Arab Academy for Science, Technology and Maritime Transport

College of Engineering and Technology

Mechanical Engineering department

B. Sc. Final Year Project

Performance of jet pump

Presented By:

Moustafa Mohamed Hassan

Ahmed Mohamed Elmamlouk

Abdelrahman taha Mohamed

Omar Mohamed elzokm

Abdelrahman agamy saleh

Supervised By:
Proff . Kamal Abdelaziz
Dr. Ahmed Samir

June - 2021

ACKNOWLEDGMENT

We would like to thank our supervisors Prof. Kamal Abdelaziz , Dr. Ahmed Samir and Dr . Rola Afify for their support , patience and great knowledge, their guidance us from the beginning till the end we also would like to thank our families for their support and patience. Finally, we really appreciate our collage arab academy for science and technology and maritime transport for being the place where we gained knowledge .

Abstract

In this topic, we talk about the jet pump. The jet pump is considered one of the most important applications in the field of petroleum and groundwater, where the jet pump withdraws petroleum materials and groundwater at different depths.

This study focuses on the mixing process of the driving jet and the induced flow in the throat to improve the efficiency of jet pumps used in Boiling Water Reactors. The effect of nozzle and throat shapes on the performance of jet pumps are examined experimentally under normal temperature and small-scale model conditions using three kinds of nozzles (i.e., circular, notched, and flower-shaped) and two kinds of throats

The aim of this study is to investigate the performance of water jet pump. the performance of water jet pump was studied. The effects of the pump operating conditions and geometries on its performance were investigated. The experimental rig was constructed such a way it can be changing the driving nozzle, mixing chamber and diffuser and we use the bernoli equation .

Table of Content

Chapter I
Introduction

Chapter I

Introduction

1.1 Principle of jet pump

The basic concept of a jet pump involves injecting power fluid (pressurized water or oil) down the power fluid flow path at a design rate and pressure. Once the fluid reaches the jet pump, the flow path area is decreased through a sized nozzle, increasing the velocity of the fluid creating a venturi effect. The differential pressure created from the venturi effect draws reservoir fluid into the jet pump. The power fluid and reservoir fluids commingle and the pressure increases as the velocity drops through the flow path of increased area. The pressure increase is sufficient to lift the commingled fluids to surface. This allows the reservoir fluids to be lifted to the surface through the annular space. The nozzle and throat are the key components of a jet pump. The ratio of the areas of these two parts is known as the area ratio of the pump and it determines the performance characteristics of the pump. Pumps with the same area ratio have the same performance and efficiency curves.

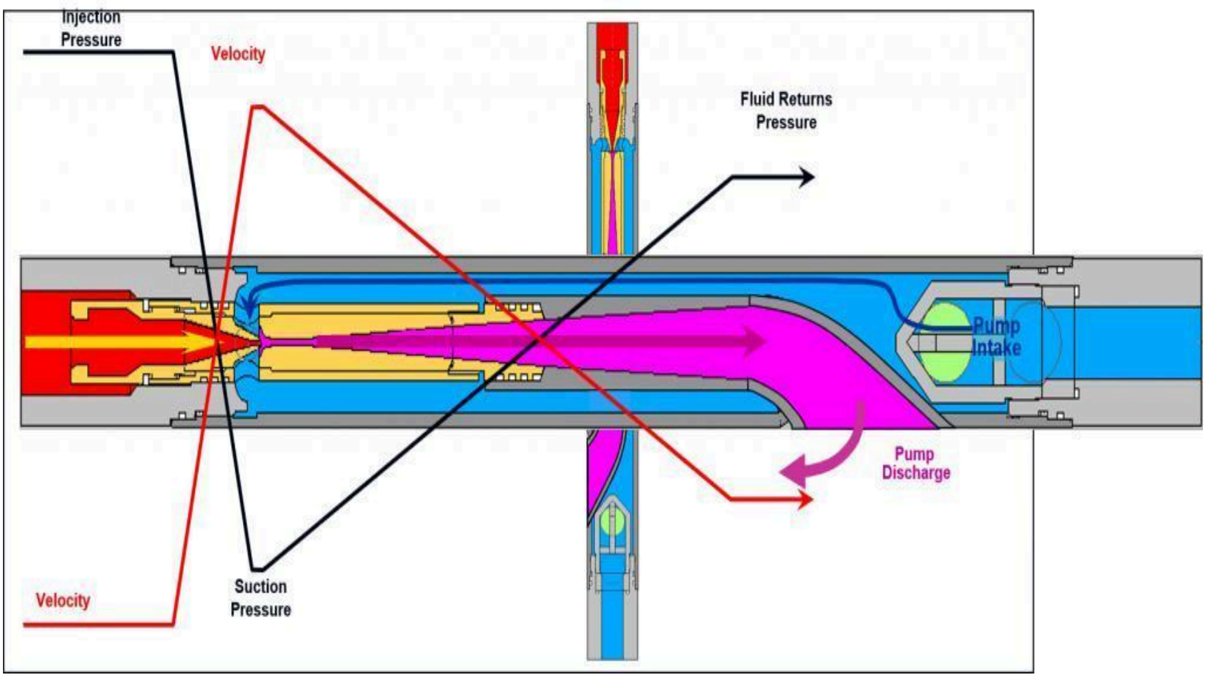


Figure 1.1. [Jet-Pump-Principles]

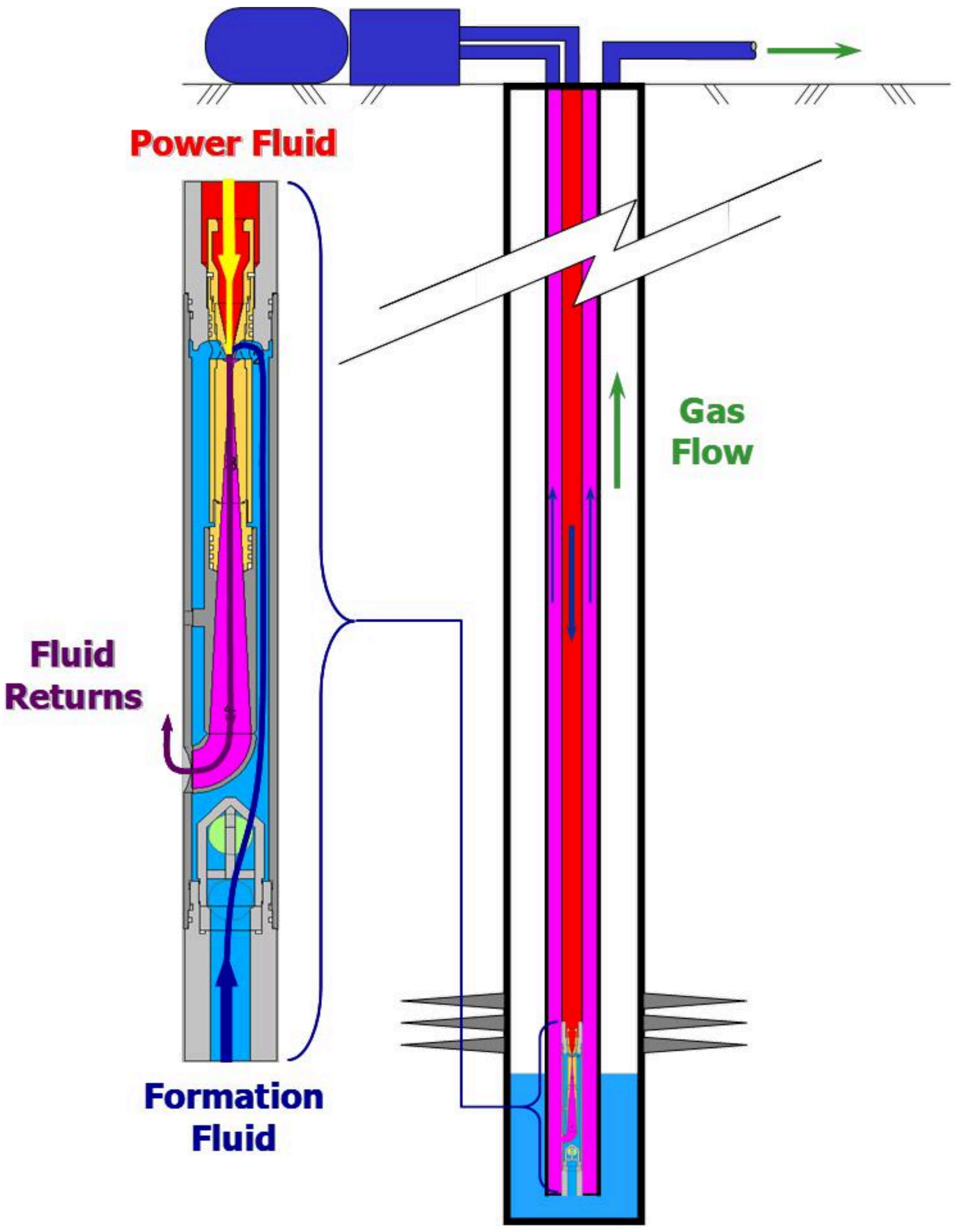


Figure1.2. [Jet-Pump-Principles2]

When the power fluid gets into the mixing tube the flow area increases, reversing the energy transformation, reducing speed, and increasing the pressure. This allows the reservoir fluids to be lifted to the surface through the annular space. Downhole jet pump compounds and their working principle are detailed in the article “How Does Jet Pump Work?”

The nozzle and throat are the key components of a jet pump. The ratio of the areas of these two parts is known as the area ratio of the pump and it determines the performance characteristics of the pump. Pumps with the same area ratio have the same performance and efficiency curves.

