Industrially based case studies

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Case studies introduced in
‘Materials Selection in Design’
in 2003
Materials Selection in Design

- Course Background
  - The course is taken in year 3/4 by 150 students from Materials, Bio-materials, Medical Engineering and Mechanical Engineering streams.
  - Mixed backgrounds and knowledge base. Project groups are engineered to get good interaction between the groups.

- Materials students have extensive experience of problem based learning in years 1 and 2.
- Engineering students have less exposure to problem solving case studies.
- More than 50% overseas students.

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Industrially Based Case Studies

● Course Structure
  ● 25 lectures on design, materials and manufacturing (basis of multiple choice exam) - 30 marks
  ● ~10 case studies (formatively marked and some assessed in an examination) - 30 marks
  ● 7 industrial case studies delivered by different industrial (examined both in session and during exam) - 40 marks

● Motivation to running industrial based case studies.
  Students have a limited:
  ● Awareness of materials selection in design.
  ● Awareness of the role of a materials engineer in industry.
  ● Exposure to role models in industry.
  ● Practical experience of making decisions in a group.

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Structure of Industrial Case Studies

- Visiting professors deliver a 1 hour lecture on a specific materials selection problem taken from industry. (7 visitors in 2003)

- Students work in teams for about 5 weeks on their specific case study. (4 teams of five/six students per case study)

- Each group presents a 15 minute review of their conclusions.

- Each group submits a 5 page group report.

- These are assessed by the visiting professor, who then gives a 1 hour report on their proposed designs and the actual solution used in practice.

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MAT 602 - The Team

● Course Organiser:
  ● Dr. James Busfield

● Guest Lecturers:
  ● Prof. Alan Richie, Du Puy
  ● Prof. Gordon White, BG
  ● Prof. Mike Collins, British Aerospace
  ● Prof. Geoff Kirk, Rolls Royce
  ● Prof. Mike Winstone, DERA
  ● Dr. Barrie Hayes, CIBA
  ● Dr. Mark French, Qinetiq
Each case study has a Visiting Professor who:

- Conceives the case study
- Writes it up for the students
- Presents the case studies to the students
- Assesses how the student groups deal with the case study
- Provides feedback at the end of the case study

Students can usually contact the Visiting Professor via E-mail during the case study.
Case 1 - Turbine blades.

<table>
<thead>
<tr>
<th>Case Study 1 - GK</th>
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<tbody>
<tr>
<td><strong>Group 1</strong></td>
</tr>
<tr>
<td>HUNDEYIN</td>
</tr>
<tr>
<td>LIN, TIE</td>
</tr>
<tr>
<td>NILAR</td>
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<td>PAN JIN</td>
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<td>WU, WEI</td>
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Possible Materials options

- SiC/SiC
- Forged Nickel Cobalt (Nimonic 105)
- Cast Nickel Cobalt
- Directionally Solidified Cast Nickel Cobalt
- Single Crystal Cast Nickel Cobalt
Case study 1 - Issues

- What would you advise for maximum turbine entry temperature and stress levels for the various materials?
- How are the requirements met by each of the material options and how successful are they?
- What material or process improvements would be beneficial to the component?
- What other material properties that have not been discussed could be important in this application?
What materials and basic manufacturing method would you propose to make a refrigerated food delivery truck body given the following requirements?

- Excellent Thermal Insulation
- Good Impact Resistance
- Easy to Clean and Sterilise
- Corrosion Resistant Exterior
- Smooth Surfaces for Cleaning and Advertising
- Low Weight
- Simple Production and Assembly
- High Strength and Stiffness
- Competitive Cost
- Size: 13m x 3m x 2m
Case 3 - Tail fin for fighter planes.

• What is the role of the tail fin?
• The structural arrangements within the fin, defining structural elements, material selection and the supporting rationale behind the choices?
• The requirements for any systems, such as electronics, air and fuel.
• Today’s design principles for manufacturing and assembling each of the elements?
Case 4 - Fighter plane tail keel design.

- High stiffness to withstand loads
- High strength/ fatigue resistance, 6000h
- High corrosion resistance for 25 year life
- Low mass for agility
- Reasonable cost
- Low production rate
- Repairable
- Low risk
- Fire resistant
- 350°C temperature
Case 5 - Offshore corrosion of gas pipes.

- Considering the gas chemistry, cost and potential repairs identify suitable materials and corrosion control for the 3 stages of the pipeline system.

- Include a discussion of corrosion allowance and the use of inhibitors with your selection.

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<thead>
<tr>
<th>FIELD A</th>
<th>FIELD B</th>
<th>FIELD C</th>
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<tbody>
<tr>
<td>1.5% CO₂</td>
<td>5% CO₂</td>
<td>1.5% CO₂ &amp; 0.1% H₂S</td>
</tr>
<tr>
<td>Water, Methane</td>
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<td>100 bar</td>
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<tr>
<td>100°C</td>
<td>50°C</td>
<td>20°C</td>
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Case 6 - Ankle Joint Design.

- Describe the possible material combinations for use in a mobile bearing ankle device in a 40 year old female.

- Describe your choice with reference to the following aspects.
  - Wear.
  - Fixation.
  - The effect of implant/bone modulus matching on the stems of the components.
  - Minimisation of bone resection.
  - Cost
Material selection for tanks:
• Consider the application of a range of materials for tanks:
  • steel, aluminium, titanium, GRP, CFRP.
• Evaluate the advantages & disadvantages covering:
  • mechanical properties e.g; strength, stiffness, fatigue,
  • material properties; wear, temperature, corrosion, impact
  • manufacturing processes, cost, health & safety
  • performance driver; weight
Reasons for Working in a Group

- Integrate knowledge and skills from a range of multidisciplinary modules.
- Acquire knowledge through self-study.
- Teach students how to work in groups and manage group projects.
- Improve and develop the communication skills of the students.
- Develop the problem solving skills of the students.
Group Meetings

- Throughout the project it is expected that you will meet at least once a week for a group discussion.

- To make these meeting work you must assign group roles.
  - The chairman has the task of directing the conversation.
  - The scribe does so by taking down important matters on a white board or flip chart.
  - One student acts as secretary.
Stepped Project Plan

- Step 1: Explain unknown wording, statements, and concepts
- Step 2: (Re/)Define the problem
- Step 3: Brain-storming
- Step 4: Make a systematic inventory
- Step 5: Formulate self-study assessments
- Step 6: Perform self-study assessments
- Step 7: Report on self-study

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Students role

- Individuals in the group should demonstrate:
  - Ability to analyse
  - Inventiveness
  - Critical ability
  - Theoretical knowledge
  - Practical skills

- As well as a group contributions which may be:
  - Role as a chairman
  - Role as a minutes secretary
  - Role as writer
  - Role as group member
Student Response to the Case Studies

Positive:

- All the lecturers were excellent.
- A fascinating course.
- I don’t like materials, but the teaching method made the course more interesting.
- The guest lecturers spoke about new and exciting topics, and have made this my favourite course in my final year.
- Course gives an insight into my potential future role in UK industry.

Negative:

- For BEng students the case study clash with the final year project.
- Too much coursework was set.
- Not enough time to prepare our case study.
- Case studies have replaced true understanding.

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