Crystallizer

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Crystallization

- Formation of solid particles within a homogeneous phase
  - Formation of solid particles in a vapor
  - Solidification of liquid melt
  - Crystallization from liquid solution

Importance

Its wide used has two fold basis

- A crystal formed from an impure solution is itself pure
- Affords a practical method of obtaining pure chemical substances in a satisfactory condition for packaging and storing

Magma

- The two-phase mixture of mother liquor and crystals of all sizes

Nucleation

- In the formation of crystal two steps are required:
  - The birth of a new particle and
  - Its growth to macroscopic size

-the first step is called ***nucleation***

Nucleation cont…

- The number of new particles formed per unit time per unit volume of magma or solids-free mother liquor
- This quantity is the first kinetic parameter controlling the ***crystal size distribution*** (CSD)

Importance of CSD

- Reasonable size and size uniformity are desirable for further processing
  - Filtering
  - Washing
  - Reacting with other chemicals
  - Transporting
  - Storing the crystals

- **CSD** is the prime objective in the design and operation of crystallizers

ΔL Law of Crystal Growth

- Major Assumptions
  - There is no nucleation
  - Every particle grows through the same increase in linear dimension

ΔL Law of Crystal Growth

- If all crystals in magma grow in a uniform supersaturation field and at the same temperature and if all crystals grow from birth at a rate governed by the supersaturation, then all crystals are not only invariant but also have the same growth rate that is independent of size

- **Equation:**

$$L_p = L_s + \Delta L$$

ΔL Law of Crystal Growth

$$m_p = \acute{\o}\rho L_p^3 = \acute{\o}\rho\,(L_s + \Delta L)^3$$

$$m_s = \acute{\o}\rho L_s^3$$

Which combine to give

$$\mathbf{m_p = m_s\,(1 + \Delta L/L_s)^3}$$

(for the entire crystal mass)

ΔL Law of Crystal Growth

- For differential parts of the crystal masses

$$\int_0^{m_p} dm_p = \int_0^{m_s} \left(1 + \frac{\Delta L}{L_s}\right)^3 dm_s = m_p$$

Problem

- A solute that form crystals is to be precipitated from solution at a rate of 10,000Ib of solid (dry basis) per hour using 1,000Ib/hr of seed crystals. If no nucleation occurs and the seed crystal have the following size distribution, determine the product size distribution

Problem

Tyler Sieve Mesh	Weight Fraction Retained
-48+65	0.10
-65+100	0.30
-100+150	0.50
-150+200	0.05
-200+270	0.05

Reference

- Foust *et al*: **Principles of Unit Operations**, second edition
- McCabe & Smith: **Unit Operations of Chemical Engineering,** fifth edition