The design of jet pumps is simple; as a result, they require virtually no repair and are highly reliable. Their operation principle is based on movement of liquid, steam or gas through a pipe with a tapered nozzle (due to this design, liquid moves at high speed). Pressure in the supply chamber is kept below atmospheric pressure. Suction is carried out from the pipeline connected with the chamber. Liquids are subsequently combined and mixed in the second chamber; the resulting mixture is delivered into the diffusor and, subsequently, into the reservoir.

The most significant parameter of a jet pump is the suction factor calculated as operating liquid volume to pumped substance volume ratio. These pumps have low efficiency; however, there are absolutely no alternatives for these pumps in some applications. For example, jet pumps are used in food industry to pump liquids from reservoirs when other types of pumping units are inapplicable.

1.1.1 Operation

Jet pumps are centrifugal pumps with an ejector (venturi nozzle) attached at the discharge outlet. They function based upon the Venturi effect of Bernoulli's principle - utilizing constriction to reduce pressure and provide suction. After the pump is primed, a motive fluid is pumped through a standard centrifugal pump and enters an ejector. At the throat of the converging section of the ejector, the pressurized fluid is ejected at high velocity. This creates a low pressure (vacuum) at the throat, drawing the target fluid (from a well or other source) up into the nozzle. This picture is a diagram of the ejector portion of a jet pump:

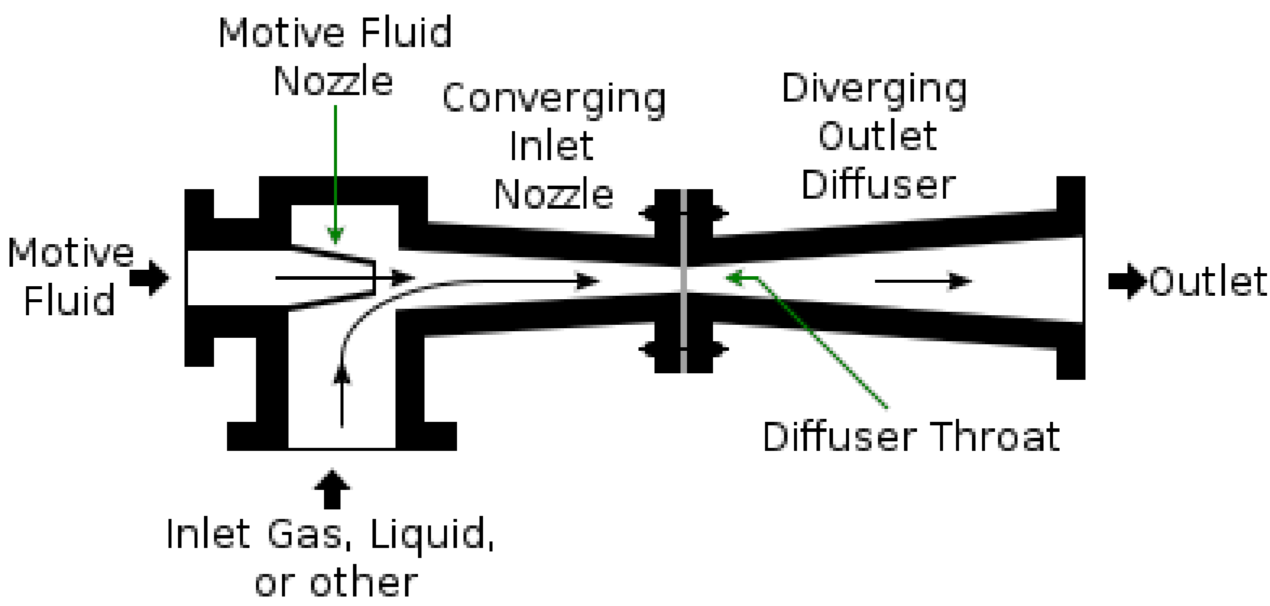


Figure 1.3. [ejector portion of a jet pump]

1.1.2 Advantages of using a Jet Pump

It is quite possible to lift water from a very down level of underground water. The quantity of lifted water depends on the size of the jet. There is no moving part in a jet pump. The pump does not require any prime mover because it does not have any rotating parts. Frictional losses in the pump are quite low simple design, long service life, low reliability, low vulnerability to corrosive substances Multiple jet pumped wells can be powered by a central surface pump package.

1.1.3 Disadvantages

The delivery rate of this pump is quite low compared to other conventional pumps. This type of pumping system always requires two pipes under the ground. This is because the pump needs to have an additional pipeline for providing water or steam supply to the nozzle in the suction chamber.

1.2 Types of jet pump

There are four main types of jet pumps, which vary based on application and size.

1.2.1 Deep well jet pump

jet pumps are used in high volume applications, such as oil wells. The ejectors in these pumps are put down the well.

Selection of a pump type is dictated by the setting depth, well design, well deviation, temperature, type and size of driver, based on lowest life cycle costs, repair costs, and availability of spare parts. The line shaft vertical turbine pumps have two basic methods for lubrication. One is the enclosed line shaft construction where oil or filtered water as a lubricant is supplied to the line shaft bearings through the enclosing tube. This report is written to cover this latter type of construction. The second method is open line shaft construction which uses the pumped fluid directly for lubrication. The line shaft and bearings are open to the pumped fluid in this case.

Deep well pumps are necessary in order to get geothermal fluids to the surface for all purposes. Well testing is required for optimum pump design and selection. Well testing involves collection of data and analysis to determine the well loss coefficient. A systematic calculation procedure is presented. The engineering equations used in detailed pump calculation are identified and explained in a case study. The study shows how seasonal and gradual variations of the water table influence the design of the pumps and selection of the optimum discharge. The proper selection of deep well pumps is important for trouble free operation and optimum production from the well. The relative movement of impellers is a critical parameter that can be calculated; the results are used to make sure that the adjustment of impeller to the bowl housing is in the best position. The proper procedures for installing and pulling a deep well pump are given in detail.

1.2.1.1 Se1cction of a deep well pump

Selection of a pump type (Fig. 1.4) is dictated by the setting depth, well design, well deviation, temperature, type and size of driver, based on lowest life cycle costs, repair costs, and availability of spare parts. The line shaft vertical turbine pumps have two basic methods for lubrication. One is the

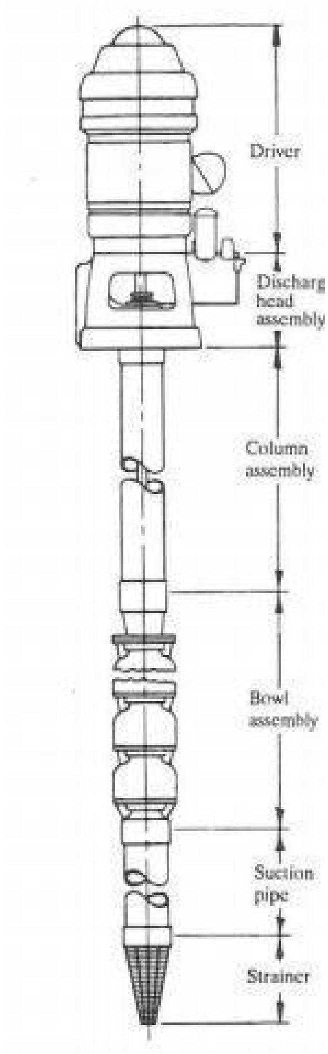


Figure 1.4. [Basic components ~ enclosed line shaft pump]

enclosed line shaft construction where oil or filtered water as a lubricant is supplied to the lineshaft bearings through the enclosing tube. This report is written to cover this latter type of construction. The second method is open line shaft construction which uses the pumped fluid directly for lubrication. The line shaft and bearings are open to the pumped fluid in this case.

1.2.1.2 Installation of deep well line shaft pump

General

Proper installation is necessary to obtain maximum service life from the pump. To insure proper alignment three items are very important during installation:

1. All machined mating surfaces must be clean and free of burrs and nicks removed with a fine file or wire brush.

2. Exterior strain must not be transmitted to the pump discharge head. The most common cause of trouble in this respect is forcing the piping to mate with the pump. It is recommended that a flexible connector is installed in the piping adjacent to the pump.

3. All threads should be checked for damage and repaired if necessary. clean all threads with wire brush and cleaning solvent, end of shafts must be cleaned and any burrs removed since alignment depends on the shaft ends butting squarely. Lubricate all screwed connections with a thread lubricant; a mixture of graphite grease is suitable for steel, an anti galling compound such as "Never·Seez" should be used on stainless and Monel mating threads.

1.2.2 Shallow well jet pump

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.

Shallow well jet pumps are practical for wells or reservoirs that require a total pumping lift of less than 5.5 m (18 ft). Industry Highlights. The three main components of the shallow well jet pump are an electric motor, an impeller and a jet assembly. Although a simple centrifugal pump would pump water at this lift, including a jet assembly will greatly increase the discharge pressure and suction. This combination makes the shallow well jet pump suitable for use in farm water pressure systems.(Figure 1.5.) shows the flow of water in a typical shallow well jet pump.

