# Demonstrating Mixing Time Estimation in a Mechanically Agitated Contactor

Simple demonstration experiments integrated into the curriculum will aid understanding and facilitate learning. As part of the Chemical Reaction Engineering Laboratory course for the final year chemical engineering degree program, a simple experiment based on pH response is described to quantify mixing in stirred tanks. Hydrodynamics and the resulting fluid-flow pattern significantly affect the performance of a given reactor. Typically, residence time distribution and mixing time studies are conducted to assess mixing in process vessels. Mixing time is defined as the time taken to achieve a certain fixed degree of homogeneity (say 99.5%) in the system (Figure 1). The experiment involved determination of mixing time by pH method in a stirred tank (Figure 2 and Table 1). In this experiment, 1.5 L of double-distilled water was added to the tank and the initial pH [pH(0) at time = 0] was noted. A known molarity of sodium hydroxide solution was used as the tracer. 10 mL of tracer was added and the pH value [pH(t)] was recorded every 5 s using a pH probe. The experiment was conducted at a fixed rpm of 50. The pH readings were noted until steady state was reached. Three trials were conducted. The mean steady state pH was calculated, and was used as the 'pH at infinite time' [pH(∞)] in order to obtain normalized pH (pH*) following Eq. (1).

$$pH^{*} = \frac{pH(t) - pH(0)}{pH(\infty) - pH(0)} \qquad (1)$$

From the plots of normalized pH (pH*) versus time, the time required to achieve normalized pH = 0.995, was taken to be the mixing time of the stirred tank at given conditions. Thus, students will understand how to quantify the mixing time in a given process vessel. The experiment can be repeated by changing the rpm, impeller types or the position of impeller. This will enable students to assess the effect of rpm, impeller type (axial or radial flow), and geometry on mixing time.

**Safety tip:** Sodium Hydroxide is hygroscopic and corrosive. Prolonged exposure causes severe skin burns and eye damage. Usage of suitable gloves and eye/face protection is required to model proper safety precautions. ❐

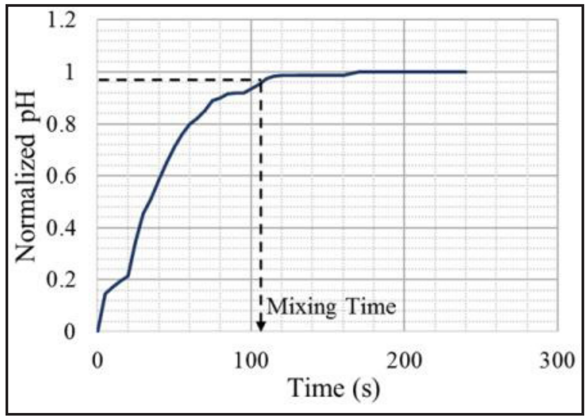


***Figure 1.*** *Typical plot of normalized pH vs. Time.*

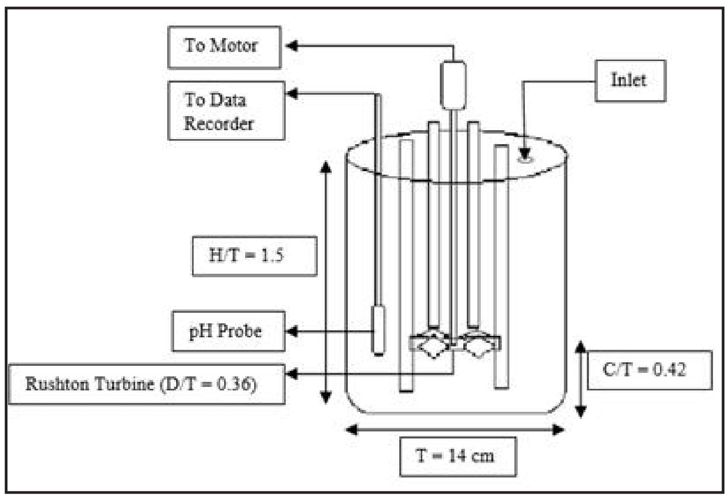


***Figure 2.*** *Schematic sketch of the stirred tank.*

**TABLE 1**
**Equipment dimensions**

| Equipment | Material of Construction | Approximate Dimensions |
|---|---|---|
| Stirred Tank | Borosilicate Glass | Diameter (T) = 14 cm,<br>Height (H) = 21 cm,<br>Capacity = 3 L |
| Impellers: Rushton turbine | Stainless Steel | Diameter (D) = 5 cm;<br>No. of blades = 6 |
| pH Probe | Glass | Position from axis of shaft = 6 cm |

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This one-page column presents practical teaching, advising, and diversity tips in sufficient detail that others can adopt the tip. Focus on the teaching method, not content. The column should be maximum 550 words, but subtract 50 words for each figure or table. Submit as a Word file to Phil Wankat <wankat@ecn.purdue.edu>.