10 Powder flow and storage

Pumping fluids is simple: you need a pump and some pipework. The higher the viscosity, the higher the pressure drop and, therefore, pump and energy costs. Much is known about how to characterise and specify a fluid system. What is the equivalent for dry particles? Also, tanks can be used to store liquids, but how should we store powders to ensure that they can be reliably used within our process? This is a subject that has received considerable attention over many centuries and is still a long way from a complete understanding. This chapter considers simple characterisation based on solid properties and a one-dimensional particle mechanics analysis. A more thorough description is possible by Discrete Element Analysis, see Chapter 7.

It would be a mistake to assume that the problem is just one of ensuring that the powder flows in a hopper, or down a chute. There are many recorded instances of process difficulties due to powders suddenly flowing too easily! If a hopper is discharging into a process and suddenly the powder surges out, it is likely that it will overflow the process vessels and cause disruption: this is called a *powder flood*. An example of a powder flood in nature is an avalanche and it is, of course, potentially very dangerous. Process operators can be killed in a powder flood, so these must be avoided at all costs. Powder flow in a controlled and predictable fashion is desired. Floods are usually associated with *aerated powders*, in which gas is mixed with the powder and it behaves in a fluidised fashion, see Chapter 7.

To flow or stick?

Property	Free flowing	Difficult flowing
Size	>400 μm	<100 μm
Range	narrow	wide
Shape	spheres	needles
Moisture	not too low*	high & none
Internal friction	low	high

* a certain amount of moisture may help to lubricate the flow and to prevent any electrostatic attraction between particles from stopping the flow.

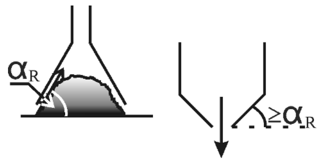

Fig. 10.1 Angle of repose and its possible relevance to hopper design

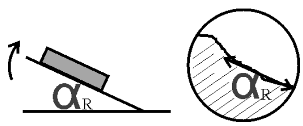

Fig. 10.2 Alternative measures

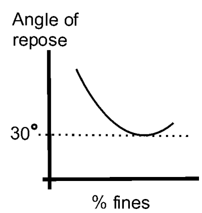

Fig. 10.3 Influence of fines on angle of repose

10.1 Powder properties

An understanding of particle behaviour starts with a consideration of particle properties and some basic techniques to measure them. One of the simplest measurements is the *angle of repose*, which is illustrated in Figure 10.1, and is often assumed to be the angle that the hopper needs to exceed in order to assure powder flow. This may be acceptable for *free flowing* powders, and the angle is typically 30°, but in most cases this ignores the tendency for particles to form a cohesive structure depending upon how they have been treated. Pouring the powder into an upside down funnel and then carefully removing the funnel to leave the heap in place can be used to measure the angle. Alternative techniques include measuring the angle of slide and the angle of rotation, as illustrated in Figure 10.2.

The particle size distribution has a complex effect on the angle of repose and a graph of the angle plotted, against the percentage of fines present, usually shows a minimum, see Figure 10.3. The angle of repose is a property of a powder that does not exist in a liquid and it is not a very consistent measurement for a powder because most powders exhibit some degree of cohesiveness.