Experiment – 3

OBJECTIVE: To estimate dimensionless mixing time in a batch reactor.

INTRODUCTION: Many processing operations depend for their success on the effective mixing of fluids. Mixing is the random distribution of two or more initially separate phases to form a solution/ suspension where concentration gradients of either phase do not exist. Efficient mixing is essential in a bioreactor in order to maintain uniform dissolved oxygen and nutrient salt concentrations. Poor mixing may result in formation of anaerobic zones in the bioreactor, which may be undesirable for aerobic processes.

The dimensionless mixing time (N_M) is given by:

$$N_M = t_m\, n \quad \text{-----(1)}$$

Where:

n impeller rotational speed , per sec

t_m mixing time, sec

The mixing time is measured as the time required to achieving 90% of steady ultimate value of tracer concentration from initial value, following addition of a pulse of a tracer.

In the turbulent flow regime ($N_{Re} \geq 2X10^4$), the dimensionless mixing time (N_M) approaches a constant value. Therefore, we may write:

$t_m \propto 1/n$, and that

$$N_M = 1.54V/D_i^3 \quad \text{------ (2)}$$

[Ref Fig 7.23 "Bioprocess Engineering Principles" by Pauline M. Doran]

If N_M is known, mixing time (t_m) can be calculated, in turbulent flow region, at different agitator speeds for geometrically similar vessels of various sizes using equation (1).

MATERIALS:

a) Fermentor 10L
b) 100ml each of 4N NaOH and 4N H_2SO_4 solutions

METHOD:

1. Fill the bioreactor with 10L of RO-Water.

2. Select agitation (n) so as to obtain turbulent flow ($N_{Re} \approx 2*10^4$, $\Rightarrow$ $n \approx 150$ rpm). To compute N_{Re}, use the equation $N_{Re} = \rho n D_i^2 / \mu$. (Take, D_i=8 cm and

use physical properties of water at room temperature: eg, $\rho=10^3$ Kg/m^3, n in rps, $\mu=10^{-3}$ Kg/(m-sec).

3. Set agitator rpm to 150. Set the stopwatch. Adjust pH to 7.

4. Add tracer pulse (2.5ml 2N Acid) and note down pH readings with time using the stopwatch until a steady value is obtained. Calculate mixing time (θ_m) from a plot of the data.

5. Set the pH back to 7 by the addition of 2.5ml 4N NaOH.

6. Repeat steps 3-5 for other impeller speeds (150, 200, 250 rpm) and tabulate your results in table given below

OBSERVATIONS:

Agitation, n (rpm)	N_{Re} ($=nD_i^2\rho/\mu$)	Mixing Time t_m (minutes)
150		
200		
250		

CALCULATIONS:

Plot t_m vs 1/n and calculate the dimensionless mixing time as the slope of the straight line.

RESULTS:

Report the value of the dimensionless mixing time (N_M) obtained from experimental data and check if it is same as that compute by equation (2).

DISCUSSION: Write a discussion on your observations.