NEAR EAST UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

EXPERIMENTAL INVESTIGATION OF PRESSURE DROP IN PIPES

GRADUATION PROJECT

ME- 400

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SUMMARY

In the fist chapter of this project, an introduction to fluid, pressure, types of pressure, pressure depth in a static fluid, and fluid kinetic energy are given. Properties of fluids which are density, mass density, specific weight, velocity, temperature, viscosity, kinematics viscosity are presented.

In the second chapter, flow in pipes, an introduction to pipes, the fluid flow through pipes, turbulent flow and laminar flow, roughness pipe including with a table of roughness material, pressure losses in pipes and velocity effects are presented.

In the third chapter, the experimental setup, the aim of experiment, equipments, experimental measurements are presented.

Finally in Chapter Four, calculations and results were presented in tables. In addition the error calculations are presented.

CHAPTER 1

INTRODUCTION TO FLUID

1.1 INTRODUCTION

There are basically three states of matter, solid, liquid, and gas. The substance H_2O is commonly called ice, in its solid state, water, in its liquid state, and water vapor, in its gaseous state. When side forces, called shearing forces, are applied to a solid piece of ice, very large forces are needed to deform or break it. The solid has a very high internal friction, or resistance to shearing. Liquids and gases are both considered fluids since they behave differently from solids. Imagine two layers of water or air. If shear forces are applied to these layers, there will be a substantial and sustained relative motion of the layers with the air layers sliding faster over one another than the water layers. However, the fact that a shear force must be applied to deform both of these fluids indicates that they also possess internal friction.

Fluid mechanics is the study of the effects of forces and energy on liquids and gases, All fluids are compressible, that is, their density increases under increasing pressure to some extent, but liquids are much less compressible than gases and are generally considered incompressible. Even gases may be treated as incompressible provided the airflow speeds involved are not great, an example, the density remains the same throughout the flow. At higher speeds, the effects of compressibility must be taken into account.

Pressure

Pressure is simply the force experienced by an object divided by the area of the surface on which the force acts.

1.1.1 Pressure Depth in a Static Fluid

The pressure at any point in a static fluid depends only on the pressure at the top of the fluid and the depth of the point in the fluid. If point 2 lies a vertical distance h below

oint 1, there is a higher pressure at point 2, the pressure at the two points is related by e equation:

$$P_2 = P_1 + \rho gh$$

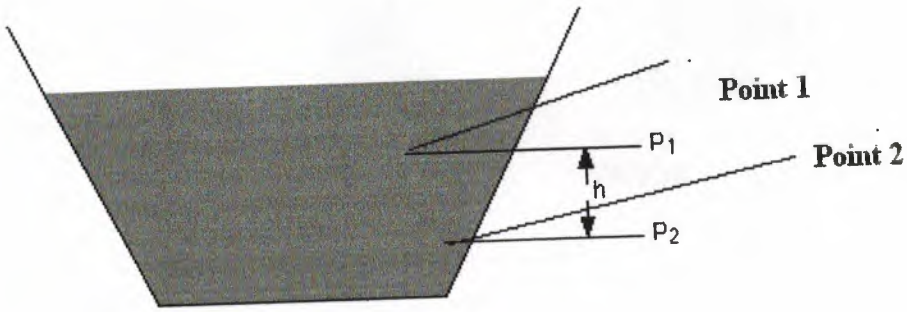


Figure 1.1 Pressure Depth in a Static Fluid

In Figure 1.1 that Point 2 does not have to be directly below point 1. it is simply a vertical distance below point Point 1. This means that every point at a particular depth in a static fluid is at the same pressure.

The pressure exerted by a static fluid depends only upon the depth of the fluid, the density of the fluid, and the acceleration of gravity.the pressure in a static fluid arises from the weight of the fluid and is given by the expression.

$$P_{\text{static fluid}} = \rho gh$$

Where,

ρ : Fluid Density, (kg/m^3)

g : Acceleration of Gravity, (m/s^2)

h : Depth of Fluid, (m)

The pressure from the weight of a column of liquid of area A and height h is

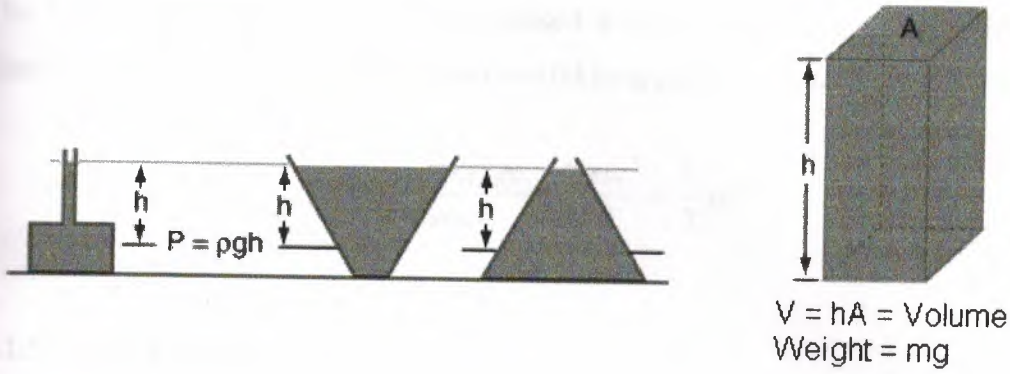


Figure 1.2 Static Fluid Pressure

Static fluid pressure does not depended on the shape, total mass, or surface area of the liquids, The fluid pressure at a given depth does not depend upon the total mass or total volume of the liquid.

1.1.2 Pressure as Energy Density

Pressure in a fluid may be considered to be a measure of energy per unit volume or energy density. For a force exerted on a fluid, this can be seen from the definition of pressure;

$$P = \frac{F}{A}$$

The most obvious application is to the hydrostatic pressure of a fluid, where pressure can be used as energy density alongside kinetic energy density and potential energy density in the Bernoulli equation.

The other side of the coin is that energy densities from other causes can be conveniently expressed as an effective pressure. For example, the energy density of solvent molecules which leads to osmosis is expressed as osmotic pressure. The energy density which keeps a star from collapsing is expressed as radiation pressure.

1.1.4 Fluid Kinetic Energy

The Bernoulli equation when it is expressed as kinetic energy per unit volume The kinetic energy of a moving fluid is more useful in applications like;

$$\frac{kinetic\ energy}{Volume} = \frac{1}{2}\frac{mv^2}{V} = \frac{1}{2}\rho v^2$$

1.1.5 Gauge Pressure

The equation for pressure we have been using is missing a potentially important term. It is the pressure at the surface of the liquid. For the glass of liquid, you probably assumed that it was open to the atmosphere a not unreasonable assumption. There is atmospheric pressure all around us.

It varies as cold and warm fronts move in and out of the area, but the variation is typically only a few percent and changes over periods of hours or days.

So did we make a mistake not including it in the derivation above? Not really, because atmospheric pressure also acts at the bottom of the glass. Let's denote the pressure at the surface from which h is measured as P_o. The pressure at a depth h is actually the sum of the surface pressure and the ρgh term, and it Given as follows;

$$P = P_0 + \rho gh$$

The net or gauge pressure at the bottom of the glass is the difference in the pressure downward pressure $P_o + \rho gh$ and the upward pressure P_o and hence is just ρgh. We often do not have to worry about atmospheric pressure if the liquid's container is completely open.

1.2 PROPERTIES OF FLUIDS

Density

The Specific density of an object is simply its mass divided by its volume. Density it's usually Specific density we're referring to. The Specific density of an object is simply its mass divided by its volume. The symbol for density is the Greek letter rho, and the equation of it we can write it as;

$$\rho = \frac{m}{V}$$

Where,

ρ : Specific density, (kg/m^3)

m : Mass, (kg)

V : Volume, (m^3)

Mass Density

Mass Density ρ is defined as the mass of substance per unit volume.

Typical values;

$\rho_{water} = 1000\ Kg/m^3$

$\rho_{Mercury} = 13600\ Kg/m^3$

$\rho_{Air} = 1.23\ Kg/m^3$

Specific Weight

Specific Weight γ is defined as the weight per unit volume, and it can be written as follow;

$$\gamma = g\,\rho$$

Where,

γ: Specific weight

g: gravity

ρ: Specific Density

Velocity

Velocity of the flow is the average speed of all molecules at a point in the flow at a given time. Velocity is a vector quantity and can be constructed from three scalar components, (horizontal, and vertical, forward).

Temperature

Temperature is a measure of the random molecular motion of the fluid at a point. The hotter the fluid the more energy is stored in random motion of molecules.

Viscosity

Viscosity is a measure of the stickiness of the fluid. High viscosity fluids stick together and produce large friction on surroundings. The viscosity of a fluid changes with temperature. For liquid it decreases with temperature whereas for gases viscosity increases with temperature.

Viscosity μ is the property of a fluid, which offers resistance to sheer deformation. Different fluids deform at different rates under the same shear stress. Fluid with a high viscosity such as syrup deforms more slowly than fluid with a low viscosity such as water. Viscosity can be calculated from this equation;

$$\mu = \frac{\gamma}{\rho}$$

Where;

μ : Viscosity

γ : Specific Weight

ρ : Density

Kinematics Viscosity

Kinematics Viscosity is the ratio of dynamic viscosity to the density of the fluid.

$$\nu = \frac{\mu}{\rho}$$

Where,

ν : Viscosity

μ : Dynamic viscosity

Fluid Shear Stress

Fluid viscosity will produce shearing between fluid layers. This is a dominant effect near surfaces. At the surface the flow is stationary. There will be a shear layer between the surface and the fast moving near surface flow, giving rise to surface friction.

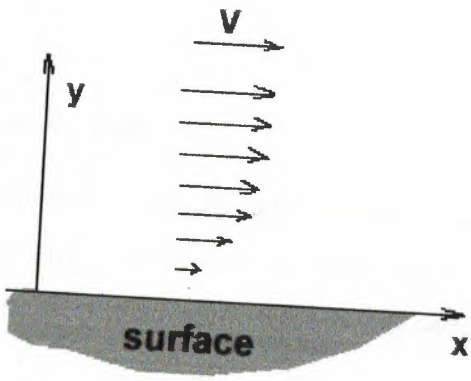


Figure 1.3 Fluid Shear Stress

r an elemental volume of fluid moving over a time step, The distortion is portional to the rate of the shear.

