Center of pressure on a plane surface:

* objectives: 1- determine the position of the center of pressure on rectangular face of toroid.

* The Force on the plane is due to pressure only and must act normal to the surface. why?
  ↳ Since there can be no shear stress in a static fluid medium.

$$F = \rho g A y_c$$

A: area of the surface
ρ: density of liquid.
g: gravitational acceleration.
y_c: coordinate of centroid.

$$\boxed{y_{cp} = y_c + \frac{I_{xx,c}}{y_c A}}$$

$I_{xx,c}$: second moment of ~~inertia~~ area (moment of inertia).

* Only the vertical face along GC of toroid has any moment about the balancing point.

* A rider weight balances the weight of the toroid in the dry Phase. why?
  ↳ so that the moment of the hydrostatic force on C is measured by the weight at the pan.

* The depth of immersion is measured by a hook gauge.

* The bouyancy effect is very small because its line of action is not far from the pivot, so it could be safely ignored.

* If we use a different kind of fluid in the tank, the location of the center of pressure ~~with~~ will not change because the equations we use are independent of the properties of fluid.

* Impact of water jet:

*obj: To determine the Force produced by a water jet.
when it strikes a flat vane and a hemispherical cup.

* The pelton wheel has been used to make flour

* The impulse turbine in first and second stages
of steam turbine.

~> Fire men make use of the kinetic energy stored in
a jet to: deliver water above
the level of nozzle to extinguish fires.

~> Fluid jets are also used in industries for cutting
metals and deburring.

* $F = \dot{m}(V_0 - V_1 \cos\beta)$

→ flat plate : $F = \dot{m} V_0$

→ hemispherical cup: $F = \dot{m}(V_0 - V_1)$

* Bernoulli's equation: $\frac{V^2}{2g} + z + \frac{P}{\rho g} = \frac{V_0^2}{2g} + z_0 + \frac{P_0}{\rho g}$

* $\dot{m} = \rho V A$

* The water is supplied to the jet in: a closed loop by a pump.

* How is the Flow rate determined?

↳ by a weighing tank and a stopwatch.

* The force on the object can be determined with the use of weights that can be hung at different positions.

* The Force on the hemisphere is twice as that of flat, why?

↳ because the mometum of equation for hemispherical is $F = 2 m v_0$ since $\beta = 180°$ $(F = m(u_1 - u_0 \cos\beta))$

but for plate $F = m(u_1 - 0) \rightsquigarrow F = m v_0$ since $\beta = 90°$

* Losses in Pipes :

* objective: - determine the variation of friction factor f with Reynolds number.

- determine the relationship between head loss and flow rate.

- determine the ~~bss~~ loss coefficient K

* The energy loss in internal flows (laminar or turbulent) is due to:

ⓐ Friction losses (major losses). (h_f)

↳ due to shear stress on wall.

ⓑ Minor losses. (h_m)

↳ losses at pipe inlet and exit and losses caused by valves, bends and elbows, and sudden contractions and expansions.

$$\boxed{h_L = h_f + \sum h_m}$$

$$\rightsquigarrow \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_T + h_L$$

h_p ↓ Pump head.

h_T ↓ Turbine head

major losses:

$$* \quad h_f = f \, \frac{L}{D} \, \frac{V_m^2}{2g}$$

L ↳ length, D ↳ Diameter, f ↳ friction factor. , V_m: mean velocity.

Laminar flow (Re < 2300): $f = \frac{64}{Re}$, Turbulent flow (Re > 2300): $\frac{1}{\sqrt{f}} = -2.0 \log\left[\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right]$

↳ Colebrook equation

Minor losses:

* The head loss is measured using pressure tapping. why?

↳ to avoid errors due to the disturbance in the flow.

* The total head loss (h_L) has two components:

1- Friction loss (h_f) in upstream and downstream pipes.

2- Minor head loss (h_m) due to fitting alone.

$$\rightsquigarrow \dots \quad h_m = \Delta h + \left[\frac{V_1^2 - V_2^2}{2g}\right] - h_f$$

* loss coefficient (K): $\boxed{K = \dfrac{h_m}{V^2/2g}}$ V: velocity in the smaller pipe.

* Both Dark blue circuit (DBC) and light blue circuit (LBC) are supplied with water from the same ~~hyrad~~ hydraulic bench.

DBC: Gate valve. , LBC: Globe valve.

* The pressure across each of the components is measured by: a pair of pressurized piezometer tubes.

⇝ except for the gate and globe valves, the pressure change is measured by: U-tube manometer containing mercury.

* The loss coefficient does not vary with the flow rate.

* The relationship between the friction factor and Reynolds number is: inverse linear

Comparison of pump characteristics :

* objectives: To establish a set of pump characteristics at constant and variable speeds for:
  1- Reciprocating pump. (Positive displacement).
  2- Centrifugal pump (horizontal).

* The primary function of pump is:
  1- Transportation of fluids.
  2- Adding energy to the transported fluids.

* Water power $= \rho g \dot{Q} h_p (10^{-3})$ (kw) = pump power

$\dot{Q}$: volumetric flow rate

h_p: head gain of water in meter.

$$h_p = \Delta P / g\rho \, 10^{-5}.$$

$\Delta P =$ Delivery pressure (P_d) − suction pressure (P_s).

