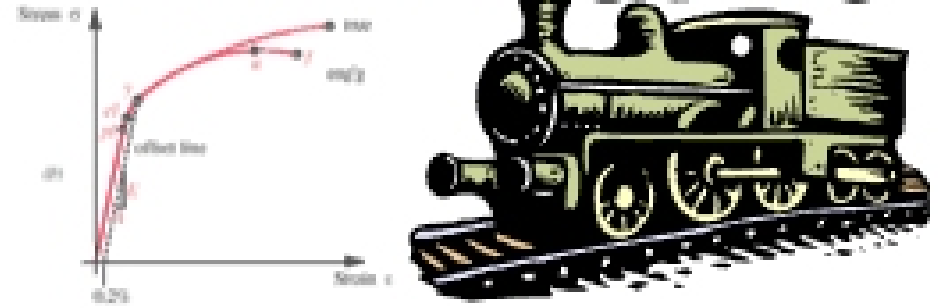


Over the Next Several Days

- ❖ What is fatigue?
- ❖ Types of Fatigue Loading
- ❖ Empirical Data
- ❖ Estimating Endurance/Fatigue Strength
- ❖ Strategies for Analysis
 - Uniaxial Fully Reversed
 - Uniaxial Fluctuating
 - Multiaxial

Some History

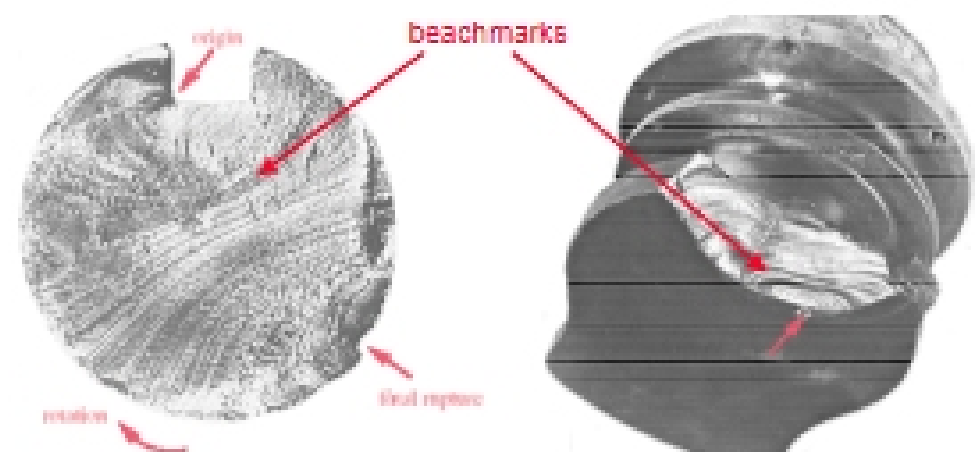
- ❖ Rail car axles
- ❖ The all-important microcrack
- ❖ Role of stress concentrations
 - Comet airplanes



Three Stages of Fatigue Failure

- ❖ Crack Initiation
- ❖ Crack Propagation
 - oscillating stress... crack grows, stops growing, grows, stops growing... with crack growth due to tensile stresses
- ❖ Fracture
 - sudden, brittle-like failure

Identifying Fatigue Fractures



Three Theories

Stress-Life stress-based, for high-cycle fatigue, aims to prevent crack initiation

Strain-Life useful when yielding begins (i.e., during crack initiation), for low-cycle fatigue

