Mixed Suspension Mixed Product Removal Crystallization (MSMPR)


Ashfaq M Ansery
Lecturer, ChE Deptt
BUET



MSMPR Crystallizer

- An idealized crystallizer model
- Served well as a basis for identifying the **kinetic parameters** and showing how knowledge of them can be applied to calculate the **performance** of such a crystallizer

Assumptions

- Steady state operation
- At all times the crystallizer contains a mixed-suspension magma, with no product classification
- At all times uniform super saturation exists throughout the magma
- ΔL law applicable

Assumptions cont…

- No size-classified withdrawal system is used
- No crystals in the feed
- The product magma leaves the crystallizer in equilibrium, so the mother liquor in the product magma is saturated
- No crystal breakage into finite particle size occurs

Interpretation

- Constant nucleation rate at all points in the magma
- Constant growth rate and independent of crystal size and location
- All volume elements of mother liquor contain a mixture of particles ranging in size from nuclei to large particles
- Particle size distribution is independent of location in the crystallizer and is identical to the size distribution in the product

Population-Density

- Basic quantity in the theory of the Crystal Size Distribution
- The population density *n* is defined as the slope of the cumulative distribution curve (*N/V vs. L*) at size L

Population-Density cont..

N → no of crystals of size L and smaller in the magma

V → volume of mother liquor in the magma

L → crystal size

at $L=0,\ N=0$

$L=L_T,\ N=N_T$

Cumulative Distribution Curve

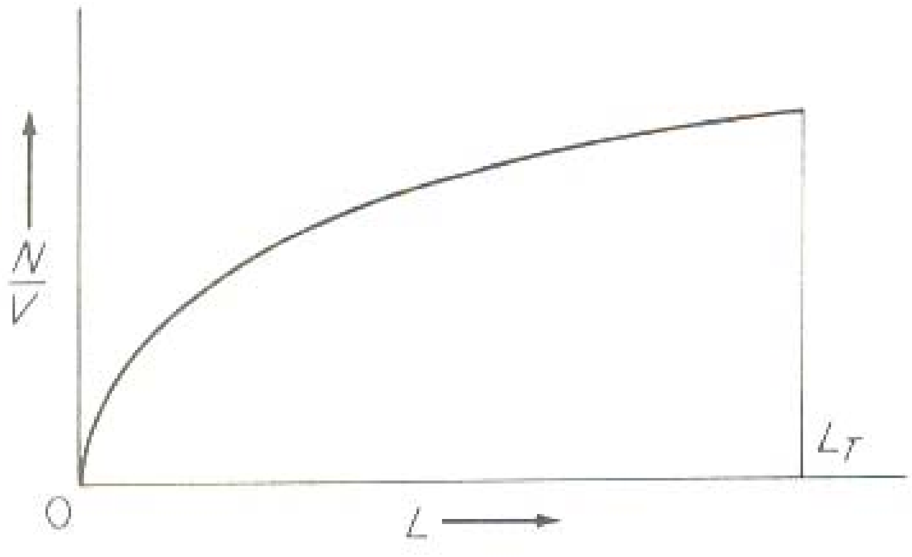


FIGURE 27.14
Cumulative number density vs. length.

Population-Density cont..

$$n \equiv \frac{d\left(\frac{N}{V}\right)}{dL} = \frac{1}{V}\frac{dN}{dL}$$

at L=0, $n=n^0$

at $L=L_T$, n=0

- n Ξ function of L and invariant in both time and location in the magma
- Dimensions of *n*:

Number/Volume-Length

Fundamental Relation of the MSMPR Crystallizer

$$n = n^o e^{-z}$$

where

$$z \equiv \frac{L}{G\tau}$$

Population Density vs. Length

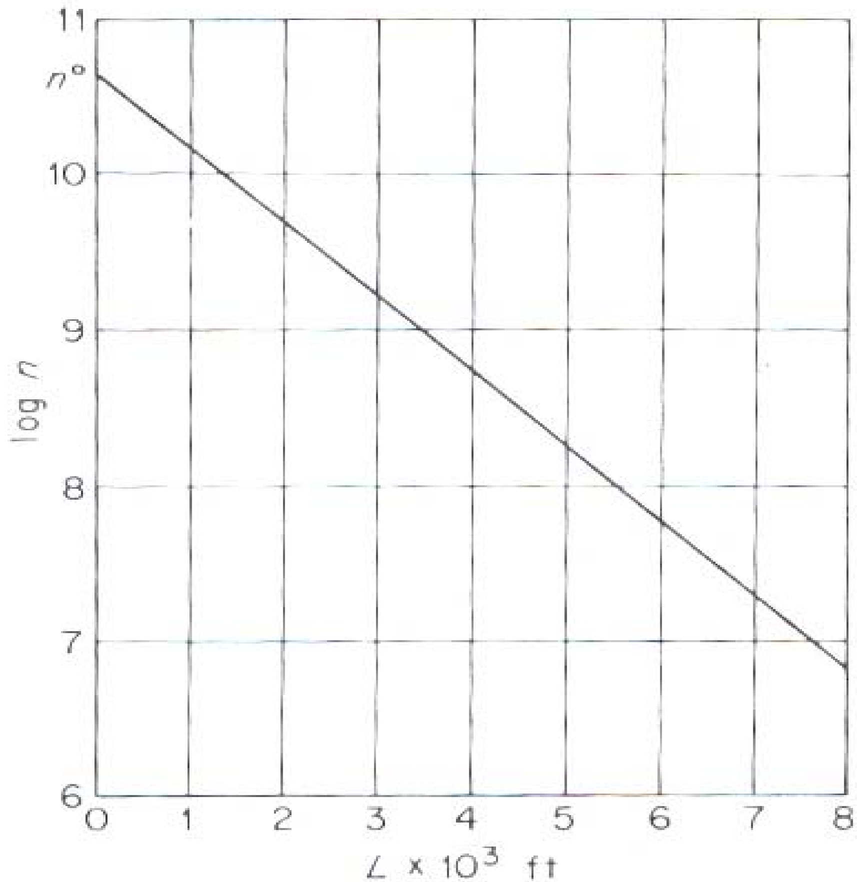


FIGURE 27.16
Population density vs. length (Example 27.6).

Moment Equations

- The normalized *j*th moment is defined by

$$\mu_j \equiv \frac{\int_0^z n z^j \, dz}{\int_0^\infty n z^j \, dz}$$

Moment Equations cont..

- Integrating for values of *j*=1 through *j*=3 gives

$\mu_0 = 1 - e^{-z}$ → number

$\mu_1 = 1 - (1 - z)e^{-z}$ → Size

$\mu_2 = 1 - (1 + z + \tfrac{1}{2} z^2)e^{-z}$ → Area

$\mu_3 = 1 - (1 + z + \tfrac{1}{2} z^2 + 1/6\, z^3)e^{-z}$ → Mass

Moment Equations cont..

