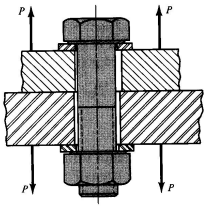
The University of Tennessee at Martin
MARTIN School of Engineering

Mechanical Fasteners –
Torque Vs Preload Relationship

Lecture 30

Engineering 473
Machine Design

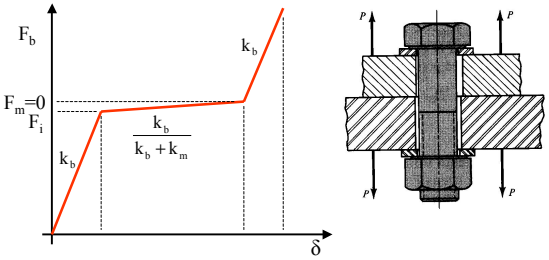
Tension Connection



- 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.

Shigley, Fig. 8-12

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

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

μ_n = Coefficient of Friction between nut and part

$d_n \equiv$ mean annulus diameter of nut

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

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

$$\boxed{T = kF_i d}$$

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

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

Experimental Data

Given
T=90 N-m

Measure
Preload, F_i

Bolt
M12x1.25

There is considerable scatter in torque-versus preload data.

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

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

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

Bolt Condition	k
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 ½-13UNC-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?