- Brake power $= 2\pi \omega F R (10^{-3})$ (kw).

ω: motor speed

F: Brake load (N) = spring load (kg) × 9.81

R: Torque arm radius. (m)

- Overall efficiency $\eta_o = \dfrac{\text{water power}}{\text{Brake power}}$

- Volumetric efficiency $= \eta_v = \dfrac{\text{measured volumetric flow rate } \dot{Q}}{\text{Calculated volumetric flow rate } \dot{Q}_c}$

* calculated volumetric flow rate:

~> Positive displacement reciprocating pump:

total cross sectional area

single acting pump: $\dot{Q}_c = A_p L w \ (m^3/s)$

stroke of piston

double acting pump: $\dot{Q}_c = 2 A_p L w \ (m^3/s)$

$$w: \text{Pump speed} = \frac{\text{motor speed}}{5}$$

~> For centrifugal pump:

$$\dot{Q}_c = \frac{0.75}{1.23} \times 10^{-3} \ w \quad (m^3/s)$$

$w = (2) \cdot$ motor speed.

* The driving motor is a: D.C machine coupled to a spring dynamometer.

* The system of pumps is instrumented for the measurment of: speed, torque, flow rate, and necessary pressures.

* Reciprocating pump: - connected to D.C motor using toothed belt.

$$\frac{\text{motor speed}}{\text{Pump speed}} = \frac{5}{1}$$

* centrifugal pump: - connected to D.C motor using toothed belt and pulley system.

$$\frac{\text{motor speed}}{\text{Pump speed}} = \cancel{\frac{2}{1}} \ \frac{1}{2}$$

* Gear pump: - connected to D.C dynamometer by a toothed belt and pulley system.

$$\frac{\text{motor speed}}{\text{pump speed}} = \frac{3}{1}$$

* **Applications of centrifugal Pump:**

- when pumping hazardous liquids.
- Provides a thermal barrier between chamber and motor
- Reduces friction.
- Cannot overloaded and get damaged.

Limitations:

- cannot be used when liquids containing ferrous particles are pumped.
- Some energy is lost in the coupling.
- If heavy loads occur, the coupling might slip.

* **Applications of Reciprocating pump:**

- Fuel oil transfer.
- High pressure evaporator.
- Lubricating oil transfer.
- General service.

Limitations:

- High cost of installation.
- Bulky size.
- High maintenance cost.
- Non-uniform torque.

* Performance of a radial flow fan:

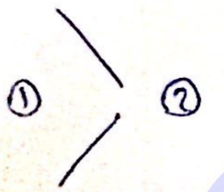
* **Objective:** Determine the performance of a radial flow rotor in air over a wide range of operating conditions

* The air enters the fan by a $\boxed{\text{nozzle}}$ from the atmosphere and exit by a $\boxed{\text{diffuser}}$.

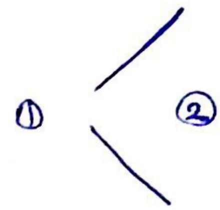
* Throttling valve: controls the process.
* The fan runs at constant speeds. (not exceeding 3000 rev/min)
  ⇝ keeping N constant and altering the throttle from open to fully shut.

T, H, Q are changing.
Torque, Pressure, volumetric flow rate

Nozzle:



Diffuser:



* Rotodynamic machines: they do the pumping job, having rotating elements called impeller.
  → ① Radial. ② Mixed (centrifugal). ③ Axial flow.
  - Radial ↓ Produces very high pressure when multistaged.
  - Mixed (centrifugal) ↓ for high pressure differences.

* Example on multistage fan: Air compressor for a jet engine.

* Fan total pressure rise: $P_{total,outlet} - P_{total,inlet}$.

⇝ Velocity pressure at inlet and outlet are equal.
  ↳ Fan total pressure Difference between corresponding static pressure.

* $V_{in} = V_{out}$ / $P_{in} = P_{out}$

↳ because the cross section at inlet and outlet are equal.

* $\Delta P = 98.1(h_3 - h_2)$ N/m^2.

Q = volumetric rate of flow (m^3/s)

↳ $Q = 1.006\sqrt{\frac{h_1 T}{P_a}}$

T: air temperature, h_1 = drop in head at the standard nozzle.

P_a: atmospheric Pressure. N/m^2

$h_3 > 0$
$h_2 < 0$

* Total air power: $Power_{air} = \Delta P . Q = 98.1(h_3 - h_2)Q$

* Power input from the dynamometer: $Power_{in\,shaft} = T\omega = \frac{F r 2\pi N}{60}$

F → load

T → torque

ω → angular velocity (rad/s)

N → angular velocity (rev/min)

r = 17.9 cm.

* How are the losses in the driving belt and fan bearing measured?

↳ By driving the fan with the impeller removed and subtracting the resultant loss from the Shaft power. (gives the impeller power).

* $\eta = \frac{\text{Total air power}}{\text{Impeller power}}$

Scanned by CamScanner

* Hydraulic jump in open channel :

* objectives: 1- Confirm theory of flow under a sluice gate with the formulation of a hydraulic jump.