LEFM (Fracture Mechanics) best model of crack propagation, for low-cycle fatigue

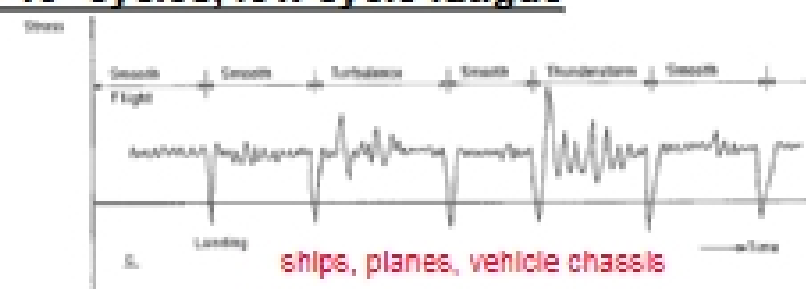
Low vs. High Cycle

>10³ cycles, high cycle fatigue

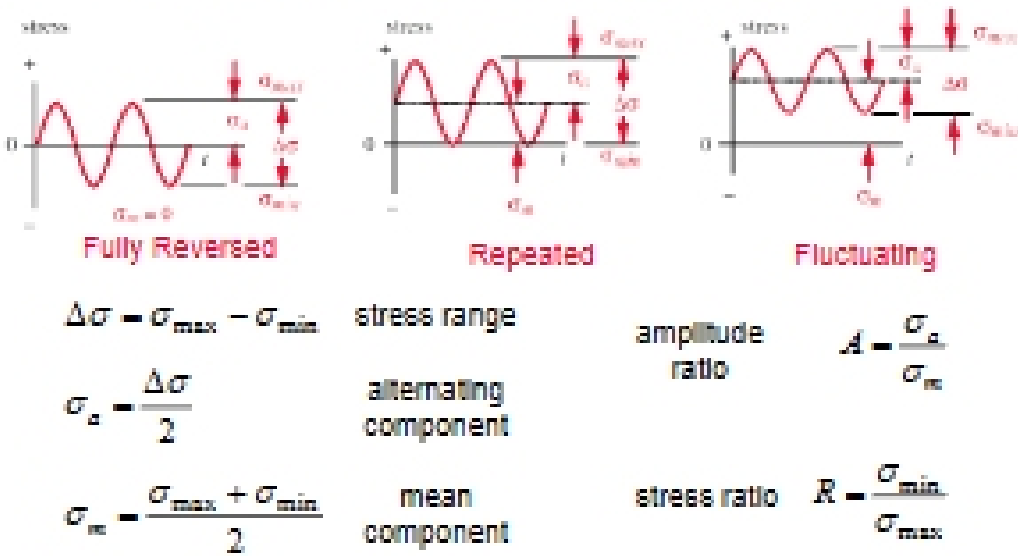
car crank shaft – ~2.5 E8 Rev/10⁴ miles

manufacturing equipment @ 100 rpm – 1.25 E8 Rev/year

<10³ cycles, low cycle fatigue



Types of Fatigue Loading



Update

- ❖ What is fatigue?
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Testing Fatigue Properties

- ❖ Rotating Beam – most data is from this type
- ❖ Axial
 - lower or higher? Why?
- ❖ Cantilever
- ❖ Torsion

Fully Reversed Empirical Data

An S-N Curve (Stress-Life)

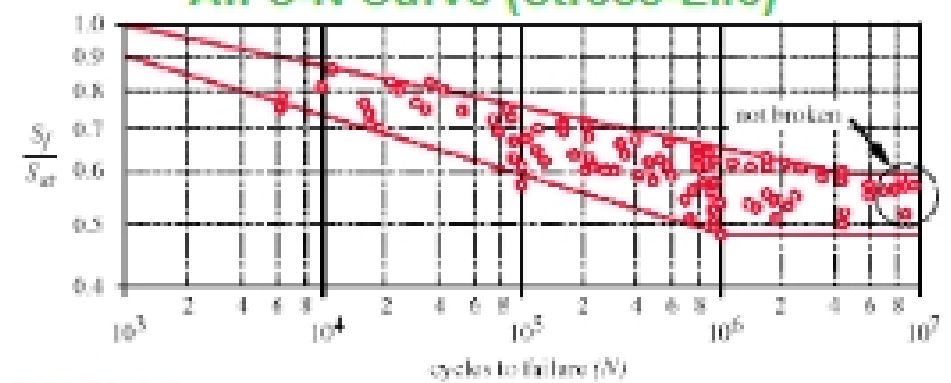
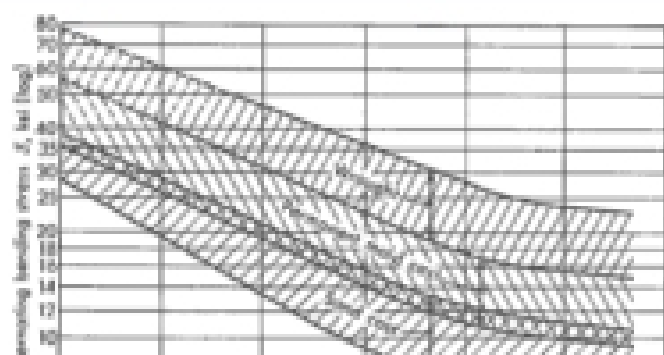