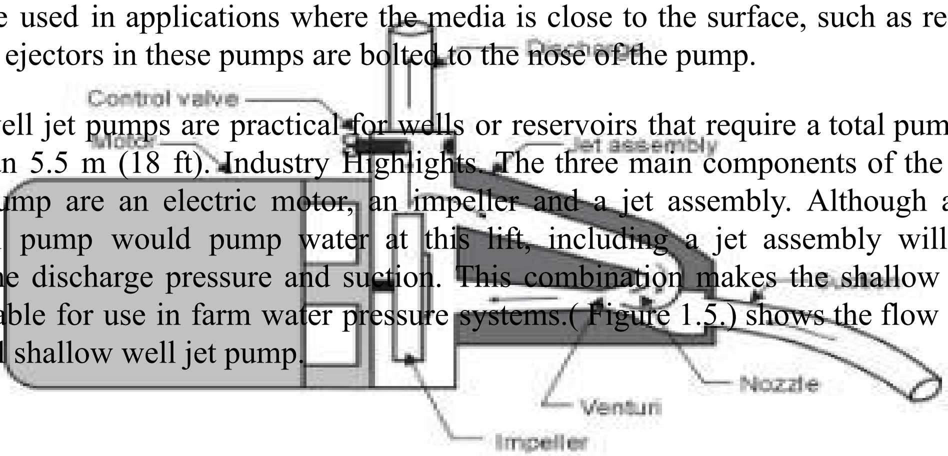


Figure 1.5. [shallow well jet pump operation]

1.2.2.1 Shallow well jet pump installation

Connect pump to well. Support suction pipe so its weight is not carried by the pump. Installation should include a foot valve in the well or a check valve close to the pump. If the distance from the well to the pump is more than 40', a check valve (installed close to the pump) is recommended in addition to the foot valve. Special care should be taken to ensure that all suction fittings are tight and sealed. Otherwise the pump will not prime.

1.2.2.2 Advantages of shallow well jet pumps

- can be offset from the well
- can be adapted to wells of various yields
- are mechanically simple and require little maintenance
- are relatively inexpensive
- can be used in wells of small diameter

1.2.2.3 Limitations

Jet pumps lose efficiency as the total lift increases. Total lift includes the vertical distance from the water to the pump plus the friction losses in the suction line and foot valve. Shallow well jets are not practical if the total lift exceeds 5.5 m (18 ft). Pumping water containing sand will cause wear and leakage around mechanical seals.

1.2.2.4 Priming process

To prime a shallow well jet pump:

1. Fill the suction line and pump casing with water.
2. Close the pump control valve.
3. Leave the priming plug slightly loose and start the pump.
4. Stop the pump when the air stops bubbling out around the priming plug.
5. Refill the pump casing with water, replace priming plug loosely and start the pump.
6. When the pump is fully primed, water will flow out continuously around the priming plug.
7. Tighten the priming plug and open the pump control valve.
8. After the pump has been primed, it may be necessary to pre charge the pressure tank. See Agri facts 716 (C31) Pressure Tanks. When trenching and laying the suction line in the trench, make sure there are no high points in the line where an airlock can form, causing difficulties in priming.

1.2.3 Convertible jet pump

Convertible jet pump will operate the same as a shallow jet pump but can easily convert to deep well operation by removing the shallow well injector and inserting a bypass plug in its place and putting a deep well injector in the well.
This pump is designed for shallow well installation for water level up to 25 feet, with injector screwed on pump body; or for deep well installation for water level up to 80 feet, with 2 pipes and injector down in the well. A pressure switch and pressure gauge are standard features. The DuroJet Convertible Jet Pump can be mounted to either a pre charged horizontal pressure tank or used with a pre charged free standing pressure tank. The pumps can also be used with conventional air to water tanks. For deep well applications

1.2.4 Miniature

Jet pumps are used for smaller (typically commercial) applications, such as aquariums.

1.2.5 PRIMING (DEEP WELL)

The motor should not be started until pump is primed. To prime the pump, remove the priming plug or discharge plumbing line and fill pump and piping with water. Replace plug or discharge line. Open faucet in water system, then release nut at bottom of control valve so you can turn valve to closed position. Turn on pump and let pressure build in system, then gradually open control valve until pump is delivering adequate amount of water without losing prime and without excessive noise. On all installations, it is best to check if your water runs clear before you connect complete system. Let pump operate until water runs clear. However, if after a reasonable time water continues to run sandy or dirty, check with your dealer for further instructions.

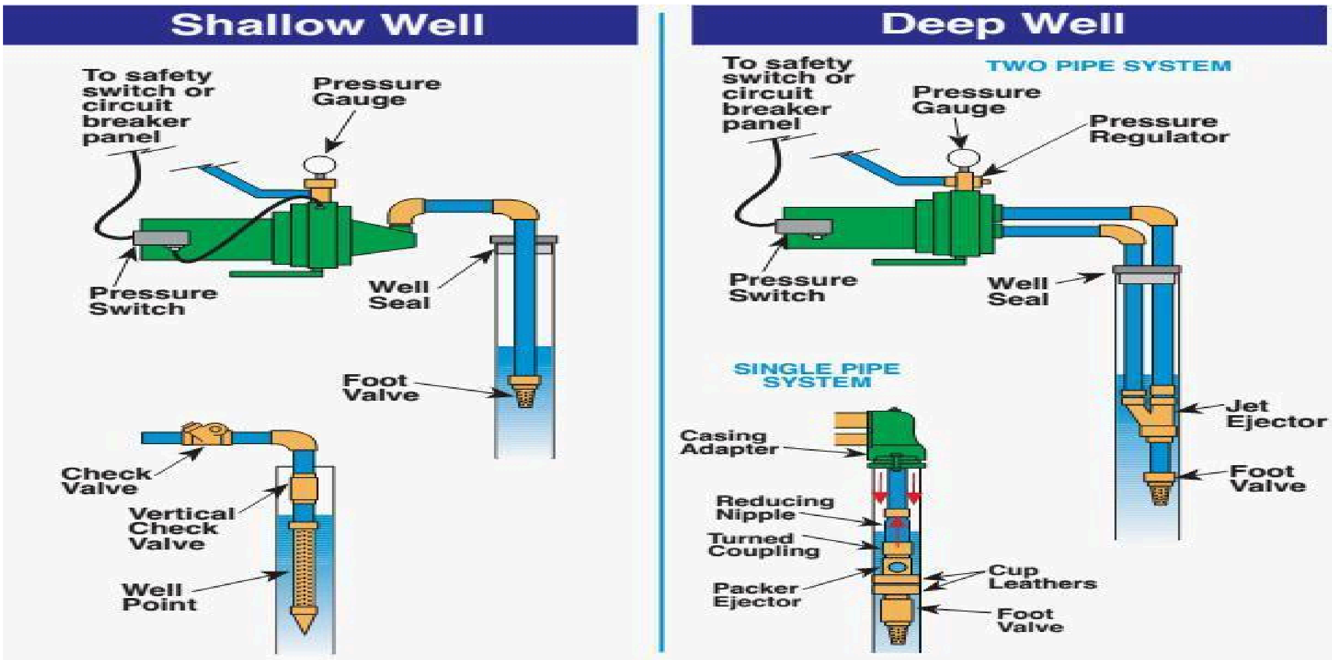


Figure 1.6.[shallow well and deep well difference]

1.2.6 Typical Jet Pump Installations

Jet Pumps are mounted above ground and lift the water out of the ground through a suction pipe.

Jets are popular in areas with high water tables and warmer climates.

There are two categories of jet pumps and pump selection varies depending on water level.

1.Shallow well installations go down to a water depth of about 18 feet (7.62 m).

2. Deep wells are down 150 feet (45.72 m) to water, where surface pumps are involved.

1.3 Applications

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.

Multi-stage steam jet vacuum pumps : are used to produce vacuum in evaporators, driers, distillation plants, rectifying, freeze drying, poly-condensation, degassing, deodorizing plants etc.

The use of product vapor as motive medium for jet pumps plays an increasingly important role in the production of polyester, foil and textiles. In this way, GEA designs completely closed systems which are characterized by their ecological and economic efficiency.

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.
Jet pump on oil and gas field:
Use high pressure (HP) liquid as catalytic flow to increase Pressure of the gas produced

The gas produced or treated is often under less pressure than required by a transmission or treatment system, and expensive compressors are generally used to increase its pressure. In some applications .

Deep well jet pump withdraw from depth 45m
Shallow well jet pump withdraw from depth 25m

Figure 1.7. [Marine Boat Water Jet Propulsion Pump]

Jet pumps use for ships , boats, construction and (seawater, well water ,nile water).shown in (fig 1.7.)

