الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحري

Arab Academy for Science, Technology & Maritime Transport

College of Engineering and Technology

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Performance of Jet Pump (Air & Water)

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Abstract

In order to understand jet pump and build a prototype, its principles had to be understood besides its advantages and disadvantages, how it performs by reading on studied graphs and data and last but not least its types and applications.

A jet pump is a mechanical machine. Its operation is based on Bernoulli's principle, which states that an increase in the speed of a fluid is accompanied by a decrease in its pressure. A nozzle in the jet pump converts the pressurized, slow-moving power fluid into a fast-moving fluid. There are two inlets used to extract a constant flow of liquid. Pressure is used to produce such a suction lift. The mixture of the velocity and the inlet pressure of the fluids cause the medium to flow out of the pit, storage tank, or well through the pump up to the outlet point. Shallow well jet pump are suitable for reservoirs or wells with a total pump height of no more than 5.5 meters.

After a proper theoretical analysis, this project's prototype will have a foundation to hold all of tools and equipment's. A motor will draw water from a tank and directs it to the jet pump. Then, the jet pump will draw water from the other tank (which represents the well) through the suction section and out from the nozzle then drop into delivery tank. Testing the pressures, volumes and mass flow rate of the jet pump and tanks will be made.

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Chapter I

Introduction

1.1 PRINCIPLES OF JET PUMP:

A **jet pump** is a mechanical machine that flow fluids through its operation and is based on Bernoulli's principle, which states that an increase in the speed of a fluid is accompanied by a decrease in its pressure. A nozzle in the jet pump converts the pressurized, slow-moving power fluid pumped down by a surface pump into a fast-moving fluid (the Venturi effect). A **jet pump** works by pulling the water toward the surface instead of pulling it like submersible pump. It is a **self-priming pump** with no moving parts. This pump creates a fast jet of almost any liquid and drives another liquid by driving the pressure recovery in the diffuser [1].

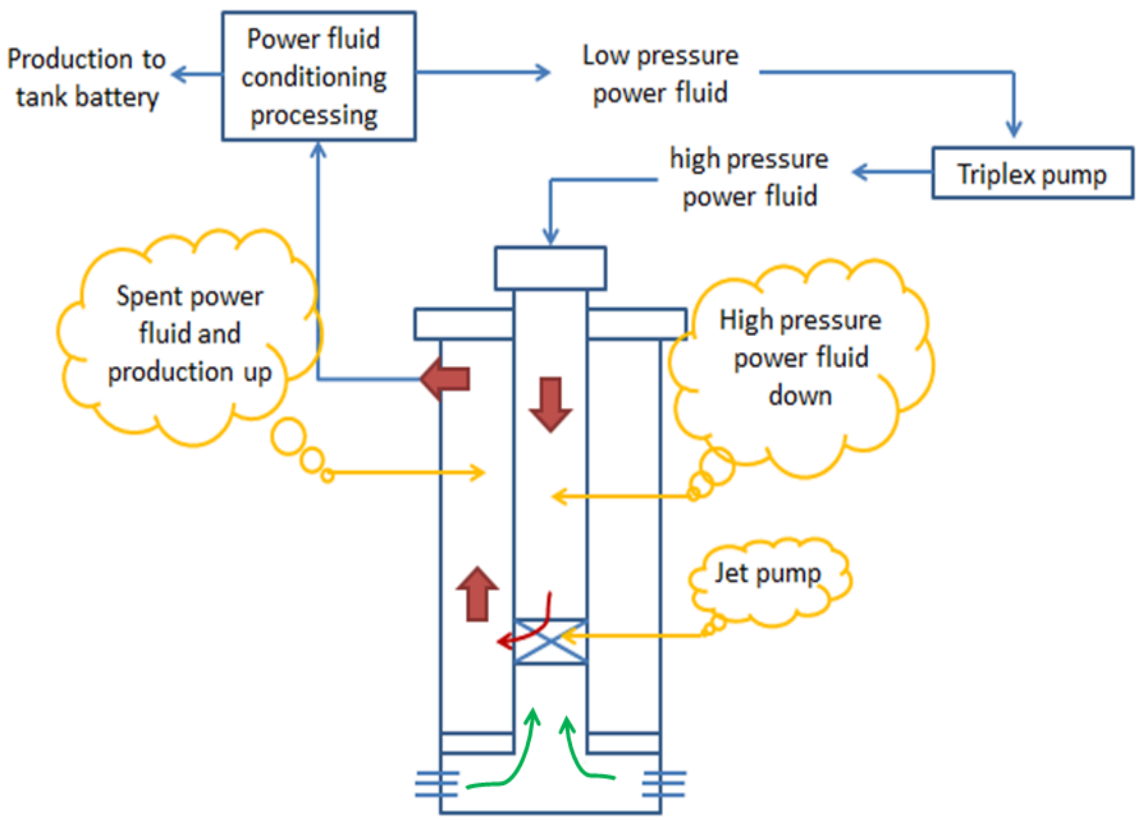

Figure 1.1: Jet Pump Principle

In **jet pumps**, **two or more inlets** use to extract a constant flow of liquid, and pressure is used to produce a suction lift. The mixture of the velocity and the inlet pressure of the gases or fluids cause the medium to flow out of the pit, storage tank, or well through the pump up to the outlet point. Due to some reasons like **friction loss**, the efficiency of the **jet pump** is lower than that of a normal centrifugal pump. However, the jet pumps have high efficiency when processing a gaseous mixed media or under various down hole conditions where the surface properties include turbulence. This type of pump has one or more impellers and diffusers with an ejector. It installs over the ground, and it pumps the water out of the ground through an inlet pipe. These types of pumps are famous in regions with high water tables. So, these are appropriate for various residential purposes such as farms, bungalows, oil rigs, and small single-family homes [2].

1.1.1Working of Jet Pump:

The Jet Pump is an artificial lifting system that consists of two main parts:

- Surface pumping device.
- Down hole jet pump.

The jet water pump uses unbalanced air pressure in its working. Its working is very similar as liquid sucks up by a straw. First of all, the pump fills with water. After coupling, the pump impeller rotates and let's water and air bubbles through. During this process, air expels from the emergency shut-off valve, creating a continuous area of low pressure that naturally forces the groundwater upwards [2]

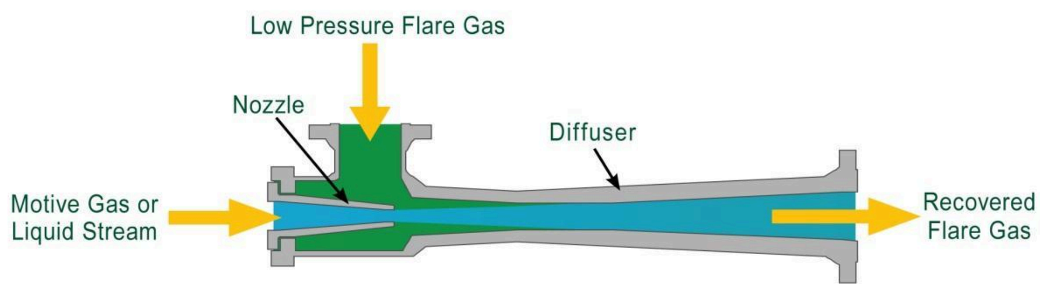

Figure 1.2: Working of a Jet Pump 1

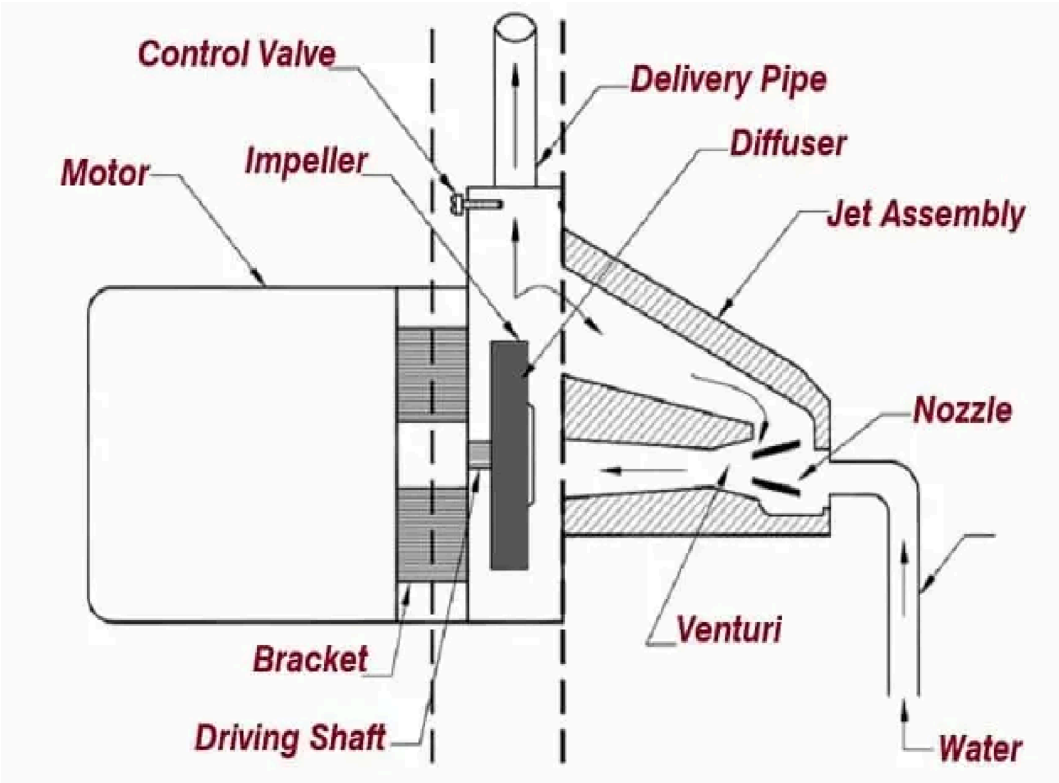

Figure 1.3: Working of a Jet Pump 2

When liquid arrives in the jet pump, the area of the flow path reduces by an appropriately sized nozzle, thereby expanding the liquid velocity and creating a Venturi effect. The pressure difference created by the Venturi effect draws liquid from the reservoir to the jet pump. Venturi can be separated from each other by a certain distance. The drive fluid and the stored fluid mix, and the pressure rise with decreasing velocity through the flow path of the increasing area. The increase in pressure is sufficient to lift the mixed liquid to the surface.