1.3 TYPES OF FLOW

1.3.1 Compressible and Incompressible Flow

A compressible if changes in the density of the fluid have significant effects on the solution. If the density changes have negligible effects on the solution, the fluid is called incompressible and the changes in density are ignored.

The behaviour of a fluid changes radically as it starts to move above the speed of sound in that fluid. For example, in subsonic flow, a stream tube in an accelerating flow contracts. But in a supersonic flow, a stream tube in an accelerating flow expands. To interpret this in another way, consider steady flow in a tube that has a sudden expansion: the tube's cross section suddenly widens, so the cross-sectional area increases.

Incompressible fluid In fluid mechanics, an incompressible fluid is a fluid whose density is constant: it is the same throughout the field and it does not change through time. It is an idealization used to simplify analysis. In reality, all fluids are compressible to some extent.

1.3.2 Steady and Unsteady Flow

Fluids in motion flow maybe steady and unsteady, with respect to time. If the characteristic of flow at any point in flow field does not change with time, The flow is called to be steady, if the flow changes with times it is called unsteady.

$$\text{For the steady flow} = \frac{dV}{dt} = \text{Zero}$$

$$\text{For unsteady flow} = \frac{dV}{dt} \neq \text{Zero}$$

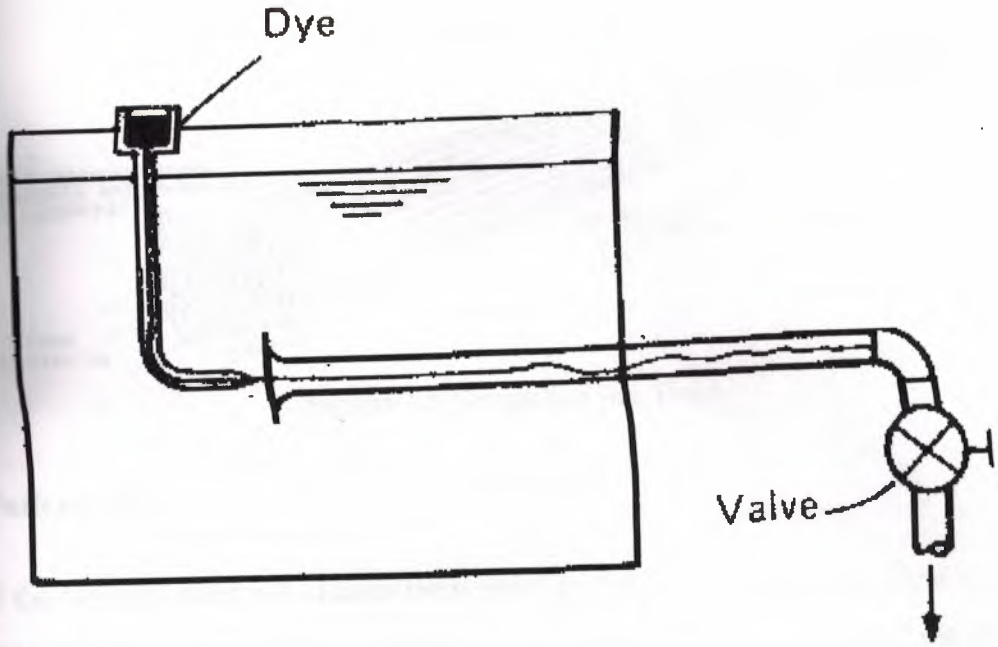


Figure 1.4 Steady Flows and Unsteady Flow

If we open the valve as shown in Figure1.4 the flow will be steady, but if you open or close the valve, continuously the flow will be unsteady.

1.3.3 Stream Lines

Streamline in a fluid

For streamline in small area the fluid velocity across the cross sections will be constant let's call the speeds V_1 and V_2 (the direction of the cross section velocities being perpendicular to the cross - section). There rate at which mass is entering the streamline is $\rho_1 V_1 A_1$ the rate at which it is leaving $\rho_2 V_2 A_2$.

If the mass inside the stream tube is not changing with time, so that the fluid is either incompressible or in steady state we have;

$$\rho_1 V_1 A_1 = \rho_2 V_2 A_2$$

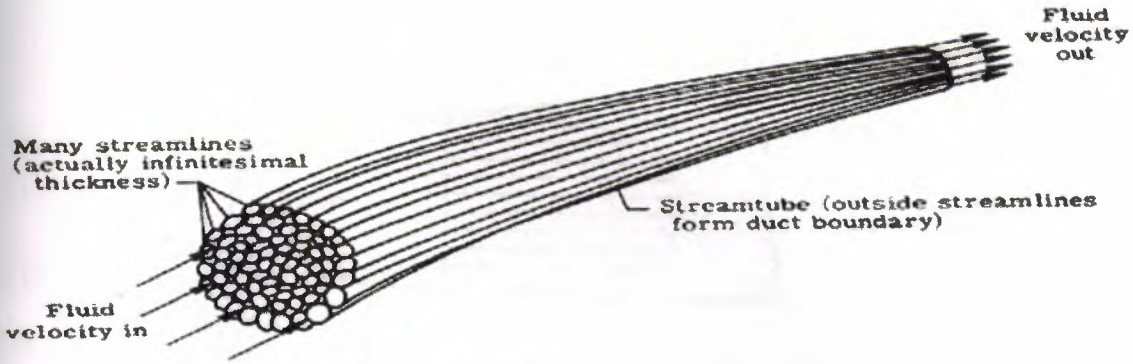


Figure 1.5 Streamline in a Fluid

Uniform flow

If the velocity does not change from point to field, this type of the fluid is called as uniform flow, if the velocity changes at different points along to any of the streamline, the flow is called is called as non-uniform flow.

Therefore,

$$\frac{dV}{dt} = 0 \text{ Means that the flow uniform}$$

$$\frac{dV}{dt} \neq 0 \text{ means that the flow is non-uniform}$$

1.3.4 One-Two and Three Dimensional Flows

If a flow has only one velocity component, it is called as are dimensional flow. If the flow has two or three velocities component, they are called two dimensional or three dimensional flows.

In Reality flow is never travel one dimensional because viscosity causes to the velocity to decreases to zero at boundaries.

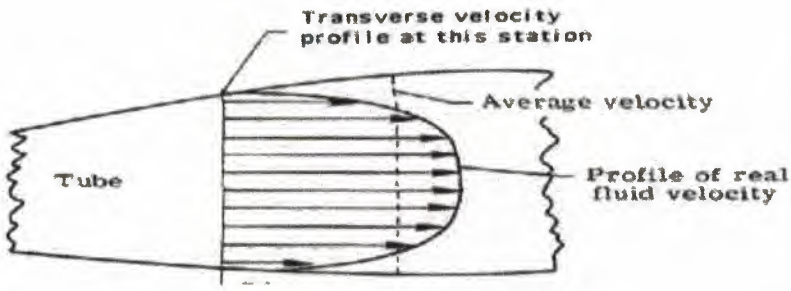


Figure 1.6 Velocity Profile for Real Fluid

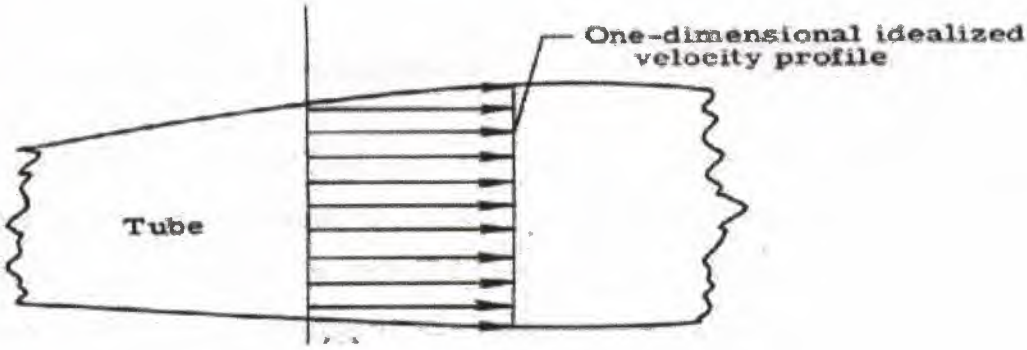


Figure 1.7 Velocity Profile of Ideal Flow

Basic equation for one dimansional flow Continuity equation

Rate of which mass enters the region = Rate of which mass leaves the region.

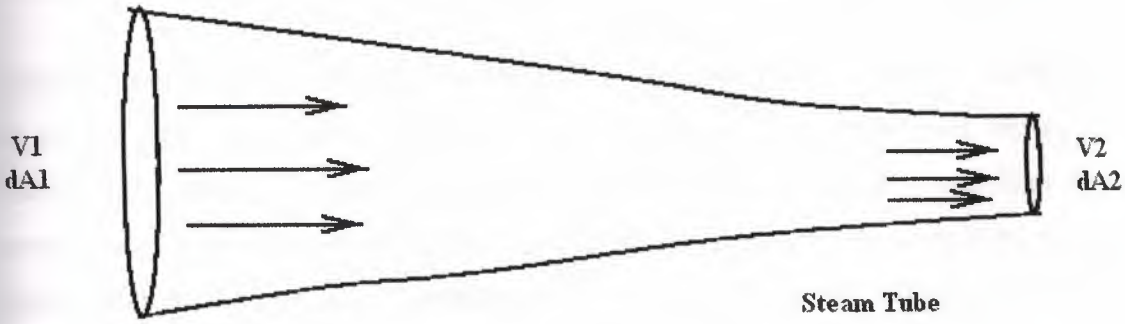


Figure 1.8 Pipes with Different velocities

So the basic equation for one dimansional flow given as;

$$V_1A_1 = V_2A_2 = \dot{Q}$$

Where,

$\dot{Q}$: Volume Flow Rate (Discharge), (m^3/s)

A_1, A_2: Cross section area, (m^2)

V_1, V_2: Velocities of the fluid, (m/s)

1.3.5 Turbulent Flow and Laminar Flow

Turbulent flow is a type of fluid (gas or liquid) flow in which the fluid undergoes irregular fluctuations, or mixing, in contrast to laminar flow, in which the fluid moves in smooth paths or layers. In turbulent flow the speed of the fluid at a point is continuously undergoing changes in both magnitude and direction. The flow of wind and rivers is generally turbulent in this sense.

