even scraping off excess chocolate from the moulds. Further automation was gradually introduced until, during the last quarter of the twentieth century, advances in electronics and automation techniques allowed the number of operators to be reduced to one per plant and sometimes even one between two plants.

At the same time, the metal moulds which were originally used have been replaced by plastic, normally polycarbonate ones, resulting in a significant reduction in noise in the production areas. The easier handling of these lighter moulds has allowed the introduction of automatic mould changers, both for complete changes of moulds and for the removal of individual moulds, which have undemoulded items left in them. Polycarbonate moulds are also more flexible, so they can be twisted to aid demoulding.

Plant speeds have increased from just a few moulds per minute (mpm) to around 70 mpm for solid items, and plant widths from 275 mm to 1800 mm (12–75 in) are now available with capacities of up to 10 000 kg/h (22 046 lb/h). This has all meant that outputs have steadily increased, whereas labour requirements have fallen. In general, reliability has also improved, though some of the earlier automated lines in particular continue to give problems unless heavily modified.

In recent years, although there has been no real "quantum leap" in moulding technology, manufacturers are constantly tweaking their designs to improve the efficiency of the processes. These improvements include easier cleaning and attention to hygiene: (i) construction methods using solid supports to eliminate hollow bodies, (ii) components being installed with a clearance to the floor to allow easy inspection and cleaning underneath and (iii) electric cables being routed away from dirty areas or made easily accessible for cleaning. Wood and plastic cladding have been replaced by clear polycarbonate so that all the components are visible, and leaks and spills can be seen and eliminated. Other improvements are in the areas of flexibility and use of modular lines that can be combined into any configuration to fulfil the requirements of customers and produce different product ranges, upgrades of software and use of wireless mobile control panels to provide more flexibility, quicker changeover to new products with equipment easier to modify and, with increasing emphasis, improving the energy efficiency and sustainability of the processes. One example of this is the reduction of the weight of moving parts by using lighter materials and clever constructions. This has an impact on the energy load and size of the electric motors, leading to lower power consumption.

14.2.2 Loose and fixed mould plants

Fixed mould plants are those with moulds attached to continuous motion conveyors, usually chains, and are well suited to large production volumes. They can reach speeds of more than 70 mpm when moulding solid chocolate and approximately 40 mpm when producing filled articles. Intermittent motion

and crowding (pushing the moulds together to prevent chocolate falling underneath during depositing) are possible for short sections, generally by using hydraulic mechanisms to slacken the drive chains. Fixed mould lines are usually arranged vertically with the return leg from the demoulding to the mould heater being above or below the depositing leg to minimise the area they occupy.

Loose mould plants have a higher degree of flexibility in terms of the variety of products that can be made on one plant (sometimes simultaneously) and in their ability to change from one product to another rapidly. They are linear and modular, and can easily be adapted to users' requirements. The moulds are moved by a variety of chains and conveyors and can switch rapidly from continuous motion to intermittent and vice versa, as required. Modern technology, in particular the servo motor, allows each section to be independently controlled electronically and has revived interest in loose mould plants, as they now have the potential to operate at much higher speeds than lines using older technologies. Conventionally, lines have had one or possibly two central motors with lengthy shafts being used to drive the individual components.

14.2.2.1 Plant layout

Simple loose mould lines are usually laid out in a square, though a figure of eight (8) layout is often adopted to allow sections not being used to be bypassed for cleaning or changeover, or just to save wear and energy. More complex layouts with parallel legs or star shapes around a central cooling zone can be found on ultra-flexible plants used to make a wide variety of assortments (Aasted, 2014). These lines can be built and expanded upwards, crosswise or lengthwise to adapt to the existing production facility. The various components may be independent or combined according to the age and design purpose of the plant. A typical layout of a loose mould line capable of manufacturing filled chocolate bars is shown in Figure 14.1. A picture of the turning point on such a line is shown in Figure 14.2.

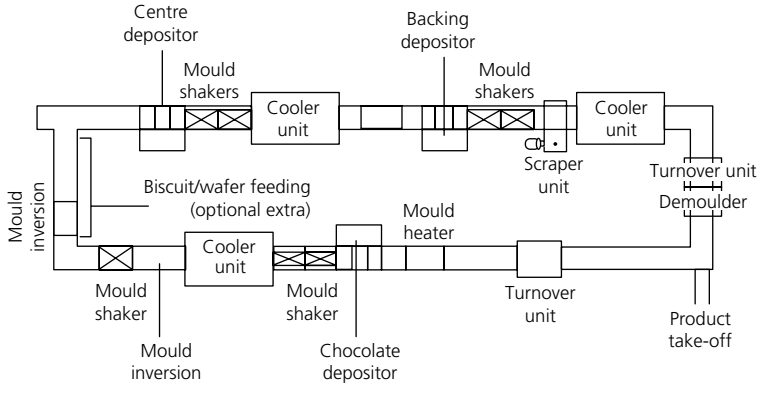

Figure 14.1 Layout of loose mould moulding plant.