Chemical Technology Lab. I

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Mixing Behavior under Various Operating Conditions

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Experiment *3*

Mixing Behavior under Various Operating Conditions using Spectrophotometer

3.1 Objective

To study the behavior of mixing under various operating.

3.2 Introduction

Mixing is applied to the processes used to reduce the degree of non-uniformity or gradient of a property in a system such as concentration, viscosity, temperature and so on.

3.2.1 Type of Mixing

There are many types of mixing:

1. **Single Phase Liquid Mixing.**

In this mixing two or more miscible liquid must be mixed to give a product of a desired specification.

2. **Mixing of Immiscible Liquids**

Two immiscible liquids are stirred together, one phase become dispersed as tiny droplets in the second liquid which forms a continuous phase.

3. **Gas- Liquid Mixing**

The purpose of mixing here is to produce a high interfacial area by dispersing the gas phase in the form of bubbles into the liquid.

4. **Liquid-Solid Mixing**

Mechanical agitation may be used to suspend particles in a liquid in order to promote mass transfer or a chemical reaction.

5. **Gas-Liquid-Solid Mixing**

Like slurry reactors, evaporative crystallization.

3.2.2 Rate and Time for Mixing

Mixing time is the time required producing a mixture or a product of predetermined quality, and the rate of mixing is the rate at which the mixing progresses towards the final state. For a single-phase liquid in a stirred tank to which a volume of tracer materials is added, the mixing time is measured from the instant the tracer is added to the time when the contents of the vessel have reached the required degree contents of uniformity.

The mixing time will depend upon the process and the following:

- System geometry.
- Impeller Diameter, D.
- Speed of rotation (revs/unit time) N
- Properties of liquids.

$$t = f\,(N, D, g, \rho, \mu, \text{system geometry})$$

3.2.3 Mixing Equipment

In designing mixing equipment there are many factors that must be considered to obtain "desired process results", among these factors are:

- Vessel size
- Vessel shape
  - ➢ Vessels are typically cylindrical in shape, defined by H/T ratio (where H: vessel height and T: vessel diameter).
  - ➢ The base of vessel may be flat, dished, or conical, or specially contoured, depend upon factors such as ease of emptying, or the need to suspend solids.
- Baffles

  Baffles are used to prevent cross vortexing, which is detrimental to mixing, particularly in low viscosity systems. The baffles are mounted flush with the wall and these take the form of thin about one-tenth of the tank diameter in width, and typically four qui-spaced baffles may be used.
- Impeller

  There are many types of impellers: propellers, turbines, paddles, anchors, helical ribbons and screws which are usually mounted on a central vertical shaft in a cylindrical tank, and they are selected for a particular duty largely on the basis of liquid viscosity.

  Propellers, turbine and paddles are generally used relatively low viscosity systems and operate at high rotational speeds.

3.3 Equipment and Material

- Water
- Dye
- Beakers (2L)
- Stirrer

3.4 Procedure

A. Effect of impeller position
B. Effect of speed
C. Effect of aeration
D. Effect of baffles

1. Fill the beaker with water.
2. Inject a dye at the top of a beaker.
3. Operate the mixer under laminar flow.
4. Observe how mixing is carried out and evaluate how long does it take to mix.
5. Observe the aeration if happen or not.
6. Repeat the same experiment but at higher speed that is in turbulent flow.
7. Repeat the above experiments with different impeller position (1/2 and 1/3 from the bottom).
8. Repeat the above experiments using baffles.

3.5 Report Requirement

1. Report on mixing time as a function of impeller speed
2. Plot mixing time vs. time at low speed and high speed.
3. Plot mixing time vs. time at different impeller position.
4. Calculate the power consumption in each case.
5. Compare between using baffles and not using it.
6. Compare your results with theoretical data.

Experiment 3

Mixing Behavior under Various Operating Conditions

Table 3.1: Experimental Data

Temperature (°C)					
Sample #	**Impeller height**	**Speed (rev/min)**	**Mixing time (sec)**	**Aeration height (cm)**	**Aeration height /impeller distance (cm/cm)**
	1/3	200			
		300			
		400			
		500			
		700			
		800			
		1000			
	1/2	200			
		300			
		400			
		500			
		700			
		800			
		1000			
	2/3	200			
		300			
		400			
		500			
		700			
		800			
		1000			

Experiment 4

Effect of fluid viscosity on mixing time

4.1 Objective:

To determine the effect of fluid viscosity on the mixing time and mixing quality.

4.2 Equipment and Material

- CMC solution of different concentration.
- Beakers.
- Stirrer
- Dye

4.3 Procedure

Following is a step-by-step procedure:

Adding non-viscous to viscous:

1. Prepare a 1L of viscous CMC solution of different concentration. Use a concentration of 0.2, 0.4 and 1%.
2. Prepare a 5 ml of dye solution of x % concentration for each concentration. This solution when fully mixed in the CMC concentration should give a final concentration of 300 ppm.
3. Fill the 2L beaker with the viscous fluid and use a low stirrer speed but adequate for mixing (corresponds to the minimum turbulent Reynolds number value).
4. Stop the mixer and gently add the dye solution at the top surface of the viscous fluid, switch on the stirrer and observe how the dye moves inside the batch.
5. From time to time take sample and find it concentration by spectrophotometer.
6. Draw a sketch for the movement of dye in the batch.
7. Repeat steps 3 to 5 for other CMC solution.

Adding viscous to non-viscous:

1. Fill a 2L beaker with 1L water and use a low stirrer speed but adequate for mixing (corresponds to the minimum turbulent Reynolds number value).
2. Prepare a 5 ml of CMC solution of different concentration (0.2, 0.4 and 1%).
3. Add x of dye for each concentration that make the solution when fully mixed in water should give a final concentration of 300 ppm.

4. Stop the mixer and gently add the dye solution at the top surface of the non-viscous fluid, switch on the stirrer and observe how the dye moves inside the batch.
5. From time to time take sample and find it concentration by spectrophotometer.
6. Draw a sketch for the movement of dye in the batch.
7. Repeat steps 3 to 5 for other CMC solution.

4.4 <u>Report Requirement</u>

1. Sketch mixing time vs time for all cases.
2. How solution viscosity affects mixing time. Support your results with any existing correlation. (Use reference).

Experiment 4

Effect of Fluid Viscosity on Mixing Time

Table 4.1: Experimental Data

Temperature (ºC)		
Type	**CMC concentration%**	**Mixing time**
Non-viscous to viscous	0.8	
	2	
Viscous to non-viscous	0.8	
	2	