3 A controlled fraction of active seed crystals (0.02–0.15% crystals is equivalent to 0.2–1.0% suspension per total chocolate masse) by precise dosing and micro-homogeneous mixing of the seed crystal suspension into the chocolate.

Consequently a large number of nuclei controlled with respect to these three aspects is present in the seed tempered chocolate, providing the basis to form a dense and finely structured fat crystal network with fast solidification kinetics.

It has been found that the triclinic crystalline structure of the $\beta_{VI}$ seed crystals makes the chocolate solidify in the triclinic $\beta_V$ state, if the cooling and solidification kinetics is faster than that of a $\beta_V \rightarrow \beta_{VI}$ polymorph transformation (Mehrle *et al.*, 2007). This condition can easily be fulfilled, because in the chocolate the $\beta_V \rightarrow \beta_{VI}$ transformation may take from about 30 min to several hours, even at an elevated temperatures of 32–33 °C (90–91 °F).Typical industrial cooling conditions [10 °C (40 °F) for 20 min] produce an insignificant amount of additional $\beta_{VI}$ crystal fraction. This is what is needed, however, because the $\beta_V$ solidification provides the desirable smooth texture and melting, and avoids a waxy mouthfeel that is commonly associated with the $\beta_{VI}$ state.

### 13.6.3.2 Industrial seeding process

These principles have been applied by Bühler AG in its industrial-scale SeedMaster Compact®.

This essentially consists of two stages. One part produces the so-called cocoa butter crystal suspension (CBCS), whereas the other is related to the chocolate masse stream, the dosing unit of the CBCS into the chocolate matrix and, finally, the mixing element to ensure homogenous outcome. The core process is the production of the CBCS and it takes place in a shear crystalliser which is divided into two cooling zones that are necessary for the nucleation, growth and transformation of the stable crystal modifications (Figure 13.17). In practice, low temperatures are applied in the first zone [15–18 °C (58–64 °F)] in order to initiate nucleation and growth of crystals. The second zone is critical for the transformation and stabilisation of the final cocoa butter crystal suspension. Usually the temperature of this particular zone lies somewhere between 20 and 28 °C (68–82 °F). The cocoa butter is circulated through the shear crystalliser and on average it takes about 30–50 min for the CBCS to stabilise in the right crystal form and concentration. This CBCS usually consists of 15–20% of the stable crystals.

As soon as the CBCS is stable, the seeding process is started. The chocolate stream is cooled down in heat exchange plates to temperatures that do not initiate crystallisation [approx. 30 °C (86 °F)]. An accurate dosing pump adds an exact amount of CBCS into the chocolate masse whilst specially designed static mixer elements ensure homogenous mixing (Figure 13.18).

The quality of the CBCS is critical for the performance of the end product and a specially designed measuring tube in the shear crystalliser circuit gives online monitoring and regulates the process (Figure 13.19).

**Figure 13.17** Shear Crystallizer in the interior of SeedMaster Compact®. Reproduced with permission of Bühler AG, Switzerland.

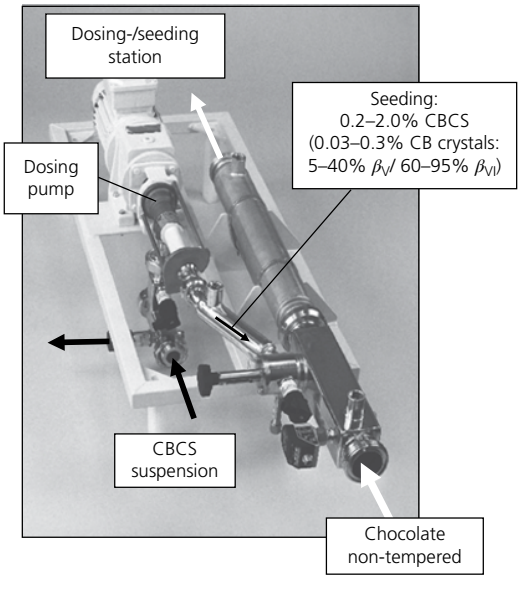


**Figure 13.18** Seeding station for dosing/mixing of CBCS into an untempered chocolate stream. Reproduced with permission of Bühler AG, Switzerland.