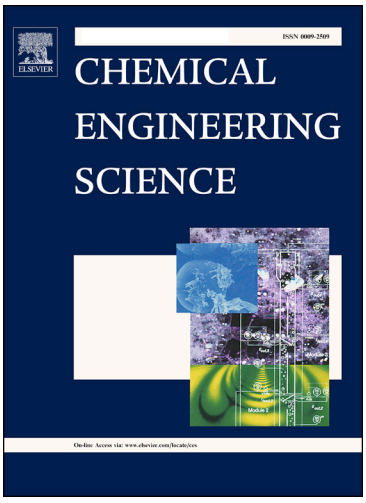

Hydrodynamic inhomogeneities in large scale stirred tanks – Influence on mixing time

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Hydrodynamic inhomogeneities in large scale stirred tanks – Influence on mixing time

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Abstract:

Aerated stirred tank reactors are widely used in chemical industry and bioprocess engineering. One major parameter to characterize the heat- and mass transfer performance of such aerated stirred tank reactors is the mixing time necessary to homogenize the reactor volume. Despite its importance, the prediction of the mixing time is still challenging due to the complex hydrodynamic inhomogeneities induced by the gaseous phase, which becomes strongly apparent in large scale systems. A precise measurement of the two phase flow on the other hand requires a volumetric insight and is thus difficult to realize. To overcome this problem a transparent stirred tank reactor on industrial scale has been erected at the Hamburg University of Technology in cooperation with Boehringer Ingelheim Pharma GmbH & Co.KG. With the decolouration method the temporal and spatial development of mixing can be taken into account. The results indicate the importance of the local inhomogeneities on large scale. A first characterization can be done by taking into account buoyancy driven flows superimposing the flow imposed by the impeller. A correlation is presented to estimate the transition between a loading and flooding regime on large scale. This correlation enables the calculation of mixing times for a wide range of stirrer frequencies and superficial gas velocities. Furthermore, this publication emphasizes the challenges of scale-up on the basis of laboratory experiments in small scale.

Keywords: mixing time; stirred tank reactor; buoyancy driven flow; flow pattern

1. Introduction:

For many applications in chemical and biochemical engineering, efficient mixing of two phase flows with high heat- and mass transfer performance is one of the most important challenges (Middleton and Smith, 2003). For this purpose, aerated stirred tank reactors are the most widely used apparatuses in industry due to their simplicity, low investment costs and flexibility. Because of their importance they have been investigated intensively in the past decades to model and simulate these processes. Over the years the investigations have changed from global measurement in the early days to more local experimental analysis in the last decades. Whereas the mixing time, global flow structure and gas hold-up has been analyzed first by overall measurements (e.g. Zlokarnik, 1967; Warmoeskerken and Smith, 1985; Haß and Nienow, 1989; Nienow, 1998; Bouaifi et al., 2001; Kong et al., 2012) in the last years more local measurements have been performed to determine the bubble size distribution (Montante et al., 2008, Laakkonen et al., 2005), the local gas hold-up (Busciglio et al., 2013, Kong et al., 2012, Lee and Dudukovic, 2014) and the liquid and gas velocities (Chara et al., 2016, Montante et al., 2007). Yet reliable design and scale-up is still challenging and a lot of open questions remain. One reason is