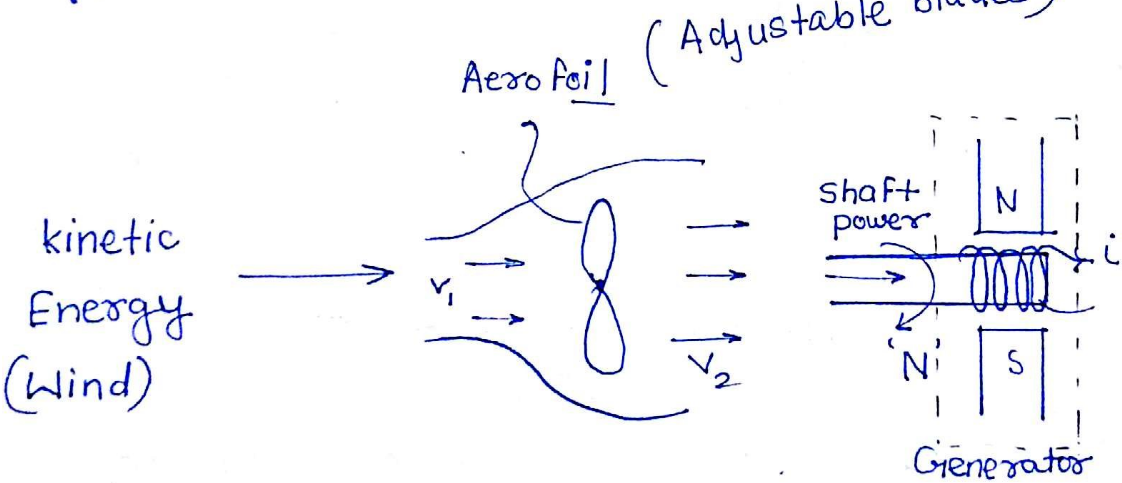
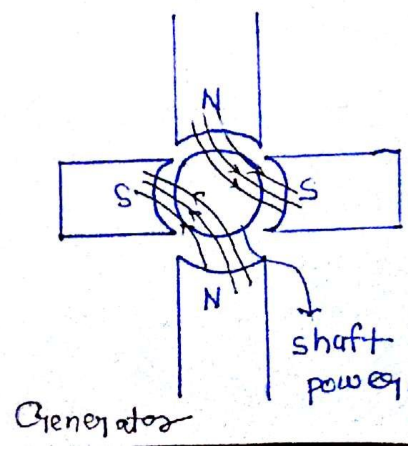
<u>Wind Energy</u> :- The wind has energy in the form of kinetic energy which can be harness to produce electrical energy.



$$f = \frac{P.N}{60}$$

Eelectric power (E.P.) $= V.I = I^2R = \frac{V^2}{R}$



Origins of Wind :- (i) local Wind (ii) Planetary Wind.

(i) Local Wind :- local wind are cause by unequal heating and cooling of the ground surface of sea, ocean, hills during day and night.

→ Costal Areas, Hills

(ii) Planetary Wind :- These wind are cause by rotation of earth around it polar axis and also due to unequal temp. between polar region and equitorial region.

The strength and direction changes with the Season.

Note :- For the pridiction and the statics of wind data analysis "weisbull distribution" is used.

$$\boxed{P(\vec{V}) = 1 - e^{-\left(\frac{V}{C}\right)^{k}}}$$

-ve exponential.

V = Wind speed

K = weisbull factor

C = weisbull constant

Variation of wind Speed with elevation : (Height)

$$\boxed{V \propto H^{\alpha}} \qquad \frac{V_1}{V_2} = \left(\frac{H_1}{H_2}\right)^{\alpha}$$

α - power Factor

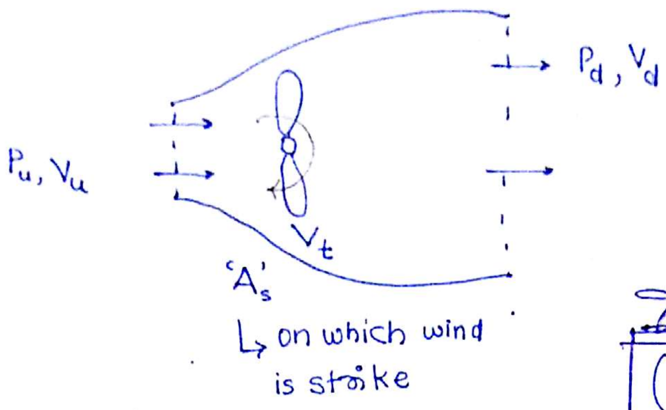
H - Height

V - Velocity

$\alpha = 1/7$ (Generally)

$\alpha \rightarrow (0.1 - 0.2)$

Energy Extraction From the wind:-



$E = \frac{1}{2} m V^2$

$(P)_{max} = \frac{1}{2} \dot{m} V^2 = \frac{1}{2} (\rho A V) . V^2$

$$\boxed{(P)_{max} = \frac{1}{2} \rho A V_u^3 \quad \text{(theorotically)}}$$

Betz Analysis

Assumption :- Incompressible Flow (ρ = Constant)

Bernoulli eqn

$$\frac{P_u}{\rho g} - \frac{P_d}{\rho g} = \frac{V_u^2}{2g} - \frac{V_d^2}{2g}$$

$$(P_u - P_d) = \frac{1}{2} \rho (V_u^2 - V_d^2)$$

Force $\quad F = (P_u - P_d) \cdot A_s \quad$ -① due to pressure diff

Momentum eqn $\quad F = \dot{m} (V_u - V_d) \quad$ -②

① = ② $\Rightarrow \dot{m} (V_u - V_d) = (P_u - P_d) A_s$

$$(\rho A_s V_t)(V_u - V_d) = A_s \times \frac{1}{2} \times \rho (V_u^2 - V_d^2)$$

$$\boxed{V_t = \frac{V_u + V_d}{2}} \quad \text{Turbine Velocity}$$

Power of turbine = (K.E.) diff

$$P_t = \frac{1}{2}\dot{m}\left(V_u^2 - V_d^2\right)$$

$$P_t = \frac{1}{2}\left(\rho A_s V_t\right)\left(V_u^2 - V_d^2\right)$$

$$P_t = \frac{1}{2}\left(\rho A_s\right)\left(\frac{V_u + V_d}{2}\right)\left(V_u^2 - V_d^2\right)$$

$$\boxed{P_t = \frac{1}{4}\rho A_s\left(V_u^3 - V_u V_d^2 + V_d V_u^2 - V_d^3\right)}$$

V_u - constant only V_d can variable

to find $(P_t)_{max}$

$\left(\frac{dP_t}{dV_d}\right) = 0$ it Gives $\boxed{V_d = \frac{V_u}{3}}$

So $\boxed{\left(P_{turb}\right)_{max} = 0.593\left(P_{\substack{max\\possible}}\right)}$

Betz limit
(59.3%)

$\left(P_{\substack{max\\possible}}\right) = \frac{1}{2}\dot{m}V_u^2$

theoretically