Lecture 25: Fatigue Failure Theories II

BAEN 375

Design Fundamentals of Agricultural Machines and Structures

Fatigue Failure Models

- There are 3 Fatigue Failure Models
  - Stress-Life (S-N)
  - Strain-Life (ε-N)
  - Linear-Elastic Fracture-Mechanics (LEFM)
- There are 2 Fatigue Regimes
  - Low-Cycle Fatigue (LCF)
  - High-Cycle Fatigue (HCF)
  - For this text/course, the assumption is 10^3 cycles divides LCF from HCF

Fatigue Failure Models

- Stress-Life (S-N) Approach
  - Most often used for HCF applications
  - Works best when load amplitudes are
    - Predictable
    - Consistent
  - Stress-based model that determines
    - Fatigue strength
    - Endurance limit
  - Attempts to keep stress in notches in elastic range to prevent crack initiation

Fatigue Failure Models

- Stress-Life (S-N) Approach
  - Pluses
    - Easy
    - Lots of relevant data available
  - Minuses
    - Most empirical
    - Least accurate
    - Not good for LCF design

Fatigue Failure Models

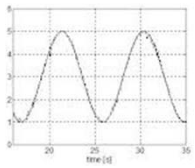
- Strain-Life (ε-N) Approach
  - Gives fairly accurate picture of crack initiation stage
  - Accounts for cumulative damage from variation in cyclic load over life of part
  - Handles fatigue loading combined with temperature because creep can be included
  - Plus
    - Works well with LCF design
  - Minuses
    - Most complicated
    - Requires computer solution

Fatigue Failure Models

- LEFM Approach
  - Provides best model of crack propagation stage
  - Applied to LCF design
  - Useful in predicting remaining life of cracked parts
  - Used with NDT in periodic service inspections
  - Requires accurate
    - Stress intensity geometry factor (β)
    - Estimate of initial crack size

Fatigue Failure Models

- Fatigue Loads
  - Rotating Machinery Loading
    - Stress-time (strain-time) functions can be represented as sinusoids characterized by
      - Minimum stress (or strain) amplitude
      - Maximum stress (or strain) amplitude



$\Delta\sigma = \sigma_{max} - \sigma_{min}$ where $\Delta\sigma$ = stress range

$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$ where σ_a = alternating component

$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$ where σ_m = mean component

$R = \frac{\sigma_{min}}{\sigma_{max}}$ where R = stress ratio

$A = \frac{\sigma_a}{\sigma_m}$ where A = amplitude ratio

Fatigue Failure Models

- Service Equipment Loading
  - Semi-random
  - Non-cyclical, so the load-time function is difficult to define
  - Good data come from measurements on machines in operation or simulated conditions

Data from the axle of a mining dumptruck