General Engineering Science (Subjective)

DETAILS EXPLANATIONS

1. Water is a chemical compound with each of its molecule (the smallest unit of a compound) containing two hydrogen atoms and one oxygen atom, and nothing else (H_2O being the chemical formula for water).

The precipitation, in the same manner, at the instant of its formation, contains no impurities but during the process of formation and fall through the earth's atmosphere, it may dissolve certain gases, traces of minerals, and other substances. When once the precipitation reaches the earth's surface, many more opportunities are presented for the introduction of various physical, chemical or bacterial impurities in it.

As the rain water flows over the surface of the earth, it picks up or dissolves particles of soil, garbage, sewage, pesticides and other human, animal or chemical wastes. It may also pick up and dissolve certain decayed organic materials, such as plants or dead animals. As the surface water seeps into the "Ground Water Reservoir, 'Most of the suspended particles are filtered out, but on the other hand, the water dissolves the minerals and salts present in the earth's layers, through which it travels before joining the watertable.

The impurities which water dissolves or picks up as suspended matter, may sometimes make it more useful and potable for public uses and especially for drinking and sometimes it may render it harmful and unfit.

But when these materials and other are dissolved in large amounts or in certain combinations, the water may become unfit or less useful for municipal, industrial and other uses.

Sometimes, the water may contain too much of common salt, thereby rendering it brackish and making it undrinkable and less useful for cloth washing or for irrigation and farming. Similarly, sometimes the water may contain harmful bacteria, the presence of which may cause diseases such as cholera, typhoid, dysentery, gastro-enteri, infectious hepatitis (i.e jaundice), etc.

To ensure safety to public health, economy and utility in industries and other uses it therefore becomes imperative on the planners and designers of the public water supply schemes, to thoroughly check; analyse, and treat the raw available water to safe and permissible limits, before supplying to the public.

Reasons for Unacceptance of Taste and Odour in Water Supply:

1. Consumers find taste and odour aesthetically displeasing for obvious reasons. Because water is taste less and odour less, the consumer associates taste and odour as a result of contamination.
2. Taste and odour in water causes health threat.
3. Sometimes, the taste and odour causing compounds may be carcinogenic.

Treatment to Remove Taste and Odour:

These are following treatments which may remove taste and odour from drinking water:

1. Aeration
2. Treatment with activated carbon
3. Treatment with C_uSO_4
4. Treatment with oxidizing agents like $K_2Cr_2O_7$, $C1_2O_3$, etc.

2. (A) (i) Given $C_p = 2.093 + \frac{41.87}{T+100}$ J/°C

For constant pressure process

$$\int dQ = \int_{T_1}^{T_2} C_p dT$$

$$\Delta Q = \int_{T_1}^{T_2} \left(2.093 + \frac{41.37}{T+100}\right) dT$$

$$= 2.0936(T_2 - T_1) + 41.87 \ln\left(\frac{T_2+100}{T_1+100}\right)$$

$$= 209.3 + 29.02 = 238.32 \text{ J}$$

(ii) Work done in the process $W = \int_1^2 PdV = P\int_1^2 dV = P(V_2 - V_1)$

$$= 1.01325 \times 10^5 \times (2400 - 2000) \times 10^{-6} = 40.53 \text{ J}$$

Change in internal energy $\Delta U = U_2 - U_1 = \Delta Q - \Delta W$

$$= 238.32 - 40.53 = 197.79 \text{ J}$$

$$\Delta U = 197.79 \text{ J}$$

(B) Initial diameter, D_1 = 1m, Initial temperature, T_1 = 300 K, final diameter d_2 = ?

Pressure P_1 = 200 kPa

Pressure P_2 = 500 kPa

Assumption

(i) Gas inside balloon is taken as system

(ii) The system is a closed system

(iii) Process is assumed to be reversible process.