1.1.2 Advantages and disadvantages of Jet Pump:

The jet pump has the following advantages and disadvantages.

1.1.2.1 Advantages of Jet Pump:

- The jet pump doesn't have mechanical or moving parts that can cause wear & tear.

- The capability of high productivity.
- It has a long service life.
- It needs a low cost for maintenance.
- By adjusting the engine oil injection rate, it can be adjusted according to the different productivity.
- Ability to walk for a long time without intervention.
- These types of pumps can obtain and exchange quickly and efficiently when maintenance is needed.
- Very high tolerance to abrasives in manufactured liquids.
- The use of CRA materials or inhibitors in the fuel fluid makes it more resistant to corrosive fluids.
- It can use in wells with large deflection angles without damaging the pipe.
- The advantages of circulating the down hole pump in and out of the wellbore involve decreased downtime and the ability to remove casing, cables, or tubing without a puller.
- It can handle high GLR.
- Appropriate for remote working.
- It can also be mounted on the entire air transport chuck with compression fittings and pipe plugs.
- It can also install in nipples and sliding sleeves with a cable.

1.1.2.2 Disadvantages of Jet Pump:

- It is low efficient than other artificial lifts.
- Space limitation problems.
- It has high-pressure surface lines.
- It also consumes high power.

1.2 PERFORMANCE OF JET PUMP CURVES:

The published pump performance curve describes the performance of particular pump (or stage). It shows the discharge head developed by the pump, brake horsepower (power consumption curve), and efficiency of the pump as a function of flow rate. It is an experimental curve given by the manufacturer and obtained with freshwater at 60 °F (S.G. = 1) under controlled conditions detailed in **API RP11 S2**. These curves are commonly available for both 50 Hz and 60 Hz operation and must represent the operation of one or more stages of each pump curve (the number of pump stages must be clearly indicated on the pump chart).

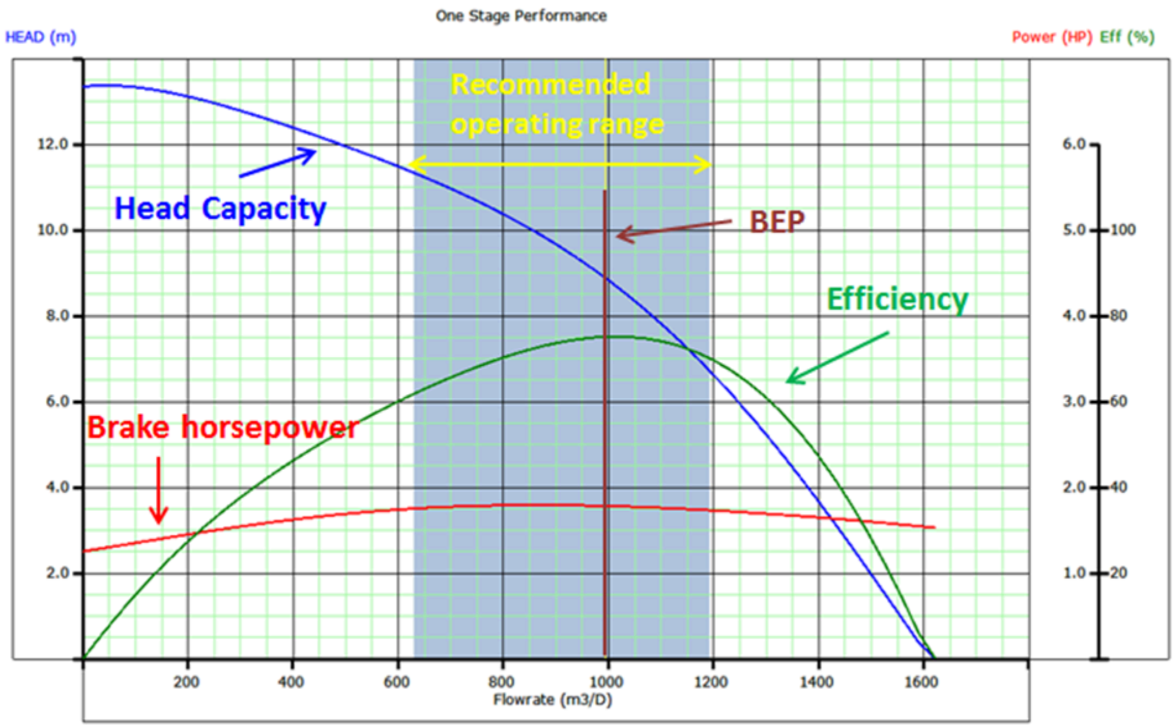

Figure 1.4: Typical Pump Curve

- The left vertical axis is scaled in feet and meters of head (or lift).
- The bottom horizontal axis is scaled in bbl/d and m3/d.
- The curve labeled Head-Capacity defines the lift (or head) the impeller can produce at all of the available flow rates.
- The first vertical axis on the right is scaled in horsepower. It is based on pumping water with a specific gravity of 1.00.

1.2.1 Definitions:

- **Total head:** the difference between the pump outlet and inlet head in feet. As detailed in the article: "Total Dynamic Head (TDH)", this is the vertical distance, in feet from the pumping fluid level to the centerline of the pressure gauge, plus the pressure gauge reading converted to feet, plus the friction loss between the pump discharge and pressure gauge in feet.

- **Brake Horsepower (BHP):** the power required by the pump corrected for a fluid with a S.G. = 1.
- **Best Efficiency Point (BEP):** Defines pump performance parameters at the maximum value on the efficiency curve.
- **Recommended Operating Range:** located between the maximum and minimum recommended flow rates.

1.2.2 Typical Jet Pump Performance Curve:

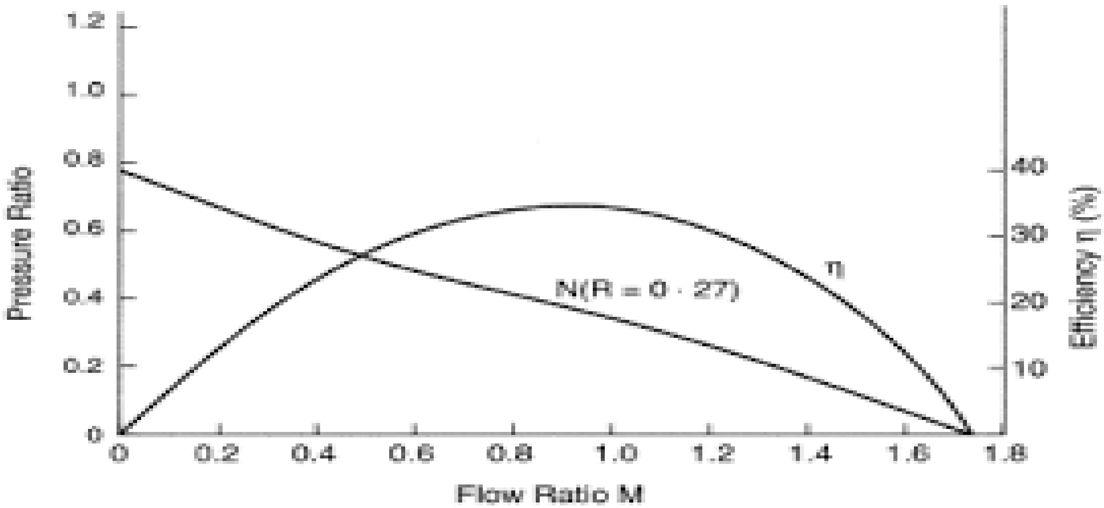

Figure 1.5: Jet Pump performance curve

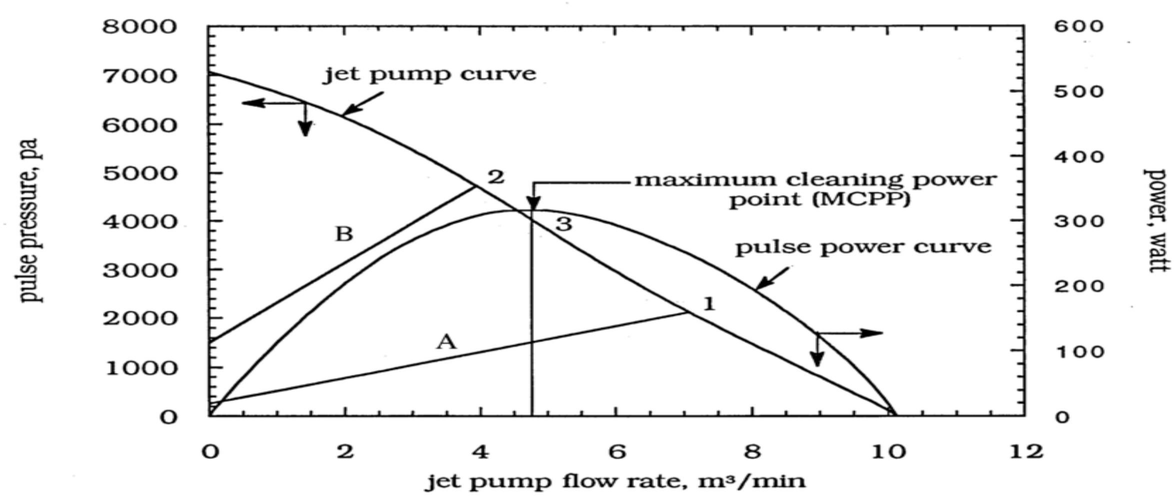

Figure 1.6: Jet Pump and pulse curves

This curve is the relationship between pressure and flow rate, and at the beginning of the curve the liquid or water enters at a high pressure, and at the end of the cycle the pressuredecreases, but the flow rate is high and this varies by the diameter of the pump.The efficiency curve shows the η (efficiency) of the pump. Efficiency is measured in %. All pumps have a 'best point' (ηmax), indicating where the pump is working most efficiently.The efficiency of the pump depends on the pump size and the quality of theconstruction/production. Small pumps normally have a lower efficiency than large pumps.

