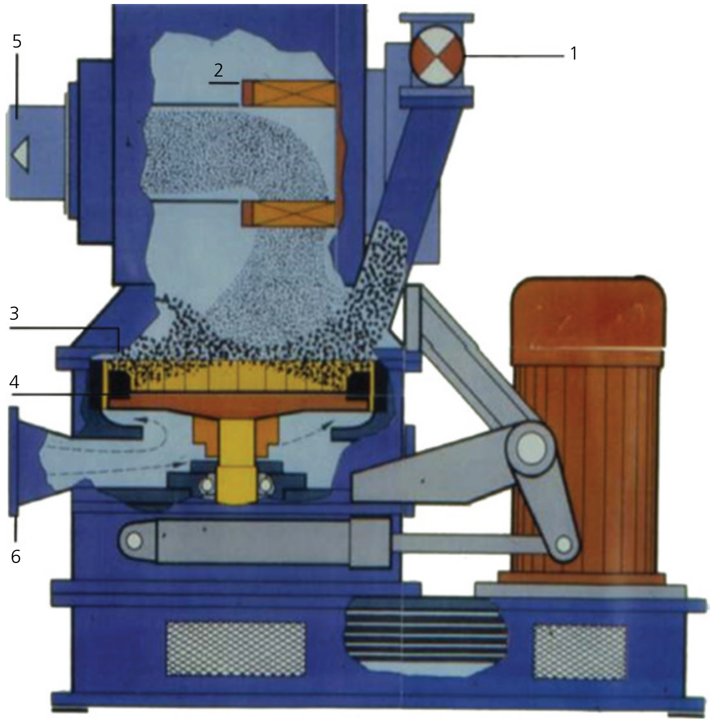

Figure 9.3 Schematic diagram of a classifier mill as manufactured by Hosakawa Micron. (1) Material inlet valve, (2) classifier, (3) milling hammers, (4) milling disc, (5) outlet to cyclones and filter bags, (6) air inlet.

Batch grinding and open-circuit continuous grinding provide little control over product size distribution, other than the "average" size. Closing a continuous grinding circuit with a classifier, or alternating stages of grinding and classification in a batch system, can provide additional control over the product size distribution by reducing over-grinding of product size material. This approach also increases mill capacity and reduces energy requirements and product contamination. Classifier mills have an integrated, internal grinding–classifying circuit. The aim is to prevent over-grinding by the continuous discharge, during grinding, of the product that has reached the desired final size. Larger particles are retained and ground further. Classifier mills are generally not as effective as separate mill and classifier circuits, and are typically limited to dry grinding operations. As fat becomes liquid during grinding, this type of machine is typically used with material with a fat content of less than about 12%, unless cryogenic techniques are applied. A classifier mill which can be used to grind cocoa powder or other low fat ingredients is illustrated in Figure 9.3.

In the design of grinding systems, especially for complex materials and mixtures like chocolate, it is important to recognise that the process may actually serve to perform other functions besides size reduction, for example mixing or surface wetting. These may be deliberate or by accident and may not even be recognised or fully understood. Replacing a mill that is a good mixer with one that grinds more effectively, but provides less mixing action, could have important implications downstream. In other words, while grinding may be an important distinct step in the overall process, it should always be evaluated in the context of other processing steps.

9.4 Cocoa nib grinding

Cocoa nib is ground to cocoa mass for the efficient removal of cocoa butter from within the cellular structure. Cocoa nib is approximately 55% cocoa butter, contained within cells of about 20–30 μm (8–12 × 10^{-4} in) in size (Beckett, 1994). It is the non-fat solids portion of the cocoa cell that must be broken to release the fat. This cell wall material and, more particularly, the cocoa shell and germ are fibrous and tough, so shear is generally required. Final maximum particle size ranges from 15–50 μm (6–20 × 10^{-4} in; by micrometer) and is dictated by the requirements for subsequent use – finer for chocolate manufacture and coarser for pressing. Particles less than 20 μm (8 × 10^{-4} in) will reduce pressing efficiency by plugging the filter, passing through the filter and absorbing excessive amounts of fat (Kuster, 1980).

When cocoa mass is to be incorporated into chocolate, it is advisable to grind nib to the desired end fineness for organoleptic considerations. This assures maximum free fat, minimum viscosity, appropriate texture and flavour. It is difficult to overgrind nib (Niediek, 1994). Shell and germ are particularly difficult to grind, and they cause excessive wear in size reduction equipment. For this reason, effective winnowing is especially important (see Chapter 3). If milling machines are set to adequately size the shell and germ, then the rest of the cocoa structure will be correctly ground (Niediek 1994). Although higher temperatures can be tolerated for nib grinding than chocolate refining, colour and flavour are influenced by high grinding temperatures (Kuster, 1984). Kuster (1980) recommended milling nib to an end fineness 2–5 μm less than the end fineness of the finished chocolate. This is said to reduce subsequent refiner wear, increase refiner throughput and improve finished product flow properties, that is lower viscosity.

Cocoa nib grinding is usually accomplished in at least two steps. Impact mills, for example pin-disc or hammer mills, are typically employed for pre-grinding. The final fineness is achieved using a stirred media mill, corundum disc mill or a three-roll refiner. The high shear of the corundum disc mills and the repeated compressive stress of agitated ball mills make them ideal for tough materials like cocoa nib. Milled cocoa particles appear as small platelets, but also include cocoa starch granules. The latter make up about 7% of the weight of the cocoa mass and from 1–3% of chocolate depending on the cocoa mass content (Schmieder and Keeney, 1980). Cocoa starch granule size varies from 2–12.5 μm (0.8–4.8 × 10^{-4} in; Schmieder and Keeney, 1980), so they could be