SIZING OF FIXED AND FLUIDISED BED REACTORS

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INTRODUCTION

Fixed and fluidised bed reactors are ***heterogeneous catalytic reactors***. A ***heterogeneous catalytic reactor*** puts emphasis on catalyst effectiveness factors and the heat and mass transfer implications. It can be understood from name that ***heterogeneous catalysis*** takes place in these reactors. Heterogeneous catalytic reactors are among the most commonly utilized chemical reactors in the chemical engineering industry.

In chemistry, ***heterogeneous catalysis*** is a catalysis reaction where the phase of catalysts differs from that of the reactants or products.

There are various classifications of heterogeneous catalytic reactors:

- Reactors with insignificant motion of catalyst:
  - *Fixed bed reactors*
  - Trickle bed reactors
  - Moving bed reactors
  - Rotating bed reactors
- Reactors with insignificant motion of catalyst:
  - *Fluidized bed reactors*
  - Slurry reactors

• FIXED BED REACTORS(FBR)

Catalytic fixed-bed reactors are the most important type of reactor for the synthesis of large-scale basic chemicals and intermediates. In these reactors, the reaction takes place in the form of a heterogeneously catalyzed gas reaction on the surface of catalysts that are arranged as a so-called fixed bed in the reactor.

In addition to the synthesis of valuable chemicals, fixed-bed reactors have been increasingly used in recent years to treat harmful and toxic substances. For example, the reaction chambers used to remove nitrogen oxides from power station flue gases constitute the largest type of fixed-bed reactors as regards reactor volume and throughput, while automobile exhaust purification represents by far the most widely employed application of fixed-bed reactors.

The purpose of a packed bed is typically to improve contact between two phases in a chemical or similar process.

Packed beds can be used in a chemical reactor, a distillation process, or a scrubber, but packed beds have also been used to store heat in chemical plants.

The packed bed reactors are widely used with immobilized cells.

SIZING EQUATIONS (FBR)

The general mole balance is given as the following for species A:

$$F_{A0} - F_A + G_A = \frac{dN_A}{dt}$$

where F_{A0} is the input molar flow rate, F_A is the output molar flow rate, G_A is the generation, and the differential term is the accumulation (all units are moles/time)

For a heterogeneous reaction (e.g. fluid-solid interactions), the mass of solid catalyst, W, is what matters instead of the system volume – Therefore, the reaction rate has units of moles of A per unit mass of catalyst per unit time

For a heterogeneous reactor, $G_A = r_A W$

where G_A is the generation of species A and r_A represents the rate of formation of species A per unit volume.

The packed-bed reactor (PBR), a type of catalytic reactor operated at steady state, can have a reaction rate described by

$$dF_A / dW = r_A$$

If the pressure drop and catalyst decay are neglected,

$$W = \int_{F_{A1}}^{F_{A0}} \frac{dF_A}{-r_A}$$

where W is the catalyst weight needed to reduce the entering molar flow rate of A, F_{A0}, to some F_{A1}

ADVANTAGES OF USING FIXED BED REACTORS

• By using a packed bed reactor is the higher conversion per weight of catalyst than other catalytic reactor.

• The reaction rate is based on the amount of the solid catalyst rather than the volume of the reactor.

• Low operating cost and low maintenance by using this kind of reactor.

• The process using packed bed reactor operates continuously. • Little wear on catalyst and equipment.

• Simple analysis

• Only practical, economic reactor at very high pressures.

• Usually high ratio of catalyst to reactants long residence time complete reaction

LIMITATIONS OF USING FIXED BED REACTORS

- Large temperature gradient or undesired thermal gradient may occur.
- Inefficient heat exchange
- Suitable for slow-or-non-deactivating processes.
- Regeneration or replacement of the catalyst is difficult- shut down is required.
- Pore diffusional problems intrude in large pellets

FLUIDISED BED REACTORS

A **fluidized bed reactor** (**FBR**) is a type of reactor device that can be used to carry out a variety of multiphase chemical reactions. In this type of reactor, a fluid (gas or liquid) is passed through a solid granular material (usually a catalyst) at high enough speeds to suspend the solid and cause it to behave as though it were a fluid. This process, known as fluidization, imparts many important advantages to an FBR. As a result, FBRs are used for many industrial applications.

It consists of a vertical cylindrical vessel containing fine solid catalyst particles. The fluid stream (usually a gas) is introduced through the bottom at a rate such that catalyst particle are suspended in the fluid stream without being carried out.

With this reactor, it is possible to regenerate the catalyst continuously without shutting down the reactor. This reactor is particularly suitable when the heat effects are very large or when frequently catalyst regeneration is required.

ADVANTAGES OF USING FLUIDISED BED REACTORS

- It has the ability to process large volumes of fluid.
- Heat and mass transfer rates between gas and particles are high when compared with other modes of contacting.
- No hot spot even with highly exothermic reaction.
- Ease of solids handling.

LIMITATIONS OF USING FLUIDISED BED REACTORS

- Broad or even bimodal residence time distribution of the gas due to dispersion and bypass in the form of bubbles.
- Broad residence time distribution of solids due to intense solids mixing.
- Erosion of internals.
- Attrition of catalyst particles.
- Difficult Scale-up due to complex hydrodynamics.