Jet pumps are frequently used as additional equipment, because they can easily be installed in combination with other types of pumps:

in sewerage systems;

in fire-fighting systems;

in integrated systems with impeller pumps, to improve efficiency.

in integrated systems with centrifugal pumps, to remove air from these pumps before

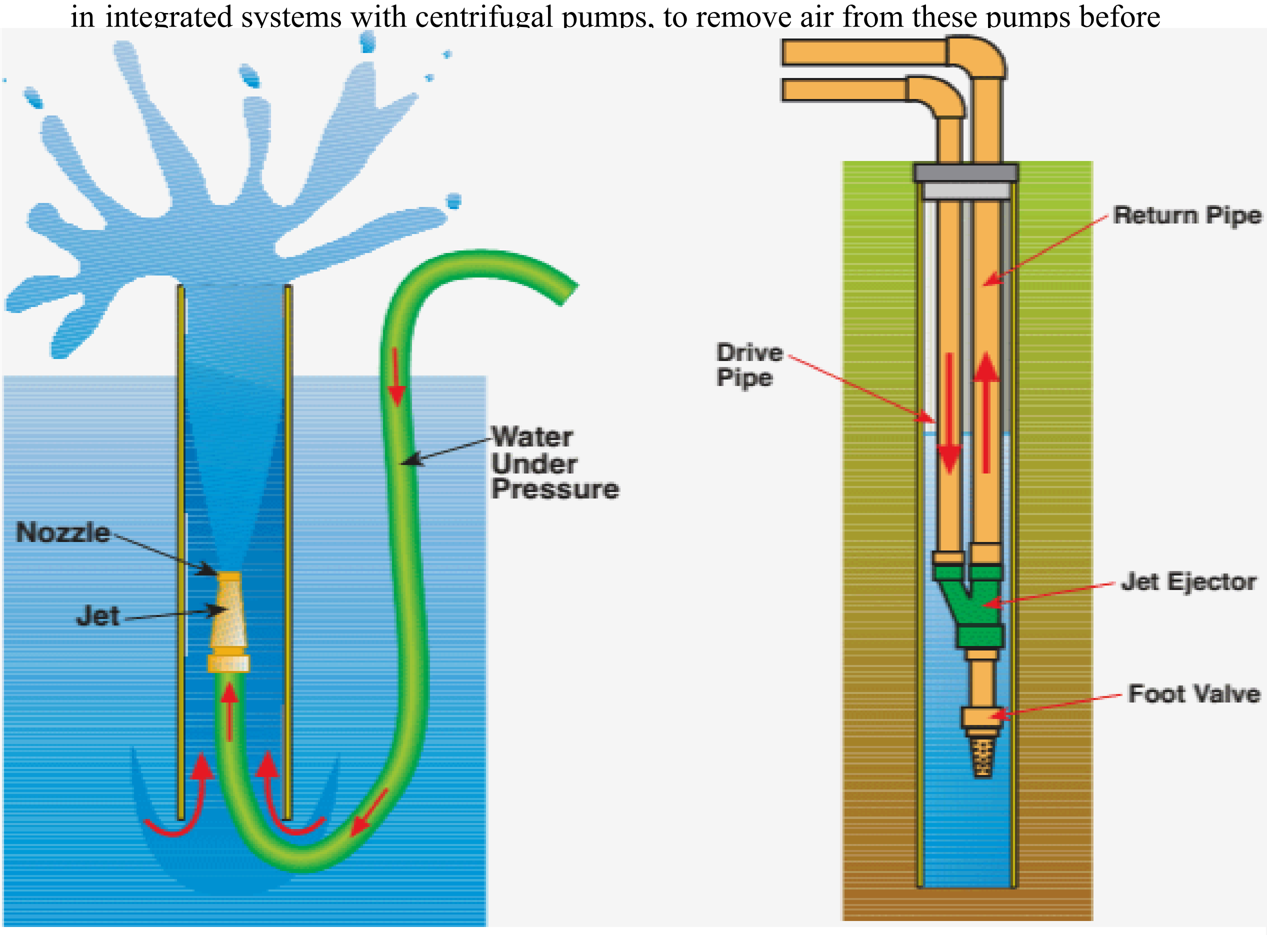


Figure 1.8.[jet pumping action]

Figure 1.9.[firefighting jet pump]

1.4 <u>performance of jet pump curves</u>

<u>1.4.1 Pump Curve:</u>

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).

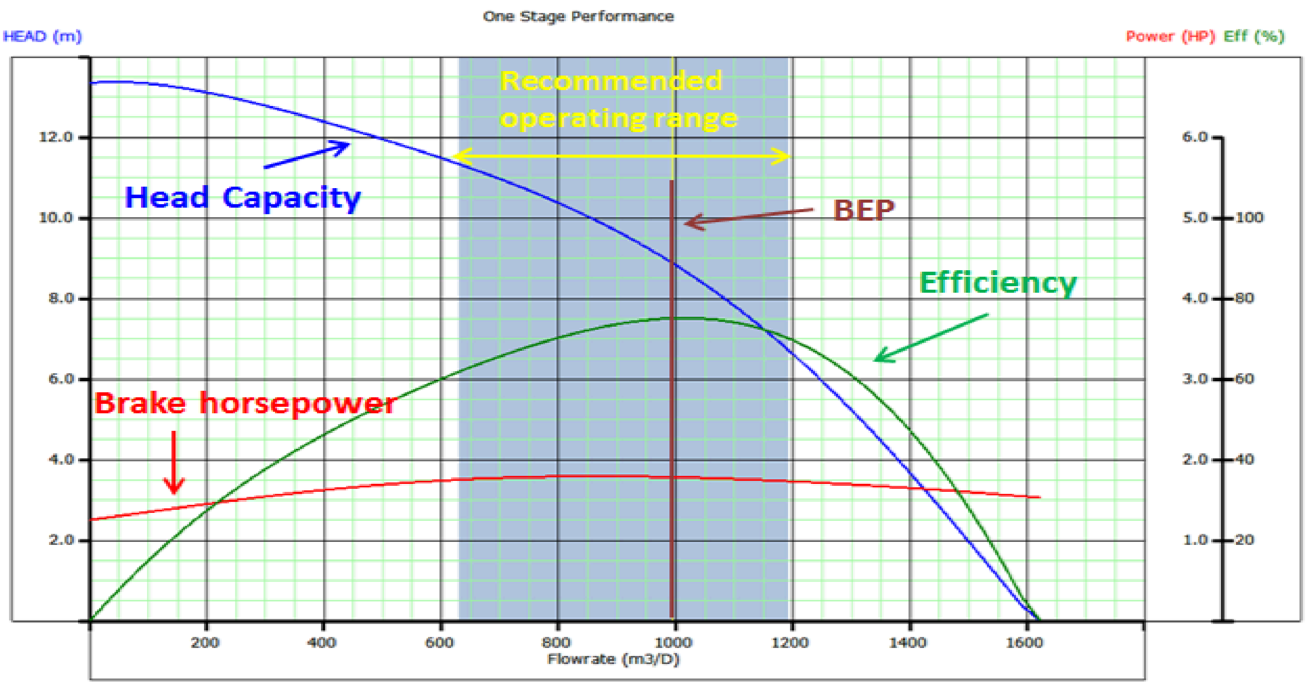


Figure 1.10.[typical pump curve]

Jet Pump Performance When the pressure drop across the fabric bag is greater than a designated value, a short burst of compressed air is discharged from a nozzle and usually directed through a venturi into the filter bag to increase the pulse pressure within the bag. The nozzle venturi assembly system converts the velocity energy into pressure energy. Therefore, the sudden increase of the air pressure in the bag leads to the acceleration of the bag cloth and creation of reverse air through the bag, resulting in the removal of dust cake. This nozzle-venturi system is so-called jet pump (Bakke, 1974; Morris et al., 1991; Ravin et al., 1988). Figure 1 shows a typical jet pump curve, pulsing power curve, and bag operating lines of a pulse-jet fabric filter (after Bakke, 1974). A jet pump characteristic curve varies with the initial tank pressure, nozzle size, venturi configuration, and the distance between the nozzle and venturi. The maximum pulse pressure developed in the bag by the jet pump is obtained at zero flow rate. Conversely, the maximum flow rate through the venturi is obtained at zero pulse pressure, or when the bag has zero resistance. The jet pump curve can be obtained easily by measuring the pulse pressure developed in the bag by the jet pump at various airflow rates using bags of different resistance.

1.4.2 jet pump performance 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.

Definitions in figure 1.11.:
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.

