Basics of Engineering properties

By

Dr. Irfan Khan

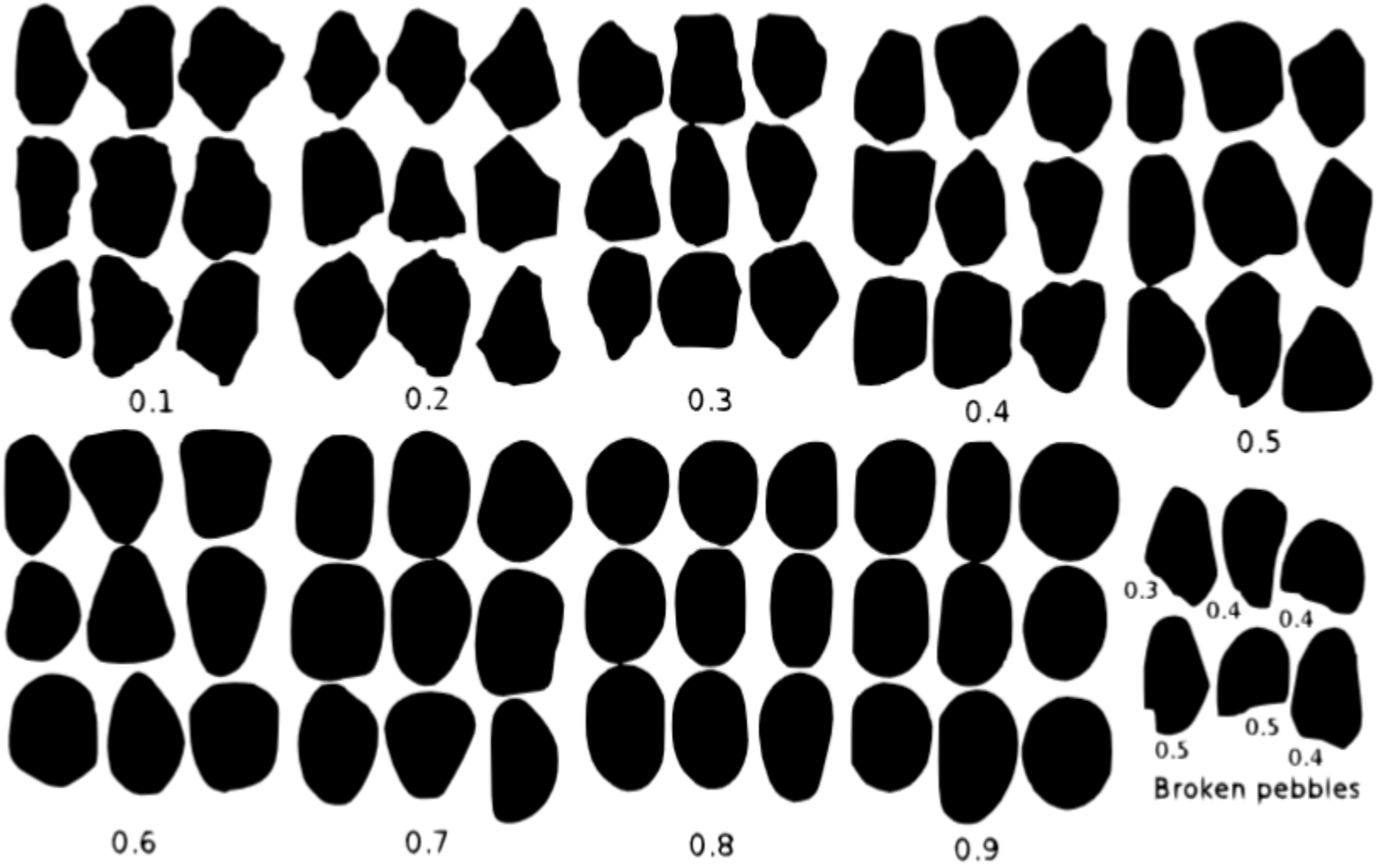
(M.Tech., Ph.D., Food Process Engg., AMU)

Engineering properties of Food/Biomaterials

- Shape and size
- Volume
- Density
- Roundness
- Sphericity
- Aerodynamic property
- Friction
- Surface area

Roundness

- **Roundness** is the measure of how closely the shape of an object approaches that of a mathematically perfect circle
- **Roundness** applies in two dimensions
- Roundness is the measure of irregular shapes of food items.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Broken pebbles

Sphericity

- Sphericity is a measure of how spherical an object is. Proposed by Waddell in 1935, the sphericity of a particle is defined as the ratio of the surface area of an equal-volume sphere to the actual surface area of the particle.
- Sphericity related indices have also been computed at nanoscopic scale. An equivalent spherical diameter is used to obtain a pore size distribution in nanoporous materials.
- Length measurements are the lengths of the three representative axes of an object, $a = d_L$ (longest), $b = d_I$ (intermediate) and $c = d_S$ (shortest) and correspond to its OBB or reference ellipsoid. They can be computed by principal component analysis (PCA) on the corresponding voxel model.

