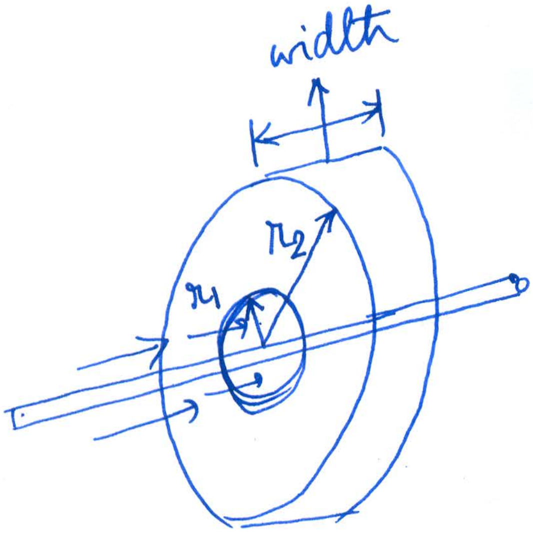
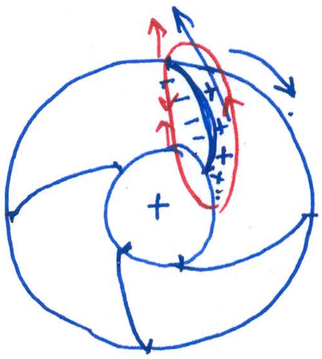
Turbomachines

Impeller

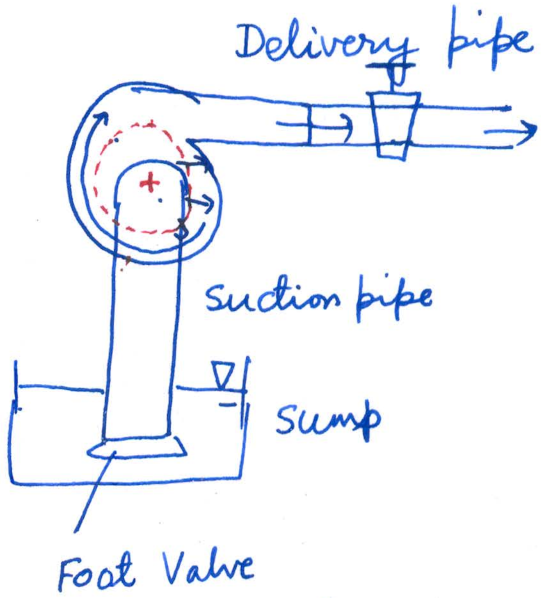
runner





Q m^3/s $\quad H$ m of water

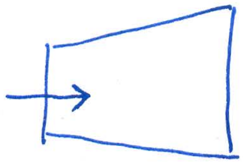
$$H = \frac{\Delta p}{\rho g}$$

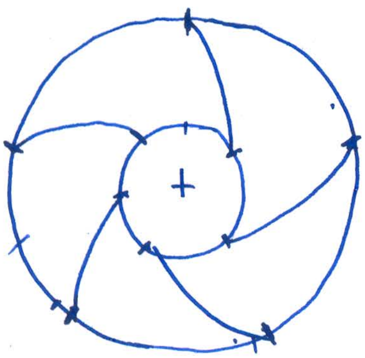


$$p = \rho R T$$

r_1, r_2 length

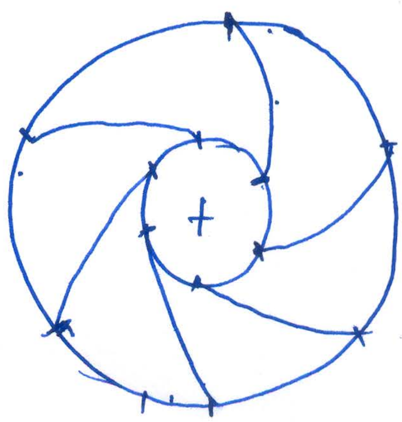
N rpm





$$\frac{p}{\rho} + \frac{v^2}{2} + gz = C$$

NRV → Non-return valve



- Direction of flow inside impeller
  centrifugal; axial; mixed flow

- energy adding device   pump handling incompressible
  compressor " compressible

- inlet and outlet diameter
  r_1 r_2

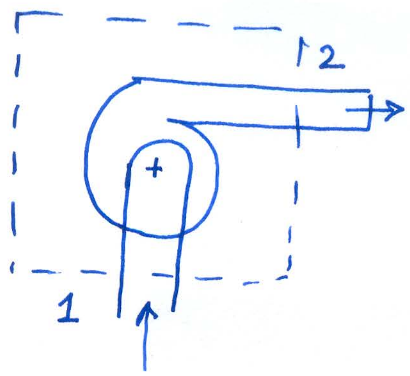
- rpm of machine

- direction of rotation of machine

- non-dimensional number decides the type of machine i.e. centrifugal, axial, mixed flow

Rotodynamic machine ✓

Positive displacement machine ×



Steady flow energy equation (SFEE)

$$\dot{Q} - \dot{W} = \dot{m}_2\left(h + \frac{V^2}{2} + gz\right)_2 - \dot{m}_1\left(h + \frac{V^2}{2} + gz\right)_1$$

$\dot{Q}$ = +ve energy added

$\dot{W}$ = +ve work done

Reynolds Transport Theorem (RTT)

