UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014 / January 2015

EBB 524/3 – COMPOSITE MATERIALS

Duration : 3 hours

Please ensure that this examination paper contains SIX printed pages before you begin the examination.

This paper consists of SIX questions. THREE questions in PART A and THREE questions in PART B.

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A and **TWO** questions from PART B. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.

The answers to all questions must start on a new page.

You may answer a question either in Bahasa Malaysia or in English.

PART A

1. [a] What weight of glass fibers must be added to 1 kg of epoxy to produce a composite with a density of 1700 kg/m^3, ρ_f = 2500 kg/m^3 and ρ_m = 1200 kg/m^3.

(20 marks)

[b] By using schematic diagrams, discuss and compare fabrication processes for short fiber reinforced thermoplastic composites and continuous fiber reinforced thermoset composites.

(30 marks)

[c] Combining two or more materials can produce a composite with improved properties compared to the original materials. Referring to a specific product with which you are familiar, explain the following statements.

(i) Three reasons for using the polymer composite material in the product you have named in (c).

(ii) 4 factors that might influence the properties of your product.

(iii) By referring to the traditional materials, explain the benefit and the drawbacks of the use of polymer composites in the product.

(50 marks)

2. As a materials engineer, you are given a responsibility to develop a new metal matrix composite by combining titanium as the matrix and niobium particles as the strengthening phase. However, prior to execution of the production line, you need to convince the management team. Thus, you are required to write up a proposal. In the proposal you should include the following contents:

[a] Suggest suitable processing method for producing the composite. Draw diagram to represent the fabrication step.

[b] Suggest characterization techniques to confirm the successful of the composite development, instead of forming an alloy.

[c] Justify the expected result of analysis outlined in [b].

[d] Briefly explain **three** major factors that could affect the actual properties of the resultant composite. Propose remedial action.

(100 marks)

3. [a] Ceramic matrix composites (CMC) materials are fabricated by several processing methods, which determine their mechanical and thermal properties. One of them was self-propagating high temperature synthesis (SHS). Discuss about SHS in ceramic matrix composite fabrication. List the advantages and disadvantages of this process.

(50 marks)

[b] In a table, differentiate between solid state and liquid state in ceramic processing.

(50 marks)

PART B

4. [a] The longitudinal modulus of a glass /epoxy composite containing short aligned fibers of length (l) is E_1: 40 GPa. Using Halpin-Tsai equation, determine the length (l) of the fibers for the composites.

Given: $V_f = 0.6$

$d_f = 10\ \mu m$

$E_f = 70$ GPa

$E_m = 3.5$ GPa

(30 marks)

[b] In the non-destructive testing of composite materials, ultrasonic technique is widely used in most of the structural integrity evaluation purposes during production and in-service. Discuss the following;

(i) Working principle of the techniques

(ii) Type of defects that are detectable using the technique.

(iii) Advantages and disadvantages of this method compared to other non-destructive testing.

(30 marks)

[c] Explain the following statements;

(i) For the past several decades, carbon-based fillers have been applied to modify the properties of polymers.

(ii) The way in which the clay layers are dispersed in the polymer materials will influence the interfacial bonding and the level of interaction between the clay layers and the polymer.

(iii) Particulate composite materials (PCM) consisting of a matrix reinforced by micro to nano-sized dispersed phase are an important class of polymer composites. The mechanical properties of these materials are strongly influenced by many factors.

(iv) Figure 1 shows the failure modes of cross sections carbon fiber reinforced epoxy after certain testing. Discuss on the type of failure mode, how it occurs and how to prevent the occurrence of this defect in the composite structure.

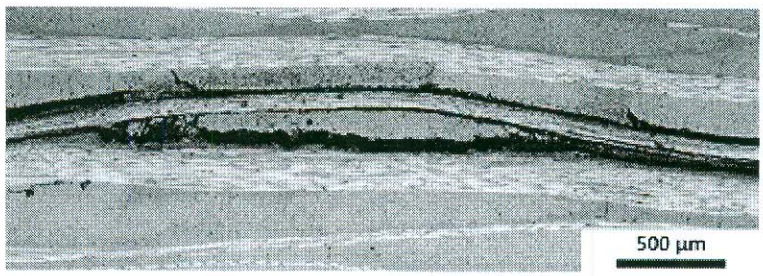

Figure 1: Micrograph of carbon fiber reinforced epoxy after characterization

(40 marks)

5. [a] It is well known that ceramic reinforcement provide significant effect to metal matrix composite as they are harder, tougher and more stable to high temperature in comparison to the soft metal matrix. However, this ceramic particle will also influence the ageing properties of age hardenable aluminum alloys. Discuss the possible modification that ceramic particles could do to the ageing behavior of the metal matrix that are made of age hardened aluminum alloys.

(50 marks)

[b] In a table, differentiate between solid state and liquid state in metal processing. Propose strategies to enhance the interface bonding between ceramic reinforcement phase and metal matrix.

(50 marks)

6. [a] CMCs exhibit a number of different toughening mechanisms. These includes crack bowing, crack deflection, transformation toughening, waking toughening and fibre pull out. Discuss the two method of crack deflection in ceramic toughening mechanism. How was the effect of volume fraction and aspect ratio of rod shape reinforcement on crack deflection toughening?

(70 marks)

[b] The most promising toughening mechanism for ceramic materials involves phase transformation and the method is referred as transformation toughening. Describe the transformation toughening and give one example of material that has been used in this toughening mechanism.

(30 marks)