MSE 440 Composites Technology
Mechanics of composites
Exo corrections

(1)

$E_c = 250\,GPa$

$E_f = 400\,GPa$ $\quad V_f = ?$

$E_m = 3\,GPa$

$$E_c = E_f \cdot V_f + E_m (1 - V_f)$$

$$V_f = \frac{E_c - E_m}{E_f - E_m} = \frac{250 - 3}{400 - 3} = 0{,}62 = 62\,\%$$

(2)

$V_f = 0{,}4$

$E_f = 140\,GPa$ $\quad E_T = ?$

$E_m = 0{,}5\,GPa$

$$E_T = \frac{E_m \cdot E_f}{E_f(1 - V_f) + E_m V_f} = \frac{0{,}5 \cdot 140}{140 \cdot 0{,}6 + 0{,}5 \cdot 0{,}4} = 0{,}83\,GPa$$

$$E_T = \frac{E_m (1 + \xi \chi V_f)}{1 - \chi V_f} = 1{,}48\,GPa$$

$\xi = 2$

$$\chi = \frac{E_f - E_m}{E_f + 2 \cdot E_m} = 0{,}989$$

Halpin Tsai is better than mixture law

$E_c = 56\,GPa$

(3)

$E_f = 70\ GPa = 70'000\ MPa$

$E_m = 1\ GPa = 1000\ MPa$

$l_i = 3\ mm = 3\ mm$

$d = 20\ \mu m = 0{,}020\ mm$

$l_{fi} = 400\ \mu m = 0{,}400\ mm$

$V_f = 0{,}3$

injection moulding

$\Delta E_c = ?$

$$E_{ci} = \frac{E_m (1 + \xi_1 \chi_1 V_f)}{1 - \chi_1 V_f} = 18'838\ MPa = 18{,}8\ GPa$$

$$\xi_1 = \frac{2 \cdot l_i}{d} = 300$$

$$\chi_1 = \frac{E_f - E_m}{E_f + \xi_1 E_m} = 0{,}186$$

$E_{cfi} = 10'504\ MPa = 10{,}5\ GPa$

$\xi_2 = 40$

$\chi_2 = 0{,}627$

$\Delta E_c = 18{,}8 - 10{,}5 = 8{,}3\ GPa$

(4)

$A_{11} = 7{,}5\,10^4$ N/mm
$E_2 = 10$ GPa $= 10^{10}$ N/m^2 $= 10^4$ N/mm^2
$\nu_{12} = 0{,}2$
$\nu_{21} = 0{,}014$

$$A_{ij} = \overline{Q_{ij}}_{/0°}\,(0-(-0{,}5)) + \overline{Q_{ij}}_{/90°}\,(0{,}5-0)$$

$$= \frac{1}{2}\,\overline{Q_{ij}}_{/0°} + \frac{1}{2}\,\overline{Q_{ij}}_{/90°}$$

$$A_{11} = \frac{1}{2}\,\overline{Q_{11}}_{/0°} + \frac{1}{2}\,\overline{Q_{11}}_{/90°}$$

$$= \frac{1}{2}\left(\cos^4 0 \cdot Q_{11} + \ldots \underbrace{\sin^{\ldots} 0}_{0}\right) + \frac{1}{2}\left(\cos^4 90 \cdot Q_{11} + \ldots 0 + \sin^4 90\, Q_{22}\right)$$

$$A_{11} = \frac{1}{2}\,Q_{11} + \frac{1}{2}\,Q_{22}$$

$$A_{11} = \frac{1}{2}\,\frac{E_1}{(1-\nu_{12}\nu_{21})} + \frac{1}{2}\,\frac{E_2}{(1-\nu_{12}\nu_{21})}$$

$$\rightarrow E_1 = 2\left(A_{11} - \frac{1}{2}\,\frac{E_2}{(1-\nu_{12}\nu_{21})}\right)(1-\nu_{12}\nu_{21})$$

~~$E_1 = 1{,}5\,10^{11} = 150$ GPa~~

$E_1 = 140$ GPa

(5) $[M] = [B]\{\varepsilon^0\} + [D] \cdot \{K\}$

Symmetric laminate $\Rightarrow [B] = 0$

$M_{xy} = D_{16} K_x + D_{26} K_y + D_{66} K_{xy}$

Only 3 out-of-plane deformations

(6) Design map of slide 23

$\alpha = 0,83\ 10^{-5}\ K^{-1}$