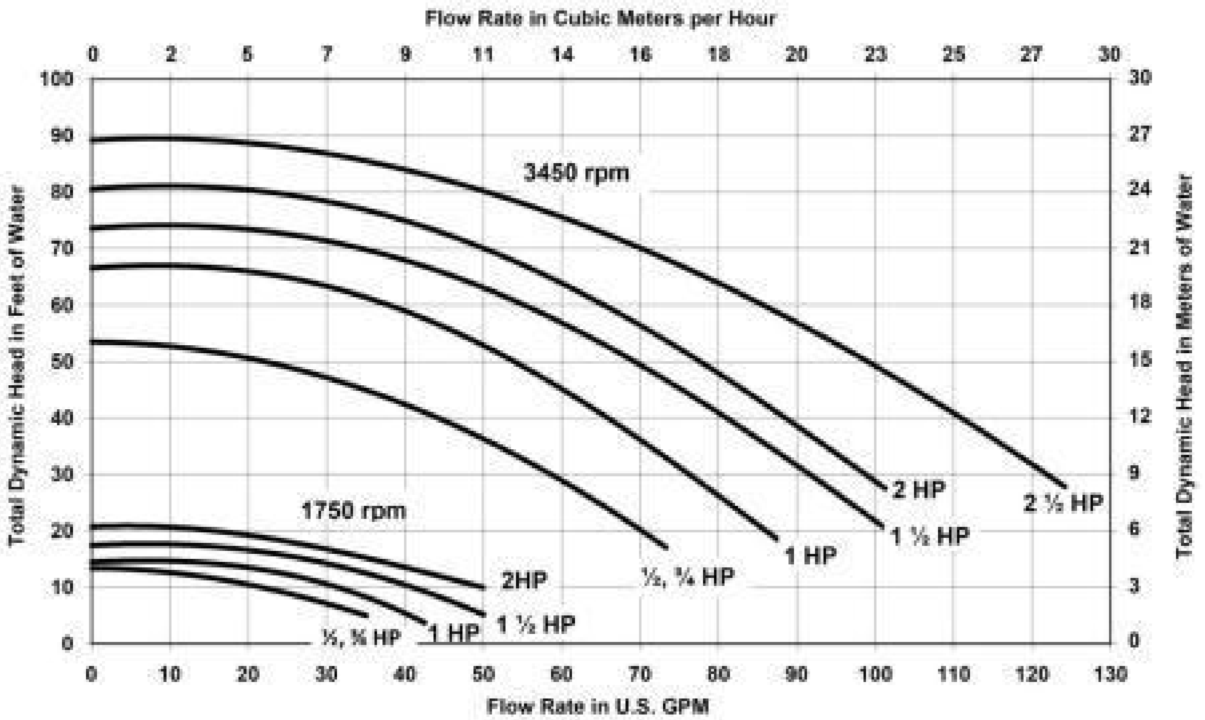
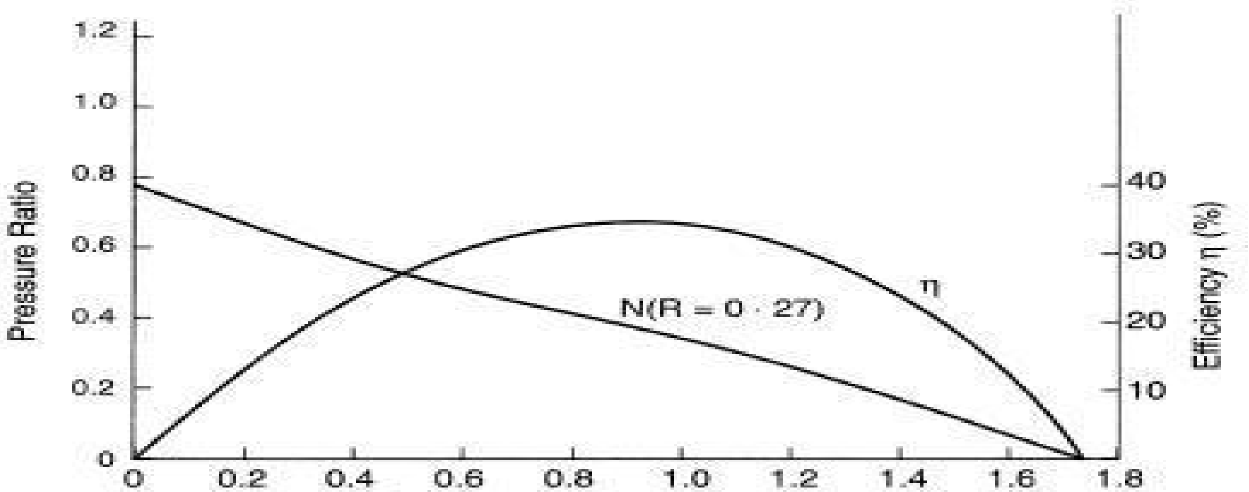


Figure 1.11.[jet pump performance curve]

Recommended operating range: located between the maximum and minimum recommended flow rates.

Figure 5 shows a typical efficiency and performance curve for a jet pump, as a function of secondary flow rate. Note the typical shape, with a peak efficiency of around 35%.

1.4.3 typical jet pump performance curve



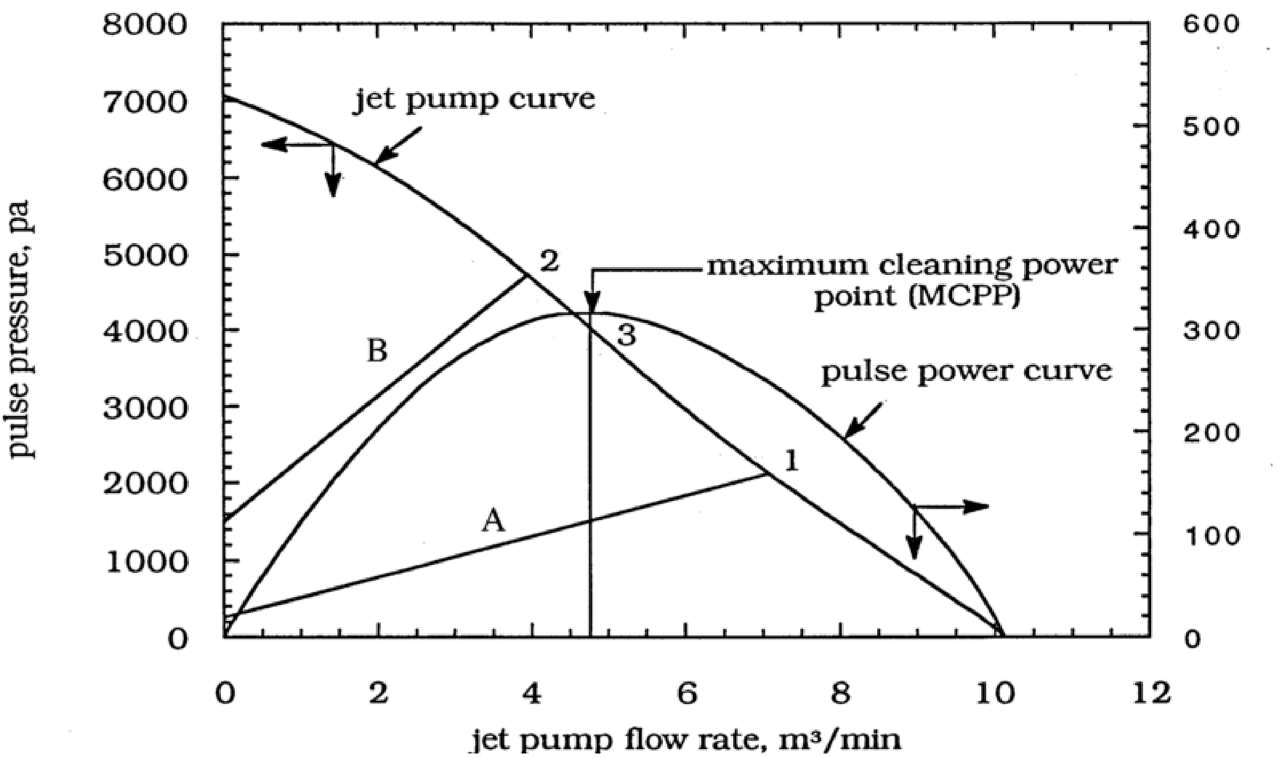


Figure1.12. [typical jet pump performance curve]

Figure 1.13. [typical 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 pressure decreases, 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 the construction/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:
$p = \rho \times g \times H$ [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 minimum and 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.

1.5 Two and three phase flow of jet pump

1.5.1 Two phase flow

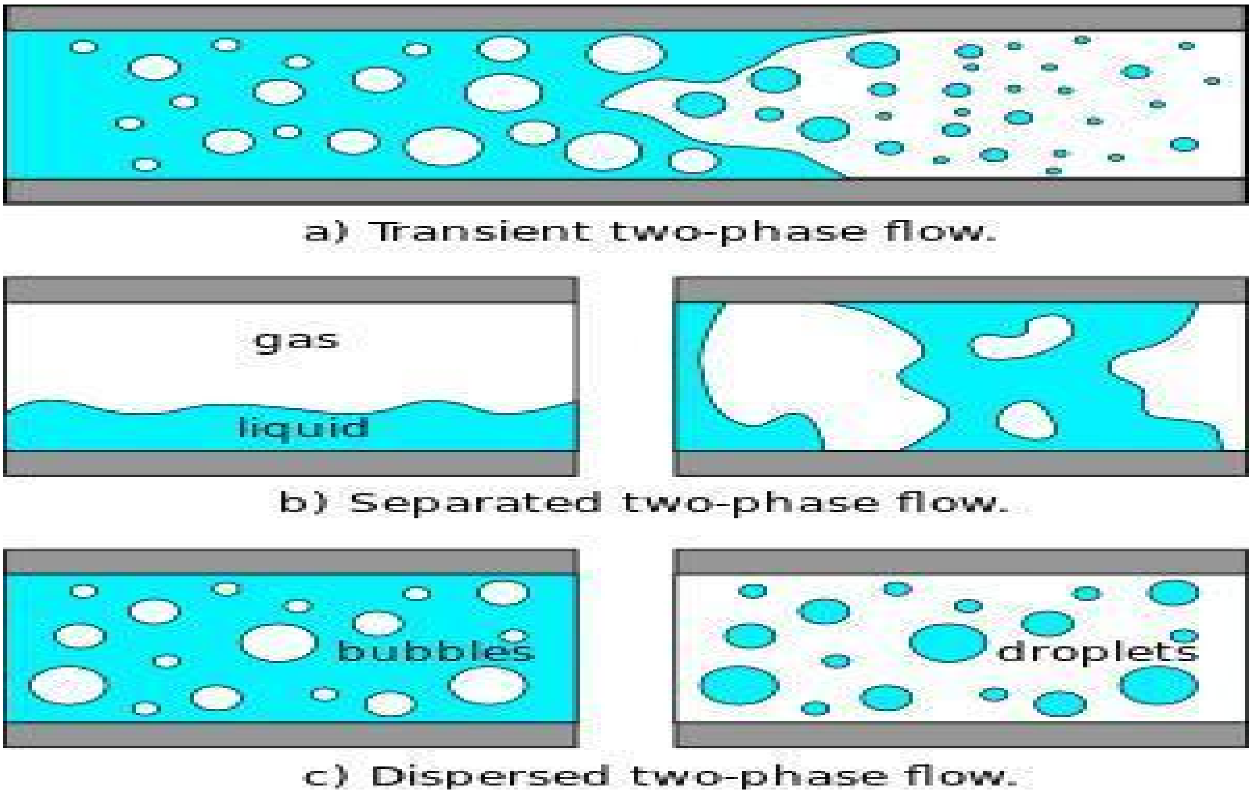


Figure 1.14. [Different modes of two-phase flows]

In fluid mechanics, two-phase flow is a flow of gas and liquid — a particular example of multiphase flow. Two-phase flow can occur in various forms, such as flows transitioning from pure liquid to vapor as a result of external heating, separated flows, and dispersed two-phase flows where one phase is present in the form of particles, droplets, or bubbles in a continuous carrier phase (i.e. gas or liquid).