(i) Workdone

For a closed system undergoing reversible process

$$W = \int PdV$$

$P \propto D$ $\qquad P = KD$

Volume of Sphere $\qquad V = \frac{4}{3}\pi R^3$

Total diameter = D

$$V = \frac{\pi D^3}{6}$$

Total Volume V and Change in volume $dV = \frac{3\pi D^2}{6} dD = \frac{\pi}{2} D^2 dD$

$$K = \frac{P}{D} = \frac{200}{1}$$

$$\frac{P_1}{D_1} = \frac{P_2}{D_2}$$

$$D_2 = d_1 \times \frac{P_2}{D_1} = 1 \times \frac{500}{200}$$

$$D_2 = 2.5\text{m}$$

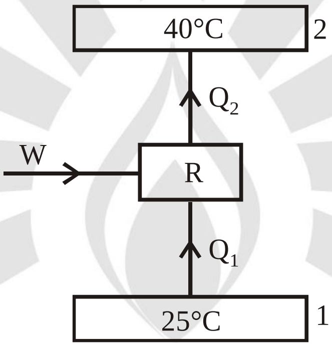
$\therefore$
$$W = \int P dv = \int_{D_1}^{D_2} KD \frac{\pi D^2}{2} dD = \frac{K\pi}{2} \times \left[\frac{D_2^4 - D_1^4}{4}\right]$$

$$= \frac{200 \times \pi}{8}\left[(2.5)^4 - 1^4\right]$$

$$W = 2989.42 \text{ kJ}$$

3. In summer, ambient at 40°C.

For a reversible heat engine



$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$$

Now Q_1 = (energy loss per degree × ΔT) kW

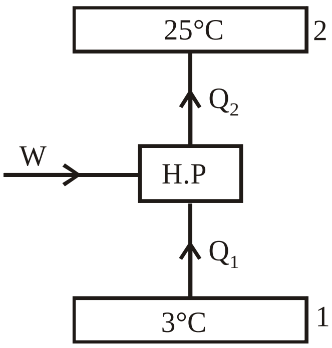
= 5 × 15 = 75 kW

$\Rightarrow$ $$\frac{75}{Q_2} = \frac{298}{313}$$

$\Rightarrow$ $Q_2 = 78.78$ kW

Power required $(Q_2 - Q_1) = 78.78 - 75 = 3.78$ kW

In winter, ambient is at 3°C



Now $Q_2 = 5 \times (22) = 110 \text{ kW}$

and $\dfrac{Q_1}{Q_2} = \dfrac{T_1}{T_2}$

$\Rightarrow$ $Q_1 = \dfrac{276}{298} \times 110 = 101.88 \text{ kW}$

$\text{Work done} = Q_2 - Q_1$

$= 110 - 108.88 = 8.12 \text{ kW}$

4. **(A)** Resistance at ice point $R_0 = 3980\ \Omega$

Absolute temperature of ice point = 273 K

$3980 = a \times 3980 \times \exp(b/273)$

$1 = a \exp(b/273)$ ....(i)

Resistance at 50° C $R_T = 794\ \Omega$

Absolute temperature = 273 + 50 = 323 K

$794 = a \times 3980 \exp\left(\dfrac{b}{323}\right)$ .....(ii)

From (i) and (ii) $a = 30 \times 10^{-6};\ b = 2843$

Absolute temperature at 40° = 273 + 40 = 313 K

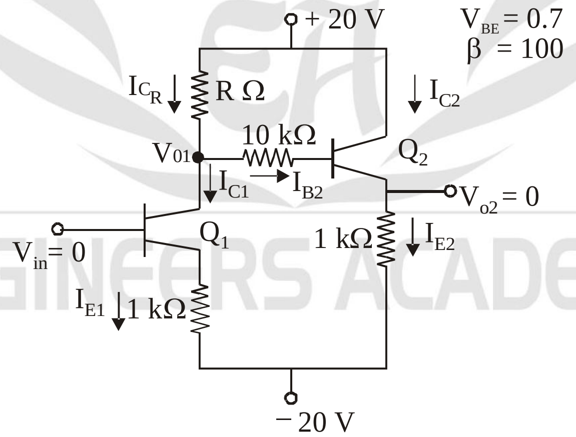
Resistance at 40°C $= 30 \times 10^{-6} \times 3980 \times \exp(2843/313)$

