MTE321 Formulas

Stresses

Deformation Elongation

$$\delta = \frac{FL}{EA}$$
$$\delta = \frac{\sigma L}{E}$$

Torsional Forumals

Stress

R is the radial distance

$$\tau = \frac{Tr}{J}$$
$$Z_p = \frac{J}{c}$$
$$\tau_{max} = \frac{T}{Z_p}$$

Deformation

θ is the angle of twist across L
For non-circular shafts K is section polar second moment of area and Q the section polar modulus

$$T = \frac{P}{\omega} \quad T_{lb\cdot in} = 63000\frac{P}{\omega}$$
$$\theta = \frac{TL}{GJ}$$
$$Non\text{-}Circular\ \tau = \frac{T}{Q}$$
$$Non\text{-}Circular\ \theta = \frac{TL}{GK}$$

Thin-Walled Closed Tubes

A = median area boundary, U is length of median boundary

$$K = \frac{4A^2t}{U}$$
$$Q = 2tA$$

Shear Stress

V section shear force, Q is the first moment area, and t is the section thickness

$$\tau_{(y)} = \frac{VQ}{It}$$
$$Rectangular\ Beam\ \tau_{max} = \frac{3V}{2A}$$
$$Solid\ Round\ Beam\ \tau_{max} = \frac{4V}{3A}$$
$$Hollow\ Round\ Beam\ \tau_{max} = \frac{2V}{A}$$

Beam Bending

M is the moment at the section, y is the distance from the neutral axis

$$\sigma_y = -\frac{My}{I}$$

Stress Concentrations

Stress Concentration Factor

K_t is material and loading dependent, values greater than 3 are a waste

$$\sigma_{max} = K_t\sigma_{nom}$$

Curved Beam Bending

R = $\frac{A}{ASF}$
r = distance to required stress location
r_c= centroid distance
A = cross-sectional area

$$\sigma_{(r)} = \frac{M(\theta)(R-r)}{Ar(r_c - R)}$$

Thermal Strain

$$\epsilon_x^m = -\alpha\delta T$$

Principle Stresses

$$tan2\theta_\sigma = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$
$$Max\ \sigma_{norm} = \frac{1}{2}(\sigma_x + \sigma_y) + \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$
$$Min\ \sigma_{norm} = \frac{1}{2}(\sigma_x - \sigma_y) - \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$

Lecture 5

Loading

$$\sigma_m = mean\ stress = (\sigma_{max} + \sigma_{min})/2$$
$$\sigma_a = stress\ amplitude = (\sigma_{max} - \sigma_{min})/2$$
$$R = stress\ ratio = \sigma_{min}/\sigma_{max})$$
$$A = stress\ ratio = \sigma_a/\sigma_m)$$
$$Loading\ Cycle : period\ between\ peaks$$

Fatigue Testing

$$tan2\theta_\sigma = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$
$$Max\ \sigma_{norm} = \frac{1}{2}(\sigma_x + \sigma_y) + \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$
$$Min\ \sigma_{norm} = \frac{1}{2}(\sigma_x - \sigma_y) - \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$

Endurance Limit

$$tan2\theta_\sigma = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$
$$Max\ \sigma_{norm} = \frac{1}{2}(\sigma_x + \sigma_y) + \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$
$$Min\ \sigma_{norm} = \frac{1}{2}(\sigma_x - \sigma_y) - \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$

Goodman Method

$$K_t tan2\theta_\sigma = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$
$$Max\ \sigma_{norm} = \frac{1}{2}(\sigma_x + \sigma_y) + \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$
$$Min\ \sigma_{norm} = \frac{1}{2}(\sigma_x - \sigma_y) - \sqrt{\left[\frac{1}{2}\sigma_x - \sigma_y\right]^2 + \tau_{xy}^2}$$

Design: Dynamic Loads

Stress

Periodic

Fluctuating $\sigma_m \neq 0$, R = -1
Pulsating $\sigma_m = 0$, R =1

Endurance Limit

$$s_a = s_n N^b$$

$$s_n^{'} = C_m C_{st} C_R C_S s_n$$

s_a =Stress Amplitude Level
N: number of cycles to failure
s_n = fatigue limit
Assume $s_n = 0.5 s_u$ if no data

s_n from table appendix 3
C_m material flaws
C_R Reliability Factor

C_s = size factor (5-12,5-4 circular),(5-13 for other)

Goodman Method

Gears

Pitch Line Speed

$$V_T = \frac{\pi D \cdot n_p}{12}$$