Experimental investigations of stirred liquid-liquid systems in slim reactors: Mixing time and minimum dispersion speed.

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Abstract

Although investigations in the field of stirred liquid/liquid dispersions have a long history, still new questions are arising in dealing with all the different facets of industrial applications like suspension polymerisations. This process is commonly used in the chemical industry for producing a wide variety of commercially important polymers. Growing markets and growing economies lead to higher production rates. For cost reduction newly build production reactors are increasing in size, while the diameter is fixed because of limits of space and transportation issues. As a consequence the ratio of liquid level height H versus tank diameter T of such apparatuses is enhanced; a ratio of 2.5 or higher is common, values of four are expected for the future. The understanding of dispersion processes in slim reactors is fragmentary but differences compared to the standard system (H/T = 1.0) introduce extra difficulties.

Obviously a multiple impeller system should used in slim reactors [1]. As each impeller produces its own flow pattern, the coupling becomes more intricate and the regularities known from single impeller systems are no longer valid. Due to the extreme rising number of combination possibilities (impeller type and stage distance) existing experimental results are very specific not general. There is a major need of quantitative results of the flow pattern, mixing and dispersion characteristics of multiple impeller systems depending on impeller type and impeller clearance.

The aim of this work is to provide fundamental information for stirrer applications useable in polymerization processes in cooperation with an industrial partner (Vinnolit GmbH). Therefore three different impeller types were taken into account: Retreat curve, leaf and blade impellers. They have been used as single or multiple systems with different number of stirrers and various impeller clearances. The liquid level to diameter ratio was varied from 1.0 - 5.0.

Three major objects of the experimental results are presented in this study. Firstly – the power uptake of all analyzed systems to judge the energy efficiency. Secondly – the mixing time to evaluate the liquid phase homogenization and thirdly – the minimum dispersion speed to ensure complete incorporation of the dispersed phase into the liquid phase.

While scaling up a slim reactor from pilot plant to industrial scale is still an issue where much empiricism is used, the experiments have been carried out in four different scales. The used diameters start at lab scale size (T_1 = 0.15 m, T_2 = 0.4 m, T_3 = 0.45 m, T_4 = 0.9 m) and end at pilot plant size. All experiments are compared with prediction rules from literature [2, 3] and recommendations, based on the results, for the most suitable impeller application are given.
The results show clearly, that a minimum height of 2.5 T is necessary to gain an advantage from multiple impellers compared to the single ones. The studies also show that the consideration of further parameters, like the baffle length and baffle type, is of major importance for the scale up results.

References

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