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Chapter 5 Image Slides

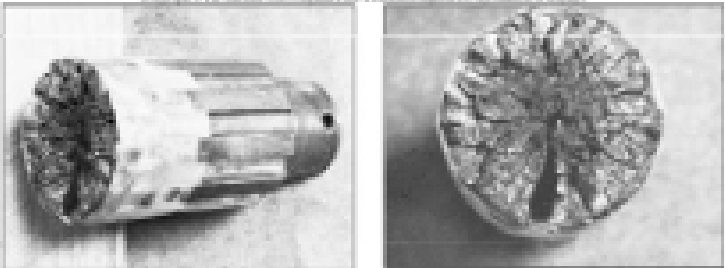


Shigley's
Mechanical
Engineering
Design

Richard C. Hibbeler and Charles N. Smith
Eighth Edition

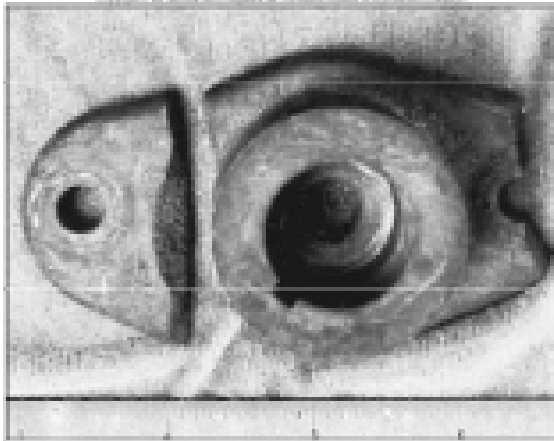
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5-1 Drive Shaft Failure