$= 1051\ \Omega$

Resistance at 100°C $= 30 \times 10^{-6} \times 3980 \times \exp(2843/373)$

$= 244\ \Omega$

(B) In DC condition when $V_{in} = 0$, V_{out} of second transistor is zero or $V_{02} = 0$



$$I_{E2} = \frac{0-(-20)}{1K} = 20\text{mA}$$

$$I_{B2} = \frac{I_{E2}}{1+\beta} = 198\ \mu\text{A}$$

$$I_{C2} = \beta I_{B2} = 19.8 \text{ mA}$$

$$V_{01} = (10 \text{ K}) I_{B2} + .7 + 0$$

$$V_{01} = 2.68 \text{ V}$$

$V_{in} = 0$ So, KVL at input mesh

$$0 = 0.7 + I_{E1}(1K) - 20$$

$$I_{E1} = 19.3 \text{ mA}$$

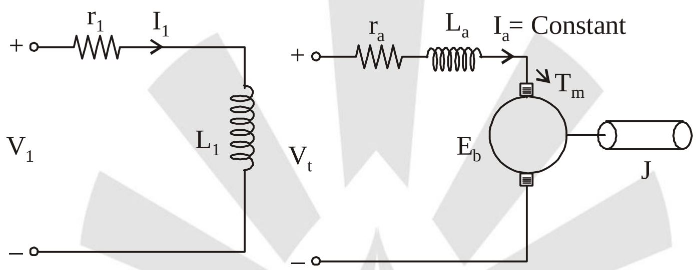
$$I_{C1} = \frac{\beta}{1+\beta} I_{E1} = 19.1 \text{ mA}$$

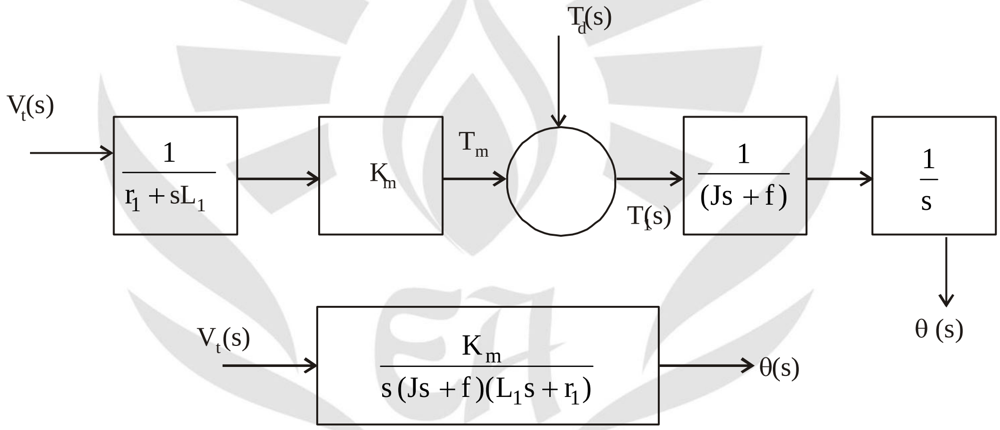
Current in R $\quad I_{C_R} = I_{C1} + I_{B2}$

$$I_{C_R} = 19.29 \text{ mA}$$

$$R = \frac{V_{CC} - V_{01}}{I_{CR}} = \frac{20 - 2.68}{19.29 \times 10^{-3}} = 898\ \Omega$$

5. (A)





(B) No-volt release coil consists of an electromagnet connected in series with shunt field which holds the arm in the "ON" position. Now when the supply fails or gets disconnected the electromagnet demagnetizes and so releases the starting arm A, which goes back to "OFF" position due to the spring attached to it and gets disconnected from the supply mains.

The other important advantage of connecting the no-volt release in series with the shunt field winding is that it prevents the motor from running away owing to an open shunt field because open-circuited shunt field will demagnetise the electromagnet and release the starter arm A and, thus the starter arm will go back to its OFF position and the supply will be disconnected.

Overload Release Coil. The OLR is a small electromagnet connected in series with the armature circuit. This coil is provided for the protection of the motor against the flow of excessive current due to overload. This coil is connected in series with motor so carries full-load current. When the motor is overloaded, it draws heavy current, which also flows through this coil and magnetises it to such an extent, that it pulls its armature upwards and so short circuits the no-volt release coil. The no-volt release coil, being short circuited, demagnetises and releases the starting arm, which goes back to "OFF" position with the action of spring attached to it and the motor is automatically disconnected from the supply mains. Thus the motor is disconnected from the supply and is protected against over-loading.