Most kinds of fluid flow are turbulent, except for laminar flow at the leading edge of solids moving relative to fluids or extremely close to solid surfaces, such as the inside wall of a pipe. Common examples of turbulent flow are blood flow in arteries, oil transport in pipelines, lava flow, atmosphere and ocean currents, the flow through pumps and turbines, and the flow in boat wakes and around aircraft-wing tips.

Laminar flow is a type of fluid gas or liquid flow in which the fluid travels smoothly or in regular paths, in which the fluid undergoes irregular fluctuations and mixing. In laminar flow, sometimes called streamline flow, the velocity, pressure, and other flow properties at each point in the fluid remain constant. Laminar flow over a horizontal surface may be thought of as consisting of thin layers, or laminae, all parallel to each other. Laminar flow in a straight pipe may be considered as the relative motion of a set of concentric cylinders of fluid, the outside one fixed at the pipe wall and the others moving at increasing speeds as the centre of the pipe is approached.

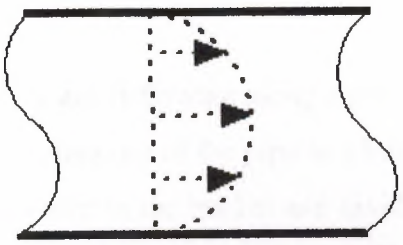


Figure 1.9 Laminar Flow

Figure 1.9 is shown the laminar flow inside of pipe and the way is moving and how laminar flow looks like.

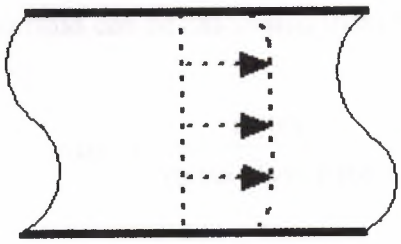


Figure 1.10 Turbulent Flow

Figure 1.10 is shown the turbulent flow isnide of pipe and how the way it's moving inside of it.

1.4 FLOW RATE

There are two types of flow rate;

-Mass flow rate.

-Volume flow rate.

1.6.1 Mass Flow Rate

To measure the rate at which water is flowing along a pipe, a very simple way of doing this is to catch all the water coming out of the pipe in a bucket over a fixed time period. Measuring the weight of the water in the bucket and dividing this by the time taken to collect this water gives a rate of accumulation of mass. This is known as the mass flow rate, and can be calculated from this equation;

$$\dot{m} = \frac{\text{mass of fluid in bucket}}{\text{time taken to collect the fluid}}$$

And time taken to collect the fluid can be calculated from this equation:

$$\text{time} = \frac{\text{mass}}{\text{mass flow rate}}$$

1.6.2 Volume Flow Rate

Volume Flow Rate which also called Discharge; is the volume of fluid flowing per unit time, its is given in this equation;

$$\dot{Q} = \frac{mass\ flow\ rate}{density}$$

$$\dot{Q} = \frac{\dot{m}}{\rho}$$

1.5 CONTINUITY EQUATION

$$\text{Mass Flow Rate} = \frac{\Delta m}{\Delta t}$$

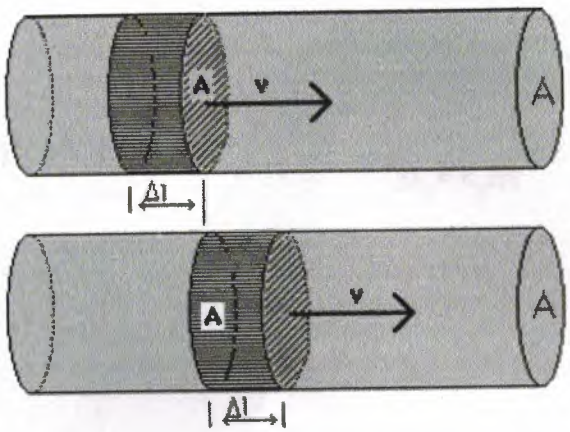


Figure 1.11 Flow Rate Inside of Pipe

$$\Delta V = A\,\Delta l$$

$$\Delta l = V\,\Delta t$$

$$\Delta m = \rho \Delta V = \rho A V \Delta t$$

$$\text{Mass Flow Rate} = \frac{\Delta m}{\Delta t} = \rho A V$$

Where,

A : Cross sectional area, (m^2)

V : Velocity, (m/s)

how can we handle this if the cross section changes?

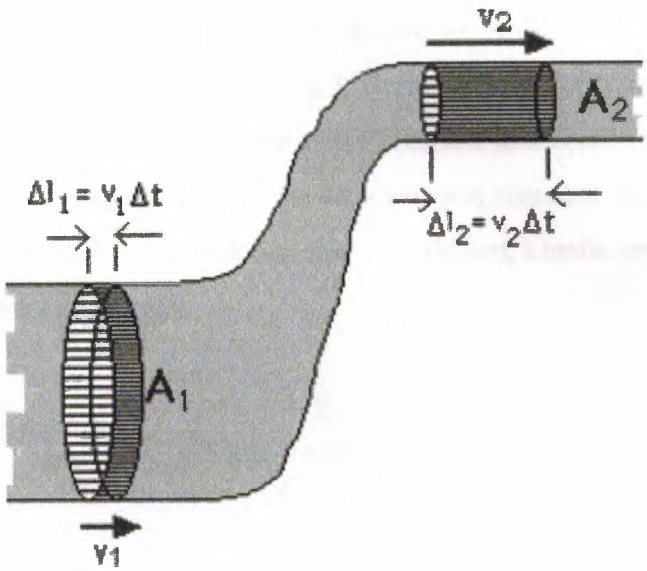


Figure 1.12 Flow Rate In Different Section Areas

$$\Delta \dot{m}_1 = \rho_1 A_1 V_1 \Delta t$$

$$\Delta \dot{m}_2 = \rho_2 A_2 V_2 \Delta t$$

The mass Δm_1 that flows into a region must equal the mass Δm_2 that flows out of the region. That is;

$$\Delta \dot{m}_1 = \Delta \dot{m}_2$$

$$\rho_1 A_1 V_1 \Delta t = \rho_2 A_2 V_2 \Delta t$$

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$$

1.6 BERNOULLI EQUATION

The Bernoulli Equation can be considered to be a statement of the conservation of energy principle appropriate for flowing fluids. The qualitative behavior that is usually labeled with the term Bernoulli effect is the lowering of fluid pressure in regions where the flow velocity is increased. This lowering of pressure in a constriction of a flow path may seem counterintuitive, but seems less so when you consider pressure to be energy density. In the high velocity flow through the constriction, kinetic energy must increase at the expense of pressure energy.

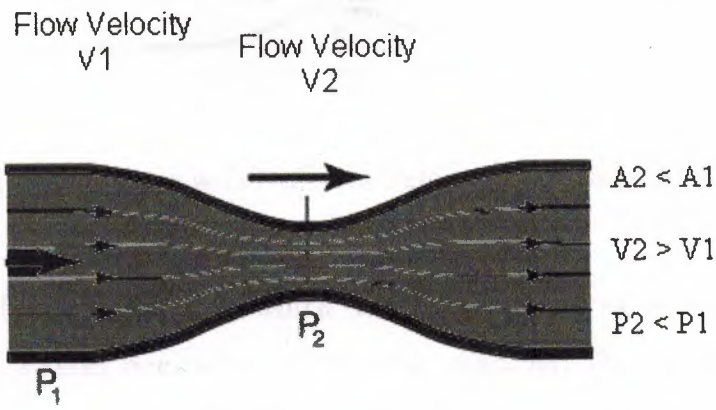


Figure 1.13 Increased Fluid Speeds, Decreased Internal Pressure

In Figure 1.13 of the Bernoulli equation is the reduction in pressure which occurs when the fluid speed increase.

Bernoulli equation is one of the most important equations in fluid mechanics. It may be written;

$$\frac{V_1^2}{2} + \frac{p_1}{\rho} + gz_1 = \frac{V_2^2}{2} + \frac{P_2}{\rho} + gz_2$$

The calculation of the real world pressure in a constriction of a tube is difficult to do because of viscous losses, turbulence, and the assumptions which must be made about the velocity profile, which affect the calculated kinetic energy. The model calculation

here assumes laminar flow-no turbulence, assumes that the distance from the larger diameter to the smaller is short enough that viscous losses can be neglected, and assumes that the velocity profile follows that of theoretical laminar flow. Specifically, this involves assuming that the effective flow velocity is one half of the maximum velocity, and that the average kinetic energy density is given by one third of the maximum kinetic energy density.

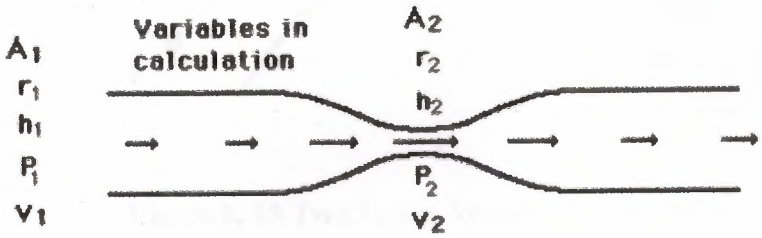


Figure 1.14 Three Pipes with Different Velocities and Different Pressures

In Figure 1.14 There are two pipes which two pipes with the same area, means same diameter and the another one with different area, diameter. This equation relates the pressure, velocity and height in the steady motion of an ideal fluid. The usual form is;

$$\frac{V^2}{2} + \frac{P}{\rho} + gz = \text{Constant}$$

Where,

V: is the velocity at a point

p: Pressure

ρ: Density

g: The acceleration of gravity

z: The height above an arbitrary reference level

The Bernoulli equation applies to conditions along a streamline. It can be applied between two points, 1 and 2, on the streamline as shown in Figure 1.15:

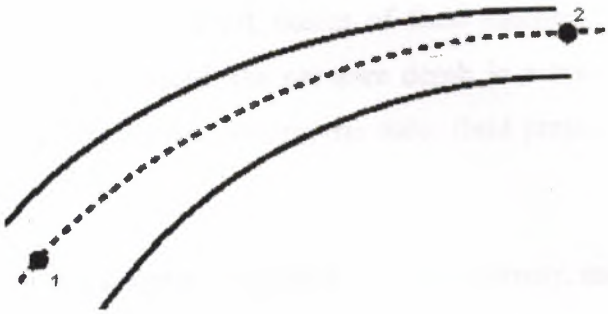


Figure1. 15 Two Points Joined by a Streamline

Total energy at 1 = Total energy at 2

Total head at 1 = Total head at 2

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2} + z_2$$

CONCLUSION

In this chapter an introduction to fluid, basics of fluid mechanics, the pressure, the relations between pressure and fluid, the pressure depth in a static fluid, the relation between the pressure and the energy density, the static fluid pressure, and fluid kinetic pressure are presented.