1.5.1.1 Examples and applications of two phase flow

Historically, probably the most commonly studied cases of two-phase flow are in large-scale power systems. Coal and gas-fired power stations used very large boilers to produce steam for use in turbines. In such cases, pressurized water is passed through heated pipes and it changes to steam as it moves through the pipe. The design of boilers requires a detailed understanding of two-phase flow heat-transfer and pressure drop behavior, which is significantly different from the single-phase case. Even more critically, nuclear reactors use water to remove heat from the reactor core using two-phase flow. A great deal of study has been performed on the nature of two-phase flow in such cases, so that engineers can design against possible failures in pipework, loss of pressure, and so on (a loss-of-coolant accident (LOCA)).

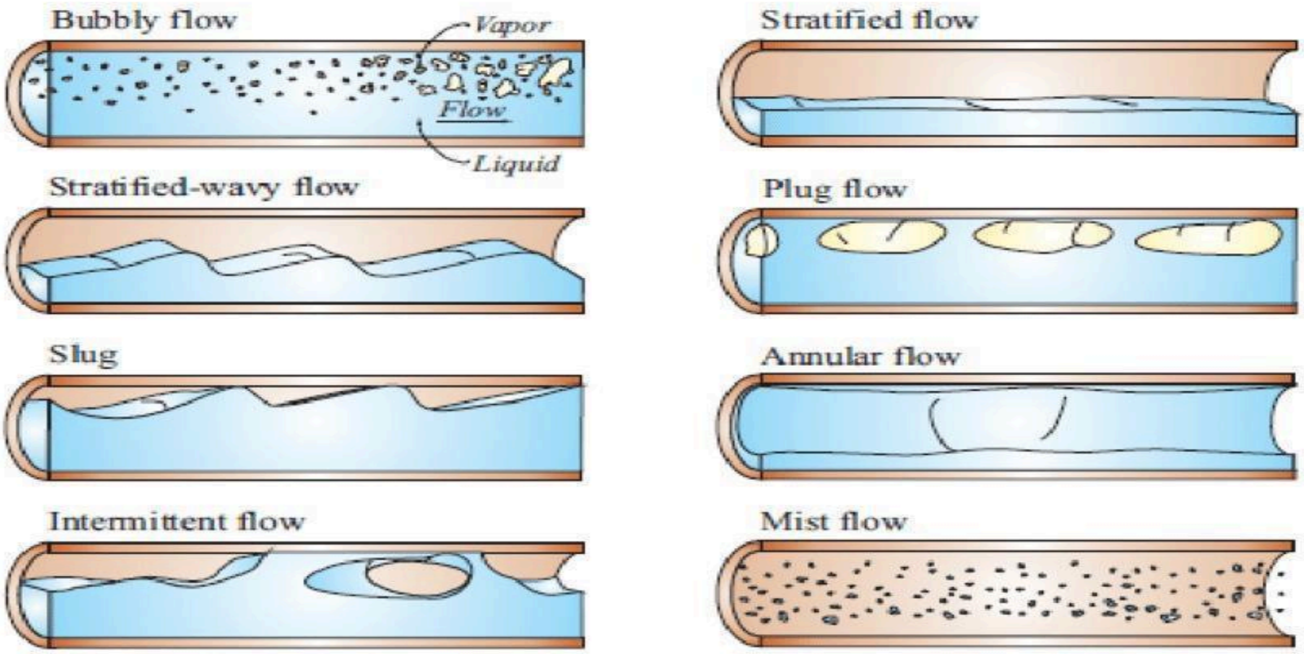


Figure 1.15.[types of two-phase flows]

Figure 1.16. [two phase flow jet pump]

Another case where two-phase flow can occur is in pump cavitation. Here a pump is operating close to the vapor pressure of the fluid being pumped. If pressure drops further, which can happen locally near the vanes for the pump, for example, then a phase change can occur and gas will be present in the pump. Similar effects can also occur on marine propellers; wherever it occurs, it is a serious problem for designers. When the vapor bubble collapses, it can produce very large pressure spikes, which over time will cause damage on the propeller or turbine.

The above two-phase flow cases are for a single fluid occurring by itself as two different phases, such as steam and water. The term 'two-phase flow' is also applied to mixtures of different fluids having different phases, such as air and water, or oil and natural gas.

Sometimes even *three*-phase flow is considered, such as in oil and gas pipelines where there might be a significant fraction of solids. Although oil and water are not strictly distinct phases (since they are both liquids) they are sometimes considered as a two-phase flow; and the combination of oil, gas and water (e.g. the flow from an offshore oil well) may also be considered a three-phase flow.

Other interesting areas where two-phase flow is studied includes in climate systems such as clouds, and in groundwater flow, in which the movement of water and air through the soil is studied.

1.5.1.2 Characteristics of two-phase flow

Other examples of two-phase flow include bubbles, rain, waves on the sea, foam, fountains, mousse, cryogenics, and
oil slicks. One final example is in the electrical explosion of metal.

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

Surface tension makes all dynamical problems nonlinear (see Weber number).
In the case of air and water at standard temperature and pressure, the density of the two phases differs by a factor of about 1000. Similar differences are typical of water liquid/water vapor densities.
The sound speed changes dramatically for materials undergoing phase change, and can be orders of magnitude different. This introduces compressible effects into the problem.
The phase changes are not instantaneous, and the liquid vapor system will not necessarily be in phase equilibrium.
The change of phase means flow-induced pressure drops can cause further phase-change (e.g. water can evaporate through a valve) increasing the relative volume of the gaseous, compressible medium and increasing exit velocities, unlike single-phase incompressible flow where closing a valve would decrease exit velocities.

1.5.2 Three phase flow

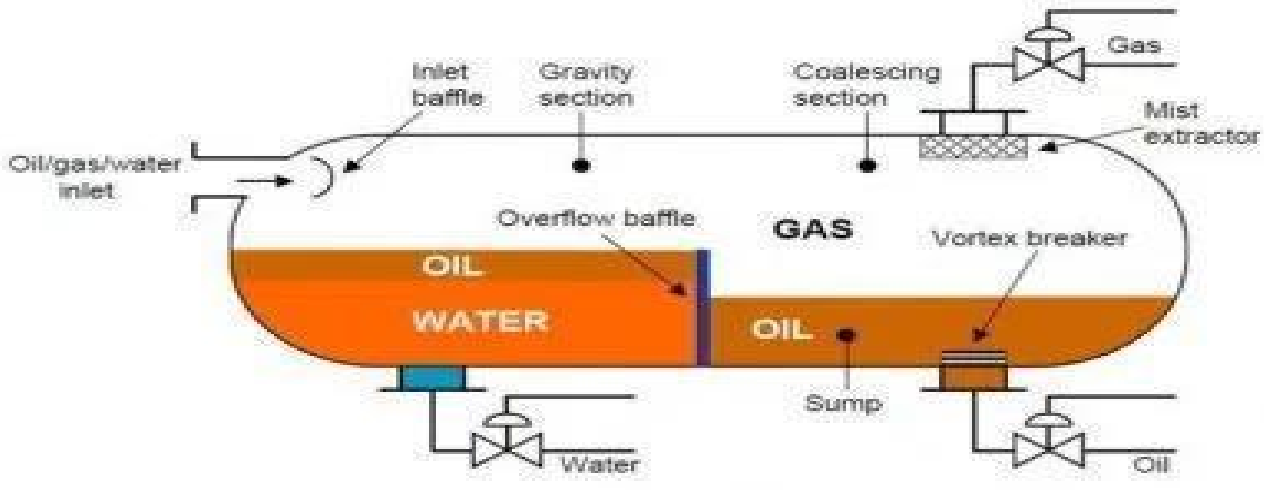


Figure 1.17.[three phase flow separator]

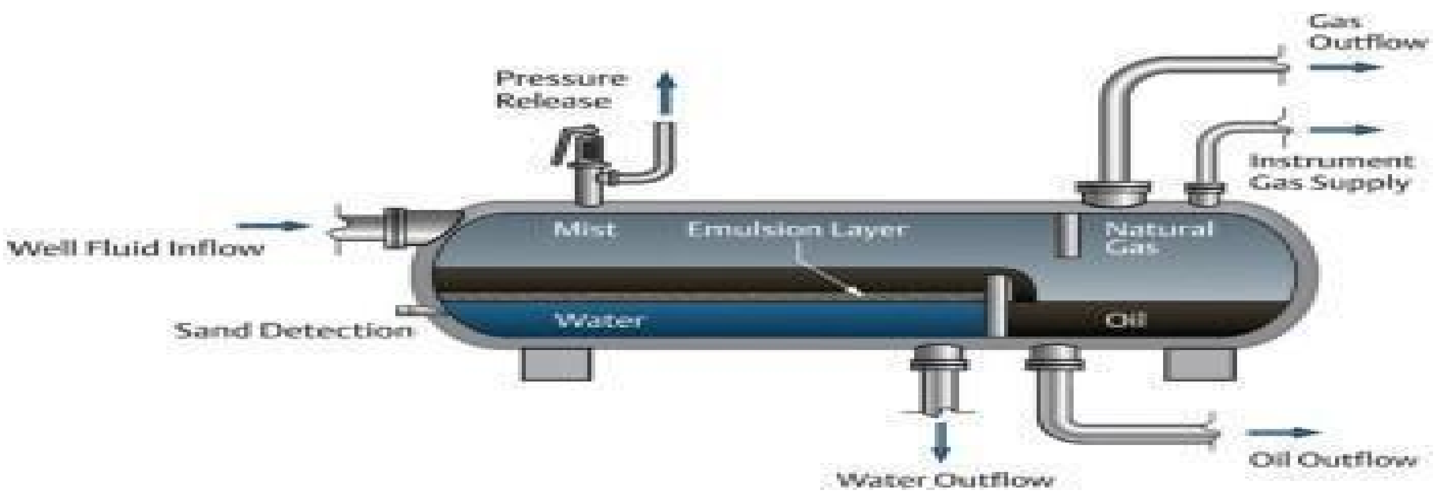
3 Phase Flow Jet Pump is a type of jet pump which introduces air into water jet nozzle (via natural suction), possible to transport solid objects, for which the interior of the pipe contains a 3-phase-flow of solid, gas, and liquid.

