# Fiber Compression

The useful equation is $$\sigma = \frac{3\pi E}{\beta^4} \frac{1 - \sqrt{\frac{v_f}{v_0}}}{\left(\sqrt{\frac{V_a}{V_f}} - 1\right)^4}$$

substituting values

$$\sigma = \frac{3 \times \pi \times 10{,}5 \times 10^6}{(300)^4} \frac{1 - \sqrt{\frac{0{,}5}{0.35}}}{\left(\sqrt{\frac{0.785}{0{,}5}} - 1\right)^4}$$

$$= -0{,}58 \text{ psi} \quad \text{(compression)}$$

## Permeability

(a) Find S for tow

$$S = \frac{r_f^2 (1-v_f)^3}{4k\ v_f^2} = \frac{(4\times10^{-3})^2 (0.15)^3}{4\times 18 \times (0.85)^2}$$

$$S = 1.04\times10^{-9}\ mm^2$$

(b) Tow penetration time

$$A = \frac{12000}{0.85} \times \frac{\pi}{4} \times (8\times10^{-3})^2 = 0.71\ mm^2$$

$$= 6t \times 1t = 6t^2$$

so $t = 0.34\,mm$ , $w = 6t = 2.06\,mm$

$$t = \frac{-\eta z^2}{2S\Delta P}$$

$\eta = 1P = 10^{-4}$ kPa s

$\Delta P = -100\,psi = -689.5$ kPa

$$t = \frac{10^{-4} \times (0.34)^2}{2 \times 1.04 \times 10^{-9} \times 689.5} = \underline{\underline{8.1\,s}}$$

ⓒ S for fabric

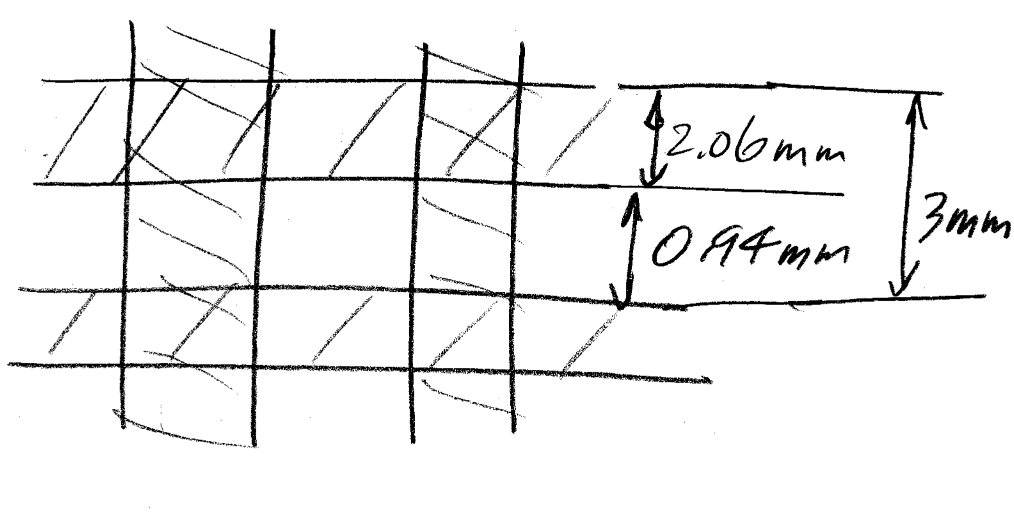
$$S = (1 - v_f) S'$$

$$S' = \frac{r_h^2}{K}$$

$$r_h = \frac{\text{flow area}}{\text{wetted perimeter}}$$

here, we need to calculate the size of the holes (pores) in the fabric, assuming flow is from the top to the bottom.

Here is a unit cell



If we assume the hole is two tows thick,

then the flow area $= 0.94 \times 0.94$
$= 0.88 \ mm^2$

and the wetted perimeter $= 4 \times 0.94$
$= 3.76 \ mm$

so $r_h = \frac{0.88}{3.76} = 0.23 \ mm$

$$S' = \frac{r_h^2}{K} = \frac{(0.23 \times 10^{-3})^2}{18} = 2.94 \times 10^{-9} m^2$$

now we need $V_{tows}$

Assume 1m × 1m fabric size
Fabric thickness $T = 2t = 0.68 \ mm$
There is one tow every 3.3 mm or
333 tows / meter, hence there
are 667 tows / $m^2$

$$V_{tows} = 667 \times (0.71 \ mm^2) \times (10^{-3} \ m/mm)^2 \times 1m$$
$$= 4.74 \times 10^{-4} \ m^3$$

$V_{fabric} = 0.68 \times 10^{-3} \times 1 m^2 = 6.8 \times 10^{-4} m^3$

$v_{tows} = \frac{V_{tows}}{V_{fabric}} = \frac{4.74}{6.8} = 0.697$

so $S = (1 - v_f) S' = (1 - 0.697) \times 2.94 \times 10^{-9}$

$\underline{S = 8.9 \times 10^{-10} m^2}$

<u>or</u> using the model fabric

$V_{fabric} = 3 \times 3 \times 0.68 = 6.12 \; mm^3$

$V_{holes} = 0.94 \times 0.94 \times 0.68 = 0.60 \; mm^3$

so $v_{tows} = \frac{6.12 - 0.6}{6.12} = 0.901$

and $S = (1 - 0.901) \, 2.94 \times 10^{-9}$

$\underline{S = 2.91 \times 10^{-10} \; m^2}$

(d) $t = \frac{-\eta z^2}{2 S \Delta P} = \frac{10^{-4} \times (0.68 \times 10^{-3})^2}{2 \times 8.9 \times 10^{-10} \times 689.5}$

$t = 3.77 \times 10^{-5}\ s$

or

$t = \frac{(10^{-4})(0.68 \times 10^{-3})^2}{2 \times 2.91 \times 10^{-10} \times 689.5}$

$t = 1.15 \times 10^{-4}\ s$

In either case, it is much easier to permeate the fabric than the tows, due to the much more open structure of the fabric