CHAPTER 1

INTRODUCTION

Chapter 1

INTRODUCTION

The Slurry Bubble Column (SBC) is a subclass of gas-liquid-solid fluidized beds. In general, a fluidized bed is a bed of solid particles held in suspension by the upward flow of one or more fluids, depending on the type of fluid involved, we can therefore distinguish:

a) Gas-solid fluidized beds.

b) Liquid-solid fluidized beds.

c) Gas-liquid-solid fluidized beds known as ebullated bed.

The random motion of the particles caused by fluid flow can only be achieved if the upward velocity of the fluid exceeds a certain limit. This limit is generally called the minimum fluidization velocity $(V_{sf})_m$. Above this velocity, the bed is set in motion and expanded. Below this limit, the relative position of the particles is preserved, and the bed remains fixed. In slurry bubble columns, the liquid phase may be stationary in most cases, while the particles are kept in suspension by momentum transfer from the upward rising gas bubbles. Another mode of operation would be moving the liquid phase at very low superficial velocity and simultaneously carrying with it the solid particles and returned back to the reactor. In either case there is no sharp demarcation of the expanded bed height, i.e. the solid particles are evenly distributed throughout the whole column.

This is contrary to fluidized bed, which is characterized by expanded bed height and a free board above it. The choice of a fluidized bed reactor or a slurry bubble column depends on a number of qualitative considerations, which can be classed into advantages and drawbacks.

Advantages

[Kunii, et al. (1969), Davidson, et al. (1971), and Sue, et al. (1976)]

- Possibility of continuous solid withdrawal and reintroduction. This is extremely valuable if the catalyst is rapidly deactivated.
- Elimination of any inter-particulate diffusion, due to utilization of small particle size.
- Elimination of internal and external concentration and temperature gradients.
- Elimination of radial gradients.
- Diminution of axial gradient.
- Minimization of the risks of hot spots and thermal instability. The fluidized bed is hence ideal for exothermic reactions.
- Experience has also shown that the heat transfer coefficient at the surface immersed in the bed is high.

Drawbacks

- The resulting random motion and mixing lead to an overall reactor behavior that is much closer to that of a back mix reactor than that of a plug flow reactor for most reaction systems, this means an increase in reaction volume and loss of selectivity.
- The hydrodynamics and modeling of these reactors are highly complex. Hence, their scaling up raise serious problems and their use is therefore reserved for applications that can justify major research and development efforts, as for example, very high capacity production units.
- Erosion of the internal parts.

Slurry Phase bubble columns are receiving much attention as the favorable reactors for Fischer-Tropsch synthesis for the conversion of natural gas to liquid fuels, because of their high capacity, isothermal conditions and ease of operation. They have been chosen by the big

Fischer-Tropsch developers Exxon, Mobil, and Sasol, where cobalt based catalyst is employed. Also slurry bubble columns are finding increasing application in biotechnology e.g. waste water treating systems. [Shah t al., (1983)], and bio-desulfurization.

The design of a general three phase reacting system (gas-liquid-solid reactors) is complex because of simultaneous occurrence of chemical reactions and transport process, which mutually interact in the presence of the three phases. The gas bubbles formed at the distributor rise through the slurry and provide the agitation necessary to maintain the catalyst particles in uniform suspension.

The equilibrium size of bubbles, gas hold-up, specific gas-liquid surface area, and the mass transfer coefficient are important parameters establishing the degree of chemical conversion in a bubble column reactor. Bubble velocity and its residence time in the column are controlled by the properties of the liquid or slurry phase in addition to its size and configuration. These phase properties in turn are also influenced by the operating conditions, such as temperature, pressure, catalyst particles size , size ranges, and slurry concentration. The configuration of the internal heat exchanger also controls the equilibrium bubble size and liquid mixing. Thus, it is obvious that the selection of all these interacting design parameters for a real reacting system is a difficult task.

