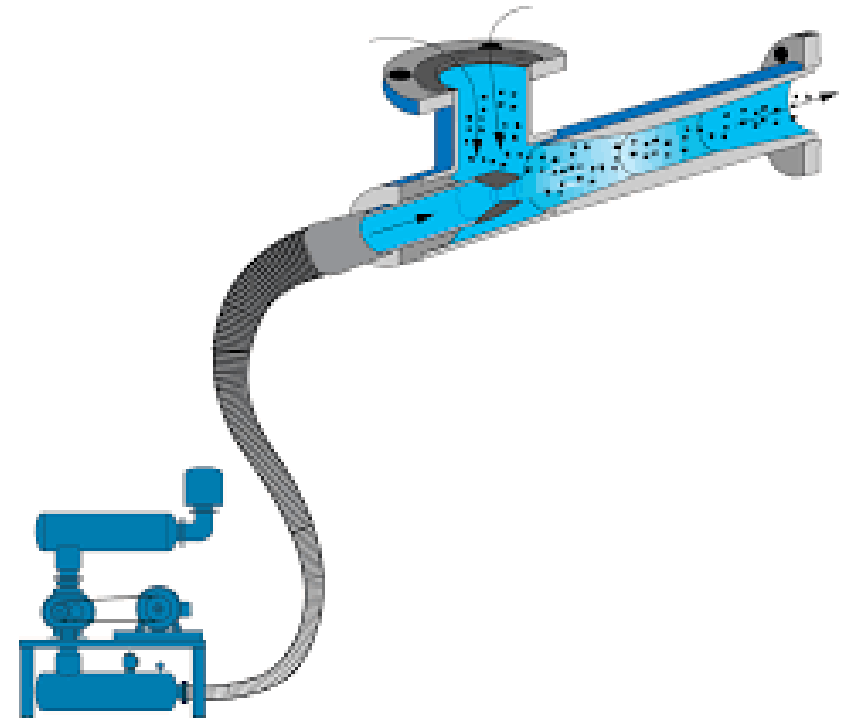


PROTECTED CULTIVATION AND
POST HARVEST TECHNOLOGY
(ASAE3204)

ENGINEERING PROPERTIES-
(Aero and Hydro Dynamic Properties)

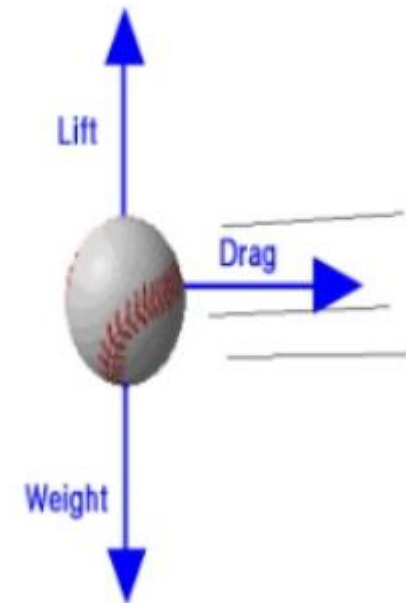
Aero and Hydro Dynamic Properties

- Water or air is used as a carrier for transport
- It is also used for separation of desirable products from unwanted materials.
- Pneumatic separation and conveying has been in tradition of food processing industry for many years.
- However, water being used as a more economical and less injurious means of transport for fruits and vegetables is relatively a new idea.



Aero and Hydro Dynamic Properties cont.

- When a particle is immersed in a stagnant fluid Buoyant force (weight of displaced fluid)
- When particle is immersed in a fluid in motion along with buoyant force two other forces act, i.e.,
 1. Normal to surface of object due to fluid flow
 2. Shear stress acting tangential to the surface in the direction of flow and resulting from frictional effects.
- The resultant forces may be resolved into two components
 1. F_H , the drag and
 2. F_V , the lift.



Aero and Hydro Dynamic Properties cont.

- These forces are depended on
 1. Projected area of the object (A_p)
 2. Fluid mass density (ρ_f)
 3. Viscosity (μ)
 4. Modulus of elasticity (E)
 5. Velocity (V)

- As in real engineering applications the moving objects orient randomly, the net resultant force can be written as:

$$F_r = \frac{1}{2} C A_p \rho V^2$$

C = overall drag coefficient (dimensionless)

V = relative velocity between main body of the fluid and object

Aero and Hydro Dynamic Properties cont.

- The drag coefficient of the material and its resistance to air flow depend upon, **bed thickness of the material**, **type shape and size of the grain**, **air velocity** and **orientation and packaging of material**.

- This is quantified using Reynold's number (N_{Re})

i.e., Ratio of inertia forces tend to produce velocity change to viscous forces, tend to resist vel change)

$$N_{Re} = Vd\rho/\mu$$

When the value of Re_p is less than 0.2, the flow is laminar and the drag coefficient can be determined from:

$$C_D = \frac{24}{Re_p}$$

For Reynolds numbers in excess of 200,000, where the flow is turbulent:

$$C_D = 0.44$$

Finally, for the values of Re_p between 500 and 200,000:

$$C_D = \frac{24}{Re_p} \left[1.0 + 0.15 (Re_p)^{0.687} \right]$$

Aero and Hydro Dynamic Properties cont.

Terminal Velocity

- The terminal velocity of particle may be defined as equal to the air velocity at which a particle remains in suspended state in a vertical pipe.
- In the conditions of free fall, the particle attains a constant velocity (V_t), when the net gravitational accelerating (F_g), equals the resisting upward force (F_r). If $V = V_t$, $F_g = F_r$

$$F_g = F_r, \text{ Without Buoyancy}$$
$$F_g = F_r + F_b, \text{ With Buoyancy}$$

- In steady state conditions, after attaining the terminal velocity,
 - ❑ If density of the particle is greater than, the density of the fluid, the particle will move downward.
 - ❑ If density of the particle is less than, the density of the fluid, the particle will rise upward.

Aero and Hydro Dynamic Properties cont.

By substituting the values of F_g and F_r , the terminal velocity can be expressed as;

$$m_p g \left[\frac{(\rho_p - \rho_f)}{\rho_p} \right] = \frac{1}{2} C A_p \rho_f V_t^2$$

$$V_t = \left[\frac{2W(\rho_p - \rho_f)}{\rho_p \rho_f A_p C} \right]^{\frac{1}{2}}$$

$$\text{and } C = \frac{2W(\rho_p - \rho_f)}{V_t^2 A_p \rho_p \rho_f}$$

If separation of mixture of grain and foreign materials is to be achieved by air stream, the terminal velocities of each component of the mixture decide the range of air velocity to be used for a definite extent of separation.

where,

V_t = terminal velocity, m / s

C = overall drag coefficient

g = acceleration due to gravity, mls^2

m_p = mass of the particle, kg

ρ_p = mass density of particle, $kg.s^2/m^4$

ρ_f = mass density of fluid, $kg.s^2/m^4$

A_p = projected area of particle in perpendicular direction of motion, m^2

W = weight of particle, kg