The pump performance curve shows the correlation between media flow (Q) and the pressure differential or head (H) that the pump creates:-

The units for Q are normally [m3/h] or [l/s]

The unit for H is normally [m]

H (head) can be recalculated to p (pressure) by using the following equation:

p = ρ x g x H [pa]

p = pressure [pa]

ρ = density [kg/m3]

g = acceleration due to gravity [m/s2]

H = head [m]

Flow is normally given in m3/h or l/s. Pressure differential or head is given in kPa or mws(meter water column). For variable-speed pumps, the performance curve is given at minimumand maximum RPM. When several pumps are connected, the final performance curve is achieved by combining the characteristics of the individual pumps. Parallel-connected pumps are added horizontally to increase Q. For two identical pumps, the maximum Q will double, yet maximum H will be the same. This principle is commonly used in pump systems. Series-connected pumps are added vertically to increase H. For two identical pumps, the maximum H will double. Maximum Q will remain the same. This principle is commonly used in multi-stage pumps. The performance curve is used together with the system characteristics when dimensioning and selecting pumps. Use the sizing tool to find a specific pump's efficiency curve and performance curve.

1.3 TYPES & APPLICATIONS OF JET PUMPS:

1.3.1 Types of Jet Pumps:

The jet pump has three main types that are

1.3.1.1 Deep Well Jet Pump:

A deep well jet pump uses to pump water from deep underground wells. A deep well is an excavated structure formed to obtain groundwater. These structures create with the drilling method. A deep well pump is mainly found in rural areas where water is not easily available. These pumps can lift water by suction lift from about 22ft to about 120ft. deep well jet pumps use the principles of centrifugal pumps and fuel injectors to provide water that meets our requirements. Mostly these pumps use to pump water to meet household demands. It is also known as a deep-well water pump.

Figure 1.7: Deep Well Jet Pump

1.3.1.1.1 Advantages of Deep Well Jet Pump:

- It requires low maintenance and a relatively low price
- 2. Adapted to draw water from different suction heads.
- A deep well jet pump has a low price.
- Easy maintenance.
- Long service life.
- It can install away from the water source.

1.3.1.1.2 Disadvantages of Deep Well Jet Pump:

- Abrasives in wells such as sand can damage the housing and runner.
- Only submersible pumps can use for higher suction heads.

- If the water level becomes below the lower valve of the inlet line, it must be filled with water.

1.3.1.2 Shallow Well Jet pump:

These pumps are suitable for reservoirs or wells with a total pump height of no more than 5.5m. The shallow well jets pump uses for purposes where the medium is close to the surface, e.g., residential wells.

The three major parts of a shallow jet pump are jet assembly, an impeller, and an electric motor. The cost of drilling a shallow well is usually low due to the small amount of labor and material involved. This pump requires for wells less than 25ft in length. However, shallow pumps are not submersible. As an alternative, these set in the well casing.

Pumps are used in applications where the media is close to the surface, such as residential wells. The ejectors in these pumps are bolted to the nose of the pump.

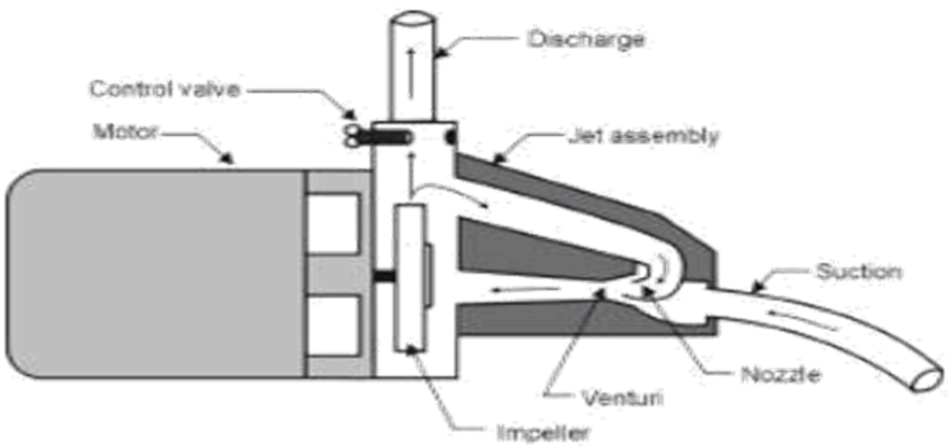

Figure 1.8: Shallow Well Jet Pump

1.3.1.2.1 Advantages of Shallow Well Jet Pump:

- This pump can offset the well.
- Can adapt to wells with different production rates.
- Simple machine, almost maintenance-free.
- A shallow well pump is inexpensive.

1.3.1.2.2 Disadvantages of Shallow Well Jet Pump:

- These have cavitation issues.
- These pumps have priming problems.
- The efficiency of the sallow jet pump decreases with increasing total lift.

1.3.1.3 Convertible Jet Pump:

The convertible jet well pump can pump water from a depth of 70 feet. It is called a "convertible" pump because it can use as a shallow well pump for water sources up to 25 ft. deep and a deep well pump for water sources up to 70 ft. It also uses when the pump is above the water source. The convertible jet pump uses two suction pipes to pump water out of the well. As the name of this pump suggests, you can connect the jet assembly to a suction tube and convert it into a shallow bore jet pump. This will reduce the water depth to less than 25 ft. convertible jet pumps can be used in shallow or deep well applications.

Figure 1.9: Convertible Well Jet Pump

1.3.1.3.1 Advantages of Convertible Jet Pump:

- Lower price.
- Needs minimal maintenance.
- Highly Efficient.

- These can pump water from deeper depths.
- Large capacity.

1.3.1.3.2 Disadvantages of Convertible Jet Pump:

- Slightly damaged by sand.
- Cavitation problems.
- Occasionally there are gas blockages.

1.3.2 Applications of Jet Pumps:

Jet pumps are typically inserted vertically into the process media, but can be mounted horizontally as well. They are often used in applications where the material that is pumped assists in creating the motive force needed to move through the pump. For example, in marine applications, jet pumps are used to transfer seawater. In home applications, they are used to move wastewater up to the sewer line. A float level sensor and switch are used to turn on the pump.

- Jet air pump: Use when no vapor is available as a propellant.
- Liquid jet mixer pump : Use to mix and rotate liquids
- Liquid jet vacuum pumps: Liquid jet vacuum pumps are based on proven jet pump.
- Technology and are often using in chemical laboratories to produce vacuum.
- Liquid jet solids pump :Liquid jet solids pumps are based on proven jet pump.
- Technology and are often used to transfer types of solids.
- Deep well jet pump withdraw from depth 45m.
- Shallow well jet pump withdraw from depth 25m.

1.4 TWO-PAHSE FLOW OF JET PUMP:

1.4.1 Two-Phase Flow:

In fluid mechanics, two-phase flow is a flow of gas and liquid, a specific illustration of multi-phase flow. Two-phase flow can happen in different structures, for example, flows progressing from liquid to gas because of outer heating, isolated flows, and scattered two-phase flows where one phase is available as particles, drops, or bubbles in a consistent transporting state such as gas or liquid.

1.4.1.1 Case 1:

All things considered, likely the most regularly researched topic of two-phase flow is in enormous scope power systems. Coal and gas heat power stations utilized exceptionally enormous boilers to create steam for use in turbines. In such cases, compressed water is gone through warmed pipes and it changes to steam as it travels through the pipe. The plan of boilers requires a definite comprehension of two-phase flow heat move and pressure drop characteristic, which is altogether not the same as the single phase case. Much more fundamentally, nuclear reactors use water to eliminate heat from the reactor core utilizing two-phase flow. A lot of study has been performed on the idea of two-phase flow in such cases, so that engineers can plan against potential disappointments and failures in pipework, loss of pressure and furthermore.

1.4.1.2 Case 2:

Another situation where two-phase flow can happen is in pump cavitation. Here a pump is working near the fume pressure of the fluid being pumped. Assuming that pressure drops further, which can happen locally close to the vanes for the pump, for instance, then, at that point, a phase change can happen and gas will be available in the pump. Comparative impacts can likewise happen on marine propellers; any place it happens, it is a significant issue for designers. Whenever the fume bubble breakdowns, it can create exceptionally huge pressure spikes, which over the long haul will cause harm on the propeller or turbine.

