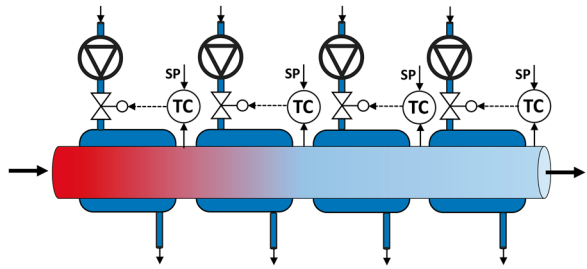

Figure 4.3 Schematic illustrations of a multi-segment plug-flow crystallizer and control loops for cooling crystallization.

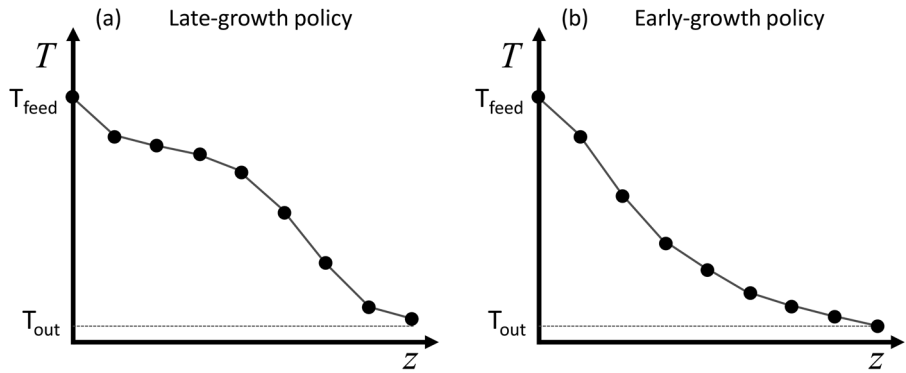

Figure 4.4 Schematic illustration of so-called early-growth (a) and late-growth (b) temperature profiles.

transferred to continuous crystallization if plug-flow behaviour is approximated. For unseeded operation, sufficient cooling should be provided in the first zone to trigger nucleation if alternative actuators for nucleation or seeds are not available at the inlet of the crystallizer. In general, the set points of the remaining temperature control loops can be designed in two opposite ways (see Figure 4.4 for schematic illustrations). One option is to provide slow cooling at the beginning of the cascade and rapid cooling at the end (so-called late-growth policy), which aims to align the generation of supersaturation with the growth of the total crystal surface area in the system (see Figure 4.4a) such that a constant supersaturation over the length of the system is achieved. Alternatively, a so-called early growth policy can be promoted, which is enabled by fast cooling in the beginning (see Figure 4.4b). Such a natural cooling curve is easier to implement, as it needs a large driving force for cooling when temperature is high. Therefore, a single temperature control loop could be used and temperature control for different zones is strictly speaking not needed. A disadvantage of using a single temperature control loop is the increased possibility for fouling and encrustation, which is a practical problem for tubular crystallizers for cooling crystallization with a relatively large temperature difference between