

the bubbles move forward gradually and leave the DN15 crystalliser. As a result, a few visible bubbles in DN15 are as normal as those in industrial batch crystallisers.

It should however be stressed that when bubbles coalesce to form a gas layer at the top of the DN15 crystalliser due to either the boiling point of a particular solvent being lower than the operating temperature or the gas volume fraction exceeding the operational boundary in COBC (Section 3.7), this would severely affect the propagation of the oscillation wave and in turn the mixing, as well as crystallisation. Bear in mind that this is the extreme case, either a new solvent or elevated pressure operation is required (see Section 3.6 for more details).

3.4.1.5 Generic Comments

From the above example and operational principles, the following advantages of continuous crystallisation can be drawn:

- a) Fluid mechanical conditions (mixing is one element of these) are consistent once plug flow is achieved;
- b) Heat transfer is enhanced, since there is no mixing or concentration gradients;
- c) The increased specific surface areas allow any type of cooling profiles to be readily implemented;
- d) Crystallising solution goes through the COBC in a one pass fashion and harvesting crystals, such as by filtration and drying, can also be done continuously;
- e) There is no accumulation or storage required, avoiding the potential of entrapping impurity;
- f) All the above can be obtained in lab, pilot and full scales.

Crystallisation was singled out in 2005 by NiTech as the platform process for NiTech continuous technology; a large number of organic (some inorganic) chemicals, pharmaceuticals, speciality and food compounds have since been tested using NiTech DN15 series, covering a wide range of solubility and crystal shapes; the consistent outcome is that it works and delivers the above benefits when operated correctly (See Section 3.5.4) and within the operational boundary of DN15 (See Section 3.7).

3.5 What Has Been Done?

3.5.1 Cooling Crystallisation

3.5.1.1 Unseeded Cases

Nucleation is the very first step of the crystallisation process when the first nuclei appear from the solution that is supersaturated. Considering the solubility diagram in Figure 3.11, it is certain that nucleation won't