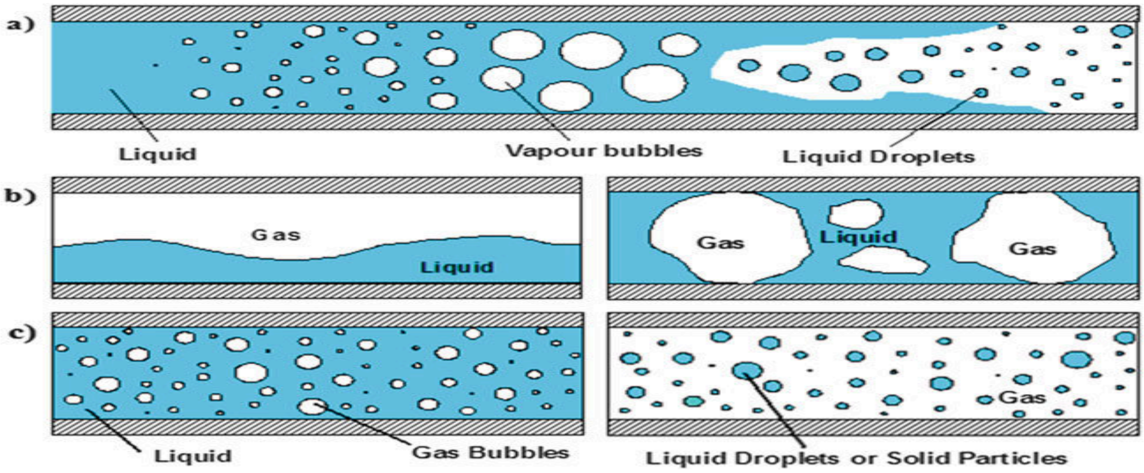

Figure 1.10: Different states of Two-Phase Flows

The previous two-phase flow cases are for a single fluid happening without anyone else as two unique phases, like steam and water. The term two-phase flow is likewise applied to combinations of various fluids having various phases, like air and water, or oil and natural gas. Once in a while even three-phase flow is thought of, for example, in oil and gas pipelines where there may be a huge part of solids. In spite of the fact that oil and water are not stringently particular phases, since they are the two liquids they are in some cases considered as a two-phase flow; and the mix of oil, gas and water for instance the flow from a an oil well may likewise be viewed as a three-phase flow. Researching over the two-phase flow topic is also found in clouds climate systems as well as in ground water flow due to the streams of water and air through the soil. Moreover of two-phase flow topics such as bubbles, rain, waves on the sea, foam, fountains, mousse, cryogenics, and oil slicks and last but least is in the electrical explosion of metal.

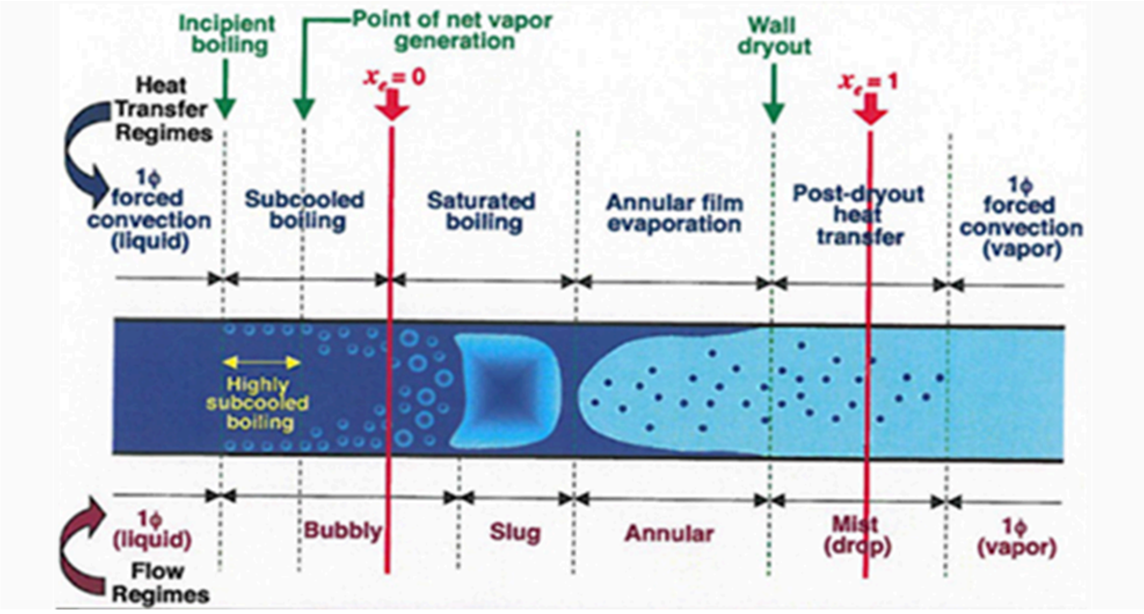

Figure 1.11: Sequence of Two-Phase-Flow through a Pipe

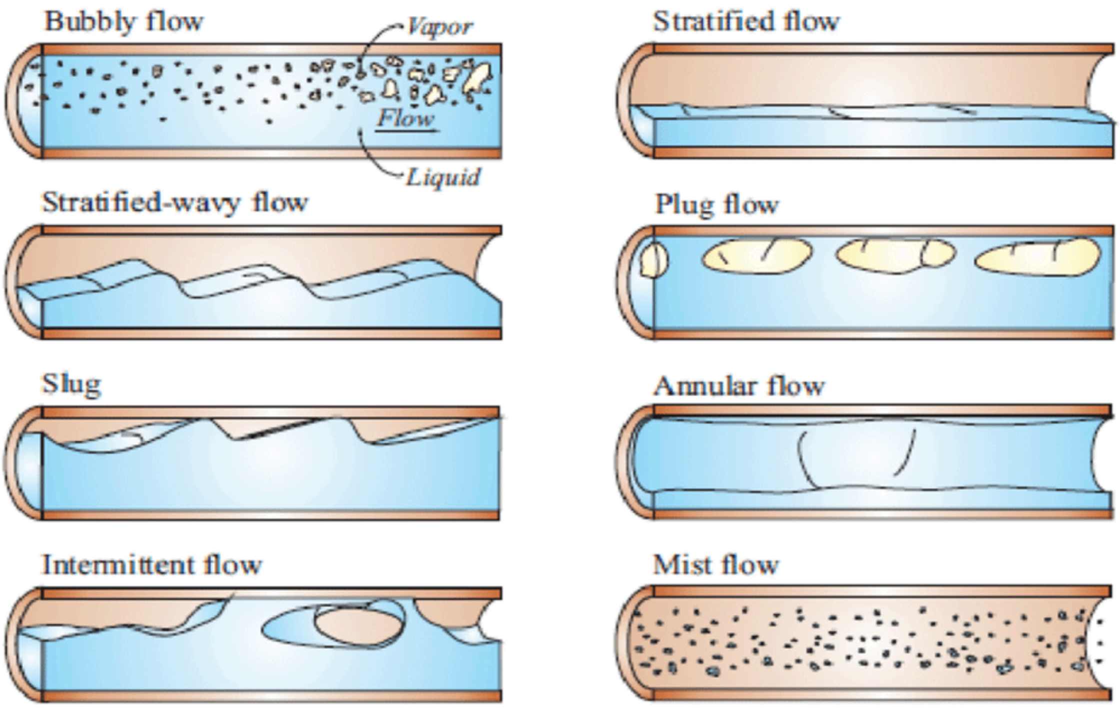

Figure 1.12: Every type of the Two-Phase Flow Sequence

1.4.1.3 Characteristics of Two-Phase Flow:

Several features make two-phase flow an interesting and challenging branch of fluid mechanics:

- In the case of air and water at widespread temperature and pressure, the density of the two phases differs by a factor of approximately 1000. Similar variations are standard of water, liquid and water vapor densities.
- The sound velocity adjustments dramatically for materials undergoing phase conversion, and may be orders of magnitude difference. This introduces compressible consequences into the hassle.
- The phase changes are not on the spot, and the liquid vapor system will now not necessarily be in phase equilibrium.
- The exchange of phase means flow-induced pressure drops can cause additional phase- alteration for instance while water can evaporate through a valve which will increase the relative volume of the gaseous, compressible medium and increasing evacuation velocities, unlike single-phase in-compressible flow in which shutting down a valve might decrease evacuation velocities.
- Can give rise to other counter-intuitive, negative resistance-type instabilities, like chugging, relaxation instability, and flow misdistribution instabilities as examples of static instabilities, and other dynamic instabilities.

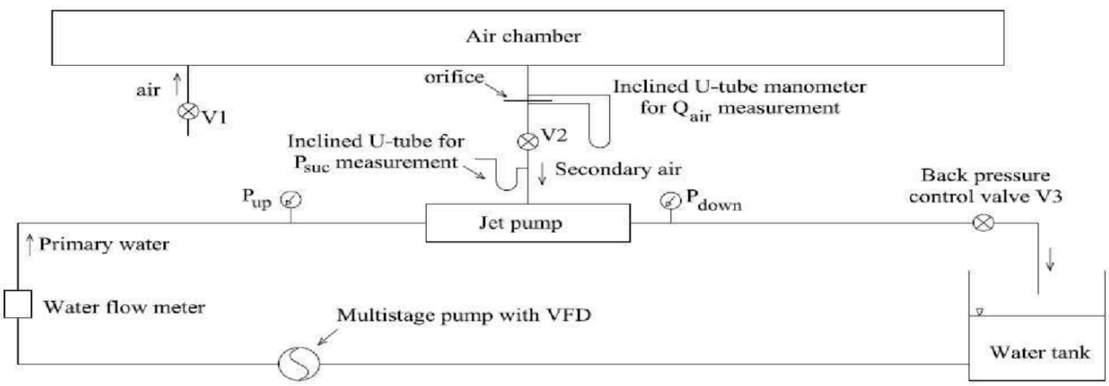

Figure 1.13: Schematic Arrangement of Two-Phase Flow Jet Pump Test Set Up

1.4.2 Liquid Jet Pumps for Two-Phase Flows:

Isothermal compression of a bubbly secondary fluid in a blending-throat and diffuser is defined by a one-dimensional float model of a liquid-jet pump. Friction-loss coefficients used inside the four equations can be decided experimentally, or taken from the literature. The version reduces to the liquid-jet gas compressor case if the secondary liquid is zero. Conversely, a zero secondary-gas flow reduces the liquid-jet gas and liquid (LJGL) version to that of the familiar liquid-jet liquid pump. A "jet loss" takes place in liquid-jet pumps if the nozzle tip is withdrawn from the entrance plane of the throat, and jet loss is included in the efficiency equations. Comparisons are made with published take a look at facts for liquid-jet liquid pumps and for liquid-jet fuel compressors. The LJGL version is used to discover jet pump responses to two-phase secondary flows, nozzle-to-throat area ratio, and primary-jet pace. The outcomes are shown in terms of overall performance curves as opposed to flow ratios. Predicted top efficiencies are approximately 50 percent. Under severe working situations, LJGL pump performance curves showcase maximum-flow ratios or cut-offs. Cut-off occurs whilst two-phase secondary-flow with the flow streams attain sonic values at the entry of the mixing throat. A dimensionless number correlates flow-ratio cut-offs with pump geometry and running situations. Throat-entry choking of the secondary float may be predicted, for this reason prevented, in designing jet pumps to deal with two-section fluids.

