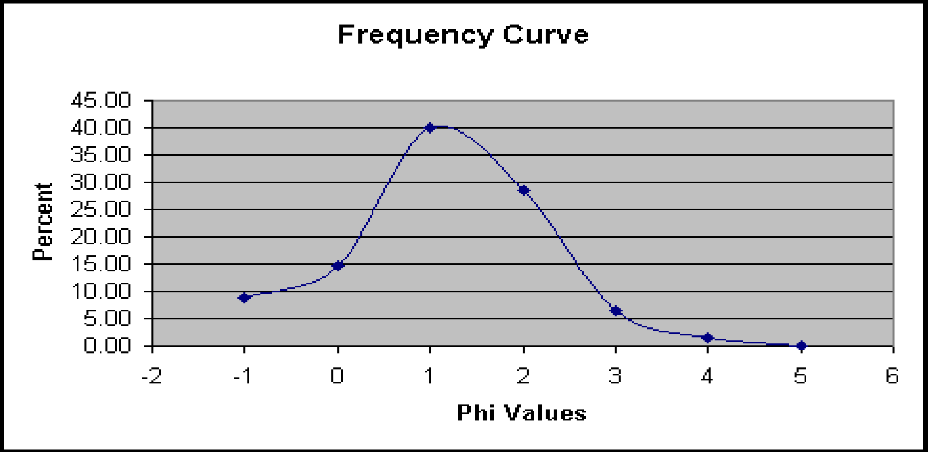
Fine Particle-Size Distribution



Ashfaq M Ansery
Lecturer
ChE Department, BUET

Limitations

Screen analysis

- cannot be made to determine particle size distribution below 0.0015 inch
- are unsatisfactory below 0.003 inch

- Calculational methods have been developed to estimate the fine particle size distribution

Calculational Methods

$$\frac{-dx}{d\overline{D_P}} = a(\overline{D_P})^k$$

Integrating gives

$$x = \frac{-a}{k+1}\overline{D_p^{k+1}} + b$$

Calculational Methods cont..

- Logarithmic fractional distribution plot should show a **straight line** relationship in the fine particle region

Example

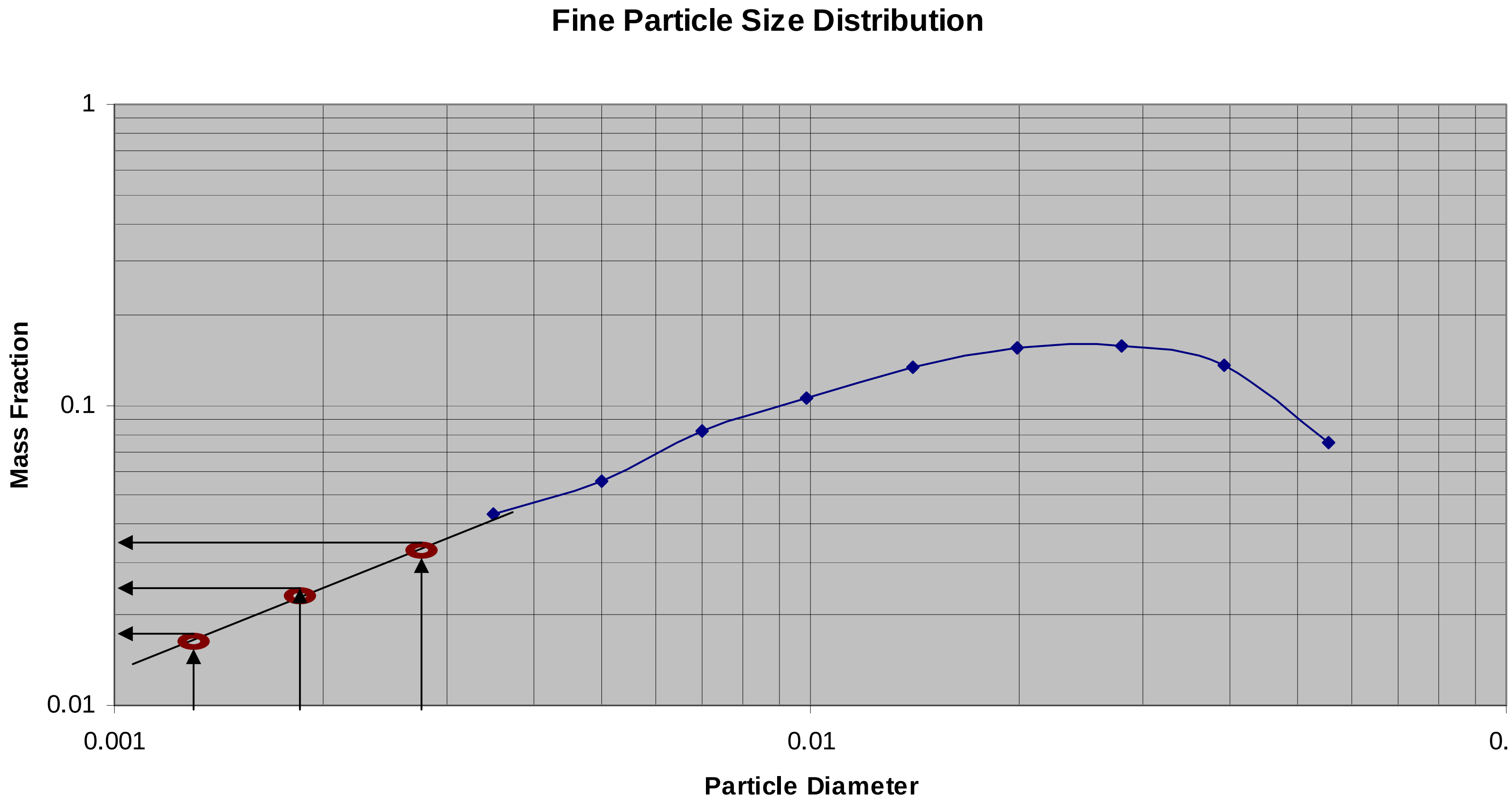
Tyler Mesh	Wt. fraction	D_p, inch
-10+14	0.075	0.0555
-14+20	0.136	0.0394
-20+28	0.158	0.0280
-28+35	0.154	0.0198
-35+48	0.133	0.0140
-48+65	0.106	0.0099
-65+100	0.082	0.0070
-100+150	0.056	0.0050
-150+200	0.043	0.0035
200	0.057	