In the second section of this chapter, properties of fluids, density, mass density, specific density, velocity, temperature, pressure, viscosity, kinematics viscosity, and fluid shear stress are given.

In the third section of the chapter, types of flow, incompressible and incompressible flow, steady and unsteady flow, stream lines, one-two and three dimensional flows, the basic equation for one dimensional continuity equation are given. In addition the turbulent flow and laminar flow are presented.

In the fourth section of the chapter, continuity equation, the mass flow rate in a pipe are explained. In the last section of this chapter, Bernoulli equation, energy equations are given.

CHAPTER 2

FLOW IN PIPES

2.1 INTRODUCTION TO PIPES

There are hundreds of varieties of pipe. Each is designed to carry specific types of fluids and gases under varying conditions.

Pressure Pipe

Pressure pipe must be heavy enough to hold continuous pressure without rupture, and all connections must be leak proof. This pipe tends to be of a smaller diameter, and it must be made of material that will not react with the chemicals or minerals in the water. The standard sizes used in residential plumbing are 1-1/2, 2, 3 and 4 in. As a general rule, 3 inch. pipe is soil pipe (used for carrying solids), while 1-1/2- and 2-inch. pipe carry gray water from sinks, laundries, showers and tubs. 3 inch soil pipes raise the flow level in horizontal runs and, as a result, suffer fewer clogs.

4 inch soil pipe offers a more efficient way to dispose of solid material, but the introduction of low-volume toilets and other water-conserving measures, Pipe was originally sized based on the inside diameter of the pipe that was typical of the period, which was cast iron. A half inch cast iron pipe was exactly one half inch inside diameter. The thickness of its wall determined the outside diameter. In order to insure that all pipes and fittings would go together, the standard was established based on that specific outside diameter.

Metal Pipe

Plastic pipe has been become widely-accepted as the standard for using lines in the world, but it has yet to capture a significant portion of the pressure pipe market. Copper is clearly the choice of most plumbing contractors to supply residential drinking water. But metal pipe has a number of other uses for which plastic is not suited, such as for steam heat and for natural gas distribution, or in industrial environments where strength and durability are vital.

Metal pressure pipe with a diameter of 2 inch or larger is usually welded end to end. This is the most economical and leak proof way of joining large diameter piping. The disadvantage of this type of joint is that weld metal may intrude inside of the piping, which could affect flow of some materials. A backing ring can be inserted in between the joint to prevent this. Plastic pipe is not welded in this manner, but always requires fittings to be joined. Pressure pipe with a diameter of 1 1/2 inch, or less is usually joined by socket welds or threaded joints.

Galvanized Steel Pipe

Galvanized pipe is steel pipe covered with a protective coating of zinc that greatly reduces its tendency to corrode and extends its life expectancy. It may be used in residential water supply lines, but not gas lines because natural gas causes the zinc to flake off and clog the system.

It's not frequently used for water supply lines because the minerals in the water react with the galvanizing material and form scale, which builds up over time and will eventually clog the pipe.

Galvanized pipe was commonly used for water supply lines many years ago, but over time many have filled with scale, which is why some older homes suffer from low water pressure. Hard water greatly reduces the life of steel pipe.

Fittings for this type of pipe are of galvanized malleable cast iron. They connect by screwing onto the threaded pipe, after applying a small amount of pipe joint compound on the threads. Larger diameter pipe is welded rather than threaded. Galvanized pipe is cut either with a heavy-duty tube cutter or cutoff saw, or by hacksaw.

Sizing for Standard Pipes

Flow can be measured by two or three different sized flow tubes. By using the smallest possible meter, one will lower the initial cost and reduce coating build-up, but will increase erosion/corrosion rates and head loss, increasing pumping and operating costs.

Different Coriolis meters incur different pressure drops, but in general they require more than traditional volumetric meters, this higher head loss is due to the reduced tubing diameter and the circuitous path of flow. Besides pumping costs, head loss can be of concern if the meter is installed in a low-pressure system, or if there is a potential for cavitations or flashing, or if the fluid viscosity is very high.

The Length of Pipe of a Given Size

While limiting factor 4 above showed how to overcome the maximum flow rate for a given size of pipe, the length of pipe also has an effect on the force required to circulate the water. The longer the length of pipe, the greater the pressure drop for a given flow rate. This table gives the pressure drop per unit length for various flow rates and pipe sizes.

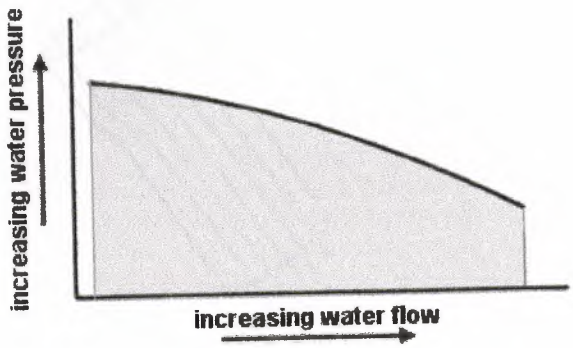


Figure 2.1 Pressure Despression

The pressure drop is important to know for setting up the circulating pump. Every pump has a performance curve which defines its capability to handle various flow rates and pressure. Providing that when the calculated flow and pressure are plotted on the graph, they met under the curve, the pump is adequate for the installation. There's not much that can be done to reduce the water flow in a system, however increasing the size of pipes will reduce the head loss.

2.2 FLUIDS FLOW THROUGH PIPES

When real fluids flow through pipes, two distinct forces act on them. One is the frictional forces exerted on the fluid by the walls of the pipe and the other is the viscous forces within the fluid. The fluid layers next to the walls of the pipe stick slightly to the pipe. As you move further from the walls towards the center of the fluid, this boundary layer ends and the fluid moves faster and more coherently. Viscous forces within the fluid produce a shearing action that results in tiny layers of fluid of ever-increasing speed which eventually reach the speed of the free stream in the center of the pipe. Energy is lost within the fluid to both of these forces.

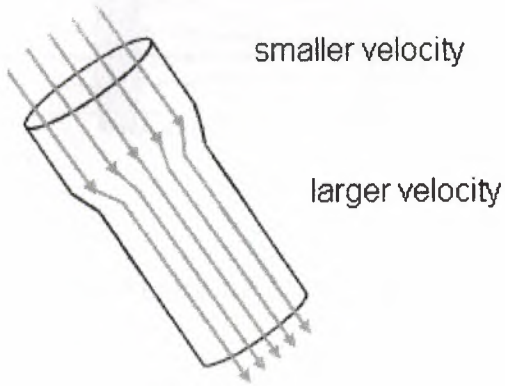


Figure 2.2 A pipe With Different Velocities

An ideal fluid is one that meets the following specifications: steady flow, irrotational flow, nonviscous flow, and incompressible flow. Steady flow is laminar flow which means that the particles flow along streamlines - that is, every particle moves along the same path as previous particles followed. Every particle at the same place in a fluid will have the same velocity. Steady flow only occurs at low velocities. When streamlines are forced closer together, the velocity in the fluid is greater. Irrotational flow means that no fluid elements (small volume packets) have angular velocity, there is no turbulence in the form of whirlpools or eddy currents. Nonviscous flow means that viscosity can be neglected that is, there are no shearing forces within the fluid which subsequently result in the production of heat as the fluid flows. Incompressible flow means that the density of the fluid remains constant.

If a fluid system has no sources providing additional fluid or or sinks draining off fluid, the volume of fluid entering the first cross-sectional area must equal the volume of fluid flowing out the last cross-sectional area.

Since density, $\rho = \frac{m}{V}$ or $\Delta V = m\Delta$ and density is a constant in an incompressible fluid, we say that mass is conserved in a closed fluid system.

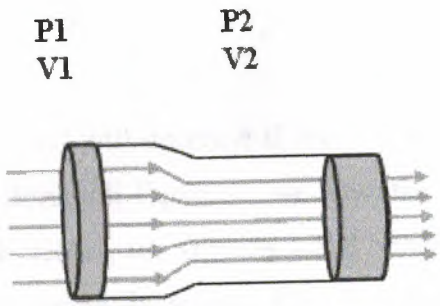


Figure 2.3 Mass Flow

$$V_1 = V_2$$
$$\rho\Delta V_1 = \rho\Delta V_2$$
$$\Delta m_1 = \Delta m_2$$

This formula states that the cross-sectional area of the pipe and the velocity of the fluid are inversely proportional - that is, fluids flow faster through narrower pipes. We can see this by the fact that the streamlines are forced closed together whenever the pipe narrows. Next time you watch water flowing from a faucet, note how the water stream narrows as the water falls. This reduction in cross-sectionalarea is required by the Continuity Equation since the water is increasing in speed as it falls.

Since the fluid is incompressible,

$$\Delta V_1 = \Delta V_2 = \Delta V \text{ and } \Delta m_1 = \Delta m_2 = \Delta m$$

$$\Delta m = \Delta V$$

And the Continuity Equation;

$$A_1V_1 = A_2V_2 = AV$$

$$P_1 + \rho g h_1 + \frac{1}{2}\rho V_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho V_2^2$$

If there is no change in potential energy along the length of the pipe, then this equation can be rephrased as;

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

The kinetic energy of the fluid will decrease if the pressure increases. Combining the Continuity Equation and Bernoulli Equation, we have the result that when the cross-sectional area of a pipe decreases, the velocity - and hence the kinetic energy - of the fluid increases, and the pressure decreases. This is called the Bernoulli or Venturi Effect.

Since P_1 and P_2 are both nearly equal to atmospheric pressure, we can consider them equal to each other.

$$\rho g h_1 = g h_2 + \tfrac{1}{2}\rho v_2^2$$

$$v_2 = \sqrt{\rho g(h_2 - h_1)}$$

2.3 TURBULENT FLOW AND LAMINAR FLOW AND RYNOLDS NUMBER

Turbulent Flow

Turbulence occurs when smoothly flowing, laminar flow is disrupted. This occurs distal to stenotic heart valves or arterial vessels, at vessel branch points, and in the ascending aorta at high cardiac ejection velocities an example during exercise.