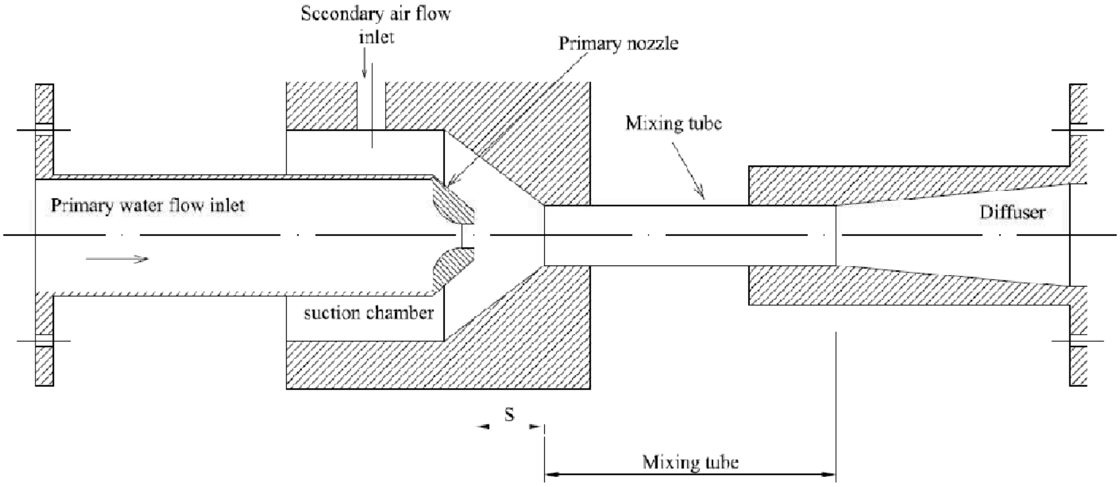

Figure 1.14: Cross Section of Jet Pump Along with Mixing Tube & Diffuser

1.4.3 Two-Phase Flow Separator:

Two-phase separator is also called gas-liquid separator. As its phrase shows, it's far used for isolating gas and liquid in wet gas current or basically gas and liquid flow, while the complicated liquid phase additives are not required to be separated from each other. Since the current conditions and required efficiency might also range broadly, the Two-section separator may be designed in many models and with one-of-a-kind performances. For example, a gas and liquid separator upstream of a gas compressor might need to be very effective, whereas in other cases only bulk separation of the gas and liquid levels is needed. Gas and Liquid Two-phase separator is often used as a buffer, surge, accumulator tank or vessel. Different names show different parts of processed stream behavior and the application emphasis. Sometimes the key structure or component may also be indicated on separator names, such as vane pack separator and coalesce separator.

1.4.3.1 Horizontal KO Drum:

Horizontal KO Drum is often used for demisting of gas where an excessive liquid management capacity desired. Comparing with Vertical KO Drum, it takes larger ground space and is surprisingly delicate to fouling, but offers higher water removal performance and large liquid capacity. For Horizontal KO Drum, mist extractor is often vital. If the mist extractor as also known as demister mat, mist lure, condensate trap, and so forth, is geared up and taken into consideration important sufficient inside the KO drum, it will also be referred to as a Demister or Demister Drum.

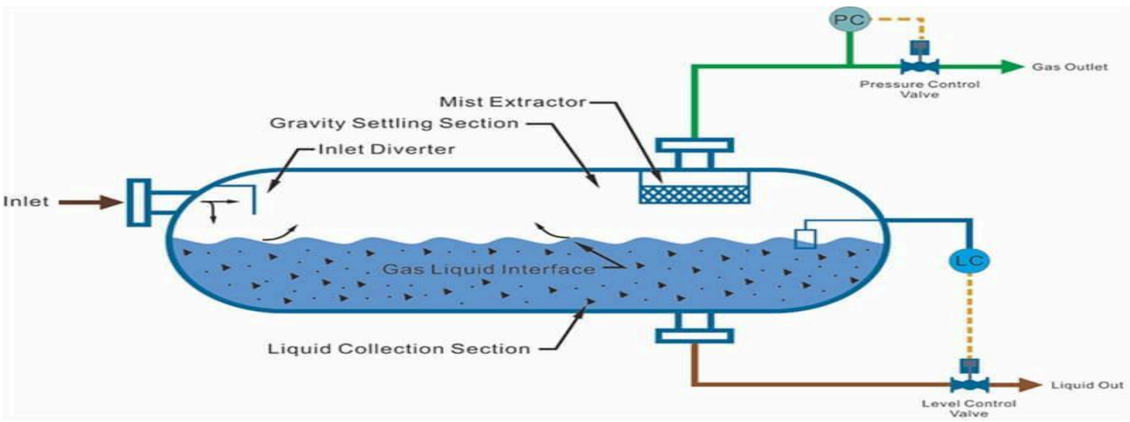

Figure 1.15: Horizontal KO Drum Two-Phase Flow Separator

1.4.3.2 Vertical KO Drum:

Two-phase separator is also regularly referred to as knockout drum, KO Drum in brief. The “knockout” indicates the free liquid droplets “knocked out” from continuous phase which carry them. For example, a low-pressure free-water KO Drum is so called as it`s designed to separate the free water from wet gas. Vertical KO Drum is regularly used for bulk separation of gas and liquid. It has very low pressure drop and takes moderately small ground area to install. It is insensitive to fouling and foaming service. It is often used to address fluid with excessive gas and liquid flow ratio.

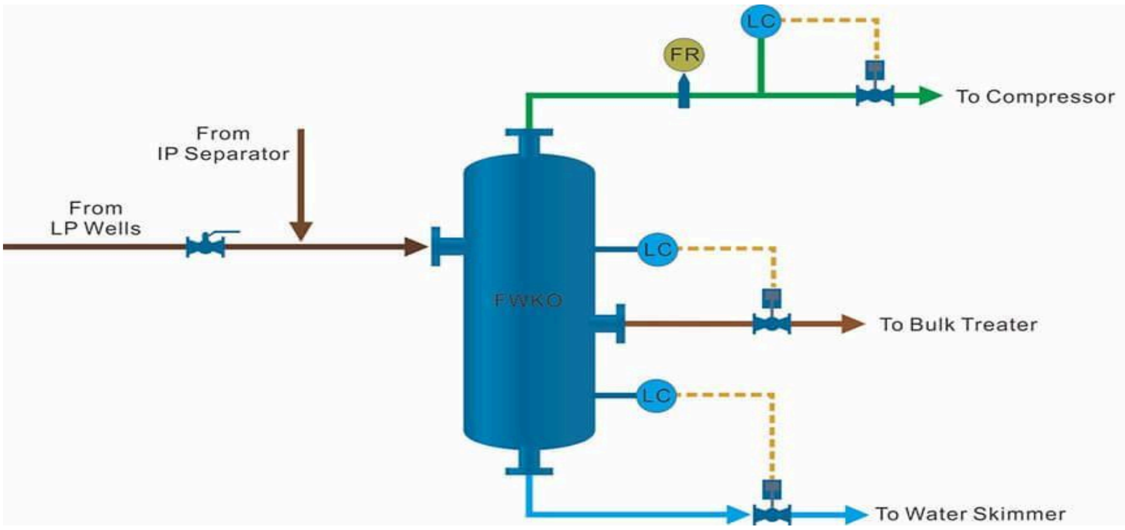

Figure 1.16: Vertical KO Drum Two-Phase Flow Separator

Chapter II

Theoretical Analysis

Chapter II

Theoretical Analysis

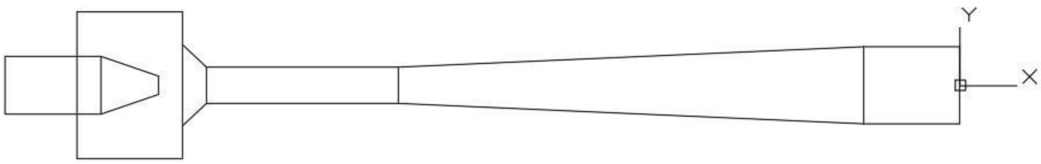

Figure: 2.1 Jet Pump 1

2.1 EQUATIONS:

$$\frac{Pb}{\rho ag} + Zb + \frac{Va^2}{2g} = \frac{Pw}{\rho ag} + Zw + \frac{Vt^2}{2g} + losses$$

$$Pb - Pw = \rho A\, g\left((Zw - Zb) + \frac{Vt^2 - Vb^2}{2g} + kt * \frac{Vt^2}{2g}\right)$$

From A to w for liquid entering from nozzle

$$\frac{Pb}{\rho lg} + Za + \frac{Va^2}{2g} = \frac{Pw}{\rho lg} + Zw + \frac{Vs^2}{2g} + losses$$

$$Pa - Pw = \rho lg((Zw - Za) + \frac{Vs^2 - Va^2}{2g} + Ks * \frac{Vs^2}{2g}$$

$$m.t = m.a + m.t$$

$$\rho T\ Avz = \delta a * Aa * Vt + \rho L * Al * Vs$$

Momentum analysis of flow system

$$\sum f = \frac{d(Mv)cv}{dt} + \sum_{out} \beta m\, v - \sum_{in} \beta m\, v$$

M=0

For no enter of forces

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

$Pa = f$

W to Z

$\frac{Pw}{\rho g} + Zw + \frac{Vw^2}{2g} = \frac{pz}{\rho g} + Zz + \frac{Vz^2}{2g} + Km * \frac{Vz^2}{2g}$