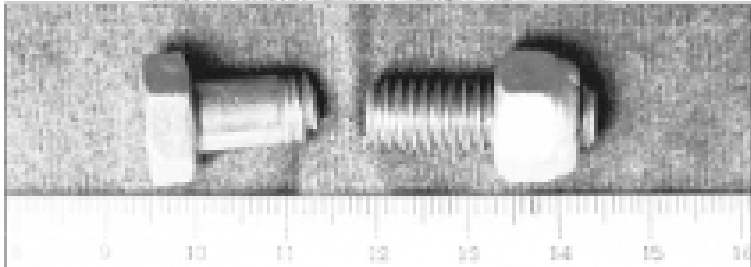


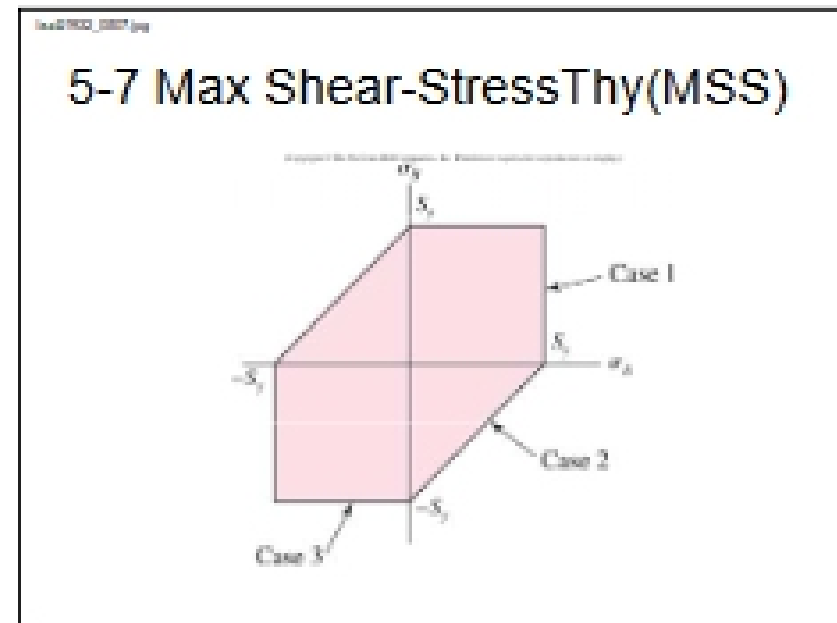
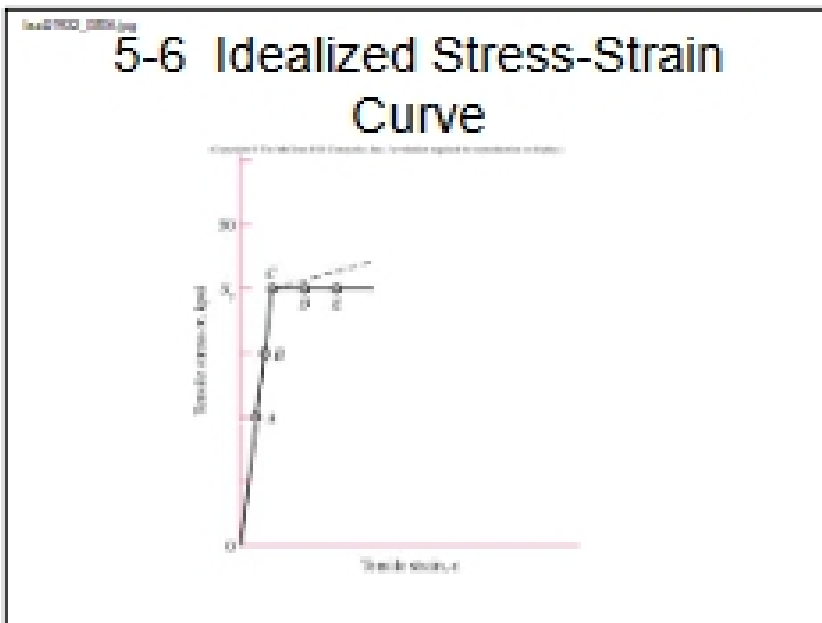
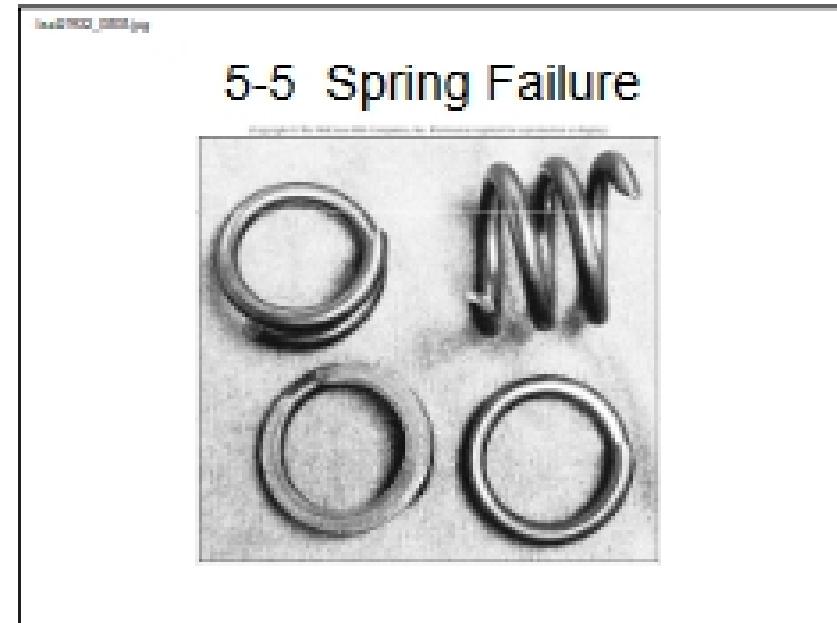
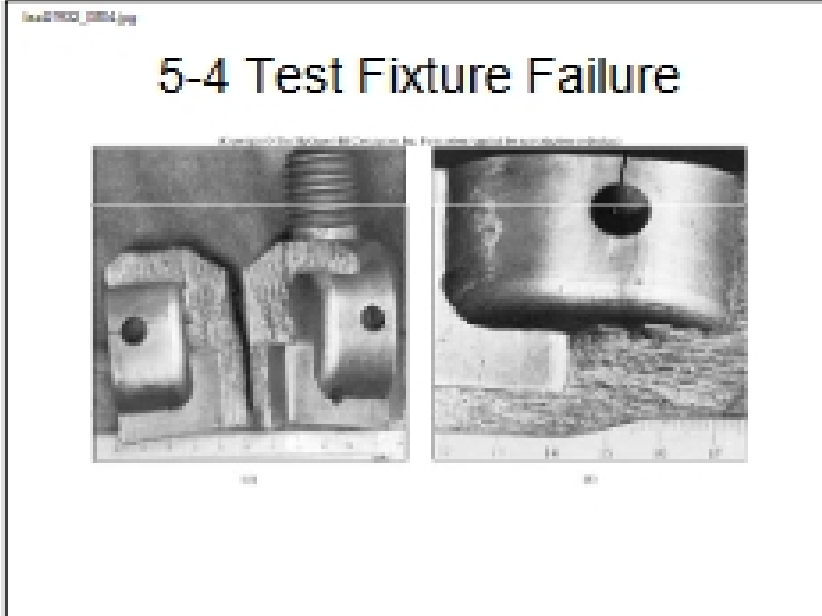
(a) (b)