The onset of turbulence under ideal conditions can be predicted by calculating the Reynolds number (Re);

$$\mathrm{Re} = \frac{V.D.\rho}{\mu}$$

Where,

V: velocity

D: diameter of pipe

μ: dynamic velocity

The measuring of Re, came from this Equation;

$$\mu = \gamma\rho$$

Where,

μ: dynamic velocity

γ: specific weight

$$\mathrm{Re} = \frac{V.D}{\gamma}$$

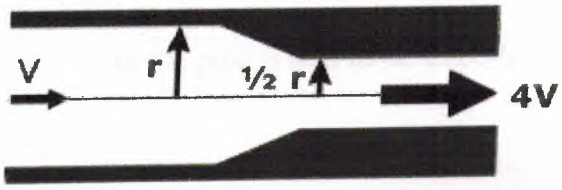
Laminar flow: Re < 2000

Turbulent flow: Re > 4000

There is a critical Reynolds number above which laminar flow is disrupted and turbulence occurs. Therefore, as blood flow velocity increases in a blood vessel or across a heart valve, there is not a gradual increase in turbulence as the Reynolds number increases. Instead, laminar flow will continue until a critical Reynolds number is reached, at which point, turbulence will develop.

Volume Flow Rate = velocity x area

Flow in = Flow out



F = V . A And A = $\pi \cdot r^2$

Figure 2.4 Volume Flow Rate Through Different Pipes

2.4 PIPE ROUGHNESS

Traditional values of absolute pipe roughness are:

Table 2.1 Roughness of Different Material

Material	**Roughness**
	mm
drawn tubing	0.0015
plastic tubing	0.0015
stainless steel	0.015
Commercial steel	0.05
Rusted steel	0.1 - 1.0
Galvanized iron	0.15

Despite its thinness, the laminar sub-layer can play a vital role in the friction characteristics of the surface.

This is particularly relevant when defining pipe friction. In laminar flow the height of roughness has very little effect. In turbulent flow if the height of the roughness of a pipe is greater than the thickness of the laminar sub-layer then this increases the amount of turbulence and energy losses in the flow. If the height of roughness is less than the thickness of the laminar sub-layer the pipe is said to be smooth and it has little effect on the boundary layer.

Table 2.2 Usual Value Index of Roughness (k) in mm

Usual value index of roughness (k) in mm		
	Nature of interior surface	Index roughness K
1	Stainless steel	0.015
2	Steel commercial pipe	0.045- 0.09
3	Weld steel	0.045
4	Galvanized steel	0.15
5	Worn cast iron	0.8- 1.5
6	Sheet or asphalted cast iron	0.01-0.015
7	Ordinary concrete	1.0
8	Well planed wood	5.0

2.5 PIPE BENDS AND FITTINGS

The pipe Bends and Fittings Apparatus enables friction losses in various types of pipe fittings to be determined experimentally. The apparatus consists of a test length of pipe work fitted to a vertical panel on a movable base.

In the pipe run are a pipe union, globe, valve, gate valve and pipe fitting are manometer each fitted with stopcock. Manometer tubes which can be connected by means of flexible rubber to the manometer on both sides of the fitting under test are mounted on the panel. The difference in manometer heights will then indicate the loss in head of water caused by the fitting. If a higher pressure flow rate is required to test the fitting the manometer can be pressurized by the use of the cycle tire type air pump supplied with the apparatus.

Table 2.3 K Factor for Fitting

K Factor of fitting	Nominal Diameter, in							
	1/2	3/4	1	1 1/2	2	3	4	5
Gate Valve (open)	0.22	0.2	0.18	0.16	0.15	0.14	0.14	0.13
Globe Valve (open)	9.2	8.5	7.8	7.1	6.5	6.1	5.8	5.4
Standard Elbow (screwed) 90	0.8	0.75	0.69	0.63	0.57	0.54	0.51	0.48
Standard Elbow (screwed) 45	0.43	0.4	0.37	0.34	0.3	0.29	0.27	0.26

2.6 HEAD LOSS

Head loss is combined of two major components: friction losses and minor losses. Friction losses are head losses due to the friction that the walls of the pipe imposes on a liquid. Friction losses are dependent on the viscosity of the fluid and the turbulence of the flow. Head loss due to friction (hf) can be calculated as:

$$h_f = \frac{fLV^2}{D2g}$$

where,

h_f: Head loss

f : Friction factor

L: Pipe length

V: Velocity

g: gravity

The friction factor, f, can be determined if you know the relative roughness of the pipe, and by solving for the Reynolds number Re, as discussed about Reynolds number before in chapter two.

Minor losses are losses due to the change in flow patterns of the liquid, i.e. bends, valves, sudden changes in pipe diameter, etc. Minor losses are usually negligible compared to friction losses in larger pipe systems. Minor losses, hm, can be determined by the following equation;

$$h_L = k\frac{V^2}{2g}$$

where,

h_L : minor loss

K : lminor head loss coefficient

The coefficient of minor head loss can also be determined from tables of fluids mechanics book. There are values for every type of valve, elbows, tees, bends, and sudden and gradual expansions and contractions.

2.6.1 Losses at Sudden Enlargement

Consider the flow in the sudden enlargement, shown in Figure 2.5, fluid flows from section 1 to section 2. The velocity must reduce and so the pressure increases this

follows from Bernoulli. At position 1' turbulent eddies occur which give rise to the local head loss.

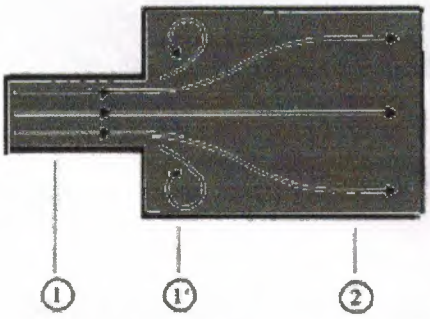


Figure 2.5 Sudden Expansion

$$k_L = \left(1 - \frac{A_1}{A_2}\right)^2$$

Where,

K_L = Losses at Sudden Friction

A_1 = Section area one

A_2 = Section area two

So h_L:

$$h_L = \left(1 - \frac{A_1}{A_2}\right)^2 V^2/2g$$

2.6.2 Losses at Sudden Contraction

In a sudden contraction, flow contracts from point 1 to point 1'. It is possible to assume that energy losses from 1 to 1' are negligible no separation occurs in contracting flow but that major losses occur between 1' and 2 as the flow expands again. As shown in Figure 2.6

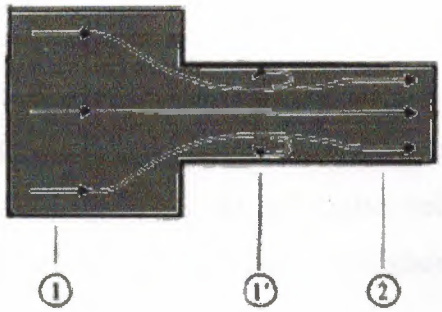


Figure 2.6 Sudden Contraction

$$h_L = 0.44\ V_2^2 / 2g$$

Where,

h_L : Sudden friction

V_2 : Velocity in pipe 2

2.7 PRESSURE LOSSES IN THE PIPES

The calculation of the linear pressure loss, that corresponding to the general flow in a rectilinear conduit, is given by the following general formula;

$$\Delta P = \frac{\frac{A}{D} \times \rho V^2}{2L}$$

Where,

Δp : pressure loss in Pa

A : friction factor (a number without dimension)

p : density of water in kg/m3

V : flow rate in m/s

D : pipe diameter in m

2.8 VELOCITY EFFECTS

At low speeds the whole flow across a pipe is laminar and the fluid slides over itself. As the speed becomes faster eddies start to form and cross the fluid layers. A transition from laminar to turbulent flow develops. At still higher velocities the flow in the core of the pipe becomes turbulent with swirling eddies throughout.

The laminar sub layer is always present against the pipe wall. But as the velocity rises the energetic swirling eddies begin to impact more deeply and the sub layer begins to thin. At still higher velocities the sub layer thins further and the taller roughness peaks stick into the turbulent region. Where the sub layer covers the roughness projections the wall is considered smooth. When the wall roughness pokes out of the sub layer the wall is considered rough. This means the same wall can be both smooth and rough depending on the fluid's velocity.

The pipe system designer has to strike a practical balance between increasing the pipe diameter to reduce energy loss and keeping the diameter small to lower installation costs.

CONCLUSION

In this chapter an introduction to pipes, types of pipes, pressure pipes, metal pipe, speically galvanized pipe are presented. Sizing pipes, pressure drop, including with a table of nominal pipe size for standard pipes are given.

In the second section, the fluid flow through pipes, with types of fluids as a steady, unsteady flow, compressible, incompressible are given. Continuity equations, and Bernoulli equation are presented.

Third and fourth section of this chapter, the turbulent flow and laminar flow are presented. Pipes roughness, pipes fitting with a table of k factor for fitting in pipes are explained. The head loss, the relations between the head loss and Reynolds number, the calculation of the pressure loss in pipes, and the velocity effects are given.

CHAPTER 3

EXPERIEMNTAL SETUP

3.1 THE AIM OF THE EXPERIMENT

The aim of the experiment is to measure pressure drops in pipes, to study how the diameter, roughness and flow rate are effect the pressure in pipes.

The factors that affect the pressure in pipes can be given as follows:

The properties of fluid.
The velocity of fluid.
The diameter of pipes.
The pipe wall roughness.
The length of pipes.
The manometer level.
The material of pipes.
The length of pipes.
The water level.
The time of flow.
The frictions of pipes.