$Pw - Pz = \rho g(Zw - Zz) - Km\frac{Vz^2}{2g} * \rho g = \frac{\Sigma F}{A}$

For steady flow

$$\sum f = \sum_{out} M.v - \sum_{in} M.\ v \qquad (2.10)$$

$= (M.a + M.l)VZ - M.a * Vt - M.l * Vs$

$(M.a + M.l)Vz - M.a * Vt - M.l * Vs$
$=$

$(M.a + M.l)Vz - M.a * Vt - M.l * Vs = (Pw - Pz)A + \rho g(Zw - Zz)A - Km$

$Pw - Pz = -\rho g(Zw - Zz) + Km * \frac{Vz^2}{2g} * \rho g + \left(\frac{M.a+M.p}{A}\right)VZ$
$\frac{-M.a}{A}Vt - \frac{M.l}{A}Vs \qquad (2.$

Z to C

$\frac{Pz}{\rho g} + Zz + \frac{Vz^2}{2g} = \frac{Pc}{\rho g} + Zc + \frac{Vc^2}{2g} + Kd * \frac{Vz^2}{2g}$

$Pz - Pc = \rho g(Zc - Zz) + \rho g\frac{(Vc^2 - Vz^2)}{2g} + Kd\frac{Vz^2}{2g} * \rho g$

B to C

$Pb - Pc = (Pb - Pw) + (Pw - Pz) + (Pz - Pc)$

$Pb - Pc = \rho a g(Zw - Zb) + \rho a(\frac{Vt^2 - Vb^2}{2})$ +Kt

$\rho a\frac{Vt^2}{2g} - \rho g(Zw - Zz) + Km\rho\frac{Vz^2}{2} + \frac{M.a+M.l}{A}Vz - \frac{M.a}{A}Vt - \frac{M.l}{A}Vs + \rho g(ZC - Zz$

$Pb - Pc = -\rho g(Zb - Zc) - \rho\frac{(Vb^2 - Vc^2)}{2g} + \rho\frac{(Vt^2 - Vz^2)}{2g} + \frac{M.a+M.l}{A}Vz - \frac{M.a}{A}Vt - \frac{M.l}{A}$

Total energy at B

$Eb = \frac{Pb}{\rho g} + Zb + \frac{Vb^2}{2g}$

Total energy at C

$$Ec = \frac{pc}{\rho g} + Zc + \frac{Vc^2}{2g}$$

B to C

$$Eb - Ec = \frac{Pb-Pc}{\rho g} + (Zb - Zc) + \frac{Vb^2-Vc^2}{2g}$$

$$Eb - Ec = \frac{Vt^2}{2g} - \frac{Vz^2}{2g} + \frac{m.a+M.l}{A\rho g} - \frac{M.a}{A\rho g}Vt - \frac{M.l}{A\rho g}Vs + Kt\frac{Vt^2}{2g} + Km\frac{Vz^2}{2g} + Kd\frac{Vz^2}{2g}$$

$$Eb - Ec = \frac{m.a+M.l}{A\rho g} - \frac{M.a}{A\rho g}Vt - \frac{M.l}{A\rho g}Vs + (Kt + 1)\frac{Vt^2}{2g} + (Km + Kd - 1)\frac{Vz^2}{2g}$$

$$M.a = \rho a(A - Anozzle)Vt$$

$$M.l = \rho l(Anozzle)Vs \qquad (2.26)$$

$$M.a + M.l = \rho AVz$$

Diameter Ratio

$$\in = \frac{dnozzle}{dz} \qquad (2.28)$$

Mass flow ratio

$$\mu = \frac{M.a}{M.l}$$

Total energy ratio

$$\pi = \frac{Ea-Eb}{Ec-Eb} \qquad (2.30)$$

Chapter III
Experimental Analysis

Chapter III

Experimental Analysis

3.1 SCHEMATIC DIAGRAM:

3.1.1 Jet Pump Dimensions:

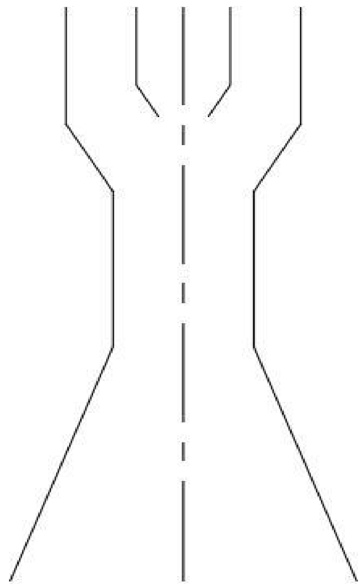

Figure: 3.1 Jet Pump 2

3.2 COMPONENTS:

3.2.1 Stand Table:

The main component of the project which holds most of the components is the stand table; it was customized depending on the components dimensions. The table stand consists of many parts, it was built to take to two large tanks (tank stand) at its base and a third tank which the water would be sucked into at the top, and was placed on a lever so we may take pressure readings on different levels, Another part of the table stand was customized to place the motor (motor stand), it was placed in the middle of the table to reduce the vibrations caused by the motor and distribute it to all parts of the table to as not to affect a specific part. Then two parts to place both air and water jets (jet stand), lastly we add traction wheels to help move to stand table around freely. A 1.5 millimeter-thick iron table made of a surface of 100 cm in length, 70 widths and 80 height of the table,

Figure: 3.2 Stand Table

Figure: 3.3 Large Tank Stand

Figure: 3.4 Small Tank Stand with Lever

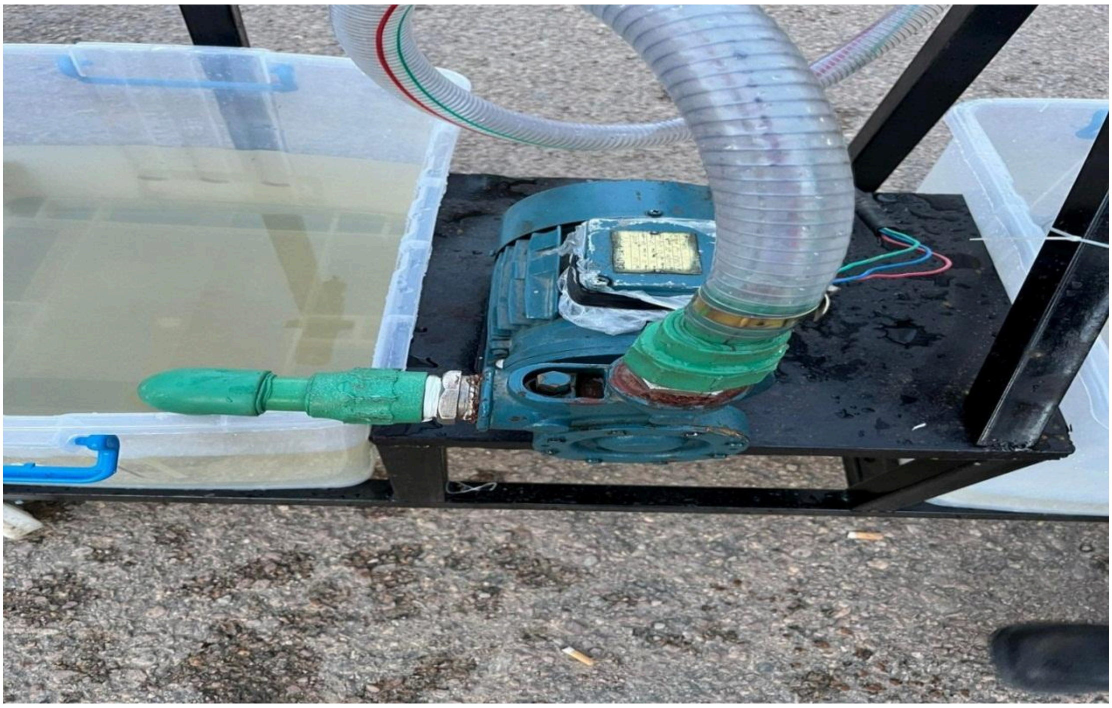

Figure: 3.5 Motor Stand

Figure: 3.6 Jet Stand 1

Figure: 3.7 Jet Stand 2

3.2.2 Tubes:

The total number of hoses was calculated and became 12 meters, and it is divided into parts. The first part is the connection from the large tank to the motor to draw the water, the second part is connected from the motor to the jet pump, the third part is connected from the outside of the pump to the small tank to drain the water, and the fourth and last part is connected from the small tank To the large tank for emptying and the continuation of the experience in operation.

Figure: 3.8 Tubes

<u>3.2.3 Motor Tube:</u>

This tube is placed on the outside of the motor and the hose is connected from the motor to the pump, and there is another tube that connects from the large tank to the motor to draw water and take it out from the other side, and this tube is 1.25 inches thick and the appropriate hose was chosen for this diameter for ease of installation.

Figure: 2.9 Motor Tubes

3.2.4 Jet Pump:

The jet pump is a model made of artylon and it is a material of molded plastic that is highly durable to pressure and temperature and is easy to shape in terms of internal turning. The first jet pump disperses water and the second jet disperses air.

Figure: 3.10 Jet Pump1 (water)

Figure: 3.11 Jet Pump2 (air and water)

3.2.5 Jet Pump Components:

The jet pump consists of three parts. The first part is the driving nozzle and the outlet diameter of the nozzle is 6.4 mm. The second part is the suction section and the diameter of the suction tube is 38 mm. The third part consists of two parts. The first is the mixing tube, the inner diameter is 14 mm and its length is 100 mm. The second part is the diffuser and its length 45 mm, the inlet diameter is 14, and the outlet diameter is 38 mm.

