

7 Fluidisation

The fluidisation principle is straightforward: passing a fluid upwards through a packed bed of solids produces a pressure drop due to fluid drag. When the fluid drag force is equal to the bed weight the particles no longer rest on each other; this is the point of fluidisation. The superficial velocity at this point is known as the 'minimum fluidising velocity' (U_{mf}). If the fluid velocity is increased further the pressure drop does not significantly increase – it remains equal to the bed weight per unit area, but the bed may expand; i.e. grow taller as illustrated in Figure 7.1. Commercial gaseous fluidised beds are usually operated at flow rates many times that required for minimum fluidisation, typically 5 to 20 times. Liquid fluidised beds operate at values closer to U_{mf} . A material balance indicates that, in general

$$C_i = \frac{C_f H_o}{H_i} \quad (7.1)$$

On page 53, the hypothetical case was made for turning the vessel containing hindered settling solids upside down and noting that the liquid velocity upwards, required to maintain the position of the interface, is equal to the settling velocity of the solids in an otherwise stationary liquid. This upward fluid flow, and balance of forces, is the hydrodynamic condition that exists during fluidisation. Thus, the Richardson and Zaki equation, page 54, is also valid for liquid fluidised systems and the minimum fluidising velocity is a superficial velocity, as illustrated in Figure 6.1 inverted.

Fluidisation is a popular means of contacting solids and a fluid because of the high degree of mixing and the resulting high transfer coefficients (heat and mass). There are numerous examples including: catalytic conversion of hydrocarbons, drying, combustion, calcination (application of heat to decompose a solid – for example calcium carbonate to oxide or gypsum solids to plaster), agglomeration, etc. Another useful advantage is the uniformity of the bed temperature, so that heat sensitive materials can be treated in a well controlled environment. However, the biggest disadvantage of gas beds is the need for dust control and treatment – which can be more expensive than the capital and running cost of the fluidised bed itself. An example of a gaseous fluidised bed is provided in Figure 7.2. In the figure several important aspects are recorded: the gas fluidised bed is not uniform, but bubbles of gas within the bed are observed (see Section 7.2), a distributor plate supports the solids and distributes the fluidising gas, above the bed the vessel diameter increases thereby reducing the gas velocity so that entrained particles may drop back into the bed from the *freeboard* and a gas cyclone is used for primary particle separation from the gas stream. The cyclone dip tube enters the bed – hence preventing gas from entering the cyclone from the

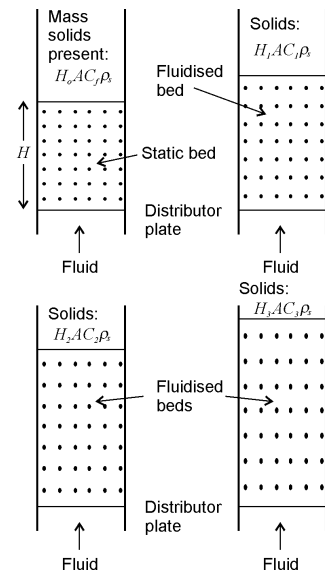


Fig. 7.1 Bed expansion during particulate fluidisation – mass of solids is the same in all beds

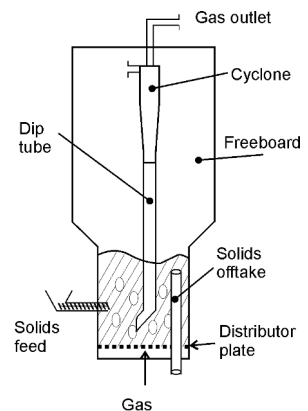


Fig. 7.2 Example design of a gas fluidised bed