3.2 EXPERIMENTAL SETUP

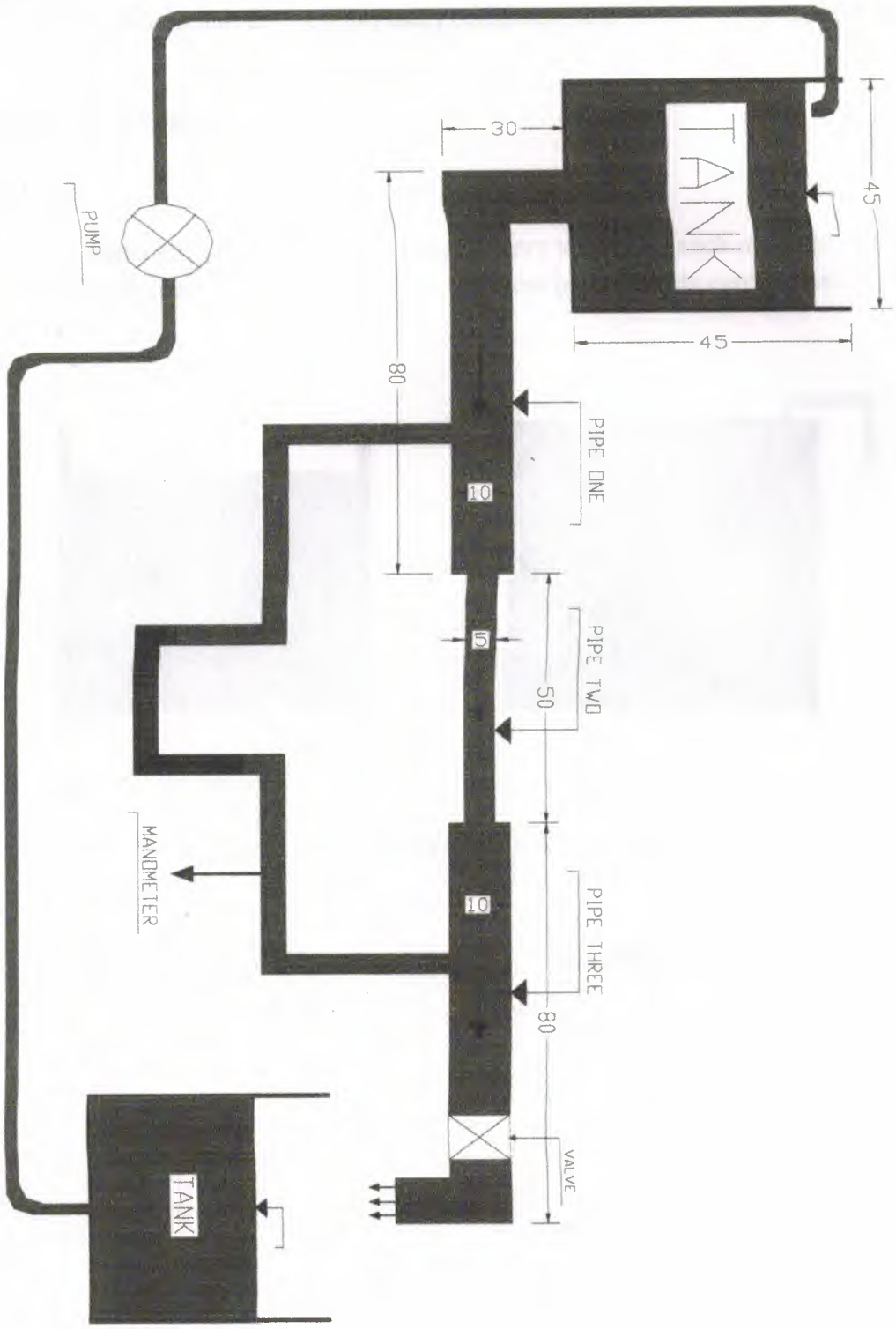


Figure 3.1 Experimental Setup

3.3 EQUIPMENT OF THE EXPERIMENT

Equipment of experiment divides into main equipment and secondary equipment.

3.3.1 Main Equipment

Two Tanks

These two tanks are galvanized tanks used to carry water and each one have a volume of $(42 \times 45 \times 45)\,cm^3$, as shown in Figure 3.2, these pipes used to carry water.

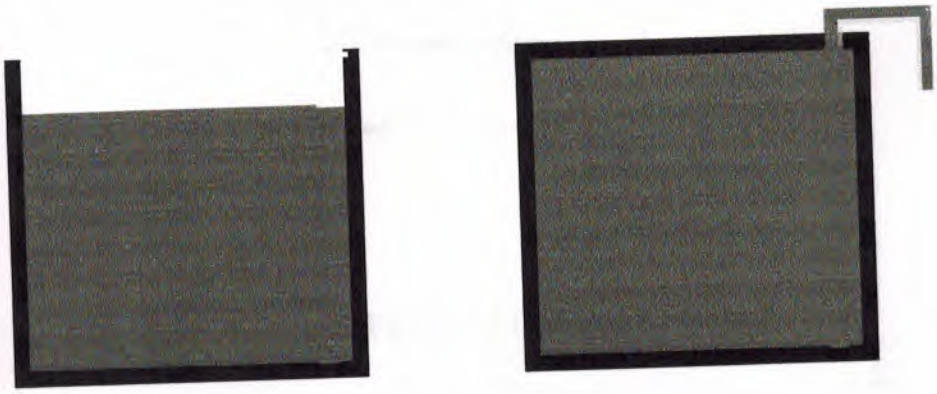


Figure 3.2 Two Tanks Used For the Experiments

Two tanks galvanized as shown in Figure 3.2, these tanks have a volume which is (0.45X0.45X0.45) m^3, these tanks used to carry water.

Three Pipes

Pipes that were used also galvanized pipes, and have a circular cross section, two of these pipes have the same cross-section with $10cm$ diameter, and length of $10\,cm$ as shown in Figure 3.3 .the third one has $5cm$ diameter and length of $50cm$ as shown in Figure 3.3, all pipes have a series connection.

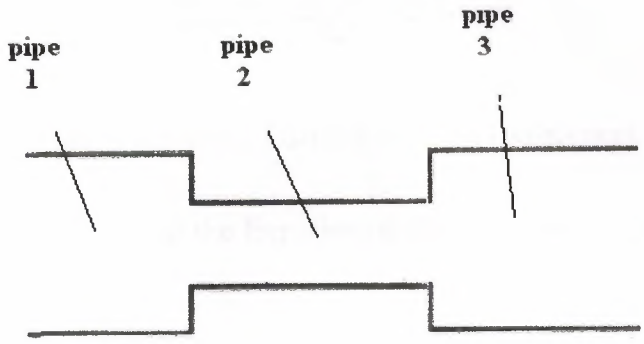


Figure 3.3 Pipes

In Figure 3.3 is shown the pipes of the experiment, these pipes are also galvanized pipes, and have a circular cross section, two of these pipes have the same diameter and its diameter is 10 cm, the third one has 5 cm diameter, all pipes have a series connection.

Manometer

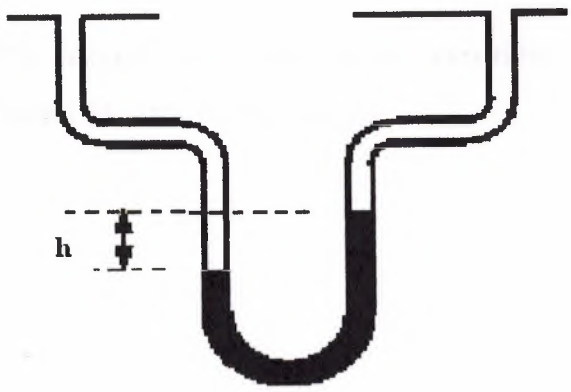


Figure 3.4 Manometer

Figure 3.4 shows the manometer of the expemiment, and this manometer has a mercury inside of it, the use from the manometer is to measure the pressure inside of pipes.

Valve

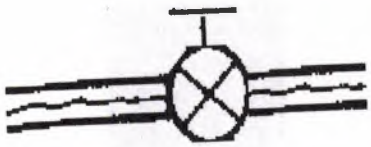


Figure 3.5 Valve Using doring the Experiment

Figure 3.5 Shows The Valve of the Experiment, the use from it to controll the flow of water in pipes.

Balance (Scale)

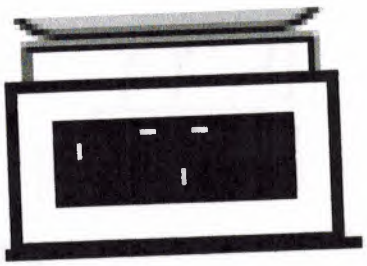


Figure 3.6 Balance

Figure 3.6 Shows The Balance which used in the experimental, the use from it to measure the mass of water Flowing through pipes.

Bucket

Used to carry the water flow from the pipe to the scale, as shown in Figure 3.7

Figure 3.7 Bucket

Standard Elbow

This elbow is used to connect two pipes. As shown in Figure3.8

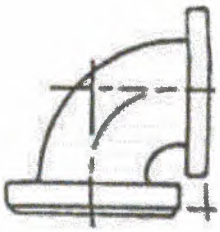


Figure 3.8 90" Standard Elbow

3.3.2 Secondary Equipment

Pump

Used to pump the water from tank 2 to tank 1, as shown in Figure3.9

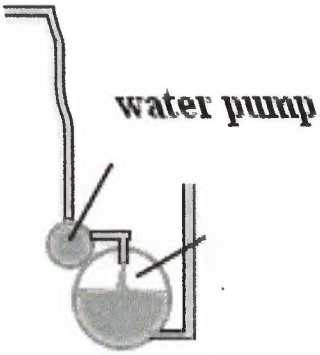


Figure 3.9 Typical pimp used in the experimental

Pail

There is a pail and the use from it to fill it with water, for measuring the mass inside of it.

Ruler

The use from the ruler is to read the level of mercury and the depth of the water in the tank.

3.4 SPECIFICATION OF THE EXPEMEMINT

Inlet

Inside diameter 0.01mm length 0.08 mm, material – Galvanized.

Manometer Tube

Material - transparent plastic.

Mercury

erial Galvanized.

Material - Two Tanks of Galvanized.

Middle Connected

Galvanized pipe, Diameter is 50mm, length is 005 mm.

Outlet

Galvanized pipe, diameter is 0.01 mm, length is 0.08 mm.

3.5 CONNECTION OF EQUIPMENT

Water is supplied through an inlet on/off the pump at the entrance to the tank, there are three pipes. All of which have circular cross sections, and are made of galvanized material.

Pipe one is connected with the tank, that means the water flow from the tank into the pipe number one, when the pipe one is connected with a manometer also, the aim of the manometer which is connected with the pipe is to measure the different pressure between the pipes (pipe number one, pipe number three), when the pipe one and pipe three are same section area.