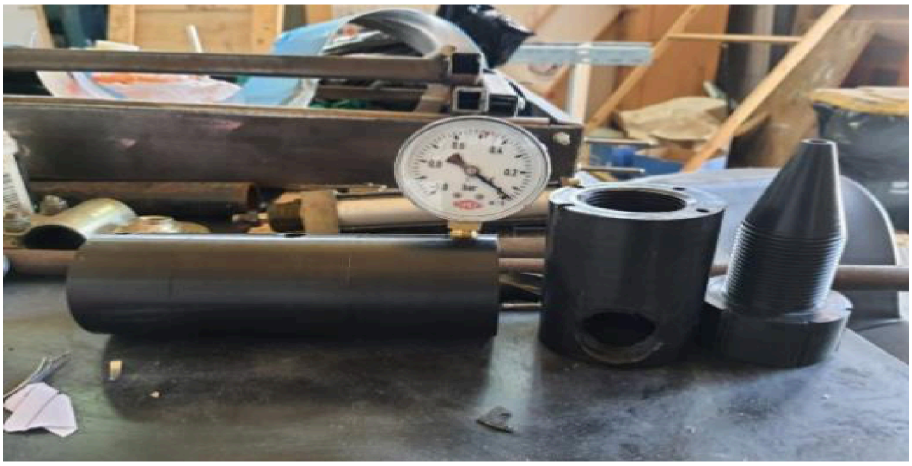

Figure: 3.12 Jet Pump Components

3.2.6 Negative Pressure Gauge:

There are three negative pressure gauges, the first is located at the intake tube to measure the output pressure, the second is located at the end of the suction section, and the third is located at the center of the mixing tube.

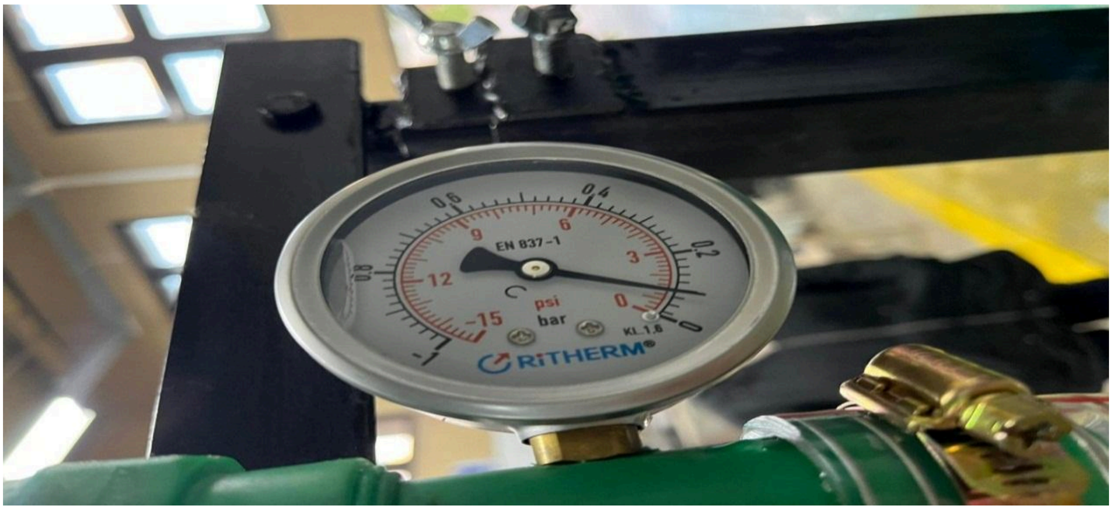

Figure: 3.13 Negative Pressure Gauges

3.2.7 Positive Pressure Gauge:

There are two positive pressure gauges; the first one is located at the pump output to measure, the output pressure of the motor and the second is located on the inlet of the nozzle.

Figure: 3.14 Positive Pressure Gauges

3.2.8 Motor:

The motor used has a power of 1 horsepower and a flow rate of 85 liters per minute.

Figure: 3.15 Motor

3.2.9 Tachometer:

The tachometer used to measure the rpm of the motor.

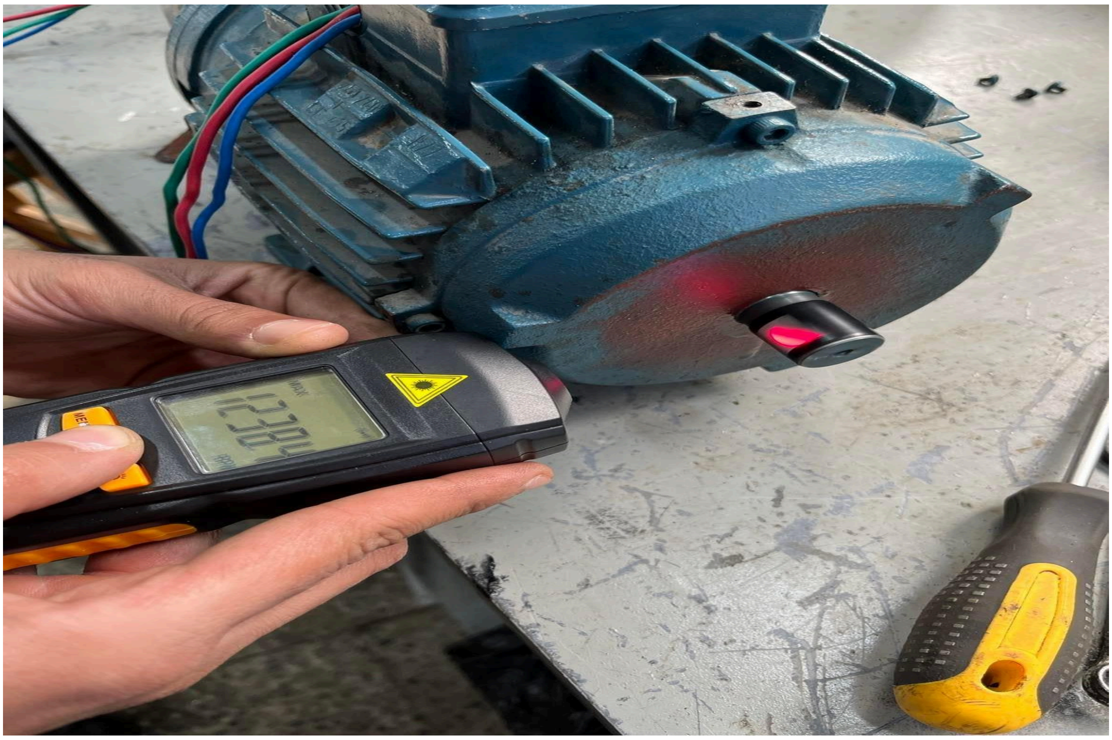

Figure: 3.16 Tachometer

3.2.10 Compressor:

The compressor used has a power of three horsepower which is connected to air jet pump.

Figure: 3.17 Compressors

3.2.11 Frequency Invertor:

The frequency invertor used helps increase the flow rate by increasing rpm due to increase in frequency.

