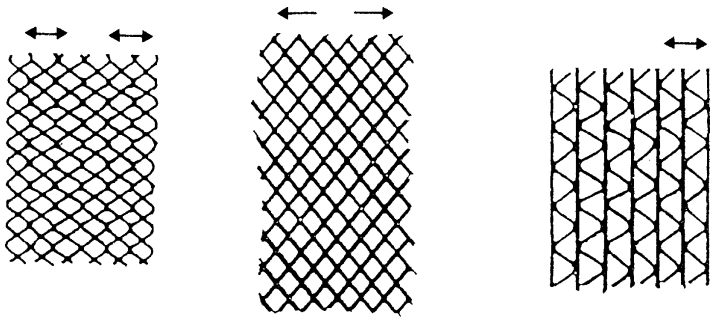

Figure 15.10 Selection of net designs produced by Cadbury (1981) extrusion technique.

being stirred, until it reaches a temperature where the chocolate becomes sufficiently viscous to extrude. Instead of extruding the chocolate through a hole, cooled net-forming dies can be used. The inner and/or outer parts of the die can be rotated or oscillated to give different patterns (see Figure 15.10). This net can be passed over a cooled mandrel to form it into a tube. If this mandrel is hollow, a filling material such as mallow, fondant, fudge or spread can be fed directly into the tube. The tube can be cut as it leaves the mandrel and is passed onto the take-away belt.

The major problem with this type of technology is that the processing conditions, in particular the temperature and the chocolate viscosity, must be very tightly controlled. If the extruded tube is too liquid the tube will collapse and become misshapen. Too thick a chocolate will not extrude properly and may have a rough surface or may crack upon bending.

Sollich GmbH and Co. has also developed a machine to extrude chocolate paste into a stick or rope (Hilker, 1996). The chocolate flow properties are influenced by the fineness of the chocolate and the recipe, but above all by the temperature which must be carefully controlled (see Chapter 11). Tempered chocolate is cooled between the pump and the extrusion nozzle, so that the chocolate rope, being discharged onto a transport belt, has a surface temperature of about 22 °C (72 °F). It is therefore sufficiently viscous to hold its shape but requires a short cooling period before it can be cut. This extruder can produce chocolate products containing solid ingredients with a diameter of up to 1 mm (0.04 in) and which have a smooth surface or have a twisted shape.

The Sollich stick-extruder has been further developed to produce a chocolate mesh. In this machine several extruding heads are located one after the other above a moving belt. The heads are moved backwards and forwards across the width of the belt. When the distance covered by one oscillation of the heads is the same as that of the movement of the transport belt itself, a diagonal pattern of thin chocolate strands is produced. This can then be repeated by a series of subsequent heads to produce a product with a woven-like appearance. The number of strands, together with their diameter, determines the height of the

product. Increased visual impact can be made by extruding different coloured chocolate for the different levels. In addition textural contrast can be achieved by putting wafers, nuts or crispies between the chocolate layers.

As with the Cadbury process, the temperature and chocolate viscosity are critical. Here it is important that each strand be present and be of the same diameter. In order to do this every pipeline from the pump to the extruding head is the same length and temperature. One feed pump is connected to three nozzles, each of which produces five strings. The chocolate mesh is still too pasty to cut cleanly when it is deposited upon the belt but would be very brittle if it were left to solidify fully. An intermediate stage is provided by passing the product for about 4 min through a conditioning tunnel. After this the chocolate mesh is cut using a slitter and guillotine. Final separation and wrapping is carried out after a second cooling tunnel. This process gives very good weight control with individual pieces being within ±2% of each other. Production lines are available which can make product at the rate of 500 kg/h (1100 lb/h).

The above processes depend upon accurate temperature control and use a chocolate that is in a semi-liquid state. An alternative approach, based on processing in the plastics and ceramic industry, was described in Beckett *et al.* (1994). Trials, where the chocolate remained essentially solid throughout the process, were carried out on a laboratory scale. Solid chocolate buttons about 10 mm (0.4 in) in diameter and 3 mm (0.1 in) in thickness were fed into a Florin ram extruder (see Figure 15.11). The extruder and chocolate were at an ambient temperature of 23 °C (73 °F). The extruder initially compacted the chocolate before extruding it in the form of a rod or tube. The extruded chocolate had no detectable temperature rise, so the processing was essentially iso-thermal and was called "cold" extrusion. It was found that a continuous uniform extrudate could be obtained

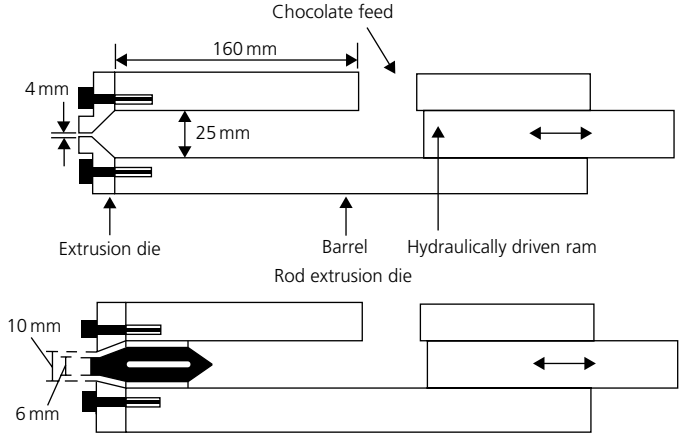

Figure 15.11 Schematic diagram of the "Florin" ram extruder when used to produce rods and tubes (Beckett *et al.*, 1994).