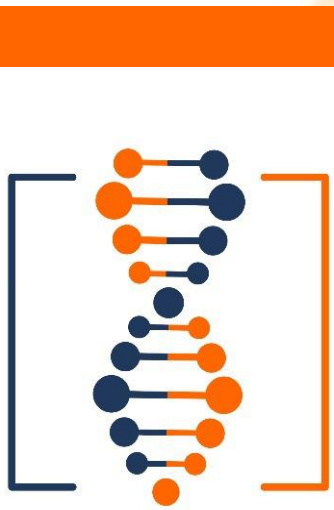

DESTINATION PHARMAGENS

# 1 Manometers

Devices used to measure pressure differences

Three different manometers available are

1. **Simple**

Simple manometer used in measuring of consumption of gases in chemical reaction

Usually combined with venture meter and office meter

Equation for pressure difference measurement immiscible liquids pair, A and B

$\Delta P = R(\rho_A - \rho_B)g$

$\Delta P$ is the pressure difference

R is the difference in levels of liquids A in two limbs

2. **differential**

Suitable measurement of small pressure differences

Micromanometers are its variants

$\Delta P = P_1 - P_2 = R(\rho_A - \rho_C)g$

# 2 Fluid Flow

Characterized by Reynolds number (Re)

## 2.1 Laminar Flow _

flow in which fluide layers moves in one layer sliding over the other

no exchange of fluide particles observed

## 2.2 Turbelent Flow _

Mixed layers of fluids flows

Exchange of fluid particles occurs in different layers

## 2.3 Critical velocity_

The change of over of viscous flow to turbulent takes place

### 2.4 Reynolds equation

$$Re = \frac{Du\rho}{\eta}$$

Re > 4000 then fluid flow is laminar
Re < 2000 then fluid flow is turbulent

D – Average diameter of pipe in meters

$\rho$ – Density of liquids in $Kg/m^3$

$\mu$ – average velocity in m/s

$\eta$ – viscocity of fluids in Pa.s

Re number is dimensionless quantity

## 3 Bernoulli's Theorem

It states that in a steady state level ideal flow of incompressible fluid, the total energy per unit mass, (this total energy consist of Pressure energy, Kinetic energy, Potential/Datum energy) is constant at any point.

Following equation represents Bernoullis equation

$$\frac{P_A}{g\rho_A} + X_A + \frac{\mu_A^2}{2g} - F + W = \frac{P_B}{g\rho_B} + X_B + \frac{\mu_B^2}{2g}$$

**In the above equation, energy term should be used in joules per unit mass.**

## 4 Energy losses in the flow of fluids

### 4.1 Friction losses:

Frictional losses and associated factors summarized by **Fannings equation**

$$\Delta Pf = \frac{2fu2L\rho}{D}$$

$\Delta$Pf- prssure drop in Pa

$\rho$-density of the liquid

f- frictional factor

L- length of pipe

D- diameter of the pipe

While in case of **viscous fluids** for calculating frictional losses **Hagen-Poisuillis equation** used

$$\Delta P = \frac{32Lu\eta}{D}$$

While $\eta$ is the viscosity of solution

**Frictional losses are permanent since due to conversion of kinetic and potential energy into heat.**

### 4.2 Losses in fittings

These losses may be due to

- Change in direction of flow of fluids
- Change in type of fittings
- Expressed by equivalent length of pipe

Elbow fitting - equivalent length around 32

Tee fitting - equivalent length around 90

Coupling fitting - equivalent length negligible

Globe valve coupling - equivalent length around 300

### 4.3 Enlargement losses

This type of pipe enlarges suddenly giving rise to losses

Sudden enlargement losses ($\Delta$He in meters) given by following equation

$$\Delta He = \frac{(u_1-u_2)^2}{2g}$$

### 4.4 Contraction losses

$$\Delta Hc = \frac{Ku_2^2}{2g}$$

K-is the constant

## 5 Measurement of Flow rate

Hydrodynamic measurements performed by following

### 5.1 Orifice meter

$u_o = C_o \sqrt{2g \Delta H}$

$u_o$ is the velocity of fluid at point of orifice meter

$C_o$ constant

$\Delta H$ is the pressure difference in manometer

**It is cheaper, easy to install, but head losses are more**

### 5.2 Venturi meter

It consist of two separate sections in the pipeline with gradual contractions at its center

Velocity of fluid is given by following equation

$U_v = C_v \sqrt{2g \Delta H}$

$U_v$ is the velocity of fluid at point of venture meter

$C_o$ constant of venture meter

$\Delta H$ is the pressure difference in manometer

**It is expensive, difficult to install, but head losses are least**

Commonly used for liquids especially for **water**

### 5.3 Pilot tube / insertion meter

Consist of small sensing element with small constriction compared to size of the flow of channels.

$$\Delta Hp = \frac{u2}{2g}$$

### 5.4 Rotameter / variable area method

It consist of transparent tube in which plummet is placed. Level of plummet indicates flow. In this pressure drop is nearly constant. It is satishfactory for both gases and liquids.

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