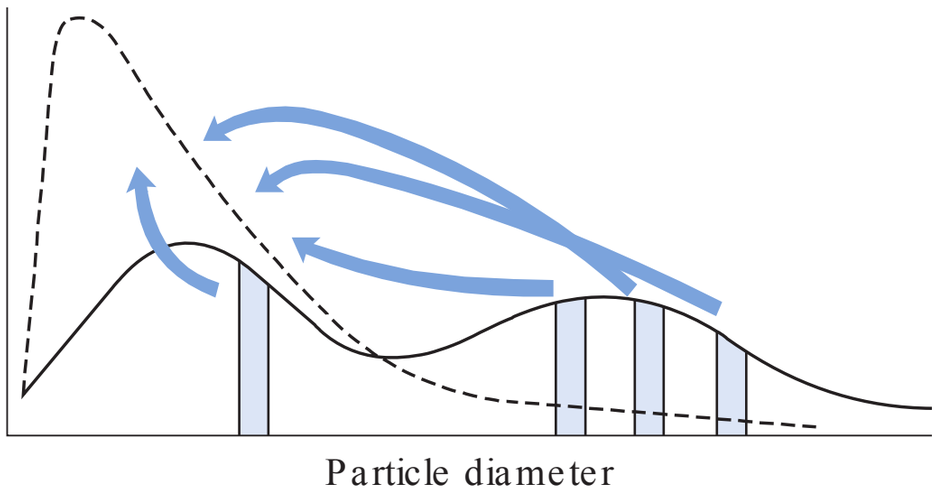

Fig. 10.4 • Transformation of a fine bimodal particle population into a finer unimodal distribution following prolonged milling.

unimodal population reappears, as the energy input is not great enough to cause further fracture of the finest particle fraction (Fig. 10.4).

The lower particle size limit of a milling operation is dependent on the energy input and on material properties. With particle diameters below approximately 5 μm, interactive cohesive forces between the particles generally predominate over comminution stresses as the comminution forces are distributed over increasing surface areas. This eventually results in particle agglomeration as opposed to particle fracture and size reduction ceases. In some cases particle agglomeration occurs to such a degree that subsequent milling actually causes size enlargement.

Size reduction methods

There are many different types of size reduction techniques and the apparatus available for size reduction of pharmaceutical powders continues to develop. This chapter illustrates the principles associated with techniques that are classified according to the milling process employed to subdivide the powder particles. The chapter does not catalogue all existing milling equipment but instead illustrates the various principles involved – examples of each type are given below. The approximate size reduction range achievable with each technique is illustrated, although it should be remembered that the extent of size reduction is always related to milling time.

Cutting methods

Size reduction range

This is indicated in Figure 10.5.

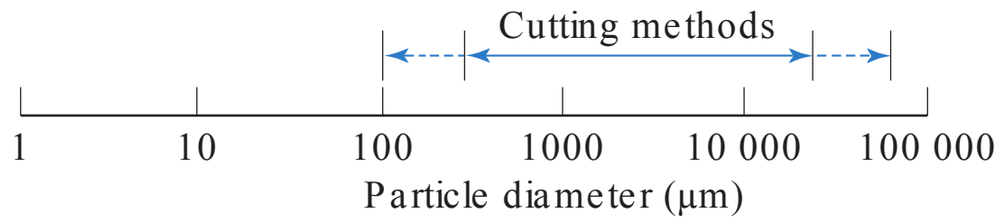

Fig. 10.5 • Size reduction range for cutting methods.

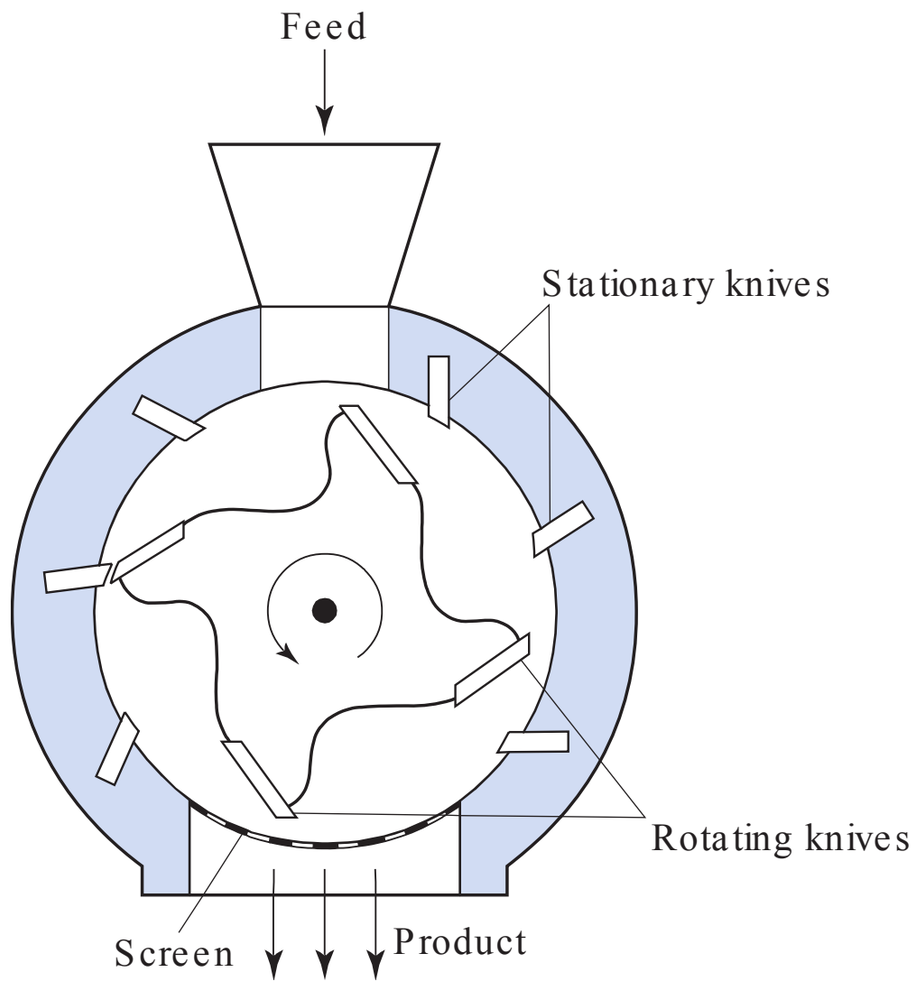

Fig. 10.6 • Cutter mill.

Cutter mill

A cutter mill (Fig. 10.6) consists of a series of knives attached to a horizontal rotor which act against a series of stationary knives attached to the mill casing. During milling, size reduction occurs by fracture of particles between the two sets of knives, which have a clearance of a few millimetres. A screen is fitted in the base of the mill casing and acts to retain material in the mill until a sufficient degree of size reduction has been effected, thus it is self-classifying.

The shear rates present in cutter mills are useful in producing a coarse degree of size reduction of dried granulations prior to tableting.

Compression methods

Size reduction range

These are indicated in Figure 10.7.

Runner mills

Size reduction by compression can be carried out on a small laboratory scale during development using a mortar and pestle.