Figure: 3.18 Frequency Invertor

3.2.12 Final Model:

Figure: 3.19 Final Model

3.3 RESULTS:

Pm: Pressure inlet to jet pump

Pd: Pressure outlet from jet pump

Ps: Pressure of suction tube

Pr: Pressure ratio

Pc: Pressure compressor

Pth: Pressure throat

Vm: Volume consumed from large tank

Ve: Volume of water suction

Vt: Total volume of water consumed

Me: Mass flow rate of suction tank

Mm: Mass flow rate of large tank

3.3.1 Frequency Curve:

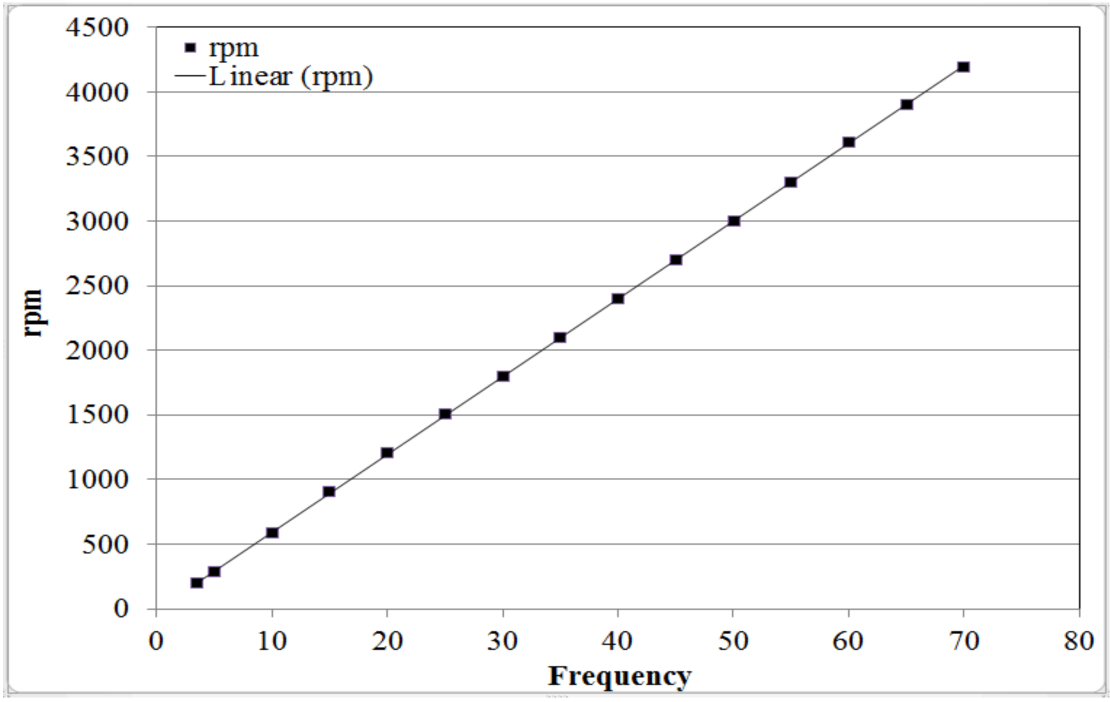

Figure: 3.20 Frequency-RPM Curve

3.3.2 Pressure Ratio Curve:

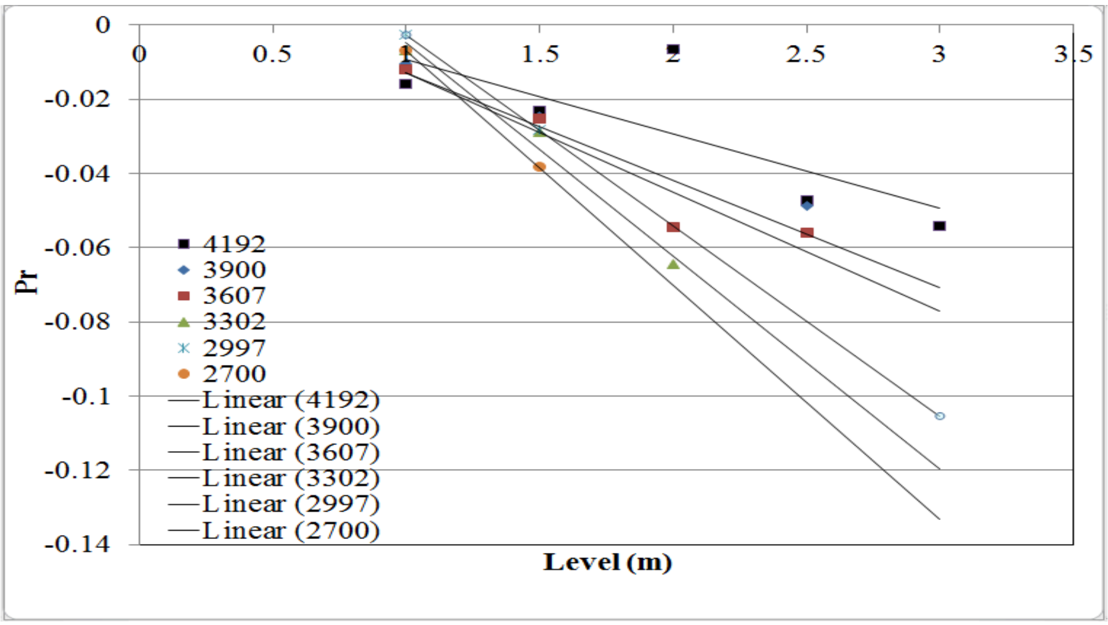

Figure: 3.21 Level-Pressure Ratio Curve

3.3.3 Pressure Suction Curve:

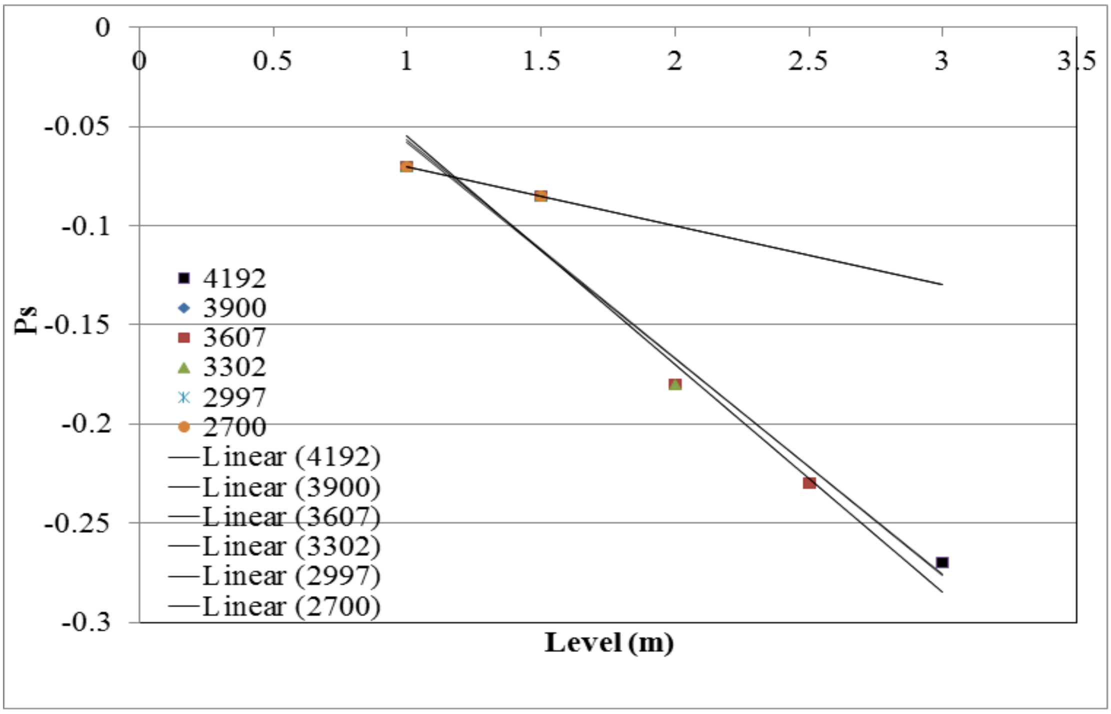

Figure: 3.22 Level-Pressure Suction Curves

<u>3.4.4 Mass flow-rate Curve:</u>

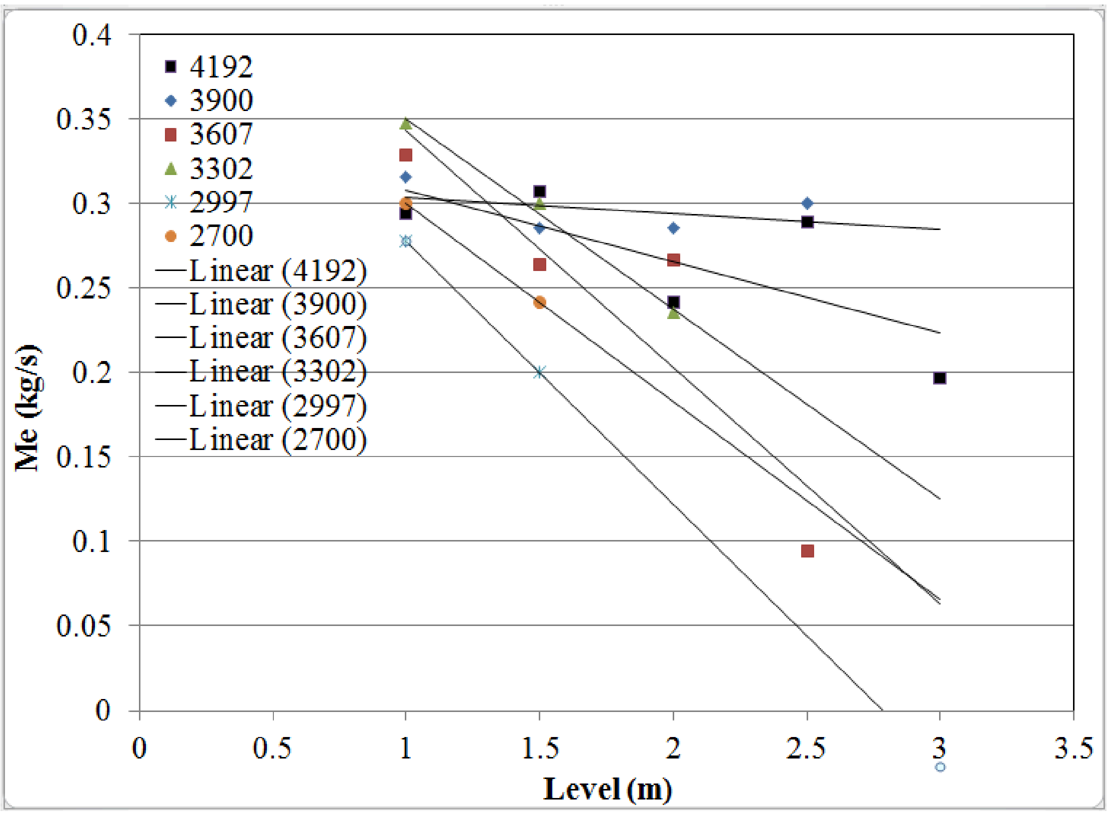

Figure: 3.23 Level-Mass flow-rates Curve

Chapter IV

Conclusions

Conclusions

The frequency invertor is connected to the motor drawing water from the large tank by increasing frequency which in return increases the rpm of the motor, and directs it to the jet pump. The jet pump draws water through the suction section through the vacuum, and this happens through the exit of the motive fluid from the nozzle. Then drop it on the small tank, the jet pump consist of three parts first part nozzle connected with the outlet of motor second part suction section that responsible of vacuum and the third part have the mixing point and diffuser and the outlet of the small tank the sum of volume at the big tank and the suction tank Vt and calculate the flow rate Q = V/T and t is the time which is measured with a stop watch until the tank full over then calculate the mass flow rate M = density of water * Q on different frequencies and different levels. We have three pressure gauges, two negative and one positive the positive pressure gauge in the outlet of motor Pm and the negative pressure gauge the Pd at the diffuser (atmospheric pressure) and the second negative pressure gauge Ps at the inlet of the suction section and we take the measurement at 5 levels then get the result the efficiency increase and mass flow rate ratio increase and the pressure ratio Pr decrease with increase of Mass flow rate ratio Mr, Efficiency = Mr * Pr. Finally the other jet pump is connected to the compressor which disperses air and water.

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