The pipe two is connected with pipe one the means also water will flow from pipe one to two, which pipe two has a different section area.
Pipe three is connected with pipe two, the water will flow from pipe two into pipe three which pipe three has the same section area of pipe one, which also connected with the manometer, that for measuring the different pressure by using the manometer, also pipe three is connected with a valve (output-on/off), that for controlling the water flow into the tank (output tank).

3.6 EXPERIMENTAL PROCEDURE

The steps were carried out of this experiment can be summarized as follows;

1- Fill up the first tank with water, and make sure that the valve is switch off on the third pipe.

- Water will flow through the pipes, check the manometer level, record the manometer level, check the manometer level is a constant or not, which means if the level is a constant there is no change in pressure through the pipes.
- Turn on the pump and the valve completely.
- Read the monometer level as quickly as possible.
- Repeat step1, four times, and record the results.

2- Control the valve with pump to make the water 38 cm high in the first tank, and check the Manometer level and record it.

- By keeping the same level in the tank, the manometer level will be the same.
- Collect the water by recording the time that used up to fill the bucket, and then weight it by using the scale and record the measures.
- Repeat step 2, four times, and record the results.

3- Decreasing the level of water in the first tank to 30 cm, and keep on this level by controlling the valve.

- Read the manometer level.
- Collect the water by recording the time that used up to fill the bucket, weight it by using the scale and record the measures.
- Repeat step 3 four time and record the result.

4- Decreasing the level of water in the first tank to 20 cm, and keep on this level by controlling the valve.

- Read the manometer level, and record it.
- Collect the water by recording the time that used up to fill the bucket, and then weight it by using the scale and record the measures.
- Repeat step 4 four time and record the result.

5- Decreasing the level water of the first tank to 10 cm, and keep on this level by controlling the valve.

- Read the manometer level, and record it.
- Collect the water by recording the time that used up to fill the bucket, and then weight it by using the scale and record the measures.
- Repeat step 5 four time and record the result.

CONCLUSION

In this chapter the experimental setup, the experimental layouts are given. The aim of the experiment, which is how to calculate the pressure drop in pipes, the roughness of pipes, the flow rate affect the pressure, factors that affect the pressure in pipes are presented.

In the second section of the chapter the equipment of the experiment, materials which are used during the experiment are explained.

In the third section of the chapter the specification of the experiment, the inlet – outlet of pipes, the manometer, the valve, tanks, which are used during the experiment are presented. The experimental connected and how the connections of pipes are presented.

In the last section of the chapter, the experimental procedure, how to record the values from the experiment are presented.

CHAPTER 4

CALCULATIONS

4.1 GENERAL INFORMATION

For our experiment, calculations can be summarized in eight steps as follows;

STEP 1

Mass Flow Rate Calculations

Mass Flow Rate can be calculated as given below;

$$\dot{m} = \frac{water\ weight}{time}$$

Where;

$\dot{m}$: Mass Flow Rate, (kg/s)

STEP 2

Discharge Calculations

Discharge can be calculated as given below;

$$\dot{Q} = \frac{\dot{m}}{\rho_{H2O}}$$

Where;

$\dot{Q}$: Volume Flow Rate (Discharge), (m^3/s)

STEP 3

Pipes Area Calculations

Cross Sectional Area can be calculated as given below;

$$A = \frac{\pi D^2}{4}$$

Where;

A: Cross sectional area, (m^2)

STEP 4

Velocities Calculations

Velocity in pipes can be calculated as given below;

$$\dot{Q} = AV$$

Where;

$\dot{Q}$: Discharge, (m^3/s)

A : Cross Sectional Area, (m^2)

V : Velocity, (m/s)

STEP 5

Reynolds Number Calculations

Reynolds number can be calculated as given below;

$$Re = \frac{\rho V D}{\mu}$$

Where;

$\mu = 0.00101$ (N.s/m^2)

D : Diameter, (m)

STEP 6

Local Head Losses h_f, Calculations

Head losses can be calculated as follows;

$$h_f = k_L + h_{L1} + h_{L2} + f$$

Where;

k_L: Bend loss, which equal to = 0.4 for galvanized bend pipes as shown in Figure 4.1

Figure 4.1 Galvanized Bend Pipes

Is shown in Figure 4.2 sudden contraction losses (h_{L1}). Where the Sudden contraction losses can be calculated as follows;

$$h_{l1} = 0.44(\frac{V_2^{\,2}}{2g})$$

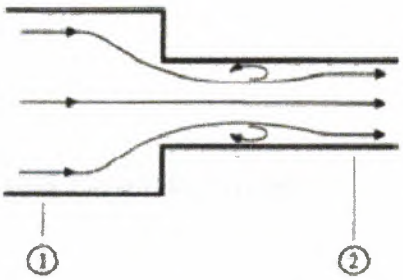


Figure 4.2 Sudden Contraction

Is shown in Figure 4.3 the sudden enlargement (h_{L2}), sudden enlargement losses which can be calculated as given below;

$$h_{l2} = (1 - \frac{A_1}{A_2})^2 \frac{V_2^{\ 2}}{2g}$$

Where,

A_1, A_2 : Cross Sectional Areas for pipes, (m^2)

V_2: velocity, (m/s)

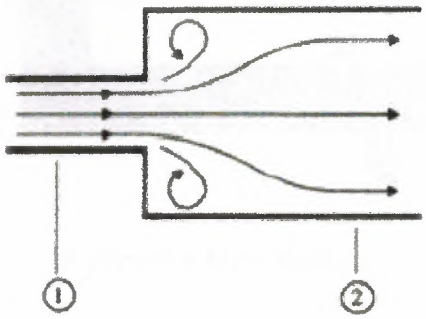


Figure 4.3 Sudden Enlargement

f : Friction of turbulent losses which can be calculated as given below;

$$f = \frac{0.079}{\mathrm{Re}^{0.25}}$$

Where,

f : Friction turbulent losses

STEP 7

Pressure Calculations by Using Bernoulli Equation

In our experiment we have four points, and each point has different pressure, and we calculated the pressure of each point in three sections;

First Section:

This section is shown in Figure 4.4

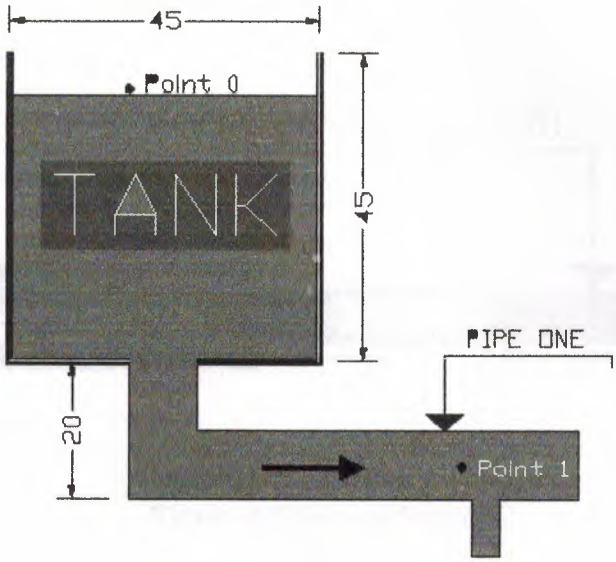


Figure 4.4 First Section

Bernoulli equation which is used to calculate the pressure at point 1 is given as below;

$$\frac{p_0}{\rho g} + \frac{V_0^{\,2}}{2g} + z_0 = \frac{p_1}{\rho g} + \frac{V_1^{\,2}}{2g} + z_1 + h_f$$

Where,

P_0 : Atmospheric pressure

V_o:Velocity at point 0

z_0 : Water depth at point 0

P_1: Pressure at point 1

V_1 : Velocity at point 1

z_1 : Water depth at point 1

ρ : Water density

g : Acceleration gravity

h_f: $k_L + h_{L1} + f$

Second Section

This section is shown in Figure 4.5

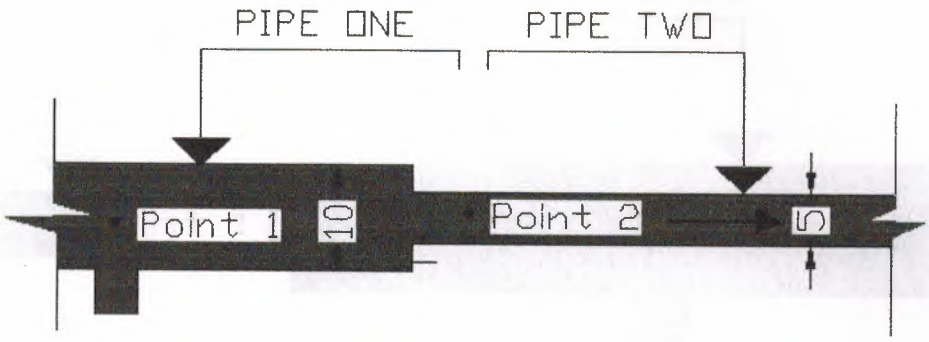


Figure 4.5 Second Section

Bernoulli equation which is used to calculate the pressure at point 2 is given as below;

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+h_f$$

Where,

P_1 : Pressure at point 1

V_1: Velocity at point 1

P_2 : Pressure at point 2

V_2: Velocity at point 2

ρ : Water Density

g : Acceleration gravity

$h_f = h_{L1} + f$

Third Section

This section is shown in Figure 4.6

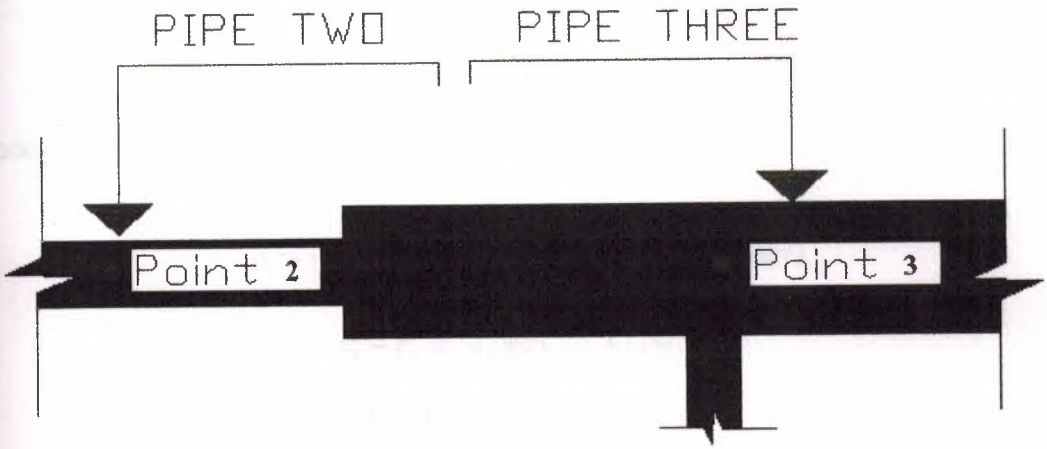


Figure 4.6 Third Section

Bernoulli equation which is used to calculate the pressure at point 2 is given as below;

$$\frac{p_2}{\rho g} + \frac{V_2^{\,2}}{2g} = \frac{p_3}{\rho g} + \frac{V_3^{\,2}}{2g} + h_f$$

