

# Composite Materials: Analysis and Design

## Homework no.5

Due Date: 10th May

### Problem 1

Using the strain energy approach, check the validity of an assumption (equal strains) leading to the equation for the longitudinal modulus.

$$E_1 = E_f V_f + E_m V_m$$

### Problem 2

Using the strain energy approach, check the validity of an assumption (equal stresses) leading to the equation for the transverse modulus.

$$\frac{1}{E_2} = \frac{V_f}{E_f} + \frac{V_m}{E_m}$$

### Problem 3

A graphite /epoxy lamina is clamped between rigid plates in a mold (Fig. 1), while curing at a temperature of 125°C. After curing the lamina/mold assembly (still clamped together) is cooled from 125°C to 25°C. The cooling process occurs in moist air and the lamina absorbs 0.5% of its weight in moisture. The lamina has the following properties:

$$E_1 = 140 \text{ GPa}$$

$$E_2 = 10 \text{ GPa}$$

$$\nu_{12} = 0.3$$

$$G_{12} = 7 \text{ GPa}$$

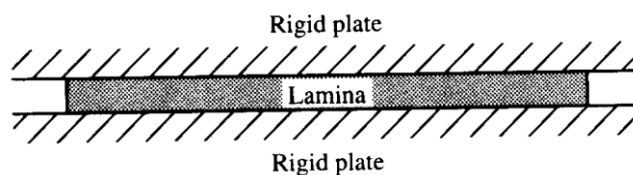
$$\alpha_1 = -0.3 \times 10^{-6}/K$$

$$\alpha_2 = 28 \times 10^{-6}/K$$

$$\beta_1 = 0$$

$$\beta_2 = 0.44$$

Assuming that the lamina properties do not change over this temperature range and that the lamina is initially dry and stress free, determine the residual hygrothermal stresses in the lamina at 25°C for  $\theta = 0^\circ$  and  $45^\circ$ .



**Fig. 1**

#### **Problem 4**

Condense the following expanded laminate codes:

1. [0/45/-45/90]
2. [0/45/-45/-45/45/0]
3. [0/90/60/60/90/0]
4. [0/45/60/45/0]
5. [45/-45/45/-45/-45/45/-45/45]

#### **Problem 5**

Expand the following laminate codes:

1. [45/-45]<sub>s</sub>
2. [45/-45<sub>2</sub>/90]<sub>s</sub>
3. [45/0]<sub>3s</sub>
4. [45/±30]<sub>2</sub>