Example cont…

Question:

- Complete the screen analysis by determining the size distribution in the -200 mesh cut

Solution



Fine Particle Size Distribution
1
0.1
0.01
Mass Fraction
0.001
0.01
0.1
Particle Diameter

Results

- The results are

D_p, inch	Wt Fraction	Adjusted Wt Fraction
0.0025	0.032	0.032
0.00175	0.023	0.023
0.00124	0.017	0.002
	0.072	0.057

Sampling

- Errors arising because of poor sampling can be greater by manifold than those that occur because of
  - insufficient care in timing the fall of a particle in a liquid phase
  - poor calibration of microscope
  - inefficient screening

Problems in Particulate Solids

- The problem is aggravated in the case of particulate solids because of the tendency of these materials to classify themselves
- Unlike a liquid phase, a solid phase cannot always be remixed by agitation because of the delicacy of the products

Sampling Methodology

- Manual Splitting
- Mechanical Splitting

Manual Splitting

- Piled in a uniform pyramid
- Quartered by drawing a cross through the peak of the pile and separating the four segments
- The process is repeated with any one of the four segments
- Successive steps finally result in a sample of the desired size

Mechanical Splitting

- Mechanical splitting is done with the help of a splitter
- The device is made of many parallel equally spaced thin metal walls
- The walls form the sides of chutes that alternately discharge to the right and left sides of the splitter

Mechanical Splitting cont…

- A material poured into the top of a splitter will form two separate and identical piles
- One of the piles is then discarded and the other retained
- Successive splitting will result in a uniform small test sample

Analytical Representation of Particle-Size Distribution

- Analytical Distribution Expression
- Mean Diameter Expression

Analytical Distribution Expression

- The normal distribution function expresses the frequency of occurrence of a value as a function of its deviation from a most common value when the deviations result from purely random effects

Example

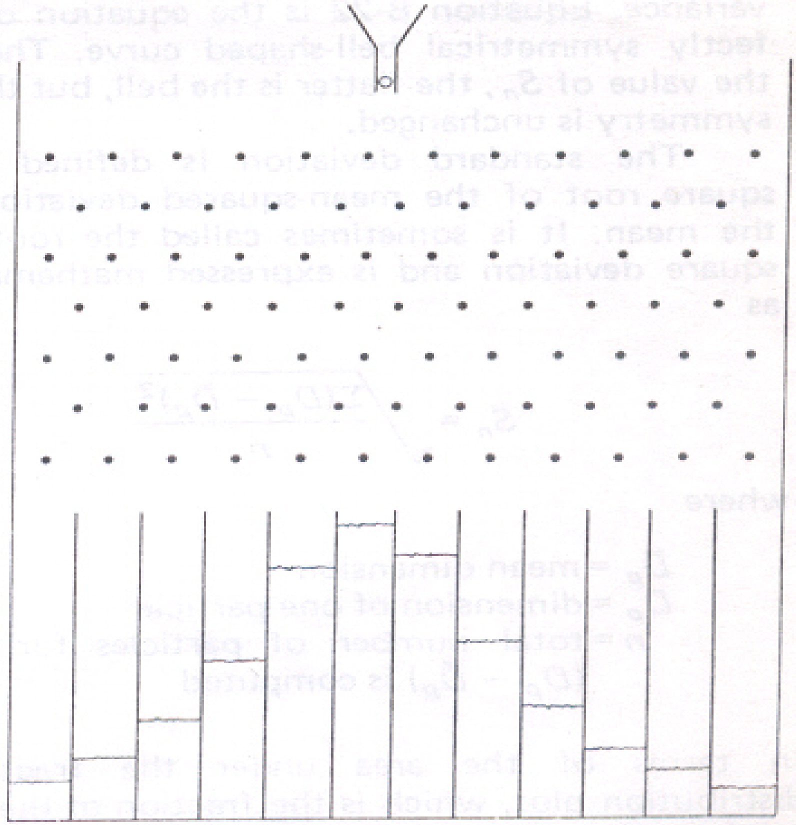


Figure B-8. Random-distribution experiment.

