PD268: Fracture Mechanics Approach to Life Prediction (3 Days)

Day 1

- Introduction – Lecture, video, and discussion.
  - Video: "The Last of the Liberties", which documents the brittle fracture of the Liberty Ships in WW II and the resulting birth of fracture mechanics as an engineering discipline.
  - Fracture mechanics versus strength-of-materials approach to design against fracture.
  - Fracture mechanics versus S-N curve approach to design against fatigue failure.
- Linear elastic fracture mechanics (LEFM) – Lecture, discussion, and examples.
  - The Griffith model for cracks.
  - The energy release rate parameter.
  - The stress intensity factor (K)
  - Crack tip similitude.
  - Crack tip plasticity
  - K_{Ic} testing
- Elastic-plastic fracture mechanics – Lecture, discussion, and examples.
  - Crack tip opening displacement (CTOD) parameter.
  - J-integral parameter
  - J_{Ic} and J resistance curve testing
  - Similitude under elastic-plastic conditions.

Day 2

- Introduction to fatigue crack growth – Lecture, discussion, and examples.
  - Similitude in fatigue.
  - Empirical crack growth equations.
  - Life prediction by numerical integration.
  - Using crack growth analysis to define inspection intervals.
- Advanced topics in fatigue – Lecture, discussion, and examples.
  - Crack closure.
  - Linear damage model for variable-amplitude loading
  - Retardation and load interaction.
  - Growth of small cracks.
- Environmental cracking – Lecture, discussion, and examples.
  - Basic principles and terminology in corrosion engineering.
  - Stress corrosion cracking (SCC)
  - Hydrogen embrittlement.
  - Corrosion fatigue.
  - Laboratory testing.
- LEFM Applications – Lecture, discussion, and examples.
  - The principle of superposition.
  - Computing stress intensity factor for polynomial stress gradients.
  - The weight function method for arbitrary stress gradients.

Day 3

- Elastic-plastic applications – Lecture, discussion, and examples.
  - The EPRI J estimation handbook.
  - Ductile instability
  - The failure assessment diagram (FAD) method.
  - Incorporating weld residual stresses into the FAD method.
  - Monte Carlo probabilistic analysis
- Finite element analysis of components with cracks – Lecture, discussion, and examples.
  - Incorporating a crack into a finite element mesh.
  - Comparison of methods to compute K_I.
  - Modeling crack growth with finite element analysis.
- Fracture mechanisms in metals & alloys – Lecture, discussion, and examples.
  - Ductile fracture (microvoid coalescence)
  - Cleavage fracture
  - The ductile-brittle transition region.
  - Intergranular fracture.
- General discussion and course wrap-up/