The procedure for designing bubble column reactor [BCR] should start with an exact definition of the requirements, i.e. the required production level, the yields and selectivity. These quantities and the special type of reaction under consideration permits first choice of the so called adjustable operation conditions.

In multiphase reactor design, the hydrodynamic properties constitute another group of important parameters. These are more or less "non adjustable" or "self adjusting" quantities that depend on the chosen reactor geometry, the adjustable operation conditions as well as the process data.

All these quantities, i.e. the process data, the geometry of reactor, the adjustable and non adjustable parameters, are then introduced in the reactor model equations derived on the basis of the physical and chemical phenomena which are suspected to take place within the reactor.

The general scheme outlined in Fig. (1-1) represents the requirements for a reactor model. The use of models and model simulations are extremely useful in all design and scale up considerations.

The present work focuses on some of the hydrodynamics aspects of slurry phase bubble columns namely gas hold-up and dispersion coefficient in the liquid phase in presence of bed internals such as cooling tubes. The effect of bed internals on the above mentioned hydrodynamic parameter is usually overlooked in the current literature.

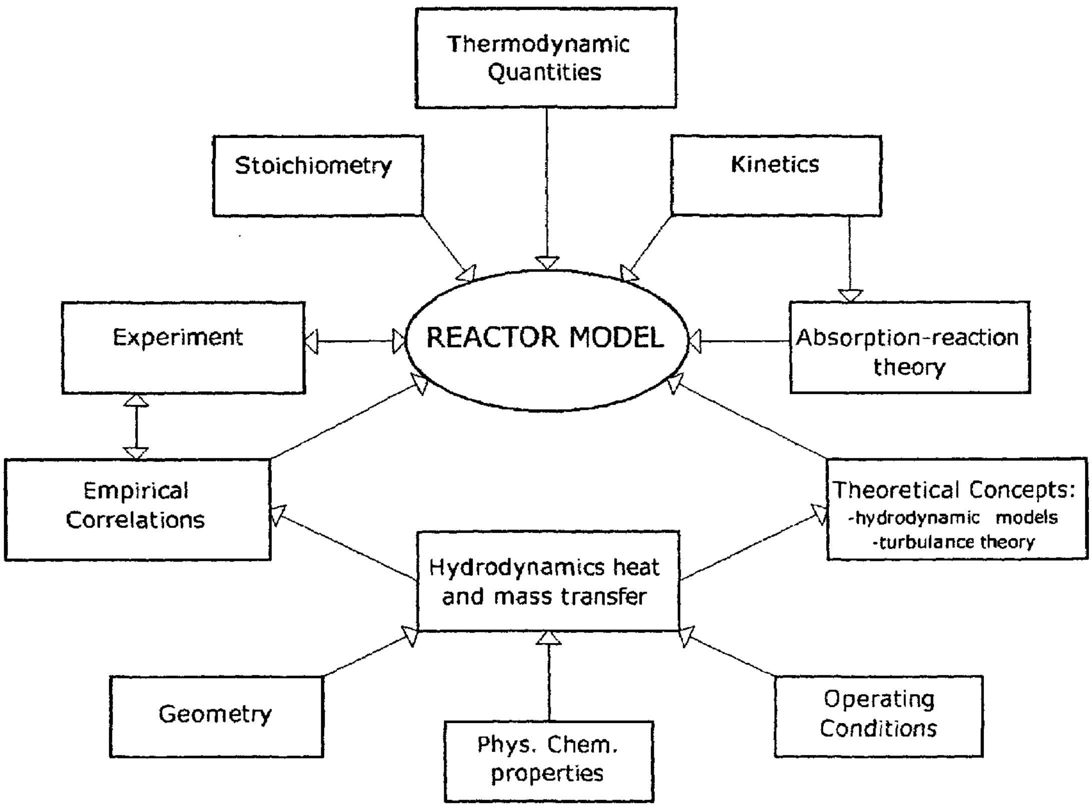

Figure (1-1): Phenomena Involved in Modeling Bubble Column Reactors