

MANUFACTURING OF COMPOSITES

MECH 425/MECH6521

FINAL EXAM

April 25, 2003

Closed book

1. Question 1: (6 marks)

A pipe of 20 inch in diameter is filament wound with glass fibers. Three types of wind angle will be used. These are:

$\theta_1 = 30^\circ$

$\theta_2 = 45^\circ$

$\theta_3 = 90^\circ$

$$30000(t_1 + t_2 + t_3) = 200000 t_1 \cos^2 30^\circ + 200000 t_2 \cos^2 45^\circ + 200000 t_3 \cos^2 90^\circ$$

\downarrow $2.5t_1$

The thicknesses of the three layers are related to each other as follows:

$t_1 = t_2 = 0.5t_3$

$\sigma_h = \frac{pr}{t}$ $\sigma_a = \frac{pr}{2t}$

$\sigma_h = \frac{(3000)(10)}{t}$

$\sigma_h t = 30000$

Assume that the strength of the fiber glass is 200,000 psi. Determine the thickness of each type of winding to contain an internal pressure of 3,000 psi.

2. Question 2 (6 marks):

Edge injection is used to inject resin in an RTM process to make a rectangular piece. The length of the piece is 200 mm and the width is 100 mm. The equation that may be used to estimate the time for injection is given as:

$T_f = c \frac{\mu L^2 \phi}{\Delta p K}$

\downarrow Nim^2

$F = ma \rightarrow \text{N} \rightarrow \text{Pa} \cdot \text{sec}$

$\rightarrow \text{Kg} \cdot \frac{\text{m}}{\text{s}^2}$

where $c = 0.5$, pressure gradient 100 kPa, porosity is 0.4, and permeability is $1.5 \times 10^{-9} \text{ m}^2$.

The gel time of the resin is 3 hours. What would be the viscosity of the resin that you would select for this?

* 3. Question 3: (8 marks):

In a pultrusion process, the maximum pressure measured is 0.6 MPa. the volume fraction of the fiber is $V_f = 0.6$. The fiber volume fraction before the pultrusion process is $V_o = 0.50$. The modulus of the fiber is 234 GPa. The β value is 200. What would be the maximum fiber volume fraction possible?

If the pulling force gives an axial stress of 6 MPa, what would be the axial strain in the material?

4. Question 4 (6 marks):

The fiber radius is 5 μm , what are the permeabilities along the fiber direction (use Carman-Kozeny equation) and transverse to the fiber direction (use Gutowski equation). The Kozeny constant along the fiber direction is 0.5 and the Kozeny constant transverse to the fiber direction is 0.75. Assume a fiber volume fraction of 0.68. The volume fraction at which transverse flow is not possible is 0.8.

* 5. Question 5: (6 marks)

The prepregs of carbon/epoxy were left in room condition at 30% relative humidity. The maximum temperature during the curing cycle for the material is 177 °C. What would be the minimum autoclave pressure required to avoid void growth during curing? $E = 234$ GPa, $\beta = 200$, $V_o = 0.50$, $V_a = 0.8$, $V_f = 0.65$.

6. Question 6: (6 marks)

Twelve layers of XAS/914C is to be cured using autoclave process. The lay up sequence is $[0_2/90_2/45/-45]_s$.

- What is the coefficient of thermal expansion of the final composite piece?.
- Based on the coefficient of thermal expansion, what should be the material to be used for the tool?
- What would happens if aluminum is used as the tool material?

Give the name of the following material knowing their chemical formula:

1. (1 mark)

2. (1 mark)

The following are true false questions. Each question is worth 1 mark. Each statement has to be completely correct to be marked as True. Please circle the correct answer.

1. T F: The main reason why there are not many developments in metal matrix composites as compared to polymer matrix composites is because metal matrix composites require higher temperature for processing.
2. T F: The three main functions for the matrix material are to protect the fibers, to provide shear load transfer between the fibers and also to give good appearance to the composite material.
3. T F: Five most commonly used processes for manufacturing of composites are Autoclave Curing, Filament Winding, Pultrusion, Liquid Composite Molding and Processing of thermoplastic composites.
4. T F: Two most important parameters affecting wetting of the fibers by the matrix material are the thermodynamic compatibility between the fiber and the matrix (surface tensions) and the hardness of the fibers.
5. T F: The main reason why there are more thermoset matrix composites than thermoplastic matrix composites is because thermoset matrix composites are more ductile than thermoplastic composites.
6. T F: Glass material in bulk form has higher strength than glass material in fiber form because the bulk form has less defects. *no fiber has a compressive strength*
7. T F: Kevlar fibers have higher compressive strength than tensile strength.
8. T F: Silicon Carbide fibers are made by using a chemical vapor deposition process starting with a tungsten filament.
9. T F: Plain weave fabric is less drapable than satin weave fabric.
10. T F: For processing of thermoplastic composites, the cooling rate is not as important as compared to processing of thermoset composites.