1.5.2.1 Characteristics

1. The "cavitation phenomenon", which occurs during high-speed rotation upon using only water pump, does not occur.
2. Due to utilizing pipe structure, it is possible to transport mixtures of multiple substances, such as sludge, muddy water, etc. which consist of solid matter and fluid.
3. Since no impeller is used for the pump, there is no concern about solid matter would get entangled with impeller causing "clogging", or mixed substances would cause "damage".
4. It is possible to perform suction at a narrow location if the location is wide enough to place a single suction pipe.
5. With the principle of sucking solid objects, as a "washing machine", it is extremely effective to clean those objects in series flowing inside of the narrow tube.

1.5.2.2 Application of three phase flow

Civil Engineering: Conveyance of gravel and soil for reclamation work (Able to convey materials having heavy specific gravity or rope-like objects without causing clogging.)
Civil Engineering: Excavation work (Able to convey and transfer underground gravel, soil, and stones in a vertical manner.)
Civil Engineering: Dredging operations for seabed, lakebed, and dam bottom (As the jet effect provides great separation for extracted gravel and soil, the speed of sedimentation is



fast.)

Figure 1.18. [three phase flow separator]

Civil Engineering: Pumping-up operations of sediment for sewer pipes and U-shaped gutters (It is possible to perform such operations at a narrow location or deep area on or under the ground.)
Water treatment: Filtering device (Internal circulation of filter tank and separation of materials from sand)
Fish Culturing: Feeding (Feed does not get deformed, crushed, and clogged up.) l Washing

Machine: Able to perform jet cleaning to vessels and tanks as well as collecting sludge (Cleaning and pumping-up sludge can be performed at a time.)
Food Production: Fluid flow cleaning (Focusing on grain, it is able to clean fluid flow objects within a short period of time.)

- Food Production: Pneumatic Conveyance (Suction is performed by the air generated from a vacuum state via water circulation, and fine particles do not scatter.)

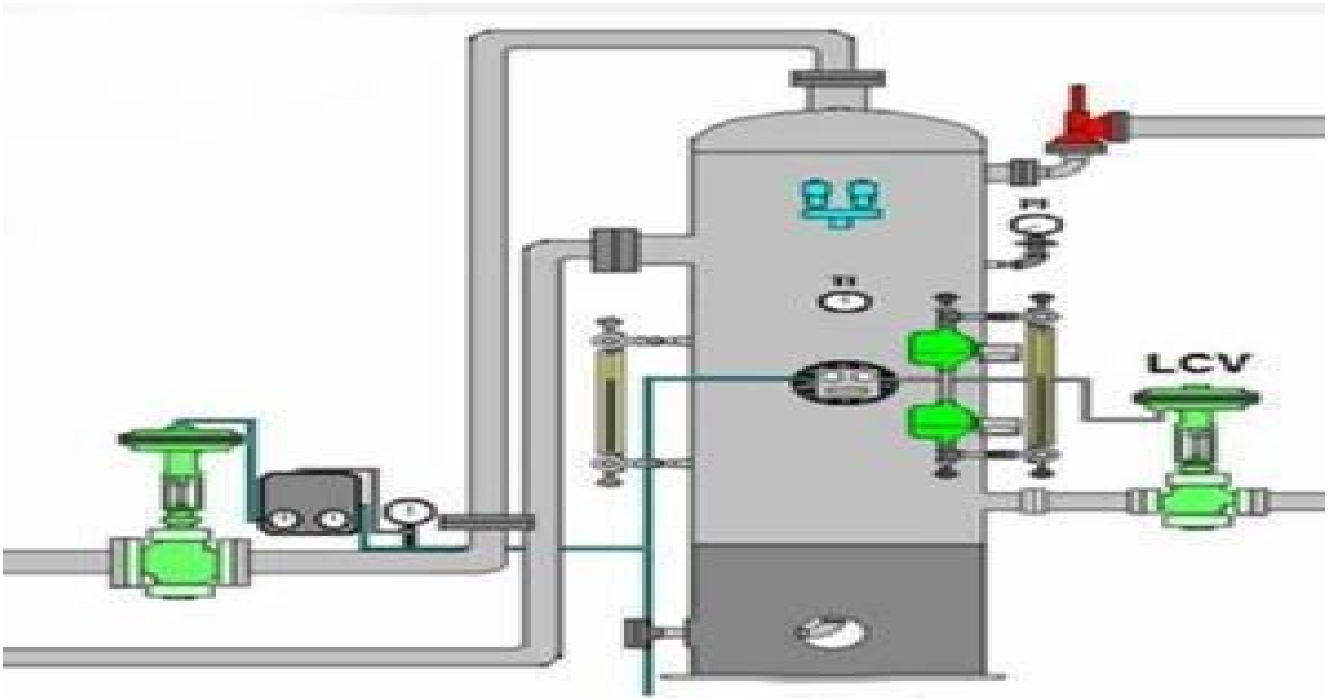


Figure 1.19.[two-three phase separator]

Food Production: Water Conveyance (Water is sucked via a vacuum state. As there is a lesser chance of clogging compering to the pressure feeding, damage to the food is much smaller.

Chapter II

Literature Survey

Literature Survey

Experimental observations for the performance of a jet pump are presented with two different suction configurations and designs. The experimental rig was constructed in such a way it can be used with up feed (negative suction head) or down feed (positive suction head). During experimental programme water is used in both motive and pumped sides. The effect of nozzle-to-throat spacing to nozzle diameter ratio "X", on the jet pump performance was also tested, with different flow rates and motive pressures, in both cases (up feed and down feed). It was found that the best efficiency for the jet pump is attained with the up feeding configuration [1].

This research covers the experimental results obtained in the current work. A set of experiments were carried out to study the effect of some parameters on the performance of the suggested jet pump. These parameters such as: area ratio (four different area ratios of 0.16, 0.22, 0.26 and 0.3 were used), driving nozzle outlet diameter to mixing chamber diameter ratios (four ratios were tested with values of 1, 1.5, 2 and 2.5). Also, two suction inlet configuration were selected (one with cylindrical inlet part, and the another with conical inlet part) and two vertical level positions for jet pump at 10 and 30 mm from sand bed were studied. In addition, the experimental study also includes the performance of the slurry jet pump in two cases (stationary and movable), for the movable case, two speeds for jet pump of 0.7 and 0.35 m/min were tested. One type of quartz sand was used with 0.52 mm mean particle size diameter and with a specific gravity of 2.65. Furthermore, one suction nozzle of semi cone angle 24° was used with one diffuser of semi cone angle 5.5°. One fluidizer of 3 mm holes diameter was used too. A special experimental test rig has been designed and built to study the effect of these parameters experimentally. The performance of slurry jet pump is described by two sets of curves. The first shows the relationship between the head ratio (N) and the mass flow ratio (M). The second set shows the relationship between the jet pump efficiency (η) and the mass flow ratio [2].

The jet pump generally needs a long throat to mix the driving and induced fluids and transfer the momentum of driving fluid to induced fluid. Simultaneously, the energy loses when the fluids flow through the long throat because the friction loss occurs inside of the throat wall. Therefore, it is known that the throat length largely affects the jet pump efficiency. In this study, experimental studies are performed for a typical single nozzle jet pump using water at room temperature. It is revealed that surface roughness located nearer the throat inlet has a greatest effect on the jet pump efficiency because the local skin friction coefficient nearest the throat inlet is the largest. The best efficiency and its flow rate ratio decrease linearly as surface roughness increases. The frictional resistance coefficient in the throat for each roughness is made clear by fitting a one-dimensional theoretical prediction equation to the experimental results [3].

This study focuses on the mixing process of the driving jet and the induced flow in the throat to improve the efficiency of jet pumps used in Boiling Water Reactors. The effect of nozzle and throat shapes on the performance of jet pumps are examined experimentally under normal temperature and small-scale model conditions using three kinds of nozzles (i.e., circular, notched, and flower-shaped) and two kinds of throats (i.e., conventional straight throat and diverging throat with a very gentle gradient). A nozzle throat area ratio, which influences the flow rate ratio at peak efficiency, is kept constant to avoid significantly changing the flow rate ratio. The velocity profile and local skin-friction coefficient in the throat are investigated experimentally to evaluate the effect of nozzle and throat shapes on the mixing process. The following results are obtained. The diverging throat reduces skin-friction loss and improves efficiency for all three nozzles. The efficiency curve of the circular nozzle with eight notches slightly shifts to higher flow rate region by the reduction of the jet size compared with the circular nozzle. The flower-shaped nozzle decreases efficiency owing to the increase of the skin-friction loss caused by enhanced mixing. The circular nozzle with a diverging throat improves the peak efficiency about 2% without changing the nozzle throat area ratio [4].

