Figure 24.2 Incremental encoder on a drive shaft.
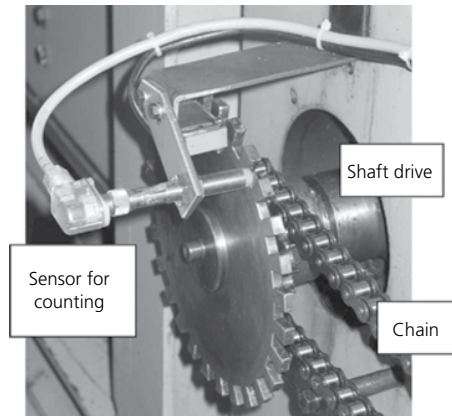

Table 24.2 Typical examples of length/position-based measurements.

	Dimension as example	Typical examples
Dimension		
Length as basic variable,	mm	Effective roll length in a roll mill
Distance	mm	Crown: increase in roll diameter in a roll mill
Gap size	units	Gap between two matched rolls in a roughing mill
Diameter	mm	Diameter of balls in a ball mill
Surface area	m²	Surface area in a heat exchanger
Volume	m³	Volume of air provided for ventilation

in handle angle with time is an indication of variations in throughput in a control loop. Alternatively rotary motions can be monitored for example by attaching an incremental encoder to the drive shaft of a conveyor belt (Figure 24.2). Typical location/position measurements are listed in Table 24.2. Charge couple device (CCD) cameras are often used where two-dimensional information is required. Depending on the measurement task, a CCD linescan or CCD array camera can be used. Triggering ensures undistorted information, which is then converted into an image by a computer system. (see Figures 24.3–24.7).

Imaging methods record specific areas of the product, as well as detecting defects and their type, for example Figure 24.3 (chocolate tablet 1 without defects, chocolate tablet 2 with damage at lower right, chocolate tablet 3 with damage at the upper right). As a further refinement, 3-D sensors can obtain height information for specific locations in order to provide complete spatial imaging of surfaces (see Figures 24.4, 24.6 and 24.7). The principle of operation employed in 3-D sensors is based on triangulation (see Figure 24.5).
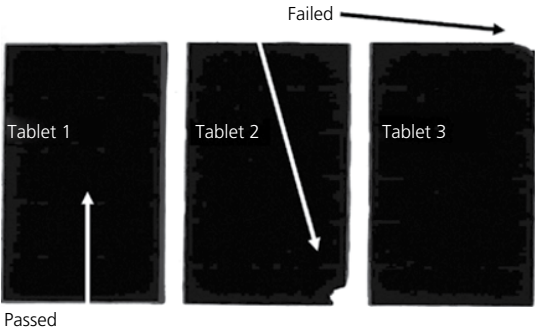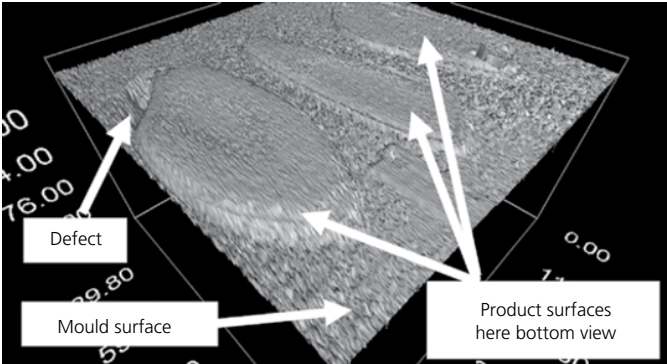
Figure 24.3 Results from a CCD line scan.

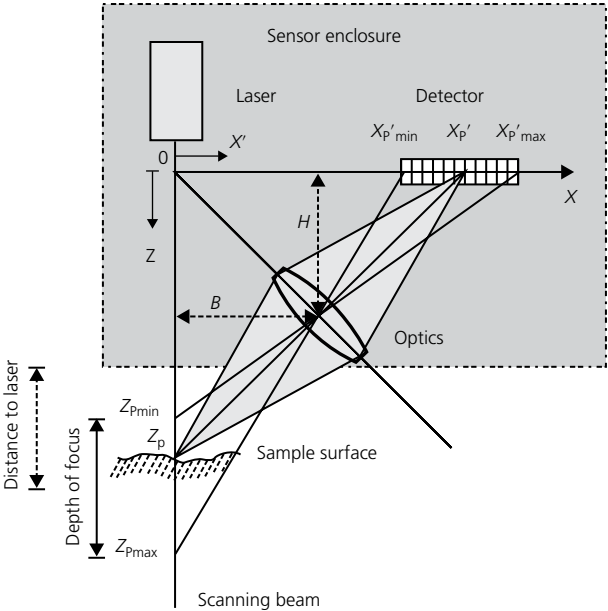**Figure 24.4** Use of a 3-D scanner. Reproduced with permission of Rohwedder AG, Germany.

Figure 24.5 Triangulation. Reproduced with permission of Rohwedder AG, Germany.