AERODYNAMIC PROPERTIES OF BIOMATERIALS

Lecture 08

(PFE-2.4.5)

By:

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Aerodynamic properties

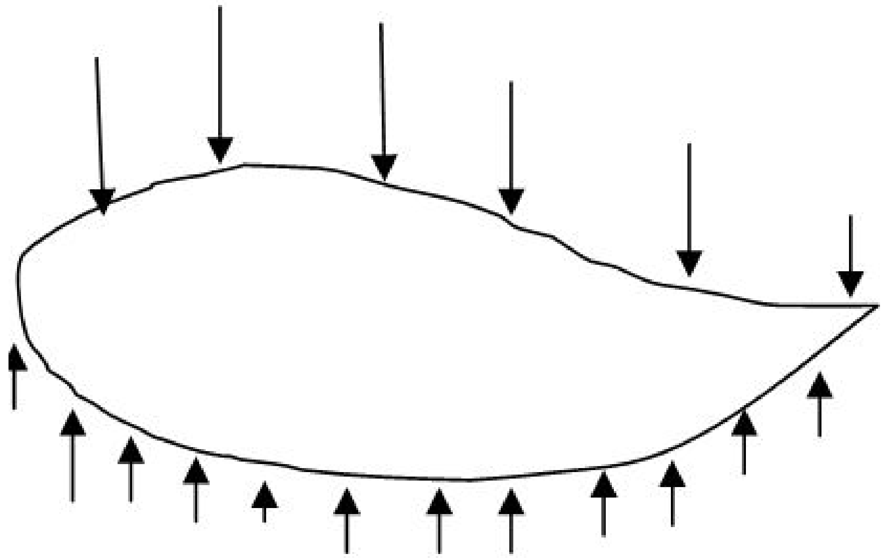
- Sorting and sizing of agro commodities
- Transportation of material

Properties

- **Terminal velocity**
  - The constant speed that a freely falling object eventually reaches when the resistance of the medium through which it is falling prevents further acceleration.
- **Aerodynamic drag**
  - aerodynamic drag is the fluid drag force that acts on any moving solid body in the direction of the fluid free stream flow

Drag Coefficient

- It is used to quantify drag or resistance of an object is a fluid environment such as air or water.
- It is a dimensionless quantity.
- Drag coefficient is always associated with surface area



- When fluid flow occurs about immersed objects, the action of the forces involved can be illustrated as follows.
- The pressure of the upper side of the object is less than that of lower side is great than that of & that of lower side is greater than the pressure p in the undisturbed fluid stream.
- In addition to these force normal to the surface of the object, there are shear stresses, C acting tangential to the surfaces in the direction of flow & resulting from frictional effects.
- The resultant force for may be resolved into components, F_D the drag & F_V the lift force.

$$F_D = f_1(A_P, \rho_f, \eta, E, V)$$

$$F_L = f_2(A_P, \rho_f, \eta, E, V)$$

Where,

A_p=Projected area of the object

ρ_f =Fluid density,

h =Viscosity of fluid

E = modulus of Elasticity

V = Velocity of the object relative to fluid

Employing dimensional analysis,

$$F_D = C_D \frac{A_p \rho_f V^2}{2} \text{……………………….1}$$

$$F_L = C_L \frac{A_p \rho_f V^2}{2} \text{……………………….2}$$

Where,

C_D and C_L are drag coefficient & lift Coefficient

$$F_r = \frac{1}{2} C A_p \rho_f V^2 \quad \text{.........................} 3$$

Where,

F_r=resistance drag force or wt. of particles at terminal velocity (kg)

C= overall drag coefficient

ρ_f =Fluid density (kg. s^2/m^4)

A_p=Projected area of the object and (m^2)

V = relative velocity between main body of fluid and material (m/s)

TERMINAL VELOCITY

"***In free fall, the object will attain a constant terminal velocity (V_t) at which, where acceleration will be zero***".

Net gravitational accelerating net upward equals to the sum of buoyant force and drag force.

Gravitational force acting downward =

buoyant force exerted by the fluid on the body in upward direction

+

drag force (frictional resistance due to motion of the body in the fluid medium)

$$m_p g = m_p a_f + \frac{1}{2}\left(A_p P_f V t^2\right)..$$

$$m_p g\left(\frac{\rho_p - \rho_f}{\rho_p}\right) = \frac{1}{2}\left(A_p \rho_f V t^2\right)..$$

$$V_t = \left[\frac{2W(\rho_p - \rho_f)}{\rho_f \rho_p A_P C}\right]$$

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Where,

V_t = terminal velocity (m/s)

C = overall drag coefficient

g = acceleration due to gravity (m/s^2)

m_p = mass of particle (kg)

