blocked either by resting the tray on a plane surface or by the presence of a simple shutter. The critical orifice diameter is the size of the smallest hole through which powder discharges when the tray is lifted or the shutter removed. Sometimes repetition of the experiment produces a range of values for critical orifice diameter; in these cases maximum and minimum values are sometimes quoted.

An alternative critical orifice method for determining powder flowability uses a cylinder with a series of interchangeable base plate discs having different diameter orifices. Flow rate through a particular orifice size can be used as a simple standard to specify materials for use in filling given capsule sizes, sachets or producing particular tablet sizes at a specified rate.

Direct measurements of flow

Hopper flow rate

A simple direct method of determining powder flowability is to measure the rate at which powder discharges from a hopper. A simple shutter is placed over the hopper outlet and the hopper is filled with powder. The shutter is then removed and the time taken for the powder to discharge completely is recorded. By dividing the discharged powder mass by this time, a mass flow rate is obtained which can be used for quantitative comparison of different powders.

Hopper or discharge tube outlets should be selected to provide a good model for a particular flow application. For example, if a powder discharges well from a hopper into a tablet machine feed frame but does not flow reproducibly into the tablet die, then it is likely that more useful information will be generated by selecting experimental conditions to model those occurring in flow from the feeder to the die, rather than those in flow from the hopper to the feeder.

Recording flowmeter

A recording flowmeter is essentially similar to the method described above except that powder is allowed to discharge from a hopper or container onto a balance. The digital signal from the balance records the increase in powder mass with time. Recording flowmeters allow mass flow rates to be determined and also provide a means of quantifying uniformity of flow.

Improvement of powder flowability

Alteration of particle size and size distribution

Because coarse (largest) particles are generally less cohesive than fine (smaller) particles and an optimum size for free flow exists, there is a distinct processing disadvantage in using a finer grade of powder than is necessary.

The size distribution can also be altered to improve flowability by removing a proportion of the fine particle fraction or by increasing the proportion of coarser particles, such as may be achieved through granulation.

Alteration of particle shape or texture

In general, for a given particle size, more spherical particles have better flow properties than more irregular particles. The process of spray-drying can be used to produce near-spherical excipients, for example spray-dried lactose. Under certain circumstances, drug particles that are normally acicular (needle-shaped) can be made more spherical by spray-drying or by temperature-cycling crystallization.

The surface texture of particles may also influence powder flowability, as particles with very rough surfaces will have a greater tendency to interlock than smooth-surfaced particles. The shape and texture of particles can also be altered by control of production methods, such as crystallization conditions.

Alteration of surface forces

Reduction of electrostatic charges can improve powder flowability and this can be achieved by altering process conditions to reduce frictional contacts. For example, where powder is poured down chutes or conveyed along pipes pneumatically, the speed