Water Treatment (CEng 5403)

Assignment For Chapter 5: Coagulation and Flocculation

1. How much alkalinity (as CaCO₃) is consumed by a dose of 60 mg/L of each of the following coagulants: Al₂(SO₄)₃·14H₂O, Fe₂(SO₄)₃, and FeCl₃? If the water has alkalinity of 100 mg/L as CaCO₃, determine additional lime required.

2. Design a cylindrical flash mixing basin by determining the basin volume, tank diameter, dimensions, required input power, impeller diameter from manufacturer’s data provided below, and its rotational speed using the following parameters:
   - Design flow rate = 11.5 x 10³ m³/d
   - Rapid mix t = 5 s
   - Water temperature = 15°C
   - Place impeller at one-third the water depth

   From manufacturer’s data, the following impellers are available:

<table>
<thead>
<tr>
<th>Impeller type</th>
<th>Impeller diameters (m)</th>
<th>Power number (Nₚ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Axial</td>
<td>0.8</td>
<td>1.4</td>
</tr>
</tbody>
</table>

3. A water treatment plant is processing a flow of 42,000 m³/d. The flocculation system consists of three identical parallel units. A side view of one of the units is shown in the sketch below. The dimensions of each flocculation unit are 4.0 m wide by 4.0 m deep by 15.5 m long. The inlet baffle is located 0.4 m from the front wall. Each unit has three sets of paddles mounted on a horizontal shaft. There are three sets of paddles attached to the shaft. The first set of paddles has four paddles on each arm (total of eight paddles) with centers located at 1.6, 1.4, 1.2, and 1.0 m from the shaft. The second set has three paddles on each arm with centers located at 1.6, 1.4, and 1.2 m from the shaft, and the third set has two paddles per arm with centers located at 1.6 and 1.4 m from the shaft. Each paddle is 0.1 m wide and 3.2 m long. The first paddle set is 0.8 m from the inlet baffle and the paddle set are separated by a distance of 0.8 m. At temperatures of 20 and 25°C what is the rotational speed of the shaft to achieve a mean velocity gradient of 30 s⁻¹ in a unit? What is the local velocity gradient for each paddle set? Cₐ = 1.8, k = 0.75.

![Sketch of flocculation system]
4. A flocculation basin designed to treat 50,000 m$^3$/d of water is 21 m long, 15 m wide, and 3.60 m deep. The paddle-wheel units consist of four horizontal shafts that rotate at 4 rpm. The shafts are located perpendicular to the direction of flow at mid-depth of the basin. Each shaft is equipped with four paddle wheels 3 m in diameter and each wheel has four blades 3.30 m long and 150 mm wide with two blades located on each side of the wheel. The blades are 300 mm apart. Assume the water velocity to be 30% of the velocity of the paddles and that the water temperature is 10$^\circ$C. Determine:
1. The power input to the water
2. The velocity gradient
3. The retention time
4. The Gt value

5. The population of a town is 100,000 and the average per capita demand is 100 litres/day/capita. Design a **baffled chamber type flocculation system** for supplying water to the town. The maximum demand may be taken as 1.5 times the average demand. Detention period 30 minutes for flocculent chamber.

6. Your boss has assigned you the job of designing a rapid-mix tank for the new water treatment plant for a town. The design flow rate is 0.050 m$^3$/s. The average water temperature is 8 $^\circ$C. The following design assumptions for a rapid-mix tank have been made:
   - Number of tanks: 1 (with 1 backup)
   - Tank configuration: circular with liquid depth = 1.0 m
   - Detention time = 5 s
   - Velocity gradient = 750 s$^{-1}$
   - Impeller type: turbine, 6 flat blades, $N_p = 3.6$
   - Available impeller diameters: 0.25, 0.50, and 1.0 m

Design the rapid-mix system by providing the following:
   a. Water power input in kW
   b. Tank dimensions in m
   c. Diameter of the impeller in m
   d. Rotational speed of impeller in rpm

7. Continuing the preparation of the proposal for the treatment plant (Problem 7), design the flocculation tank by providing the following for the first two compartments only:
   a. Water power input in kW
   b. Tank dimensions in m
   c. Diameter of the impeller in m
   d. Rotational speed of impeller in rpm

Use the following assumptions:
   - Number of tanks = 1 (with 1 backup)
   - Tapered $G$ in three compartments: 60, 50, and 20 s$^{-1}$
   - Detention time = 30 min
   - Depth = 3.5 m
   - Impeller type: axial-flow impeller, three blades, $N_p = 0.43$
   - Available impeller diameters: 1.0, 1.5, and 2.0 m
   - Assume $B = (1/3)H$