Development of an Interactive Self-Teaching Package in Failure Analysis

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Outline

Talk will address:

- Background to development – drivers in choosing the interactive internet route
- Format chosen for the package
- Interactive elements – what can they do?
- Demonstration of package

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Background

Author's experience:

- Applied engineering best assimilated in laboratory setting
- Particularly true for analytical skills in the synthesis of mechanical properties and metallurgy/materials science
  - Failure analysis and fractography
  - Design for fatigue and fracture
- Subtle interactions between composition, processing, structure and properties need laboratory case study development

Background

Author's experience:

- Want to develop expertise in
  - Mechanical property testing
  - Use of optical microscope and SEM
  - Metallographic interpretation
  - Fractography
- Difficult to do except in laboratory-intensive modules
- Availability of such resources diminishing due to cost, staff shortages, timetable constraints, larger cohorts

Background

Drivers:

- Industrial failure case studies highly successful
  - Raise students interest and link disparate modules
  - Ground modules firmly in practice of 'real' engineering
  - Introduce 'social consciousness' aspects
    - ✓ Ethics & litigation
    - ✓ Legal responsibility & culpability
    - ✓ Insurance & loss adjusting
  - Team experience

Background

Rationale for interactive case studies:

- Achieve aspects of the ‘reflective practitioner’ in engineering failure analysis
- Improve core specialist knowledge in the field of materials and failure
- Key aim to promote student motivation
    - Illustrate breadth of engineering practice and failure
    - Promote depth in analytical skills
    - Available in 'digestive' packet sizes over internet

Format of package

- Internet-based
  - Multimedia capability
  - Hyperlinks to focussed high-level resources
  - 24/7 access
- Easy navigation
  - Size not a daunting issue
  - Choice of entry points
- Each case study is 'stand-alone'
- Powerful associated resources in fractography and metallography

Format of package

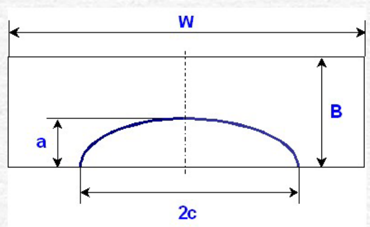
- Introductory front page states learning from each case
- Navigation for whole case study laid out
- Case studies partitioned into stages of real solution
- Interactive elements:
  - Allow reflection on critical synthesis
  - Introduce engineering estimation techniques

Interactive elements

- Example – fracture stress of undercarriage brackets:- give theory/information + test learning

CALCULATION OF FRACTURE STRESS FOR SADDLE CLAMP BRACKET

As noted in the previous page, the fracture toughness of 4340 steel in a 1060 MPa tensile strength condition, lies in a range of perhaps110 $MPam^{1/2}$ to about 87 $MPam^{1/2}$. These values can be applied to the alloy and used to calculate the fracture stress via the following equation, which applies to a semi-elliptic crack in tension:



$$K_1 = C\sigma \frac{\sqrt{\pi a}}{\Phi}$$

$$C = \left[C_1 + C_2\left(\frac{a}{B}\right)^2 + C_3\left(\frac{a}{B}\right)^4\right]C_4$$

$$C_1 = 1.13 - 0.09\left(\frac{a}{c}\right)$$

$$C_2 = -0.54 + \frac{0.89}{0.2 + \left(\frac{a}{c}\right)}$$

$$C_3 = 0.5 - \left(\frac{1.0}{0.65 + \left(\frac{a}{c}\right)}\right) + 14\left(1 - \frac{a}{c}\right)^{24}$$

$$C_4 = 1 + \left[0.1 + 0.35\left(\frac{a}{B}\right)^2\right]$$

Interactive elements

- Example – fracture stress of undercarriage brackets:- allow sensitivity analysis

Inputs	
lengths in mm	
Crack length, 2c	18
Crack depth, a	2.5
Thickness, B	7
Component length, W	38
Frac. toughness	87
Compute	
Critical stress, MPa	736.607

History					
2c	a	B	W	K1	Crit stress
18.0	2.0	7.0	38.0	110.0	1057.88
18.0	2.0	7.0	38.0	87.0	836.69
18.0	1.5000	7.0	38.0	87.0	983.97
18.0	2.5000	7.0	38.0	87.0	736.60

•Outline
•Background
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•Interactive elements
•Demonstration

Demonstration

- Package hyperlinked below:

  Run Interactive Failure Package