Chapter 8- Homework

1. Question 1 :

The bulk modulus for bulk consolidation for APC 2 thermoplastic composite is 5 MPa. How much pressure is required to consolidate a stack of thermoplastic sheets from a thickness of 3 mm down to 2 mm?

Solution:

From equation (8.14)

$$P = B_y \ln(\frac{h_f}{h_i}) = 5MPa \ln(\frac{2mm}{3mm}) = -2.03MPa$$

2. Question 2 :

What would be the autohesion time for Polyetheretherketone (PEEK) knowing that its melt viscosity is 0.8 kPa.sec? How significant is this time for the following processes:

- *Compression molding.*
- *Filament winding.*
- *Fiber placement.*
- *Pultrusion.*

Solution:

From equation (8.22), the autohesion time is estimated to be:

$$t_c = 22.9\eta$$

Where t_c is in seconds, and η is viscosity in MPa.sec.
Substituting in the value of the viscosity gives:

$$t_c = 22.9(0.8x10^{-3}) = 0.018\text{sec}.$$

For compression molding: The autohesion time is very small as compared to the time that the material is under pressure at high temperature (in order of minutes). As such there is not big concern about the autohesion time.

For filament winding, or automated fiber placement: The duration of time when the material is under high temperature and pressure is very small. This time depends on the speed of processing of the machine. The time that the material is under high temperature and pressure can be of the

same order of magnitude as the autohesion time. As such, care needs to be taken to ensure that the time that the material is under high temperature and pressure should be longer than the autohesion time in order to assure good bond, and to avoid excessive voids or defects.

For pultrusion:

For the pultrusion process the time during which the material is under high temperature and pressure can be long (depending on the length of die where temperature is high). As such, the autohesion time may be an issue.

3. Question 3 :

- *For the processing of thermoplastic composite, why is the cooling rate important?*
- *Why does the degree of crystallinity of PEEK in APC2 increase when the cooling rate is decreased?*

Solution:

For the processing of thermoplastic composite, the cooling rate is important because the slower is the cooling rate, the higher the degree of crystallinity in the material. In turn, the degree of crystallinity has strong effect on the mechanical properties of the materials. The larger is the degree of crystallinity, the stronger and stiffer is the material (but also more brittle).

The degree of crystallinity of PEED in APC2 increases when the cooling rate is decreased. This is because at slower cooling rate, the molecular segments in the material has time to align themselves. The more materials that are aligned, the higher is the degree of crystallinity.