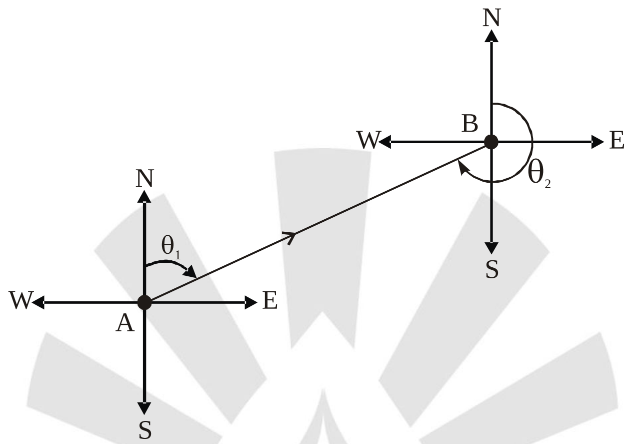
6. (A) (i) Well conditioned triangle :

A triangle is said to be well conditioned if its shape is such that any error in measurement of an angle has a minimum effect upon the computed lengths.

The best shape of a triangle is an isosceles triangle whose base angles are 54º14′ but practically it is not possible in field.

In actual practice, the triangles having an angle less than 30º or more than 120º are avoided.

(ii) Relationship between forward and backward bearing of any line



From diagram,

$$\theta_1 = \text{Fore bearing}$$

$$\theta_2 = \text{Back bearing}$$

$$\Rightarrow \quad \theta_2 = \theta_1 + 180º$$

$$\Rightarrow \quad BB = FB + 180º \text{ when } FB < 180º$$

If arrow is reversed in that case

$$BB = FB - 180º \text{ when, } FB > 180º$$

$$\therefore \text{ In general} \quad BB = FB \pm 180º$$

(B) Let L be the length of the line in the plan.

$$\text{Actual length} = 4000L \text{ m}$$

$$\text{Measured length} = 5000L \text{ m}$$

$$\text{Difference} = 5000L - 4000L = 1000L \text{ m}$$

$$\% \text{ error} = (1000L/400L) \times 100 = 25\%$$

Since area is measured in terms of the square of length,

$$\text{Actual length} = 4000L \text{ m}$$

$$\text{Actual area} \propto (4000L)^2$$

$$\text{Measured area} = (5000L)^2$$

$$\text{Let actual area be } K = K \times (4000L)^2$$

$$\text{Measured area} = K \times (5000L)^2$$

$$\text{Difference} = K \times [(5000L)^2 - (4000L)^2]$$

$$\% \text{ error in area} = \{K \times [(5000L)^2 - (4000L)^2][K \times (4000L)^2\} \times 100$$

$$= [(25-16)/16] \times 100 = 56.25\%$$

7. **(A)** Let the major and minor principal stress in a strained material be σ_1 and σ_2 and of the same sign then, the principal strains are given as

$$\varepsilon_1 = \frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E}$$

$$\varepsilon_2 = \frac{\sigma_2}{E} - \mu\frac{\sigma_1}{E}$$

Strain energy per unit volume due to σ_1

$$U_1 = \frac{1}{2}\text{stress} \times \text{strain}$$

$$U_1 = \frac{1}{2}\sigma_1\left(\frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E}\right)$$

$$U_1 = \frac{\sigma_1^2}{2E} - \frac{\mu\sigma_2\sigma_1}{2E}$$

$$U_1 = \frac{1}{2E}\left[\sigma_1^2 - \mu_1\sigma_1\sigma_2\right]$$

Similarly

$$U_2 = \frac{1}{2E}\left[\sigma_2^2 - \mu_1\sigma_1\sigma_2\right]$$

Total strain energy per unit volume,

$$U = \frac{1}{2E}\left[\sigma_1^2 + \sigma_2^2 - 2\mu\sigma_1\sigma_2\right]$$

(B) Euler's column formula

(i) Both ends are fixed

As we know, generally

Eulers' column formula is –

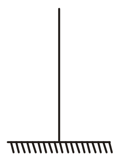
$$P = \frac{\pi^2 E I}{l_{eff}^2}$$

But when ends are fixed

$$l_{eff} = \frac{l}{2}$$

$$P = \frac{\pi^2 E I_{min}}{l^2} = \frac{4\pi^2 EI}{l^2} = \frac{4\pi^2 EI}{l^2}$$

