National Exams May 2016

07-Mec-B8 Engineering Materials

3 Hours Duration

NOTES:

1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an open book exam.

3. Any **five** of the **eight** problems given constitute a complete paper.

4. All problems are of equal value.

1- The lower skin panels of the wing of a 12 passenger business jet are made from aluminum 2024-T4. Those panels are subjected to fluctuating tensile loads while the airplane is in flight and fluctuating compressive loads when it is on the ground. An engineer recommended replacing this material with aluminum 7075-T6 on an extended version of that jet that weighs 40% more than the original design. Why in your opinion the engineer may have made this recommendation? Answer this question by comparing the main physical and mechanical properties of the two materials and the possible trade-offs resulting from the proposed replacement.

2- Advanced fiber-reinforced plastic composites are now commonly used in aircraft structural design for both primary and secondary load bearing applications.
   a- Present four different processing methods that may be used to consolidate those composites
   b- Discuss the main advantages and disadvantages of each method in relationship to such considerations as mechanical properties, geometrical aspects, processing speeds, cost, size, etc.

3- The presence of carbon, while producing the necessary hardening of conventional high tensile steels, causes brittleness and distortion, which makes machining difficult and cold forming impracticable. Welded fabrication is also impracticable or very expensive. To overcome some of these difficulties, some types of steels were developed from which carbon is either eliminated entirely or present only in very small amounts. The hardening of such steels is achieved by the addition of other elements such as nickel, cobalt and molybdenum. What in your opinion are the main reasons for carbon to cause brittleness and the associated machining and welding difficulties of conventional steels? Also explain how the replacement of carbon with nickel, cobalt and molybdenum help alleviate these difficulties.

4- A box is to be placed on a bracket attached to the engine in an automobile. Two polymeric materials have been short-listed as primary candidates for this application, namely ABS and hardened PVC.

   a- Compare the two materials in terms of strength, impact resistance, manufacturing methods, chemical resistance, heat resistance and cost.
   b- What material would you select and why?

5- Discuss the following two applications where corrosion is an issue:

   a- A brass faucet is connected to an iron pipe. Discuss this coupling from a corrosion viewpoint and explain which metal is likely to corrode and why?
   b- Steel screws used as fasteners on aluminum siding experienced severe corrosion. Would you have expected this, why or why not? Explain why this might have occurred.

6- Floor beams of a transport airplane have been designed using an aluminum alloy containing 5.5 wt% Cu and 1.6 wt% Mg and 1.2 wt% Mn for a total weight of 10500 kg. A customer has ordered the airplane but requested that its total weight be reduced by 1500 kg for fuel saving purposes. An engineer in the design and analysis department has suggested that almost all of that weight saving objective can be accomplished by replacing the aluminum alloy of the floor beams with an aluminum-lithium one containing 5 wt% Li and 1 wt % Cu. Is this possible? Answer the question by estimating the percentage of the weight savings that will take place using the Al-Li alloy. Assume weighted averages of density and use the following densities for the mentioned materials:

$Al = 2.70$ g/cm^3 $Cu = 8.92$ g/cm^3 $Mg = 1.74$ g/cm^3 $Mn = 7.47$ g/cm^3 $Li = 0.53$ g/cm^3

7- Describe the heat treatment scheme that would provide the following property changes to 1080 steel: (refer your treatments to the appropriate time-temperature-transformation curve)

    a- Pearlite to bainite
    b- Martensite to fine pearlite
    c- Pearlite to martensite
    d- 100% pearlite to a mixture of 50% pearlite and 50% martensite
    e- Mixture of 75% pearlite and 25% martensite to 100% tempered martensite

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8- A 0.8 kg magnesium sacrificial anode in a hot water heater is used up in 15 years.

    a- What is the anode reaction?
    b- What is the average corrosion current supplied by the anode?
Use an electromechanical valence of 2 and an atomic mass of 24.3 amu for Mg.