Physical properties of selected fruits

Apple- 0.89-0.90 sphericity

Property	Guava (SD)	Sapota (SD)	Papaya (SD)
Moisture content (% w.b.)	78.63 (0.83)	77.93 (0.64)	90.43 (1.17)
Weight (g)	55.88 (17.7)	48.42 (4.91)	1022 (162.12)
Length (cm)	4.76 (0.56)	4.51 (0.24)	17.67(1.36)
Breadth (cm)	4.71 (0.37)	4.16 (0.24)	12.03 (0.55)
Width (cm)	4.57 (0.5)	4.3 (0.22)	12.43 (0.37)
Weight of peel (g)	3.28 (2.45)	15.32 (2.34)	81.1 (8.39)
Weight of pulp (g)	52.6 (6.74)	32.26 (3.45)	940.7 (152.78)
Bulk density (g cm^{-3})	0.55 (0.01)	0.61 (0.02)	0.44 (0.01)
True density (g cm^{-3})	0.82 (0.2)	1.12 (0.25)	1.12 (0.12)
Porosity (%)	0.32 (0.001)	0.35 (0.002)	0.47 (0.002)
Surface area (cm^2)	69.25 (14.4)	58.82 (6.42)	580.55 (24.34)
Sphericity (%)	98.51 (3.06)	95.78 (0.540	81.15 (2.45)
Aspect ratio	99.50 (5.31)	92.22 (1.23)	71.91 (2.84)
Roundness index (%)	92.18 (4.19)	93.93 (3.11)	69.44 (6.25)
Shell ratio	0.16 (0.002)	0.40 (0.002)	0.18 (0.012)
Packing coefficient	0.52 (0.001)	0.55 (0.002)	0.36 (0.002)

Frictional properties of food materials

- Frictional properties viz., coefficient of friction and angle of repose properties of grains play important role in selection of design features of hoppers, dryers, storage bins and other equipments for grain flow.


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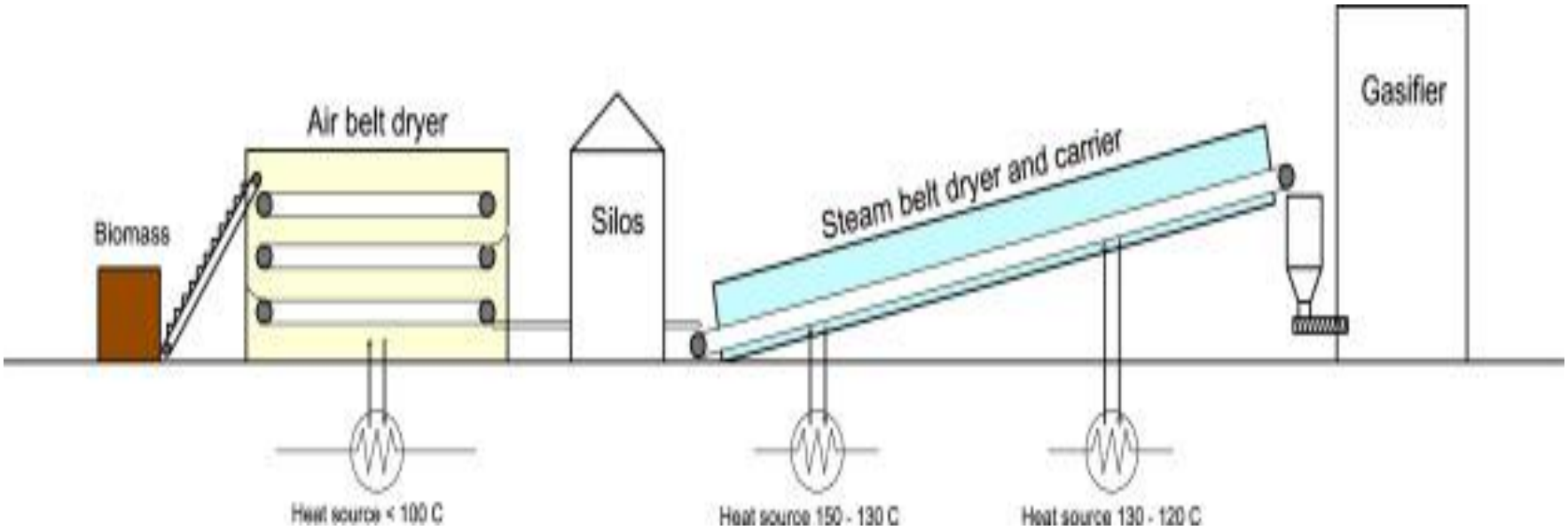

