CHAPTER 1

Introduction

1.1 General Ideas

In chemical/biochemical processes, stirred tanks are commonly chosen as operating reactors because of their well studied behavior. Although intensive investigations on stirred tanks can be found in literature, there are inherit disadvantages especially for biochemical industry. Firstly, the systems require high power input, which is not necessary for low viscosity fluids. Secondly, with high shear stress imposed by the agitator, using stirred tanks in biochemical systems can damage weak cells or enzymes. (Chisti *et al.*, 1986; and Royse, 1987). The presence of propeller or impeller also leads to the possibilities of easy contamination through mechanical seals. Moreover, the assembly of sterilable stirred tanks requires high capital investment, especially for large systems. Hence, alternative bioreactor designs have been investigated as potential replacements of stirred tanks particularly for the work in the biochemical field.

The simplest type of reactor is a bubble column which is simply a gas-liquid contacting system with only a sparger for gas distribution installed at the base. As a result, no mechanical movements involve, and this leads to a low energy consumption of such reactor. However, bubble columns suffer a serious drawback from its poor liquid circulation in the system particularly for the three-phase systems where circulation of liquid is needed to enhance mass transfer. An airlift contactor (ALC) has been developed to compensate this disadvantage in the bubble column. An ALC is a special type of bubble column where the internal structure is divided into two separate sections (riser and downcomer). The configuration of ALC naturally induces the liquid movement in the system, and this advantage finds this system one of the potential alternatives in bioprocesses (Blenke, 1979; and Orazem *et al.*, 1979). In addition, ALCs offer a number of benefits over stirred tanks, i.e. simpler design, easy handling, and most of all, cheaper operation. This is because ALCs provide mixing without mechanical components (unlike stirred tanks that need agitators for mixing), therefore no extra charge due to mechanical operation is incurred. Furthermore, the absence of moving mechanical parts produces low shear stress and reduces the risk of enzyme/cell damages. This is particularly useful for systems in which plant and animal cells are involved, where cells are susceptible to high shear force.

Despite all the advantages described above, gas-liquid mass transfer in ALCs is relatively low compared to other types of gas-liquid contactors especially in large scale systems (Zhao *et al.*, 1994). There is therefore a clear need for the improvement of the ALC in term of its mass transfer performance, as the rate of gas-liquid mass transfer is one of the most important parameters for the biological processes such as waste water treatment unit and plant cell cultivation.

The aim of this work is to investigate the hydrodynamics and gas-liquid mass transfer in the pilot scaled ALC. The specific emphasis will be given to the effect of the insertion of perforated plates inside the system on the gas-liquid mass transfer coefficient in concentric ALCs.

1.2 Objectives

This work is set out to:

1. Compare the performances of ALC with perforated plate (ALC-P) with those of conventional ALCs and bubble column.
2. Investigate the effect of the number and sizes of holes in the perforated plate on the hydrodynamic behavior of ALCs. i.e. gas holdup and liquid velocity
3. Investigate the effect of the number and sizes of holes in the perforated plate on the gas-liquid mass transfer in ALCs.
4. Investigate the effect of number of perforated plate(s) on the gas-liquid mass transfer in ALCs.

1.3 Working Scopes

1.3.1 Equipment Limitation

1. The experiment is limitted by the air flowrate produced by the air compressor which only ranges from 81 to 364 cm^3/s ($1.889 < U_{sg} < 8.453$ cm/s).
2. The DO probe can be located only at the gas separator due to the geometrical design constraint of the contactor.

1.3.2 Design Configurations

Gas-liquid contacting systems employed in this work only include:

- bubble column (BC)
- concentric airlift contactor (ALC)
- concentric airlift contactor with perforated plate(s) (ALC-P)

with dimensions as given in Figure 3.2.

1.3.3 Assumptions

1. Newtonian fluid
2. Completely mixed gas separator
3. Constant gas holdup for each section in the ALC
4. Constant rate of gas-liquid mass transfer through the ALC