FIGURE 6-8

Log-Log Plot of Composite S-N Curves for Wrought Steels of $S_y < 200$ ksi (from Fig. 11.7, p. 210, R. C. Ferrett, *Steel, Strain, and Strength*, McGraw-Hill, New York, 1967, with permission)

Wrought Steel

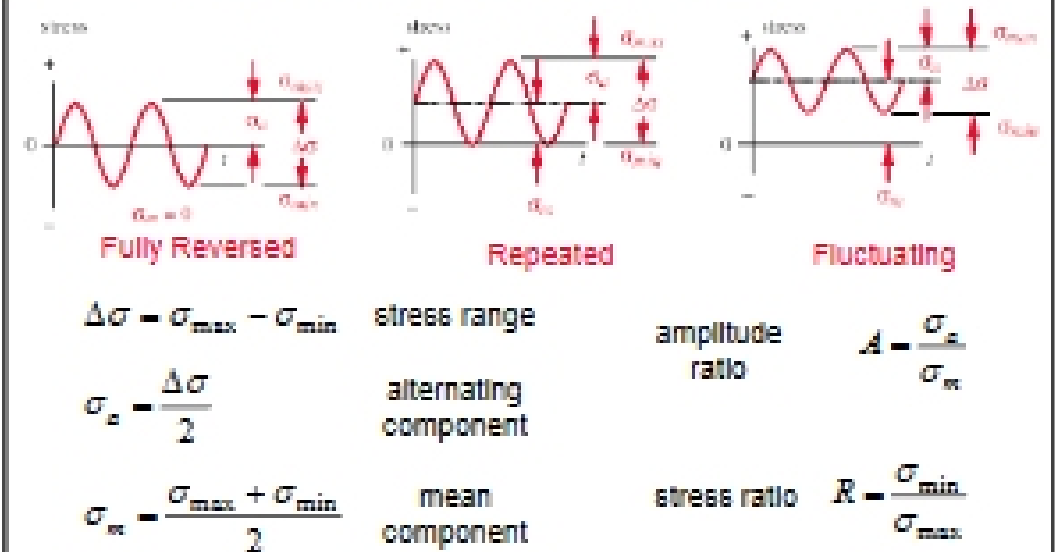
Fully Reversed Empirical Data



Update

- ❖ What is fatigue?
- ❖ Types of Fatigue Loading
- ❖ Empirical Data
- ❖ **Estimating Endurance/Fatigue Strength**
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 - Uniaxial Fully Reversed
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Types of Fatigue Loading



Getting Fatigue Data

- 1) Test a prototype
- 2) Test the exact material used
- 3) Published fatigue data
- 4) Use static data to estimate

Estimating S_e From Static Data

see page 345 in your book...

steels	{	$S_e \approx 0.5S_{ut}$	for $S_{ut} \leq 200$ ksi
		$S_e \approx 100$ ksi	for $S_{ut} \geq 200$ ksi
irons	{	$S_e \approx 0.4S_{ut}$	for $S_{ut} \leq 60$ ksi
		$S_e \approx 24$ ksi	for $S_{ut} \geq 60$ ksi
aluminums	{	$S_{f_{\text{static}}} \approx 0.4S_{ut}$	for $S_{ut} \leq 40$ ksi
		$S_{f_{\text{static}}} \approx 19$ ksi	for $S_{ut} \geq 40$ ksi

BUT, these are all for highly polished, circular rotating beams of a certain size

Correction Factors

$$S_e = C_{load} C_{size} C_{surf} C_{temp} C_{reliab} S_e'$$

$$S_f = C_{load} C_{size} C_{surf} C_{temp} C_{reliab} S_f'$$

pages 348-353 in your book

Residual Stresses

- ❖ Temperature
 - through hardening
 - case hardening
- ❖ Surface Treating
 - cold forming
 - shot peening: $C_{surf}=1$