Fatigue – Lecture 1

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Preliminaries

Textbooks:

- Mechanical Engineering Design
  Shigley and Mischke
- Fundamentals of Machine Component Design
  Juvinall and Marshek

Notes for This Lecture:

`http://mconry.ucd.ie/`

Introduction

Fatigue is concerned with the effect of varying loads.
Almost every structure is subject to nonsteady loads:

- Car suspension
- Engine components
- Civil structures
  - Bridges
  - Buildings
  - Railway tracks

Introduction

In General, if a load is repeatedly applied to a structure, it is more likely to cause failure than a steady load would.

Factors that affect fatigue

- Nominal Stress level
- Surface finish
- The scale of the component (e.g. radius of a cylinder)
- Temperature
- Microstructure
- Geometry
- Type of load (axial tensile, bending, etc.,)
- Loading history

- etc.,

Introduction

Mechanism

- Even though the stresses applied may be below the yield strength of the material and well within the elastic region, there can still be local regions of plastic deformation.
- Fatigue is all about plastic deformation
  - Plastic $\Rightarrow$ strain does not disappear when stress removed
  - Material permanently changed by the stress
  - Repeated application adds more and more effect
- Though stress may be low, locally it can be raised
  - Geometrical stress concentrators

– Material imperfection
– Surface flaws

Introduction

Mechanism

Effect is that crack growth occurrs

- Each cycle, crack grows infinitessimally
- Over large number of cycles crack becomes large
- Deformation is predominantly local
- Eventually catastrophic failure occurs when cross sectional area as been reduced too far to carry load.
- Failure mode is brittle rather than ductile
  - Fracture mechanics

Introduction

Experiment

The processes at play in fatigue are not entirely understood.

Experiment and empirical data are very important in design

As shaft rotates, each part of surface experiences alternating tension and compression

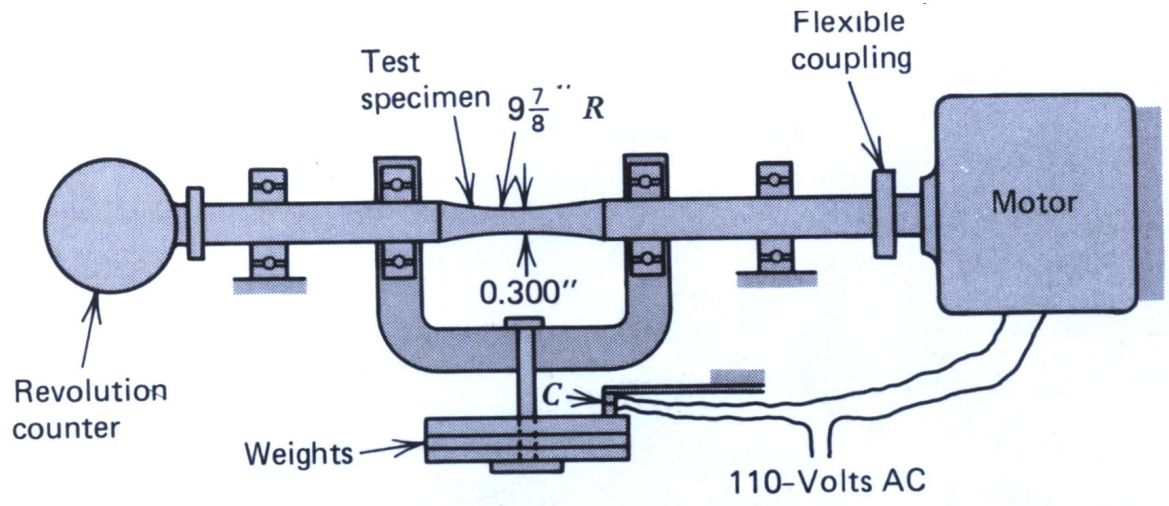


Figure 8.3 R. R. Moore rotating-beam fatigue-testing machine.

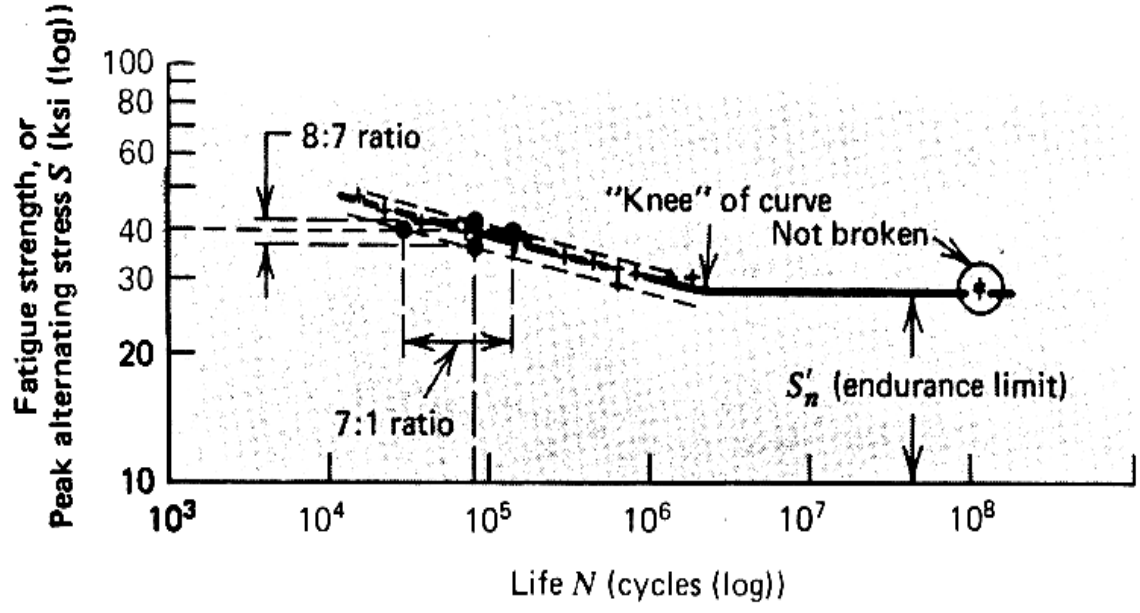
Introduction

S-N Curve

By repeating a large number of experiments, it is possible to draw the full S-N curve.

This plots the number of cycles liftime (N) predicted for a par-

ticular stress level (S).



Introduction

S-N Curve

Note that this strength applies only to the component tested. Engineering components will have different (usually lower) fatigue strength.