Where,

P_2 : Pressure at point 2

V_2: Velocity at point 2

P_3 : Pressure at point 3

V_3 : Velocity at point 3

ρ : Water Density

g : Acceleration gravity

$h_f = h_{L2} + f$

STEP 8

Pressure Measurements by Manometer

Pressure difference between point 1 and point 3 can be calculated as follows;

$$P_1 - p_3 = x(\rho_{Hg} g - \rho_{H2O} g)$$

Since;

$$p_1 + (\rho g h)_{H2O} = P_3 + (\rho g(h - x))_{H2o} + (\rho g x)_{Hg}$$

$$P_1 - P_3 = -(\rho g x)_{H2O} + (\rho g x)_{Hg}$$

$$P_1 - P_3 = x(\rho_{Hg} g - \rho_{H2O} g)$$

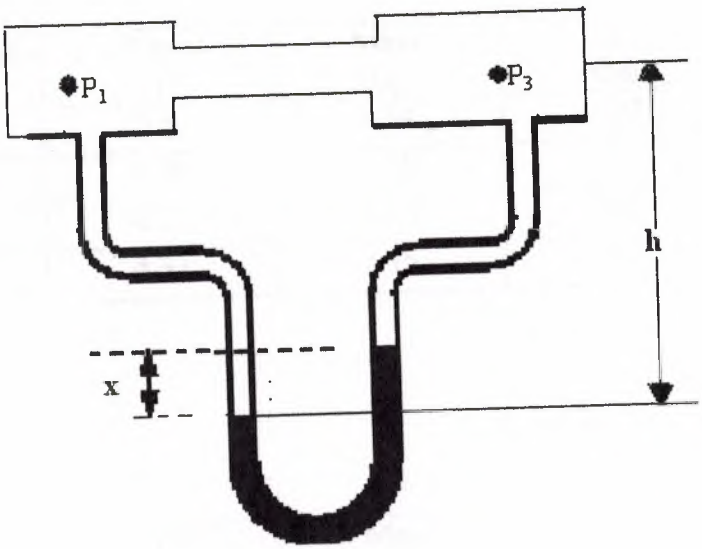


Figure 4.7 Measurement of Pressure

4.2 TABULATED DATA

Experimental Measurements

Table 4.1 Step 1

Step 1

Experimental No.	Time (s)	Mass (kg)	h (mm)	X (mm)
1	3.3	4.52	380	4
2	3.42	4.61	380	4
3	3.33	4.45	380	4
4	3.13	3.00	380	4

Table 4.2 Step 2

Step 2

Experimental No.	Time (s)	Mass (kg)	h (mm)	X (mm)
1	2.8	4.34	300	3
2	3.78	5.28	300	3
3	4.25	5.55	300	3
4	4.33	6.15	300	3

Table 4.3 Step 3

Step 3

Experimental No.	Time (s)	Mass (kg)	h (mm)	X (mm)
1	3.29	4.32	200	3
2	3.59	4.64	200	3
3	2.37	4.08	200	3
4	2.53	3.28	200	3

Table 4.4 Step 4

Step 4

Experimental No	Time (s)	Mass (kg)	h (mm)	X (mm)
1	3.31	4.98	150	2.4
2	2.98	4.49	150	2.4
3	3.88	5.38	150	2.4
4	3.67	5.18	150	2.4

Table 4.5 Step 5

Step 5

Experimental No	Time (s)	Mass (kg)	h (mm)	X (mm)
1	4.11	5.53	100	2
2	4.23	5.65	100	2
3	3.74	5.32	100	2
4	3.53	5.11	100	2
5	3.73	5.21	100	2
6	3.68	5.12	100	2
7	3.99	5.52	100	2

Mass Flow Rate Measurements

Table 4.6 Mass Flow Rate of Step 1

Step 1

Experimental No	Time (s)	Mass (kg)	Mass Flow rate (kg /s)
1	3.3	4.52	1.37
2	3.42	4.61	1.35
3	3.33	4.45	1.34
4	3.13	3	0.96
Average	3.23	4.145	1.26

Table 4.7 Mass Flow Rate of Step 2

Step 2

Experimental No	Time (s)	Mass (kg)	Mass Flow Rate (kg /s)
1	2.8	4.34	1.55
2	3.78	5.28	1.40
3	4.25	5.55	1.31
4	4.33	6.15	1.43
Average	3.79	5.33	1.41

Table 4.8 Mass Flow Rate of Step 3

Step 3

Experimental No	Time (s)	Mass (kg)	Mass Flow Rate (kg /s)
1	3.29	4.32	1.32
2	3.58	4.64	1.23
3	2.37	4.08	1.73
4	2.53	3.28	1.21
Average	2.95	4.08	1.39

Table 4.9 Mass Flow Rate of Step 4

Step 4

Experimental No	Time (s)	Mass (kg)	Mass Flow (kg /s)
1	3.31	4.98	1.50
2	2.98	4.49	1.51
3	3.88	5.38	1.39
4	3.67	5.18	1.42
Average	3.64	5.01	1.45

Table 4.10 Mass Flow Rate of Step 5

Step 5

Experimental No	Time (s)	Mass (kg)	Mass Flow Rate (kg /s)
1	4.11	5.53	1.35
2	4.23	5.65	1.34
3	3.74	5.32	1.43
4	3.53	5.11	1.45
5	3.73	5.21	1.39
6	3.68	5.12	1.40
7	3.99	5.52	1.39
Average	3.86	5.36	1.39

Discharge Measurements

Table 4.11 Discharge Measurements

Mass (kg)	Time (s)	Mass Flow Rate (kg /s)	Q (m^3/s)
4.15	3.29	1.258	0.001258
5.33	3.79	1.407	0.001407
4.08	3.00	1.360	0.001360
5.00	3.46	1.446	0.001446
5.36	3.86	1.389	0.001389

Velocities and Local Head Losses Measurements

Table 4.12 Velocities Measurements

$V_1 = V_3$ (m/s)	V_2 (m/s)	hf_1	hf_2	hf_3
0.161	0.641	0.4076	0.0152	0.0077
0.180	0.717	0.4077	0.0175	0.0079
0.174	0.700	0.4077	0.0170	0.0078
0.184	0.741	1.4078	0.0181	0.0079
0.177	0.710	0.4077	0.0162	0..0079

Pressure Measurements

Table 4.13 Pressure Measurements

z (m)	Mass Flow Rate (kg/s)	Q (m^3/s)	P_1 (N/m^2)	P_2 (N/m^2)	P_3 (N/m^2)
0.68	1.258	0.001258	89318.00	88977.22	89093.68
0.60	1.406	0.001406	90098.19	89686.79	89849.51
0.50	1.360	0.001360	91080.68	90692.18	90839.90
0.45	1.446	0.001446	91568.40	91137.26	91312.91
0.40	1.389	0.001389	92060.77	91658.22	91815.14

Pressure Differences

Table 4.14 Different Pressure Calculations

P_1-P_3 By using Bernoulli equation ($N/m^{2)}$	P_1-P_3 By using Manometer ($N/m^{2)}$
224.32	494.43
248.68	370.82
240.78	370.82
255.49	296.66
245.63	247.22

4.3 ERROR CALCULATIONS

The Error can be calculated as follows;

$$Error = \frac{(P_1 - P_3)_{manometer} - (P_1 - P_3)_{Bernoulli's\ equation}}{(P_1 - P_3)_{manometer}} \times 100\%$$

Step 1

$$\text{Error} = \frac{494.43 - 224.32}{494.43} \times 100\%$$

$$= 54.63$$

Step 2

$$\text{Error} = \frac{370.82 - 248.67}{370.82} \times 100\%$$

$$= 32.38$$

Step 3

$$\text{Error} = \frac{370.82 - 240.78}{370.82} \times 100\%$$

$$= 35.07$$

Step 4

$$\text{Error} = \frac{296.66 - 255.05}{296.66} \times 100\%$$

$$= 13.77$$

Step 5

$$\text{Error} = \frac{274.22 - 245.63}{274.22} \text{X}100\%$$

$$= 0.64$$

CONCLUSION

In this chapter the calculations of the pressure drop in pipes are explained. In the first section of this chapter there are 8 step, in step 1 and step 2 the calculations of the mass flow rate, the volume flow rate are given. In step 3 and step 4 the calculations of cross sectional area, different velocities of water in pipes are given. In step 5 and step 6 the calculation of Reynolds number, local head losses h_f are given. In step 7 and step 8 the calculations of the pressures by Bernoulli equations, different pressure by the manometer are given.

In the second section of this chapter tabulated data, the Figures related to experiments are presented. The calculations of mass flow rate, the discharge, the pressure, different pressure between two points are presented. In the end the error calculations are given.

CONCLUSION

In the first chapter of this project, an introduction to fluids, the relationship between pressure and fluid, properties of fluids, types of flow, equation of continuity, Bernoulli equation and energy calculations are presented.

In the second chapter a brief introduction for fluid flow through pipes including their types are presented. In addition the fitting of pipes, calculations regarding to pressure loss in pipes and velocity effects are presented.

In the third chapter, the experimental setup, the aim of the project, calculating the pressure drop in pipes, diameter and roughness of pipes, equipments being used and the connection of pipes are presented.

In last chapter, calculations of pressure, the Steps of calculating are given. In addition the error calculations are presented

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