2- Estimate the force exerted by the sluice gate on the flow.

3- Estimate energy head loss and power loss at the jump section.

→ Rectangular open channel.

* constant and steady supply of water, with means of varying the flow.

* specific energy (E) : $E = y + \frac{q^2}{2g_m y^2}$

Momentum function (M): $M = \frac{q^2}{gy} + \frac{y^2}{2}$ per unit width.

$\boxed{y}$: depth of flow, $\boxed{q}$: quantity of flow per unit width $= \frac{Q}{b}$

$\boxed{Q}$: total quantity of flow, $\boxed{b}$ = Channel width.

* Flow under the sluice gate:

$$E_1 = E_2$$

P = force per unit width.

$$\boxed{\frac{P}{\rho g} = M_2 - M_1}$$

* For the hydraulic jump: $M_2 = M_3$

$$\frac{q^2}{g y_2} + \frac{y_2^2}{2} = \frac{q^2}{g y_3} + \frac{y_3^2}{2}$$

$$\leadsto \boxed{y_3 = \frac{y_2}{2}\left[\sqrt{1+8 Fr_2^2} - 1\right]}$$

Fr_2 = Froude number at section (2) $= \dfrac{q}{\sqrt{g y_2^3}}$

* Power loss in the jump $= \rho g Q\, dE$

$dE = E_2 - E_3$
= energy loss.

* The energy head loss decreases decreases as the power loss and Fraud number decreases.

* Flow Visualization :

* Objective: To understand flow patterns and to see the stream lines when different shapes of objects are inserted in the flow path.

⇝ The flow visualization equipment is powered by : a synchronous A.C motor driving a centrifugal blower.

* Provision is made for the fitting of a smoke generator.

* Integrated smoke generator:

↳ oil mist formed by automization of heated mineral oil.

⇝ The resultant "vapor" form: highly visible smoke

↳ suitable for photography.

* The flexible smoke reservoir; serves to:

1- smooth the flow.

2- damp out variations in density.

3- facilitates clearance of condensed oil.

* Smoke control valve: controls the generation of smoke.

⇝ contents of smoke reservoir discharges to the smoke rake.

* Throttle clamp: enables smoke circuit oscillations to be [illegible]

* The shape of the stream line depend on the shape of the model.

* Stream lines: Family of curves that are instantaneously tangent to the velocity vector of the flow.

↳ They show the direction a fluid element will travel in at any point in time.

* Stream lines exert pressure on the object so force is being introduced causing energy difference at each particular place in the model.

* Performance of a turbine :

* objectives: 1- Establish a set of turbine characteristics, at variable speeds.

* Turbines: Devices that extract mechanical power out of fluids that are stored at high elevation or high pressure.

⟶ Hydraulic turbine: working fluid is water.

⟶ Gas turbine: working fluid is gas.

* Stator: fluid expands from high pressure through nozzles.

* Rotor: fluid's potential energy transform into kinetic energy.

* Types of turbines: 1- Impulse. 2- Reaction.

1- Impulse ⟶ fluid expands completely in the nozzle. (high speed/impulse) and hits the rotor.

2- Reaction ⟶ part of fluid expands in nozzle and part in rotor.

* Degree of reaction = $\frac{\text{expansion in rotor}}{\text{expansion in whole turbine}}$

* $P_{mech.} = \omega \cdot T$ = mechanical power. ω: angular speed. T: torque (N.m)

⟶ ω in rev/min = $2\pi n/60$ ⟶ $P_{mech} = 2\pi n \cdot T/60 = \pi n T/30$

* Hydraulic power: theoretical power given by fluid to machine.

$P_{hyd} = (P_d)(\dot{V})$

P_d: air pressure before entering the turbine. (nozzle pressure). (Pa)

$\dot{V}$: volumetric flow rate of air m^3/s

* Efficiency of turbine: $\eta = \frac{P_{mech}}{P_{hyd}}$

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* Regulation valve: regulates flow of air.

↳ flow rate is measured using a (glass cone flow meter)

↳ The load is measured by $\boxed{\text{a load unit (brake unit)}}$.

* A braking torque can be applied using a belt ⇝ that links the turbine shaft and the rotating guide roller on the loading unit.

* How is the torque calculated?

↳ from half the roller diameter and the braking force.

* Knurled bolt: adjusts the braking torque.

Tension ↑ ⇝ braking torque ↑

* The turbine is a: single-stage reaction turbine. with horizental shaft.

⇝ The wheel is overhung-mounted on the turbine shaft.

⇝ The air-cooled brake drum ⇝ measures the power.

⇝ The braking device consists of a fixed flat belt.

The tension in the belt is changed using an $\boxed{\text{adjustment bolt}}$.

↳ The belt force is measured using a $\boxed{\text{strain gauge}}$.

• ⤳ The speed is measured using a photoelectric reflex switch.

* The wheel runs in a plexiglass housing, why?

↳ So that it is also visible during operation.

* Why is the ridged bush in contact with the turbine shaft?

↳ because a non contact labyrinth seal seals the turbine shaft from the environment.