(ii) One end fixed and other end is free



$$l_{eff} = 2l$$

$$P = \frac{\pi^2 E I}{l_{eff}} = \frac{\pi^2 E I_{min}}{4l^2}$$

8. **(A)** **The standard consistency** of cement is that consistency, which permit the vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the vicat mould when tested. Procedure to determine the quantity of water required to produce a cement paste of standard consistency is described below :

- For standard consistency vicat apparatus is used.
- This test hence deals with finding the water content at which cement paste of standard consistency is prepared.
- In order to perform this test take 500 gm of cement and add 23% of water by weight of cement in first trial for the preparation of mould. Remove the air voids if any found during the preparation of the mould lower the plunger gently upto the top surface of the mould and release it quickly. Repeat the test untill penetration of 5 to 7 mm from the bottom. The % of water at which the standard consistency is observed is denoted by p.

Setting time :

- This test is used to detect the deterioration of the cement due to storage.
- The setting time of the cement is generally analysed in terms of initial and final setting time.

(i) Initial setting time :

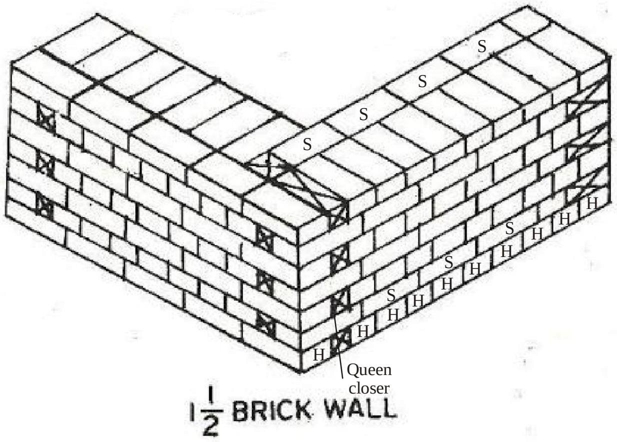
- It is defined as the time measured from the instance water is added into the cement upto the time to starts loosing its plasticity.
- In order to find the initial setting time 500 gm of cement sample is gauged with 0.85 p (85% of the water required to prepare cement paste of standard consistency is added in this test) and is filled in the mould.
- Lower the square needle gently upto the top surface of the mould and quickly note the time taken by the needle to penetrate upto 5 to 7 mm from the bottom. This time is recorded as initial setting time.

(ii) Final setting time :

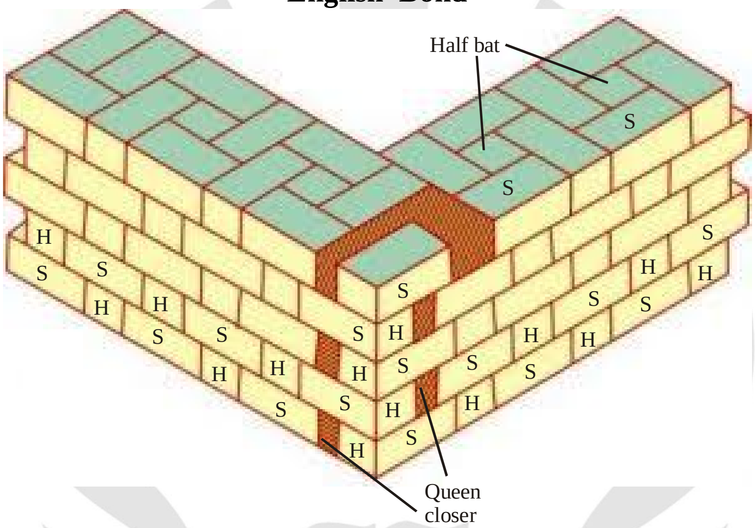
- In order to find final setting time needle with annular collar is lowered into the mould final setting time is taken as the time at which needle is able to make the impression over the mould but annular collar fails to do so.

