On the Interrelation of Flooding- and Complete Dispersion Characteristics in Agitated Gas-Liquid Contactors

By [a]Eva Babalona and [b]Joannis Markopoulos

[a,b] Department of Chemical Engineering, Aristotle University of Thessaloniki, Univ. Box 453, 54124 Thessaloniki, Greece

Summary

Gas-liquid contactors agitated by Rushton turbines are widely used in chemical and biochemical processes, offering optimal dispersion conditions and greater efficiency of gas utilization in the reactor. Despite the fact that the complete dispersion characteristics are operationally important, the flooding-loading transition is widely used as a design criterion, dew to its experimental convenience and accuracy. Moreover, limited data are available in literature on the interrelation of the flooding-loading and the loading-complete dispersion transitions, although several investigators have worked on these two transition stages. Thus, the knowledge of the interrelation between these two dispersion stages would be of great practical importance. In this work the dependence of stirrer speed at complete dispersion, n_{CD}, on the stirrer speed at flooding, n_F, is experimentally studied. The experiments were carried out using Rushton turbines of two different diameters. The experimental results, having an accuracy of 5%, are proposed in the form of a dimensionless equation between the Froude number at flooding, Fr_F, and the Froude number at complete dispersion, Fr_{CD}.

Keywords: gas-liquid systems, Rushton turbines, flooding, complete dispersion

Extended Abstract

Since the flooding-loading transition is widely used, dew to its experimental convenience, as a design criterion for mechanically agitated gas-liquid contactors, several investigators have worked on this subject, giving each of them different results [1-3]. However, at this agitation stage the dispersion is ineffective, as the gas bubbles are sufficiently dispersed only in the zone above the impeller. Thus, working at the flooding-loading transition, i.e. at the minimum stirrer speed at which flooding does not occur for constant gas flow rate (n_F, q_F), only 1/2 or in some cases even 2/3 of tank volume is efficiently used; the same approximately occurs, when for constant gas flow rate the speed is smaller than the speed n_{CD} for complete dispersion, as the impeller clearance is usually equal to C/D = 0.25-0.5, with C the impeller clearance and D the tank diameter [4]. So, as shown in Fig.1, it is much more effective to work at those conditions, where the whole of the vessel is used. Consequently, it is not the flooding stage but the complete dispersion stage that gives efficient dispersion characteristics.

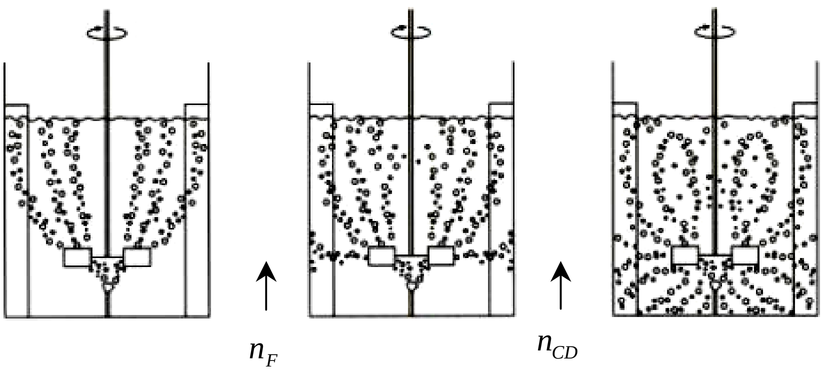

Fig.1. *Gas-Liquid dispersion stages.*

So, it is not n_F but n_{CD} which determines the optimal working conditions. Particularly, working at loading-complete dispersion transition, the whole of the vessel is efficiently used, as the gas bubbles manage to reach the bottom of the reactor. Thus, the knowledge of the interrelation between n_F and n_{CD} (or, in dimensionless form, between Fr_F and Fr_{CD}), for a given gas flow range, would be of fundamental importance, since limited data, mainly in form of regime maps, are available in literature on this interrelation [5], and since, additionally, the loading-complete dispersion transition cannot be sharply determined. On the other hand, the flooding-loading transition is a sharp transition and therefore easily to be experimentally predicted. Thus, it would be of great practical importance to use the loading-complete dispersion transition as a design criterion, knowing the interrelation between the two transition stages.

Experimental investigations were carried out in a flat-bottomed Plexiglas vessel with square cross section, having a length of the horizontal edge of $D = 0.2425m$, fitted with four symmetrically located baffles. Filtered air, with gas flow numbers, Fl, between 0.03 and 0.09, entered into the system by a tube at the bottom of the vessel and was dispersed in tap water by a single Rushton turbine of two different diameters, $d = 0.33D$ and $d = 0.49D$, respectively. The accuracy of the method used is estimated to be 5%. The experimental results were determined either visually or using the step change of power consumption, when the gas flow changed at constant impeller speed. In Fig. 2 the relation between n_F and n_{CD} is comparatively given for the gas flow range studied.

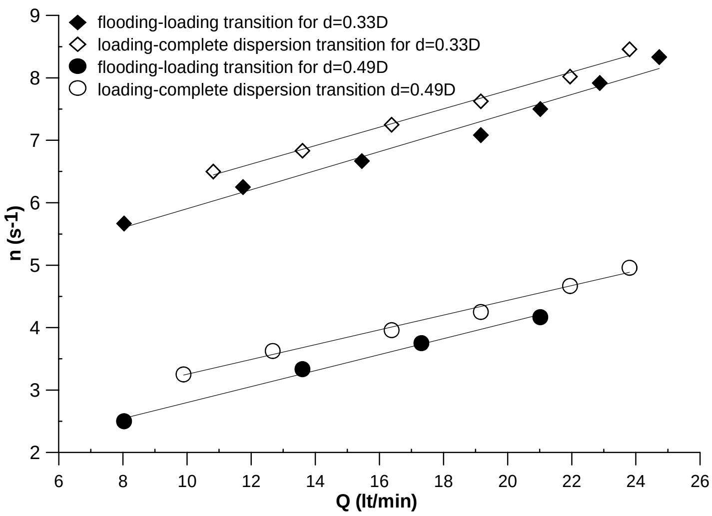

Fig.2. *Relation between flooding and complete dispersion stages.*

In dimensionless form this interrelation can be given in the form of the following equation:

$$Fr_{CD} = 1.12 Fr_F$$

This equation is valid for gas flow numbers between 0.03 and 0.09.

References

1. Wei-ming Lu, Hsuan Chen, Chem. Eng. J., 33 (1986), pp. 57-62.
2. Wiedmann, J. A., Steiff, A., Weinspach, P.M., Ger. Chem. Eng. 4 (1981), pp. 125-136.
3. Machon, V., Hudcova, V., Vlcek, J., Lepsova, P., Proc. 7th Eur. Conf. on Mixing, RFSH, Belgium 1991, pp.343-349.
4. Paul L. E., Atiemo-Obeng V. A., Kresta S. M.(eds), Handbook of Industrial Mixing, J. Wiley & Sons (2004), p. 592.
5. Smith J. M., Warmoeskerken M. M. C. G., Proc. 5th Eur. Conf. on Mixing, BHRA, The Fluid Eng. Centre, Wűrzburg 1985, pp.115-126.