$\left(h + \frac{V^2}{2} + gz\right)_2$ flux out

$\left(h + \frac{V^2}{2} + gz\right)_1$ flux in

$\dot{m}_2 = \dot{m}_2 = \dot{m}$ continuity equation

Turbomachine adiabatic $\dot{Q} = 0$

$$-\dot{W} = \dot{m}\left(h + \frac{V^2}{2} + gz\right)_2 - \dot{m}\left(h + \frac{V^2}{2} + gz\right)_1$$

$$\omega = \text{specific work} = \frac{\dot{W}}{\dot{m}} = \frac{J/sec}{kg/sec} = J/kg$$

$$-\omega = \left(h + \frac{V^2}{2} + gz\right)_2 - \left(h + \frac{V^2}{2} + gz\right)_1 \Rightarrow \text{energy absorbing device}$$

$$\omega = \left(h + \frac{V^2}{2} + gz\right)_1 - \left(h + \frac{V^2}{2} + gz\right)_2 \Rightarrow \text{energy extracting device}$$

18/7/17

$h = u + pv$

h = enthalpy J/kg

u = internal energy J/kg

p = pressure Pa

v = specific volume m^3/kg

$$-w = \left(u + pv + \frac{V^2}{2} + gz\right)_2 - \left(u + pv + \frac{V^2}{2} + gz\right)_1$$

Incompressible:

$$-w = \left(pv + \frac{V^2}{2} + gz\right)_2 - \left(pv + \frac{V^2}{2} + gz\right)_1 + (u_2 - u_1)$$

$$u_2 - u_1 \approx 0$$

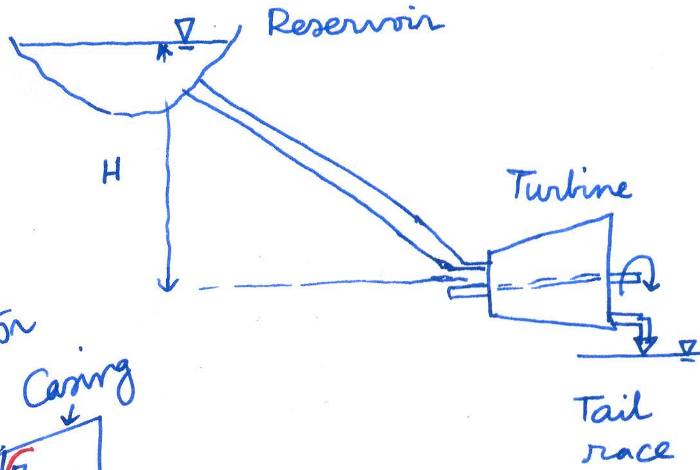
$$c_v (T_2 - T_1) \approx 0$$

$$T_2 \approx T_1$$

$$\boxed{-w = \left(\frac{p}{\rho} + \frac{V^2}{2} + gz\right)_2 - \left(\frac{p}{\rho} + \frac{V^2}{2} + gz\right)_1}$$

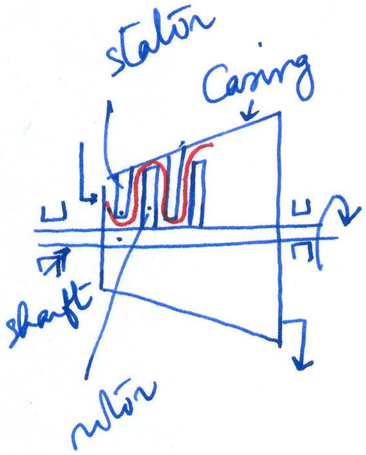
Turbine

$$w = \left(\frac{p}{\rho} + \frac{V^2}{2} + gz\right)_1 - \left(\frac{p}{\rho} + \frac{V^2}{2} + gz\right)_2$$



$\dot{Q}$ = Volume ~~rt~~ flow rate
m^3/s

H = Head, m



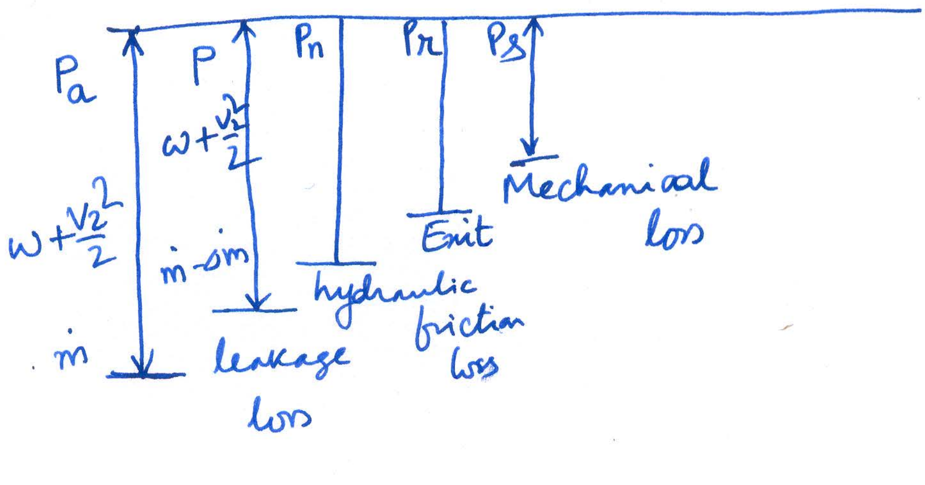
ρ = Density, kg/m^3

$\rho Q g H$

$\dot{m} = \rho Q \quad \frac{kg}{sec}$

$$w = \frac{\dot{m} g H}{\dot{m}} = gH$$

$$w + \frac{V_2^2}{2}$$



Turbomachines
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