5-2 Hub Failure



5-3 Bolt Failure





5-8 Triaxial Stress

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(a) Triaxial stress: A cube with normal stresses σ_1 , σ_2 , and σ_3 acting on its faces. Below it, the text reads $\sigma_1 \neq \sigma_2 \neq \sigma_3$.

(b) Hydrostatic component: A cube with uniform normal stress σ_{hp} acting on all faces. Below it, the text reads $\sigma_1 = \sigma_2 = \sigma_3 = \sigma_{hp}$.

(c) Distortional component: A cube with normal stresses σ_1 , σ_2 , and σ_3 acting on its faces, representing the deviatoric part of the stress state. Below it, the text reads $\sigma_1 \neq \sigma_2 \neq \sigma_3$.

5-9 Distortion-Energy Thy. (DE)

Distortion-Energy Failure Envelope for Ductile Materials under Static Loading

Hex shear load line ($\sigma_1 = -\sigma_2 = \sigma_3 = 0$)

— DE
- - - MSS

5-10 Octahedral Surfaces

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EXAMPLE 5-1

A material used for a shaft is subjected to a principal stress of $\sigma_1 = 80$ MPa and a shear stress of $\tau_{xy} = 40$ MPa. Determine the factor of safety for the following principal stress states:

- (a) 80, 10, 80 MPa
- (b) 80, 10, 0 MPa
- (c) 80, 10, -10 MPa
- (d) 80, -10, -10 MPa
- (e) 80, 0, 0 MPa

Solution: Since $\sigma_1 = 80$ MPa and $\tau_{xy} = 40$ MPa, the material is ductile and the distortion-energy (DE) theory applies. The von Mises stress (σ_{DE}) based on the σ_1 and τ_{xy} is applied and compared to the DE stress. Note that the units in both the given stress state and the DE stress are the same.

(a) The critical principal stresses are $\sigma_1 = \sigma_2 = 80$ MPa, $\sigma_3 = 10$ MPa, or 80, 80, 10 MPa.

$$\sigma^2 = \sigma_{DE}^2 = \frac{1}{2}[(80 - 80)^2 + (80 - 10)^2 + (80 - 10)^2] = 10000$$

Answer: $\sigma = \frac{1}{\sqrt{2}} \sqrt{10000} = 70.7$ MPa

MSS: Case 1, using Eq. (9-1) for the factor of safety.

Answer: $n = \frac{\sigma}{\sigma_{DE}} = \frac{70.7}{80} = 0.88$

(b) The critical principal stresses are $\sigma_1 = \sigma_2 = 80$ MPa, $\sigma_3 = 0$ MPa, or 80, 80, 0 MPa.

$$\sigma^2 = \sigma_{DE}^2 = \frac{1}{2}[(80 - 80)^2 + (80 - 0)^2 + (80 - 0)^2] = 12800$$

Answer: $\sigma = \frac{1}{\sqrt{2}} \sqrt{12800} = 89.4$ MPa

MSS: Case 1, using Eq. (9-1).

Answer: $n = \frac{\sigma}{\sigma_{DE}} = \frac{89.4}{80} = 1.12$