Air belt dryer
Biomass
Silos
Steam belt dryer and carrier
Gasifier
Heat source < 100 C
Heat source 150 - 130 C
Heat source 130 - 120 C

Coefficient of friction

- The coefficient of friction b/w granular materials is equal to the tangent of the angle of internal friction for the material.
- $\mu_s > \mu_k$- **Static friction is always greater than the kinetic friction**

- The coefficient of friction depends upon following factors:

(a) Grain shape (b) Surface characteristics of grain (c) Moisture content of grain

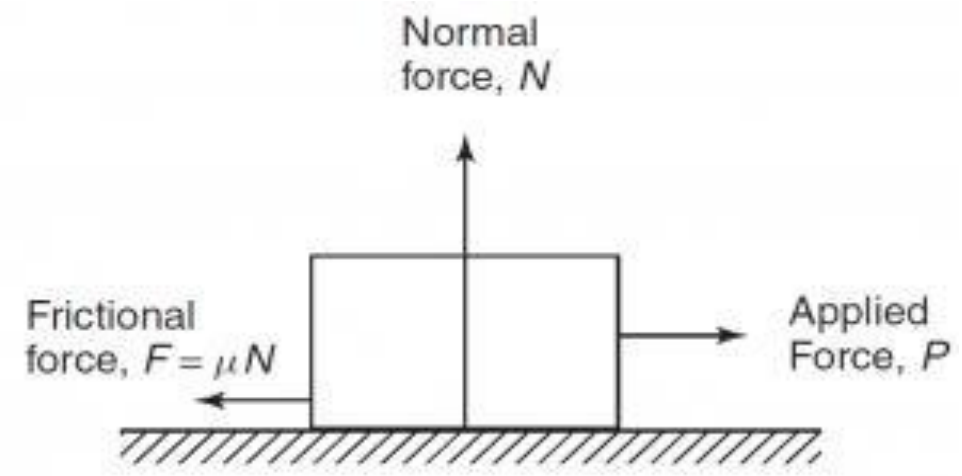
Friction force

$$f = \mu N$$

f = friction force

μ = coefficient of friction

N = normal force



Analysis of static and kinetic friction of pulses

Table 1 Static and kinetic coefficient of friction of pulses on various surfaces at different moisture content levels

Pulse	Moisture content (% (wb))	Coefficient of friction							
		Static coefficient of friction				Kinetic coefficient of friction			
		Smooth concrete	Galvanized Iron sheet	Ply wood	Glass sheet	Smooth concrete	Galvanized Iron sheet	Ply wood	Glass sheet
Chickpea	9.25	0.51	0.42	0.42	0.39	0.49	0.41	0.40	0.38
	14.29	0.53	0.44	0.43	0.41	0.50	0.42	0.41	0.40
	17.21	0.54	0.45	0.44	0.41	0.52	0.43	0.42	0.41
	21.25	0.55	0.46	0.45	0.43	0.53	0.44	0.43	0.42
	Mean	0.53 (0.02)	0.44 (0.01)	0.44 (0.01)	0.41(0.01)	0.51 (0.01)	0.42 (0.01)	0.42 (0.01)	0.40 (0.01)
Khesari	10.28	0.51	0.42	0.41	0.39	0.49	0.40	0.40	0.38
	14.16	0.52	0.43	0.42	0.40	0.50	0.41	0.41	0.39
	18.87	0.53	0.44	0.44	0.41	0.51	0.42	0.42	0.40
	22.28	0.54	0.45	0.45	0.42	0.53	0.44	0.43	0.41
	Mean	0.52 (0.01)	0.44 (0.01)	0.43 (0.01)	0.41 (0.01)	0.51 (0.02)	0.42 (0.01)	0.41(0.01)	0.39 (0.01)
Blackgram	10.38	0.50	0.42	0.41	0.39	0.48	0.40	0.39	0.38
	13.24	0.51	0.42	0.42	0.40	0.49	0.41	0.40	0.38
	17.51	0.52	0.44	0.43	0.40	0.51	0.42	0.41	0.39
	22.38	0.54	0.45	0.45	0.42	0.52	0.43	0.43	0.41
	Mean	0.52 (0.01)	0.43 (0.01)	0.43 (0.01)	0.40 (0.01)	0.50 (0.01)	0.41 (0.01)	0.41 (0.01)	0.39 (0.01)
Cowpea	8.76	0.46	0.41	0.40	0.38	0.45	0.37	0.37	0.37
	11.89	0.47	0.42	0.41	0.39	0.46	0.38	0.38	0.37

Angle of repose

- The **angle of repose**, or critical **angle of repose**, of a granular material is the steepest **angle** of descent or dip relative to the horizontal plane to which a material can be piled without slumping. At this **angle**, the material on the slope face is on the verge of sliding.

Angle of Repose	Flowability
< 25	Excellent
25-30	Good
30-40	Passable
> 40	Very poor

Particle Size Determination[10,12]