(B)

S.No.	English Bond	Double Flemish bond
1.	English bond in brick masonry has one course of stretcher only and a course of header above it, i.e. it has two alternating courses of stretchers and headers.	Double Flemish bond has the same appearance both in the front and back elevations i.e. each course consists of alternate header and stretcher.
2.	English bond is not aesthetically pleasing as compare to double Flemish bond.	Alternate header and stretchers are laid in each course. Because of this double Flemish bond presents better appearance than English bond.
3.	This bond is strong bond as compare to double Flemish bond.	This type of bonding is comparatively weaker than English bond as it contain more number of stretchers.
4.	English bond does not require greater skill for its construction and it is costly in comparision with double Flemish bond.	It is economical because half brick and three quarter brick bats are allowed for forming this bond and it requires greater skill for its construction.

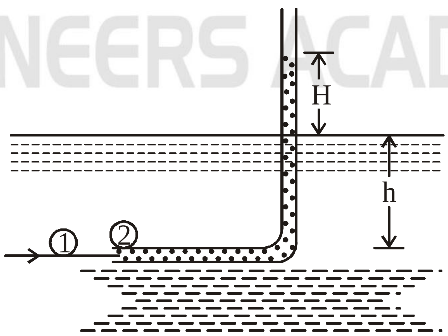


English Bond



Double flemish bond

9. Pitot-tube : It is a device used for measuring the velocity of flow at any point in a pipe or a channel. It is based on the principle that if the velocity of flow at a point becomes zero, the pressure is increase due to the conversion of the kinetic energy into pressure energy. In its simplest form, the Pitot-tube consists of a glass tube, bent at right angles as shown in figure.



The lower end which is bent through 90° is directed in the upstream direction as shown in figure. The liquid rises up in the tube due to the conversion of kinetic energy into pressure energy. The velocity is determined by measuring the rise of liquid in the tube.

Consider two points (1) and (2) at the same level in such a way that point (2) is just at the inlet of the Pitot-tube and point (1) is far away from the tube.

Let p_1 = intensity of pressure at point (1)

v_1 = velocity of flow at (1)

p_2 = pressure at point (2)

v_2 = velocity at point (2), which is zero

h = depth of tube in the liquid

H = rise of liquid in the tube above the free surface

Applying Bernoulli's equations at point (1) and (2), we get

$$\frac{p_1}{\rho g}+\frac{v_1^2}{2g}+z_1 = \frac{p_2}{\rho g}+\frac{v_2^2}{2g}+z_2$$

But $z_1 = z_2$ as point (1) and (2) are on the same line and $v_2 = 0$

$$\frac{p_1}{\rho g} = \text{pressure head at (1)} = H,$$

$$\frac{p_2}{\rho g} = \text{pressure head at (2)} = H + h$$

Substituting these values, we get

$\therefore$ $$H+\frac{v_1^2}{2g} = (h + H)$$

$\therefore$ $$h = \frac{v_1^2}{2g} \text{ or } v_1 = \sqrt{2gh}$$

This is theoretical velocity. Actual velocity is given by

$$(v_1)_{act} = C_v \times \sqrt{2gh}$$

Where, C_v = coefficient of Pitot-tube

$\therefore$ Velocity at any point $v = C_v \times \sqrt{2gh}$

For finding the velocity at any point in a pipe by Pitot-tube, the following arrangements are adopted :

1. Pitot-tube along with a vertical piezometer tube as shown in figure 1.
2. Pitot-tube connected with piezometer tube as shown in figure 2.
3. Pitot-tube and vertical piezometer tube connected with a differential U-tube manometer as shown in figure (3).

