CHAPTER-2
MANOMETERS AND PASCAL LAW

A somewhat more complicated device for measuring fluid pressure consists of a bent tube containing one or more liquid of different specific gravities. Such a device is known as manometer.

In using a manometer, generally a known pressure (which may be atmospheric) is applied to one end of the manometer tube and the unknown pressure to be determined is applied to the other end.

In some cases, however, the difference between pressure at ends of the manometer tube is desired rather than the actual pressure at the either end. A manometer to determine this differential pressure is known as differential pressure manometer.

Manometers - Various forms

1. Simple U - tube Manometer
2. Inverted U - tube Manometer
3. U - tube with one leg enlarged
4. Two fluid U - tube Manometer
5. Inclined U - tube Manometer

3.9.1 Simple U - tube Manometer

Equating the pressure at the level XX'(pressure at the same level in a continuous body of fluid is equal):

For the left hand side:

$P_x = P_1 + \rho g(a+h)$

For the right hand side:

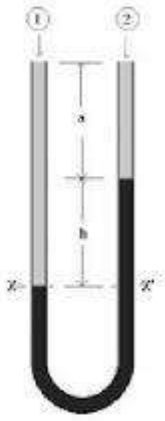
$P_{x'} = P_2 + \rho ga + \rho_m gh$

Since $P_x = P_{x'}$

$P_1 + \rho g(a+h) = P_2 + \rho ga + \rho_m gh$

$P_1 - P_2 = \rho_m gh - \rho gh$

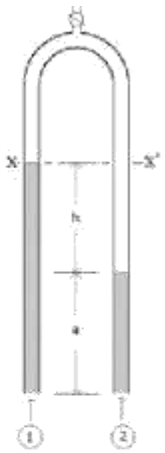
i.e. $P_1 - P_2 = (\rho_m - \rho)gh$,



The maximum value of P1 - P2 is limited by the height of the manometer. To measure larger pressure differences we can choose a manometer with higher density, and to measure smaller pressure differences with accuracy we can choose a manometer fluid which is having a density closer to the fluid density.

Inverted U - tube Manometer

Inverted U-tube manometer is used for measuring pressure differences in liquids. The space above the liquid in the manometer is filled with air, which can be admitted or expelled through the tap on the top, in order to adjust the level of the liquid in the manometer.



Equating the pressure at the level XX' (pressure at the same level in a continuous body of static fluid is equal),

For the left hand side:

$P_x = P_1 - \rho g(h+a)$

For the right hand side:

$P_x' = P_2 - (\rho g a + \rho_m g h)$

Since $P_x = P_{x'}$

$P_1 - \rho g(h+a) = P_2 - (\rho g a + \rho_m g h)$

$P_1 - P_2 = (\rho - \rho_m) g h$

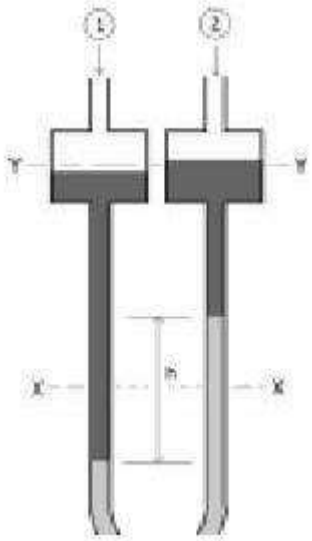
If the manometric fluid is chosen in such a way that $\rho_m << \rho$ then,

$P_1 - P_2 = \rho g h$.

For inverted U - tube manometer the manometric fluid is usually air.

Two fluid U-tube Manometer

Small differences in pressure in gases are often measured with a manometer of the form shown in the figure.



The manometer in its various forms is an extremely useful type of pressure measuring instrument, but suffers from a number of limitations.

While it can be adapted to measure very small pressure differences, it can not be used conveniently for large pressure differences - although it is possible to connect a number of manometers in series and to use mercury as the manometric fluid to improve the range. (limitation)

A manometer does not have to be calibrated against any standard; the pressure difference can be calculated from first principles. (Advantage)

Some liquids are unsuitable for use because they do not form well-defined menisci. Surface tension can also cause errors due to capillary rise; this can be avoided if the diameters of the tubes are sufficiently large - preferably not less than 15 mm diameter. (limitation)

A major disadvantage of the manometer is its slow response, which makes it unsuitable for measuring fluctuating pressures.(limitation)

It is essential that the pipes connecting the manometer to the pipe or vessel containing the liquid under pressure should be filled with this liquid and there should be no air bubbles in the liquid.(important point to be kept in mind)

PASCAL'S LAW

It states that the pressure or intensity of pressure at a point in a static fluid is equal in all directions.