Example

- Pins are placed in a regular pattern above a series of evenly spaced slots
- Marbles are dropped one by one onto the top row of pins at the center
- The marbles bounce from pin to pin in a purely random way and enter the bottom slots

Normal Probability Function

$$\frac{dn}{dD_p} = f(D_p) = \frac{1}{S_n\sqrt{2\pi}} e^{-(D_p - \overline{D_p})^2 / 2S_n{}^2}$$

S_n= Standard Deviation, measure of the dispersion of the value

$S_n{}^2$=variance

Particle Size Distribution on Probability Coordinates

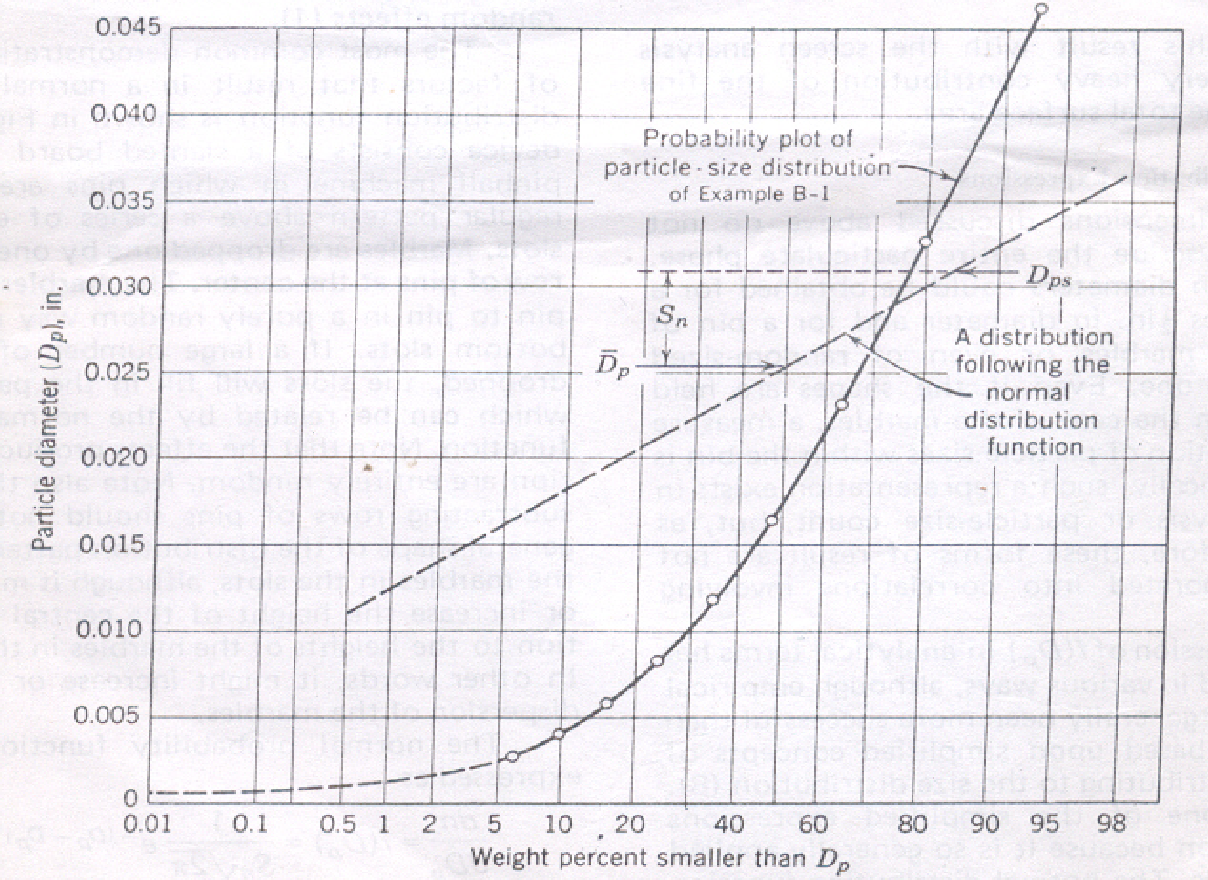


Figure B-9. Particle-size distribution on probability coordinates.

Summary of the Lecture

- Estimation of the fine particle size distribution
- Sampling
- Analytical Distribution

Reference

- Foust *et al*: **Principles of Unit Operations**, second edition, John Wiley & Sons