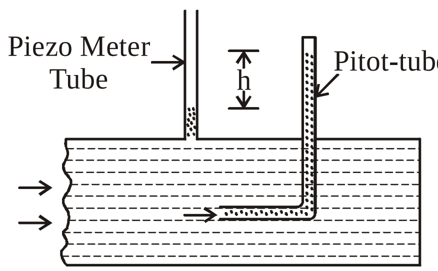


Fig. (1)

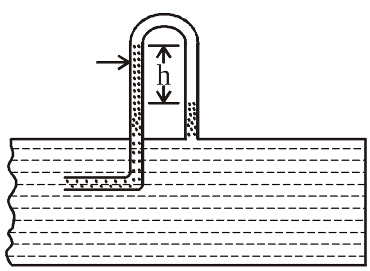


Fig. (2)

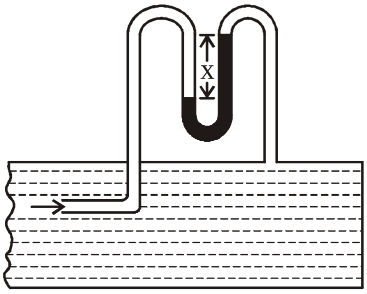


Fig. (3)

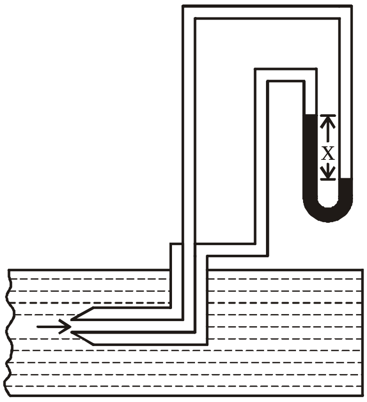


Fig. (4)

4. Pitot-static tube, which consists of two circular concentric tubes one inside the other with some annular space in between as shown in figure (4). The outlet of these two tubes are connected to the differential manometer where the difference of pressure head 'h' is measured by knowing the difference of the levels of the manometer liquid say x. Then $h = x\left[\frac{S_g}{S_0} - 1\right]$.

10. (A) Limitation of pelton wheel turbines :

1. These turbine require large operating heads.
2. To generate a given output power under a smaller head, the rate of flow through the turbines has to be higher which requires an increase in the jet diameter.
3. Overall the size of the pelton wheel turbine is large and the setup appears bulky.
4. Variation in the operating heads is very difficult to control.
5. The efficiency of these turbines reduces with the time.
6. The operating head cannot be utilized even when the variation in the tail water level is relatively large when compared to total head.

(B) 1. Acceleration of fluid in the boundary layer.

- This method consist of supplying additional energy to the particle of fluid which are being retarded in the boundary layer.
- This may be achieved by injecting fluid into the region of boundary layer from the interior of the body with the help of some suitable device.

2. Suction of the fluid from the boundary layer.

- In this method the slow moving fluid in the boundary layer is removed by suction through slots. So that on the downstream of the point of suction a new boundary layer start developing which is able to with stand an adverse pressure gradient and hence separation is prevented.

3. Motion of Solid boundary :

- The formation of the boundary layer is due to the difference between the velocity of the flowing fluid and that of the solid boundary.
- As such it is possible to elimiate the formation of boundary layer by causing the solid boundary to move with the flowing fluid.

4. When the flow take place round a bend a pressure gradient is generated and there is a tendency of separation at the inner radius of the bend.

(C) It is defined as the difference of theoretical discharge and actual discharge of the pump. If actual discharge is more than the theoretical discharge, the slip of pump will become negative slip. If actual discharge is less than the theoretical discharge known as +ve slip.

$$\text{Slip} = Q_{actual} - Q_{theoretical}$$

$$\%\text{Slip} = \frac{Q_{actual} - Q_{theoretical}}{Q_{theoretical}} \times 100$$

$$= (1 - C_d) \times 100$$

$$C_d = \text{Coefficient of discharge}$$

(D) Specific speed of a turbine is defined as the speed of a geometrically similar turbine which produce a unit power when working under a unit head.

By geometrically similar means that turbine is identical in shape, dimensions, blade angles and gate opening etc. It is denoted by the symbol N_S. The specific speed is used in comparing the different type of turbine as every of turbine has different specific speed.

It is a biggest specification of turbine and use for selection of turbine for particular site.

$$N_S = \frac{N\sqrt{P}}{H^{5/4}}$$

$N \rightarrow$ Speed in rpm

$P \rightarrow$ Power in 'kW'

$H \rightarrow$ Head in meter 'm'

❍❍❍