A Visual Approach to Measuring Blend Time in an Agitated Vessel

Subathra and Naren described a method to determine blend time in a mechanically agitated vessel based on measuring the transient pH response at a point following addition of sodium hydroxide to water.[1] This widely used nonreactive approach can be modified to increase its impact for visual learners by incorporating an acid-base reaction that leads to a pH change that is viewed in a clear tank by means of an indicator.

This reactive approach is equivalent to performing a titration in the vessel, with the agitator providing the mixing required to bring the reagents into contact. The hydrochloric acid-sodium hydroxide-phenolphthalein system is a common choice, with the quantities noted here being used in a 0.45 m diameter tank (approximately 75 liter volume). Note that proper safety procedures must be followed when handling reactive chemicals and working with rotating equipment. Phenolphthalein indicator (20 ml, one percent solution) is added to the water in the batch vessel. With the agitator running, pH is adjusted by adding acid or base to produce a consistent intermediate pH starting point. This can be achieved by measuring pH or by visually producing a light pink color that is matched to a reference color chart. Sodium hydroxide (3 ml, 5 N) is then added to increase the pH and produce a dark pink color. Twice the stoichiometric amount of hydrochloric acid (6 ml, 5 N) is gently poured onto the liquid surface. As the acid is distributed throughout the vessel, it reacts with the sodium hydroxide, lowering the pH and causing a color change from pink to clear as illustrated in Figure 1. To determine blend time, a timer is started as the acid is added and then stopped as the last wisp of pink disappears from the liquid. Addition of sodium hydroxide (3 ml, 5 N) then returns the batch to the starting point for another measurement (although the solution should be returned to the same starting reference point for each experiment, which may require slightly more or less than 3 ml). Repeating this cycle allows a number of blend time determinations to be made in a relatively short time.

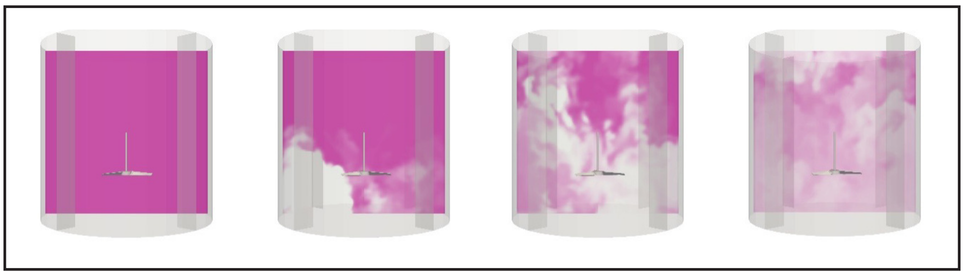

Figure 1. *Visualization of the blending process (time increases from left to right).*

Figure 2 presents an example of experimental data showing the dependence of the dimensionless blend, $N\,t_b$, on impeller-to-tank diameter ratio, D/T, for a pitched-blade turbine (N is rotational speed, t_b is blend time, D is impeller diameter, and T is tank diameter). The observed dependence is consistent with a literature correlation[2] that is commonly used to estimate turbulent blend times ($N_p^{1/3}\,N\,t_b\,(D/T)^2$ = constant where N_p is impeller power number).

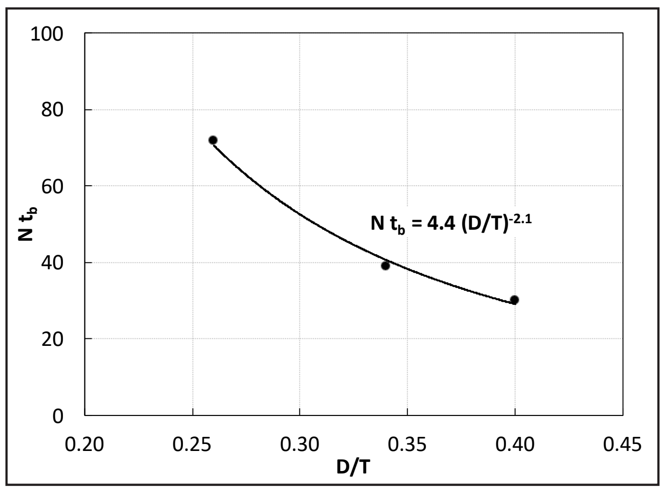

Figure 2. *Pitched-blade turbine blend time data.*

REFERENCES

1. Subathra NR and Naren PR (2018) Demonstrating mixing time estimation in a mechanically agitated contactor. *Chem. Eng. Educ.* 52(1): 68.
2. Grenville RK and Nienow AW (2004) Blending of Miscible Liquids. Chapter 9 of *Handbook of Industrial Mixing: Theory and Practice*. Wiley-Interscience. Hoboken, NJ. ❐

— KEVIN J. MYERS AND ERIC E. A. JANZ, UNIVERSITY OF DAYTON • DAYTON, OH 45469

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