Chapter I

1. Introduction

This thesis is a part of project the aim of which is to develop new optimal designs for three phase catalytic reactors which employ monoliths as catalytic support. This will be achieved by development of fundamental understanding of the flow behavior and mass transfer within these reactors. The aim of this thesis is to study flows in single channels using high speed videography and Particle Image Velocimetry (PIV). The Taylor's flow, where the flow consists of a regular intermittent flow of gas bubbles and liquid slugs, will be investigated. High speed videography will be used to confirm the flow patterns in round and square capillary tubes. Flow maps will be produced for these capillaries showing the range of gas and liquid flows over which particular flow regimes occur. The liquid's slugs, that are used to do the experiments, are a ludox solution and water solution. Monolith are attracting more and more attention as alternatives for both three phase slurry reactors and trickle bed reactors. The operating mode depends on the size of the straight parallel channels: in large channels the fluid trickles downwards along the channel walls and the gas travels, co-currently or counter-currently, through the channel in the core. In smaller channels, the dominant flow pattern is a segmented slug flow or bubble train flow of elongated bubbles and slugs. The flow of gas and liquid in the channel can occur in a number of configurations termed flow patterns. One of the most complicated flow patterns is the slug flow. It occurs over a wide range of parameters, for all pipe inclinations and for a wide range of gas and liquid flow rates. Slug flow is characterized by a quasi periodic alteration of long bullet shaped bubbles and liquid slugs. In vertical channels, elongated bubbles are axisymmetrical and have a round cup, while the tail is generally assumed to be nearly flat. The liquid around the elongated bubbles moves downstream as a thin falling film. The liquid velocity in the film is substantially larger than the mean velocity in the liquid slug ahead of the bubble. Each slug sheds liquid in its back to the subsequent film, which accelerates as it moves downward. Then it is injected into the
next liquid slug as a circular wall jet, producing a mixing zone in the bubble wake. The mixing zone is generally believed to have a shape of toroidal vortex. The flow gradually reestablishes in the body of the liquid slug behind the missing zone. In the case of downward flow of liquid in a vertical channel, the bubble shape can be asymmetrical. The tip of the bubbles is inclined to the channel wall to avoid the fast-moving liquid in the pipe center. If the liquid flow rate is high enough, the bubble may remain stationary or even descend instead of rising. The motion of a single elongated bubble in a vertical channel is closely related to the movement of Taylor bubbles in slug flow.