- The differential distributions are

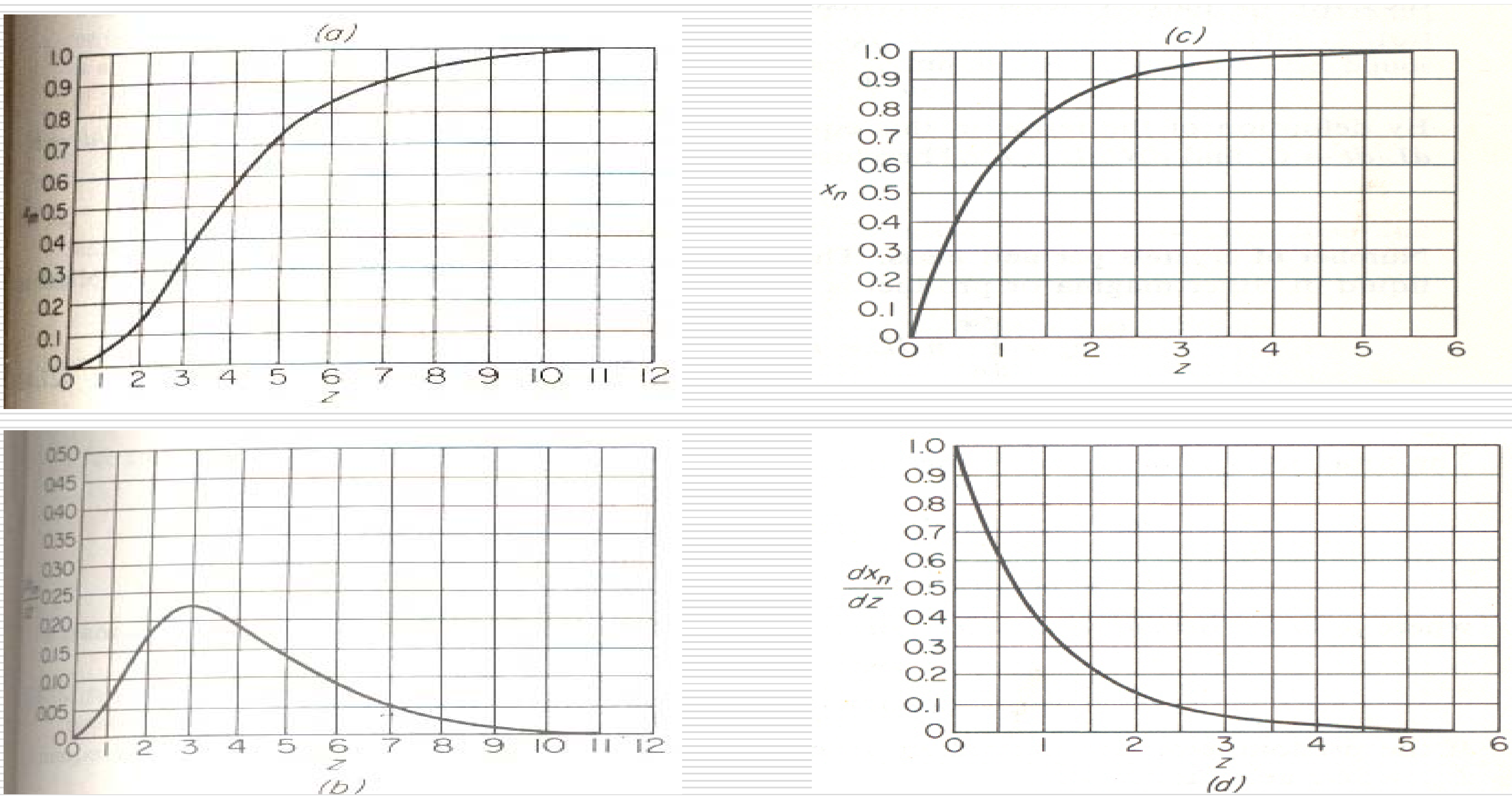
$$\frac{d\mu_0}{dz} = e^{-z}$$

$$\frac{d\mu_1}{dz} = ze^{-z}$$

$$\frac{d\mu_2}{dz} = \frac{z^2 e^{-z}}{2}$$

$$\frac{d\mu_3}{dz} = \frac{z^3 e^{-z}}{6}$$

Size Distribution Relations



Predominant Crystal Size

$\mu_3 = 1-(1+z+\frac{1}{2} z^2 + 1/6\, z^3)e^{-z}$ $\longrightarrow$ mass distribution x_m

$$\frac{d\mu_3}{dz} = \frac{z^3 e^{-z}}{6}$$

at maximum $$\frac{dx_m}{dz} = 0$$

$$-z^3e^{-z} + 3z^2e^{-z} = 0$$

$$z = 3$$

$$\text{i.e. } z_{pr} = 3$$