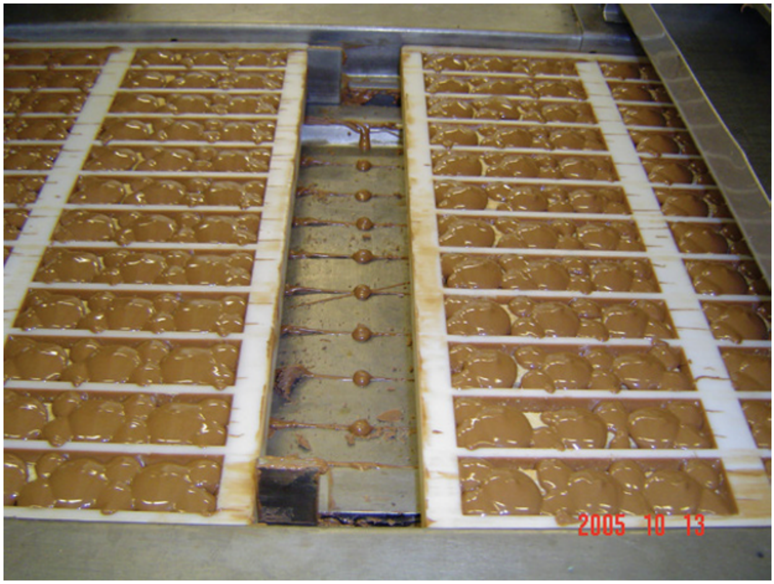

Figure 14.8 Deposit backing off. Chocolate deposited onto back of shell moulded bar with light coloured filling, prior to being shaken.

14.2.10 Cooling

When cooling and then crystallising any fat-containing product, heat has to be removed from two sources (Cruickshank, 2005):

- *Specific heat* has to be removed to cool it.
- *Latent heat* is given out when the fat crystallises and, as can be seen below, this is the more significant of the two, when solidifying chocolate.

Specific heat of fat	2.0 J/g°C
Latent heat of crystallization of fat	157 J/g
Specific heat of milk chocolate	1.6 J/g°C
Latent heat of crystallization of milk chocolate	44 J/g

(See "Useful Physical Constants", at the end of this book).

To cool 1 g of fat from 28 to 12 °C (from 82 to 54 °F) requires the removal of 32 J (specific heat of 2 J/g °C over a temperature drop of 16 °C), whilst 157 J will need to be removed due to crystallisation (latent heat of 157 J/g). Conduction or contact cooling is the most efficient because of the intimate contact with the product. Forced convection is the next most efficient form of cooling for enrobed products since the top and sides of the product are in the air stream. This is analogous to "wind chill" and high-velocity air aids cooling. Radiation, the third method of heat extraction removes a much smaller amount of heat.

The need to crystallise fat as small crystals in Form V limits the rate of cooling that can be applied. Low cooling temperatures or short cooling times, give less stable polymorphs such as Form IV and can result in a lack of stability and poor contraction (see Chapters 7 and 13). Some recipe factors such as the proportion of butterfat and the presence and type of vegetable fat (where legally allowed) will affect the maximum allowable cooling rate. These ingredients both have the potential to reduce the crystallisation rate of Form V, and therefore longer cooling times will be required. Other factors that must be considered during cooling are the rate of heat conduction (i.e. large chocolate bars will need longer cooling times), and the level of temper in the chocolate which will have an effect on contraction.

14.2.10.1 Intense cooling

Intense cooling is sometimes necessary when depositing a hot centre, for example a caramel, at 55–60 °C (131–140 °F) into a chocolate shell. An intense shell cooler will prevent the centre from melting or de-tempering the chocolate. Typically the shell is cooled to 10 °C (50 °F) prior to depositing the centre. Cooling continues immediately after depositing to ensure that the chocolate remains undamaged.

14.2.10.2 Cooler zoning

Older coolers tend not to be zoned, having one source of cold air that has to be directed in such a way as to optimise cooling, whereas the more modern ones usually have at least three temperature zones:

Zone 1 – Specific heat removal with temperature settings of 12–15 °C (54–59 °F), and typically about 5 min residence.

Zone 2 –Most of the latent heat is removed. It tends to be released suddenly as crystallisation sets in. Typical temperatures are between 7 and 10 °C (45 and 50 °F) for 10–20 min. Although, if tunnel length and throughput permit, a temperature of 10 °C (50 °F) is to be preferred for better quality crystallisation. Very large tablets can require up to 30 min cooling.

Zone 3 – The product is warmed to just above the dew point of the packing room prior to exiting. The dew point is the temperature at which moisture begins to condense from the surrounding air and this would damage the chocolate surface and cause marks or sugar bloom. (Sugar bloom has an appearance similar to fat bloom, but is actually sugar crystals on the surface. Unlike fat bloom it does not melt under warm conditions.) The actual dew point can be measured using a wet and dry bulb thermometer in conjunction with a psychrometric chart. Times are typically the same as Zone 1 though temperatures may be slightly higher.

Dark or low butterfat milk chocolates can be cooled at temperatures 2–3 °C (3.5–5.5 °F) higher than those given above.

In a cooler, the air speed needs to be high enough to give a turbulent flow across the moulds, which is generally agreed to occur once it has reached 5 m/s (990 ft/min). Air should not blow directly onto the chocolate as it can cause ripples to form on the backs. Older coolers that use cold plates to cool and have low