THICKENER DESIGN

A continuous thickener is to be designed to deal with the effluent from the last question. It will treat 1000 m$^3$ per day of suspension fed at 3% v/v solids concentration and is to discharge underflow at 13.8% v/v solids. Use the settling curve and the following relation:

$$C_0 H_0 A \rho_s = C_1 H_1 A \rho_s$$

to complete the following table.

<table>
<thead>
<tr>
<th>Conc (v/v):</th>
<th>0.03</th>
<th>0.039</th>
<th>0.045</th>
<th>0.049</th>
<th>0.056</th>
<th>0.067</th>
<th>0.074</th>
<th>0.092</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height for $H_1$ (cm):</td>
<td>28</td>
<td>21.5</td>
<td>18.7</td>
<td>17.1</td>
<td>15</td>
<td>12.5</td>
<td>11.4</td>
<td>9.1</td>
</tr>
<tr>
<td>Velocity (m s$^{-1}$):</td>
<td>$3.2 \times 10^{-5}$</td>
<td>$1.7 \times 10^{-5}$</td>
<td>$1.3 \times 10^{-5}$</td>
<td>$1.1 \times 10^{-5}$</td>
<td>$8.6 \times 10^{-6}$</td>
<td>$5.8 \times 10^{-6}$</td>
<td>$3.5 \times 10^{-6}$</td>
<td>$2.1 \times 10^{-6}$</td>
</tr>
<tr>
<td>Batch flux (m$^{-1}$):</td>
<td>$9.5 \times 10^{-7}$</td>
<td>$6.5 \times 10^{-7}$</td>
<td>$6 \times 10^{-7}$</td>
<td>$5.4 \times 10^{-7}$</td>
<td>$4.8 \times 10^{-7}$</td>
<td>$3.9 \times 10^{-7}$</td>
<td>$3.3 \times 10^{-7}$</td>
<td>$2.7 \times 10^{-7}$</td>
</tr>
</tbody>
</table>

Note that the batch flux is the product of the settling velocity and the solid concentration.

Plot the batch flux curve below.

Now a flux balance on a thickener provides the following result:

$$A(TC_u) = FC_0 = YC_u$$

where $A$ is the thickener area, $(TC_u)$ is the critical thickener flux which is the intercept of a line drawn as a tangent to the batch flux curve and going through the desired underflow concentration, $F$ and $Y$ are the volume feed and underflow rates respectively, $C_0$ and $Cu$ are the volume fraction feed and underflow concentrations respectively. Note that $T$ is, in effect, the velocity of solid movement in the thickener caused by underflow withdrawal at the solid concentration $Cu$.

The critical flux in this thickener giving an underflow discharge concentration of 13.8% v/v solids is (m s$^{-1}$):

- a: $10 \times 10^{-7}$
- b: $8.5 \times 10^{-7}$
- c: $7.2 \times 10^{-7}$
- d: $5.8 \times 10^{-7}$

The minimum thickener area for this duty is (m$^2$):

- a: 480
- b: 29000
- c: 16000
- d: 960

If the thickener is circular in cross-section the minimum thickener diameter is (m):

- a: 25
- b: 190
- c: 140
- d: 35

The underflow rate is (m$^3$ hour$^{-1}$):

- a: 1.25
- b: 2.4
- c: 4.6
- d: 9.1

The overflow rate is (m$^3$ hour$^{-1}$):

- a: 40.4
- b: 39.3
- c: 37.1
- d: 32.6

An existing 5m diameter thickener is to be used to thicken 2400 tonnes per 24 hours of flocculated slurry containing 10% solids by mass (0.037 v/v) in water. The density of the solid is 2900 kg m$^{-3}$. The following batch sedimentation results were obtained:

<table>
<thead>
<tr>
<th>Time (mins):</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>20</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface height (cm):</td>
<td>45.6</td>
<td>36.5</td>
<td>28.0</td>
<td>21.6</td>
<td>16.8</td>
<td>14.5</td>
<td>13.2</td>
<td>10.6</td>
<td>9.7</td>
</tr>
</tbody>
</table>

What will be the underflow concentration? (Ans 19% by mass)

Calculate $(TC_u)$ from operating data and draw a tangent to batch flux curve to give 0.075 v/v which converts to 0.19 by mass or 19%. Note flux theory is useful in predicting the behaviour of existing thickeners under differing operating conditions, not just for “paper” designs.