All these processes, *i.e.* reaction-, precipitation- and drowning-out-crystallization, require the mixing of two educt streams. As well in batch, semi-batch and continuous operation, this mixing step is often crucial for the quality of the product, see below.

6.4.4 Importance of Mixing and Classification

Two aspects of mixing have to be considered. One is that of mixing two educts to react with each other on the molecular level (meso- and micro-mixing). The other aspect is that of macro-mixing of the crystallizing solids in the crystallizer volume. This aspect is well known from chemical reaction technology.[41]

Solids in a continuous crystallizer may be ideally well mixed. Then the crystallizer does not exhibit spatial variation of the solids content or of the crystal size distribution. Furthermore, the exit stream may be representative. This means that the product in the crystallizer is identical in composition and particle size distribution to the product in the exiting product removal line. Typical types of such well mixed apparatuses are the ideally mixed stirred vessel and the ideally mixed forced circulation crystallizer. In principle, they are the same. Note: It is not at all an easy task to design a crystallizer (laboratory or production) for representative product removal.

In terms of macro-mixing, the other extreme of a crystallizer is an idealized plug-flow crystallizer, where all volume elements in the crystallizer exhibit the same distinct residence time. The residence time distribution is (infinitively) narrow. Typical apparatuses would be a pipe in full turbulent flow regime, a pipe with slugs of suspension segmented by an immiscible fluid (air, oil), or a cascade of an infinite number of well mixed crystallizers. All of them help in narrowing the time distribution available for the growth of the crystals. One principal problem of continuously operated plug-flow crystallizers is nucleation. If not seeded, then the locus of nucleation in such a crystallizer is not well defined. At the entrance of such an apparatus a high supersaturation builds up or already exists and gives rise to uncontrolled nucleation and in many cases to incrustation of the crystallizer internals.[42] Note: It is not at all an easy task to design a plug-flow crystallizer for no-slip between the solid and the solution. Only at no-slip are the residence time of the crystals and the solution the same.

Currently, an intense discussion takes place about the prerequisites which have to be fulfilled for making a continuously operated plug-flow crystallizer a reasonable alternative to a continuously operated well-mixed crystallizer. Besides the nucleation issue addressed above, the required residence time for crystal growth is also an issue. Eqn (6.2) holds for the plug-flow configuration, too. The required crystallizer volume, which for a given