9 Savings in fat (cocoa butter) were documented to take place because of the higher temperature of the chocolate at use.

The operation of the APV Baker tempering machine was as follows (Figure 13.16). A high-pressure metering pump took de-seeded chocolate from bulk storage and metered it into the first zone of the tempering machine. This zone was filled with Archimedes mixing discs mixing and spreading chocolate in a prescribed continuous path from the centre of the machine to the outside and back again. At the same time the chocolate progressed upwards through the machine due to the pumping action of the discs. During the passage through this first zone, sensors regulated the chocolate temperature. At the end of the first zone, at approximately 27 °C (81 °F), chocolate seeding was initiated, giving rise to very fast and fine crystal growth. If this state was allowed to proceed solidification would result.

On entering the second zone the transition from the unstable crystalline states to the β_V form took place and a natural temperature rise of 2 °C (3.6 °F) was observed. This "transition" is not seen in other machinery and is the early stage of maturing to the more stable crystal form. As the chocolate, now being rewarmed, progressed within the second zone it was intensively mixed. This shear, together with the time element, provided the necessary maturation conditions required to produce a more highly tempered chocolate. This zone had a retention time of 12–20 min, depending upon flow rate.

The next part of the machine was a disc-type heat exchanger which was capable of precisely controlling the exit temperature. This machine could handle the most difficult eutectics as well as, of course, the easier recipes. The ACS temperer filled the dual role of feeding enrober plants or moulding systems. As mentioned earlier, this machine recognised the *latent heat temperature rise* in the retention zone by sensor probes, and could be pre-set to attain a pre-determined cooling curve. Although highly tempered, this chocolate exhibited a higher melting point and a lower viscosity, with the temper cooling curve showing a higher than normal (temperature) inflection point.

13.6.3 Continuous industrial seed-tempering

13.6.3.1 Summary of the principles

In conventional tempering, the crystal seeding is performed by scraping seed crystals from a cooled wall. Whereas these needle-like seed crystals are in a semi-stable polymorph form (mostly α-form), a new methodology has been developed in the past ten years of seeding by continuously adding pure, fully matured β_{VI} or $\beta_V + \beta_{VI}$ cocoa butter seed crystals in concentrated suspension into temperature controlled, untempered chocolate. Currently commercial industrial temperers based on this principle (Seed Master tempering machines) are manufactured by Bühler AG of Switzerland.

Control of crystallisation processes by seeding is used commercially to make many different products, for example sugars (Kleinert, 1980), vitamins, drugs

(Bollinger *et al.*, 1998) and fine chemicals (Cebula *et al.*, 1991). The idea of seeding chocolates with well defined crystals has also been reported in a number of scientific and patent applications either based on specific cocoa butter crystals (e.g. Windhab and Zeng, 1998;, Bollinger *et al.*, 1998; Pate, 1983; Dieffenbacher, 1986) and a system based on BOB (1,3-behenoyl, 2-oleoylglycerol) seeding, which is used in Japan, but is not legal in most other countries. Such seed crystals are added to the chocolate in crystal powder form, or by the confectioner's "artisan methodology" (Chapter 18) of adding small amounts of solid chocolate pieces/powders into an untempered chocolate melt. The use of the former seeding concepts for continuous industrial chocolate manufacture was not significantly implemented, since they did not have the consistency or robustness to fulfil one or more of the following required aspects:

1 Good control of the tempering state with respect to resulting polymorph distribution;
2 Stable active seed crystal fraction and seed crystal size distribution;
3 Homogeneity of seed distribution;
4 Thermal stability of the seed
5 A method of handling continuous seed powder dosing and homogeneously mixing it into a chocolate stream.

Many of these problems are overcome by adding the seed (containing a majority of β_{VI} crystals) in a concentrated suspension within liquid cocoa butter. The seed crystal suspension containing cocoa butter crystals is continuously added to the pre-cooled chocolate stream in quantities from 0.2 to 1.0% and homogeneously mixed using a specially designed static mixer system. The cocoa butter seed crystal concentration in the seed suspension is fixed between 15 and 25%wt with a β_{VI} fraction between 50 and 95%. This gives the possibility to pre-crystallise and further process the chocolate at temperatures of at least 3–4 °C (5–7 °F) higher than in conventional tempering technology (depending the fat matrix of the confectionery product), leading to an improved processability during moulding and enrobing. Other advantages include improved fat bloom stability, accelerated solidification, ability to crystallise mixtures of vegetable fats and cocoa butter down to only 10% of cocoa butter fraction and diminishing the crystallisation-inhibiting effects of added milk fat or other fats without reducing their positive contribution to support anti-bloom.

These advantages are based on the fact that stable cocoa butter crystals are externally generated and introduced into the various chocolate and chocolate like systems in suspended form with:

1 Controlled polymorph distribution (preferably with a fixed β_{VI} fraction in the range 50–95%);
2 Controlled seed crystal size/size distribution (adjusted by the degree of shear treatment and residence time in the seed crystal suspension processing within a mean crystal size range of about 2–10 microns);