519a Process Intensification: Mass Transfer Characterization of Slug Flow in a Narrow Channel Reactor

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Introduction

This paper will present experimental findings of a systematic study carried out to experimentally determine the mass transfer performance of slug flow in a narrow channel reactor. The influence of liquid viscosity on mass transfer rate will be highlighted by developing an empirical correlation involving Reynolds number, Schmidt number, Bond number, bubble length and slug length. This data is being currently used by the process intensification research group at Clarkson to develop and evaluate the performance of several intensified reactors using hydraulic path lengths in the range of 500 to 1000 microns.

Background

Slug flow in capillaries is defined as a cocurrent flow of gas and liquid phase having gas bubbles separated from the wall by a thin liquid film and separated from each other with liquid slugs. The significance behind the study of slug flow in capillaries is their ability to achieve high mass transfer rates. Several authors have characterized the hydrodynamic properties of slug flow in capillaries with varying viscosities [1,2,3,4]. Only two authors developed mass transfer model and their models are based on the viscosity of water [5,6]. The aim of this study is to develop a mass transfer model for a wide range of viscosities during slug flow in capillaries. This limitation has hindered the progress of narrow channel reactors in gas liquid mass transfer activities involving removal of monomers from pre-polymers which have significantly higher viscosities than water.

Description of the research

An experimental arrangement has been developed to analyze mass transfer between bubbles and liquid during slug flow in a narrow channel reactor. A square channel reactor made of plexiglass having 0.7 mm hydraulic diameter and a length of 27 cm was used in this investigation. Mass transfer of oxygen from a liquid phase containing a mixture of water and glycerol with different compositions and nitrogen was studied. The initial and final concentrations of dissolved oxygen in the liquid phase were measured using a dissolved oxygen probe. By means of video capture device bubble velocity, bubble length and slug length were measured.

An empirical mass transfer model has developed as a function of Reynolds number, Schmidt number, Bond number, bubble length and slug length from the experimental results. Using CFD, a theoretical model of the system has also been developed and has been used to understand the experimental results.

References

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