11 Crushing and classification

Estimates vary, but it is generally accepted that of all the energy used in the World something like between 1 and 10% is in *comminution*, i.e. the processes of crushing, grinding, milling, micronising, etc. Changing the size of the particles by crushing creates many important industrial products. An example is sugar, which has three different grades: granular, castor and icing; chemically they are the same material the main difference is their particle size. So, grinding followed by *classification* is all that is needed to produce the three different products.

Historically, grinding became a mechanised industrial process with the advent of water and wind powered mills to process wheat, barley. animal feed, etc. The mills used a flat stationary stone with a moving mill wheel revolving on-top. A derivative of this type of mill, an edge-runner mill, can still be found in use today, albeit electrically driven. In old mills classification was important to separate the flour from the husk, this was often achieved by sieving. Modern mills often combine classification and milling within the same device by having an up-draught to carry the finer particles away from the milling section. These are known as air swept devices.

Milling of minerals has been an important part of the recovery of metals and industrial minerals for many centuries. Often a mineral of interest is surrounded by rock of a different type, which may be worthless; i.e. a *gangue* mineral. The grain boundary between the desired mineral and the gangue will be the weakest mechanical point and the most likely to break. Thus, grinding to the *liberation size* will release the valuable mineral so that it may then be separated from the gangue. This is a process that is employed for metal ore mining as well as precious minerals recovery – see the box below Table 11.1. In the table the Moh's scale of hardness is shown. It is based on the mineral lower in the table being able to scratch the mineral above. 'Soft' minerals are 1 to 3, 'medium' are 4 to 6 and 'hard' are 7 to 10. However, the hardness value is entirely arbitrary, it is merely a ranking of the described minerals. The table also includes the Bond Work Index, which is discussed in the next section.

An initial size reduction from material several centimetres in diameter down to one centimetre, or so, is often termed *primary crushing*. This may be followed by further size reduction, *secondary crushing*, and then *pulverising*, or *fine grinding*. The term *micronising* has become popular for the reduction of particle size to this dimension. Thus, coal being fed into a pulverised fuel burner for electricity generation will undergo the first three grinding operations. Primary crushing normally takes place close to the mine head and relies on equipment with very large throughputs, usually having two surfaces approaching and retreating from each other. Examples

Classification is the term for industrially sorting particles into different size fractions or *grades*.

Table 11.1 Moh's scale

Material	Moh's hardness	Bond Work index (kWh ton^{-1})
Talc	1	
Gypsum	2	7
Calcite	3	
Fluorite	4	10
Glass	Scratches above	11
Apatite	5	
Orthoclase Feldspar	6	12
Quartz	7	14
Topaz and beryl	8	
Carborundum	9	26
Diamond	10	

Diamonds are processed by crushing the rock to *liberate* the diamond (hopefully the diamond doesn't crush sometimes it does). One big diamond is worth a lot more than two small ones!

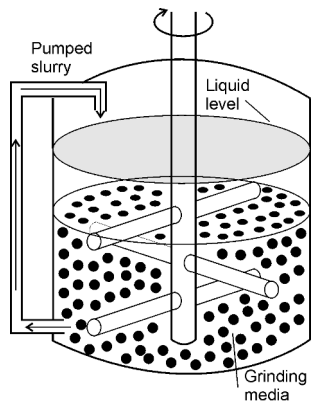

Fig. 11.1 An attritor mill