Chapter 2

Solutions Chapter 2

2.1 Exercise 2.1

See Section 2.4.3, ”Strand, tow, end, yarn, and roving”

2.2 Exercise 2.2

See Section 2.6.1, ”Polyester Resins”

2.3 Exercise 2.3

Chlorendic Polyester

2.4 Exercise 2.4

Bisphenol-A-Fumarate Polyester

2.5 Exercise 2.5

Glass fibers = low cost
Carbon fibers = high stiffness

2.6 Exercise 2.6

Polyester = low cost
Epoxy = high mechanical properties

2.7 Exercise 2.7

A 36K tow has 36,000 fibers. Assuming the fiber to be 7 microns,

$$\text{Area} = \text{K}\frac{\pi d^2}{4} = 36,000\frac{\pi\left[7\left(10^{-6}\right)\right]^2}{4} = 1.385\ \text{mm}^2$$

2.8 Exercise 2.8

Using Eq. 2.2,

$$\text{TEX(g/km)} = \frac{496,238}{56\ \text{(yd/lb)}} = 8,861\ \text{g/km}$$

Using Eq. 2.3,

$$\text{Area} = \frac{(10^{-5})8,861\ \text{(g/km)}}{2.5\ \text{(g/cc)}} = 0.035\ \text{cm}^2$$

Therefore, 112/56 = 2, so two 112 yield roving are needed.

2.9 Exercise 2.9

With a fabric weight $W = 800$ g/m^2, and density $\rho = 2.5$ g/cc $= 2.5(10^6)$ g/m^3,

$$t = \frac{W}{\rho} = \frac{800}{2.5(10^6)} = 0.32\ \text{mm}$$

2.10 Exercise 2.10

Write a spreadsheet for all materials in Table 2.1-2.2,
(a)

$$t_f = \frac{pd/2}{\sigma_{fa}/(F.S.)};\ t_c = 2t_f$$

where σ_{fa} is the average fiber tensile strength
(b)

$$\frac{W}{L} = \pi d t_c \rho_c\ ;\quad \rho_c = V_f \rho_f + V_m \rho_m$$

Use t_c from part (a)
(c)

$$\frac{\$}{L} = \frac{\$}{kg}\frac{W}{L}$$

Use \$/kg values from Exercise 1.1 for the composite and W/L from part (b).
Answers:
(a) min. thickness: $t_c = 3.116$ mm for IM6
(b) min. weight: $\frac{W}{L} = 5.75$ kg/m for IM6
(c) min. cost: $\frac{\$}{m} = 16.2$ \$/m for E-glass with $t_c = 4.63$ mm

2.11 Exercise 2.11

(a) Polyester or Chlorendic resins
(b) Bisphenol
(c) Epoxy
(d) Chlorendic

2.12 Exercise 2.12

(a) PEEK
(b) Phenolic
(c) Epoxy
(d) Bismaleimide and Thermoplastics
(e) Polyester resins with styrene/MMA blends
(f) Epoxy

2.13 Exercise 2.13

Temperature, humidity, and loading rate.

2.14 Exercise 2.14

Below.

2.15 Exercise 2.15

Thermoplastics.

2.16 Exercise 2.16

From Table 2.9,
$T_g = 185\ ^\circ\text{C} = T_{gd}$
since there is no moisture change, the retention ratio is

$$\text{retention ratio} = \left[\frac{185 - 149}{185 - 23}\right]^{1/2} = 0.471$$

From Table 2.9,
stiffness at 23 °C = 3.12 GPa
strength at 23 °C = 75.8 MPa
stiffness at 149,

$$^\circ C = (0.471)\, 3.12 = 1.47\ GPa$$

strength at 149,

$$^\circ C = (0.471)\, 75.8 = 35.7\ MPa$$

Comparison with values from Table 2.9: 1.4 GPa and 26.2 MPa shows that the retention ratio yields reasonable values.

2.17 Exercise 2.17

See Exercise 2.16

2.18 Exercise 2.18

It reduces the corrosion resistance of the PMC.

2.19 Exercise 2.19

The matrix protects the fibers from chemical attack. Mechanical loads may induce cracking of the matrix, thus accelerating the ingress of chemicals that may attack the fiber.

2.20 Exercise 2.20

From Table 2.9, at $T_0 = 24°C$ (dry),and $T_{gd} = 260°C$,

To account for moisture, Eq. 2.5,

$$T_{gw} = \left(1 - 0.1m + 0.005m^2\right) T_{gd}$$

and to add the influence of temperature, Eq. 2.6,

$$\text{retention ratio} = \left[\frac{T_{gw} - T}{T_{gd} - T_0}\right]^{0.5}$$