ρ_p=mass density of particles,

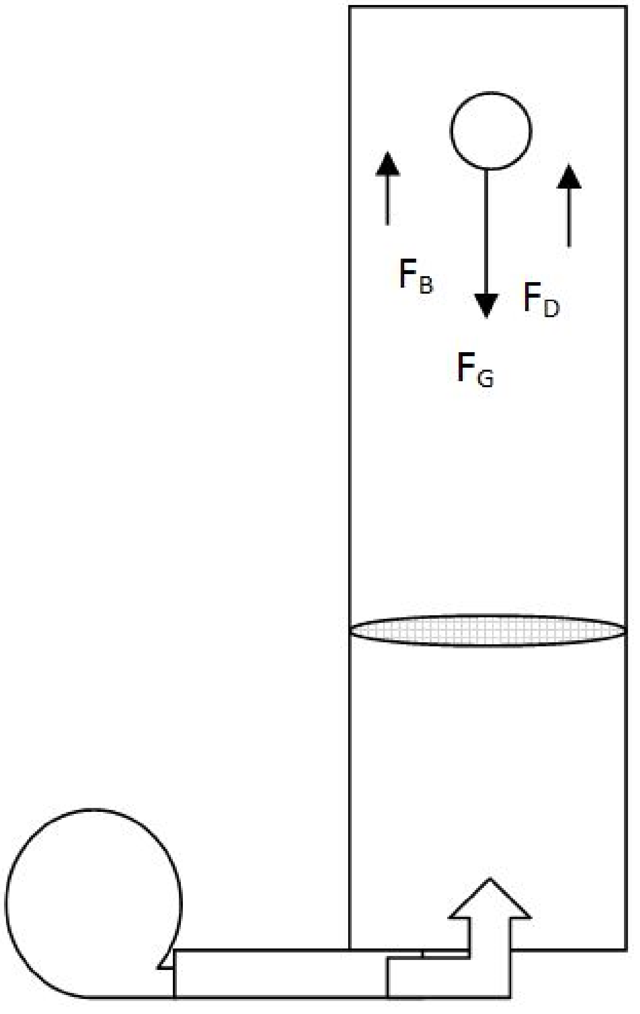
ρ_f = mass density of fluids

A_p=Projected area of the object and (m^2)

W = weight of particle (kg)

Measurement of terminal velocity:

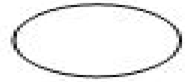
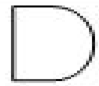
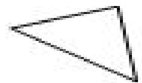
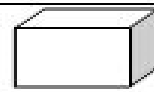
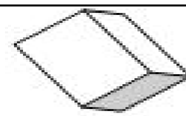
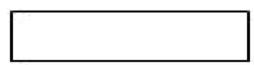
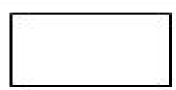
- Most scientists and researchers employ air column to find out the terminal velocity of grains.
- The set up usually consists of a vertical air column, which is blown from the bottom and passes through the screen.
- The screen uniformly distributes the air velocity. The air column is also attached with velocity measuring device.
- The blower maintains variable speed. When grains are allowed to drop into the column, initially they attains acceleration, once the velocity is adjusted they fall to the bottom with a constant velocity.
- This constant velocity is termed as terminal velocity



Factors affecting aerodynamic properties of biomaterials:

- Frontal area
- Particles size orientation(In turbulent region particles assumes position of maximum resistance)

Grains	Terminal velocity, m/s	
Wheat	9-11.5	
Barley	8.5-10.5	
Small oats	19.3	
Corn	34.9	
Soybean	44.3	
Rye	8-5-10.0	
Oats	8.0-9.0	
Grains	**Bulk Density**	**Particle density**
Wheat	850	1480-1410
Paddy	575	1411-1342
Parboiled rice	522-566	1405-1346
Rice	507-565	946-991
Bean	750	
oat grain		1380.0

Shape	Drag	Coefficient
Sphere		0.47
Half sphere		0.42
Cone		0.50
Cube		1.05
Angled cube		0.80
Long Cylinder		0.82
Short Cylinder		1.15
Stream lined Body		0.01
Streamlined half body		0.09

- In the handling and processing of agricultural products, air is often used as a carrier for transport or for separating the desirable products from unwanted materials, therefore the aerodynamic properties, such as terminal velocity and drag coefficient, are needed for air conveying and pneumatic separation of materials.

- As the air velocity, greater than terminal velocity, lifts the particles to allow greater fall of a particle, the air velocity could be adjusted to a point just below the terminal velocity. The fluidization velocity for granular material and settling velocity are also calculated for the body immersed in viscous fluid.

<u>Application to Agricultural products</u>

- Separation of foreign materials from seeds, grains potato, blue berry
- Conveying and handling of grains, chopped forage small & large fruits
- Hydraulic handling of apples, cherries, mango& potatoes etc.

Working principle of Aspirator:-

- Under steady state condition, where terminal velocity has been achieved, if the particles density is greater than fluid density, the particles motion will be downward. If particles density is smaller than the fluid density, the particle will be rise.