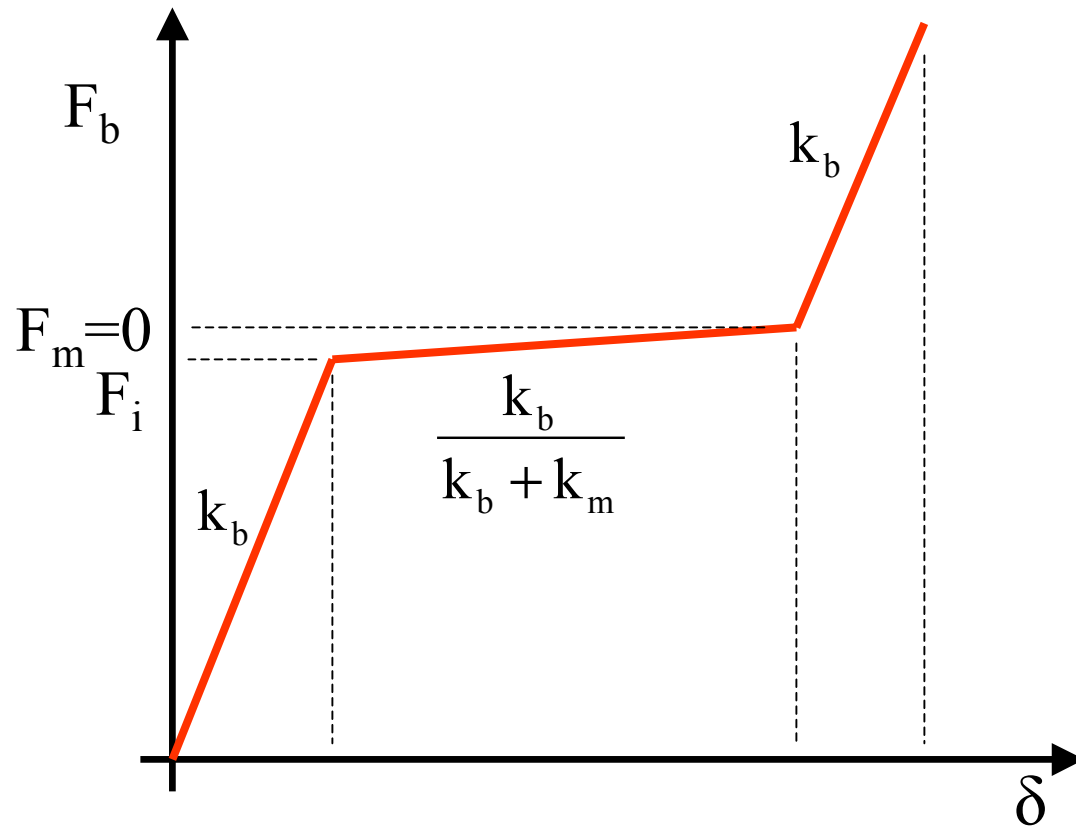


# Tension Connection



- A threaded fastener connection has clearance gaps that are used to facilitate assembly of the connection.
- A connection can be loaded in either tension/compression or shear.
- Because of the clearance gaps, dowel pins are often used for accurately positioning of mating parts and prevent sliding motion.

# How Much Torque to Achieve Preload Requirement?



In the previous lecture, it was shown that a high preload is a very desirable in a tension connection.

# Torque-Preload Relationship

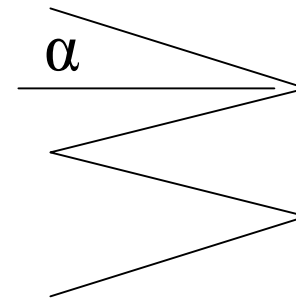
**Square Tooth  
Power Screw  
Equation**

$$T_u = \frac{FD_p}{2} \left( \frac{l + \mu\pi D_p}{\pi D_p - \mu l} \right)$$

**Modified for  
Thread Angle  
Alpha**

$$T = \frac{FD_p}{2} \left( \frac{l + \mu\pi D_p \sec\alpha}{\pi D_p - \mu l \cdot \sec\alpha} \right)$$

These equations give the torque required to impart an axial force and overcome thread friction.



# Torque-Preload Relationship (Continued)

## Nut Surface Friction Torque

$$T_n = \frac{F\mu_n d_n}{2}$$

$\mu_n$  = Coefficient of Friction  
between nut and part

$d_n$   $\equiv$  mean annulus diameter  
of nut

$$T = \frac{F_i D_p}{2} \left( \frac{1 + \mu \pi D_p \sec \alpha}{\pi D_p - \mu l \cdot \sec \alpha} \right) + \frac{F_i \mu_n d_n}{2}$$

$$d_n \approx 1.5 D_p \text{ (Standard Washer)}$$

$$T = k F_i d$$

$$k = \left[ \left( \frac{D_p}{2d} \right) \left( \frac{\tan \lambda + \mu \cdot \sec \alpha}{1 - \mu \tan \lambda \cdot \sec \alpha} \right) + 0.625 \mu_c \right]$$

$$\tan \lambda = \frac{1}{\pi D_p}$$

# Experimental Data

## Given

T=90 N-m

## Measure

Preload,  $F_i$

## Bolt

M12x1.25

## Unlubricated

Ave.  $F_i$ =34.3 kN

Std. Dev. = 4.91 kN

$$\frac{2\sigma}{F_m} = \pm 29\%$$

## Lubricated

Ave.  $F_i$ =34.2 kN

Std. Dev. = 2.9 kN

$$\frac{2\sigma}{F_m} = \pm 17\%$$

There is considerable scatter in torque-versus preload data.

J.C. Blake and H.J. Kurtz, "Uncertainties in Measuring Fastener Preload,"  
Machine Design, Vol. 37, Sept. 30, 1965, pp. 128-131.

# Typical Values of K

<b>Bolt Condition</b>	<b>k</b>
Black oxide finish	0.3
Zinc-plated	0.2
Lubricated	0.18

Bolt manufacturers often list recommended k values with their product data.

# Maximum Torque Values

It is very easy to twist off a small diameter fastener ( $< 5/16$  inch) when preloading a connection.

Design organizations often establish maximum torque values than can be applied to a fastener during installation.

# Assignment

An initial preload of 50 ksi is needed in a  $\frac{1}{2}$ -13UNC-2A steel fastener. The coefficient of friction for the threads is estimated to be 0.4, and the coefficient of friction between the bolt head and part is estimated to be 0.3. What torque should you specify on the drawing to assure that the fastener is installed with the correct preload?