The aim of this study is to investigate the performance of water jet pump. This study is reported in a series of three papers. In this paper, the performance of water jet pump was studied. The effects of the pump operating conditions and geometries on its performance were investigated. The experimental rig was constructed such a way it can be changing the driving nozzle, mixing chamber and diffuser. During experimental program water is used in both motive and pumped sides. In this study three different diameters of driving nozzles, namely (10, 12.7 and 16 mm) have been used with one mixing chamber of 25.4 mm diameter (i.e. three different area ratios of 0.155, 0.25 and 0.4). Furthermore three different mixing chamber lengths to mixing chamber diameter ratio of 6.75, 7.25 and 7.86. And three different diffuser angles of 4º, 5.5º and 7º respectively with one suction nozzle of semi cone angle of

22º. The effect of nozzle to throat spacing to nozzle diameter ratio "X" with values of 0 D, D, 1.5 D and 2 D, on the jet pump performance was also tested under different flow rates and motive pressures. In all cases, it was found that the best efficiency for the jet pump is attained with "X" equal one, and the best values for these design parameters have been obtained from the experimental work. The performance of slurry jet pump and the comparison between them will later be discussed in another further paper [5].

The slurry jet pump with scouring nozzle system can be used in dredging of sites, which are difficult to access or need handling of equipment that are used for the intake of pumping stations under bridges and concrete water channels. This system is suitable for sand, silt, sludge, mud, and other organic materials. The aim of this study is to investigate the performance of water and slurry jet pumps. The effects of the pump-operating conditions and geometries on its performance were investigated. The experimental rig was constructed in such a way that the driving nozzle diameter can be changed. In this study, three different diameters of driving nozzles, 10, 12.7, and 16 mm, have been used with one mixing chamber of 25.4 mm diameter (i.e. three different area ratios of $R = 0.155$, 0.25, and 0.4). Also, the effect of driving pressure has been investigated. The results show that increasing the area ratio decreases the maximum mass flow ratio. The results of computational fluid dynamics were found to agree well with actual values obtained from the experimental water and slurry jet pump [6].

The jet pump generally needs a long throat to mix the driving and induced fluids and transfer the momentum of driving fluid to induced fluid. Simultaneously the energy losses occur when the fluids flow through the long throat happened due to the friction loss occurs inside of the throat wall. Therefore, it is known that the throat length largely affects the jet pump efficiency. In this study, experimental studies are performed for a typical single nozzle jet pump using water as driving fluid and sand as the induced fluid.

The aim of this study is to investigate the performance of dredging jet pump. The effects of the pump operating conditions and geometries on its performance were investigated. The experimental rig was constructed such a way it can be changing the mixing chamber length and diffuser angles. In this study three different mixing chamber length to mixing chamber diameter ratio of 6.75, 7.25 and 7.86 are studied. And three different diffuser angles of 4º, 5.5º and 7º respectively with one suction nozzle of semi cone angle of 22º. Also one type of quartz sand was used with 0.152 mm mean particle size diameter and with a specific gravity of 2.65.

The effect of mixing chamber length and diffuser angles on the jet pump performance was also tested under different flow rates and motive pressures. Two different distance between the sand surface and suction pipe. Furthermore scouring nozzle system with two different scouring nozzle diameter of 6 mm and 8 mm. In all cases, it was found that the best efficiency for the jet pump is attained with mixing chamber length of 7.25 and diffuser angle of 5.5º, and the best values for these design parameters have been obtained from the experimental work [7].

The aims of this research were (i) to design a central-type jet pump model to remove wheat grains from water channels and (ii) to establish a test-rig for jet pump model performance test. Experiments were performed using wheat grains and water. The experiments deals with the performance and choice of suitable nozzle distance ratio and area ratio (area of motive flow nozzle to area of mixing chamber) for a central-type jet pump model with the following parameter: 7.25 mixing chamber length ratio (length of mixing chamber to mixing chamber diameter), diffuser angle of 5.5º and wheat concentration ratio from 5% to 35%.

The experimental rig was constructed such a way it can be changing the driving nozzle diameter and the distance between the nozzles to throat. In this study three different diameters of driving nozzles, namely (10, 12.7 and 16 mm) have been used with one mixing chamber of 25.4 mm diameter (i.e. three different area ratios of R= 0.155, 0.25 and 0.4). The effect of nozzle to throat spacing to nozzle diameter ratio "X" with values of 1, 1.5 and 2, on the jet pump performance was also tested under different flow rates and motive pressures.

From the experimental work, the beast and suitable nozzle distance ratio and area ratio are obtained. The effect of wheat concentration on jet pump efficiency was also measured. The research proved the ability to use a central type jet pump model successfully for the first time for wheat grains removing from water channels up to 35%. The results allow prediction of how a similar practical unit behaves in order to remove the wheat grains from the bottom of water channels [8].

An extensive program has been made to study the effect of many geometric variables under different operating conditions on the performance of the jet pump at the National Water Research. This paper presents results of Computational Fluid Dynamic (CFD) analysis and experimental investigation of a water jet pump. The effect of driving pressure as well as the nozzle spacing has been investigated experimentally and numerically. Computational fluid dynamics (CFD) modeling studies were undertaken to understand the hydrodynamic characteristics with reference to the jet pump geometry. The CFD model also provides a basis for quantifying the effects of operating conditions on the pump performance. In this paper, the performance measurements are carried out for four driving pressures 1, 1.5,2, and 2.5 bar, also four values of nozzle spacing to throat diameter ratio are used, they are X= 0, 0.5, 0.75 and 1. The results show that the important findings of velocity profile and pressure distributions are presented and discussed. The value of X that gives the maximum efficiency was found to be 0.5. The liquid jet pump is increasingly prone to cavitation as the nozzle to throat spacing is reduced to zero. The CFD's results were found to agree well with actual values obtained from the experimental results [9].

ABSTRACT:

Comparing to pumps with moving parts water-jet pumps have a lower efficiency and surface roughness is an important factor for these types of pumps. The aim of this simulation study is to numerically determine how the scaling-up, downscaling and change in the absolute and relative roughness would impact on the energy efficiency of the pumps, using a commercial computational fluid dynamics (CFD) solver ANSYS FLUENT. In order to select the turbulence model that produces the predictions closest to the actual data from four turbulence models, a preliminary study was conducted on a full-scale jet pump. Using the transition SST model, which gives the best results among all the models, the effects of scale and roughness on the performance of the pumps were investigated in the scale range from 1/4 to 20/1. The optimum efficiencies for different area ratios over a wide range were determined according to the scale and size of roughness. It was seen that the efficiency increases significantly up to a given scale size at a constant absolute roughness, while it is generally independent of the scale size at constant relative roughness. The relative efficiency for the area ratio 5.92 reduces to 60% at the relative roughness value of 0.05. Moreover, CFD appears to be the most appropriate tool for model studies of jet pumps [10].

In this study, the flow pattern and pressure distribution in the pump for the change of position of the drive nozzle's diameter (d/D) and position (l/D) is investigated. Figure1 shows schematic drawings of the central jet pump used in this study. Figure 2 was obtained by using the spark tracing method in the mixing throat when the drive nozzle's position (l/D) is 0.5 and 2.0 at d/D = 0.5, 0.6, 0.7, and the flow rate ratio M = 0.1. The change of velocity distribution in the mixing throat can be seen from this visualization result. When l/D is small, the flow in the circumference part shows the backflow though flow velocity at the throat entrance is constant. And the recalculating region near the wall in the mixing throat is moved to downstream and the flow velocity becomes a uniform flow. Here, the length in which flow in mixing throat reached the uniform flow velocity has been defined as mixing length. Therefore, mixing length Lm/D is about 3.5 for l/D=0.5. Moreover, Lm/D is about 1.5 for l/D=2.0. When l/D increases, it can be confirmed to show the tendency where the mixing length moves to the downstream. Moreover, the position that becomes a uniform flow when d/D increases is found moving to the downstream side [11].

A deep well jet pump combines two principles of pumping; that of the centrifugal pump and that of the jet pump. The performance of the jet pump has an impact on the deep well jet pump directly, while previous studies on jet pumps have focused on the structure parameters, which ignored the effect of structural forms such as installation direction and the structural forms of the inlet. In this paper, three turbulence models were used to calculate a 3D single-phase flow field in the jet pump and the results were compared with the experimental data to validate the simulation. Numerical simulations in different gravity fields were carried out to seek the differences of the performance between the horizontal installation and the vertical installation of the jet pump. The optimum throat pipe length formulas were deduced from analysis of the simulation results. Three kinds of structural forms for suction inlet were compared by numerical simulation. The results showed that the efficiency of the vertical inlet was the highest, and some numerical results regarding flow fields and velocity distribution were shown and discussed [12].

Jet pump is a type of mechanical device where the extra energy is provide by jet in mixing chamber. This jet is the fluid again circulate from diffuser exit to mixing chamber for better performance. This is also known as motive fluid. So the effects of change in geometrical parameter (Diffuser angle) on its performance were investigated. The set of experiment were carried out to study the effect of diffuser angle on the performance of jet pump. The performance of the jet pump is described by three sets of curves, Discharge vs. Head, Input power vs. Head, and Efficiency vs. Head. Changing the diffuser angle will affect jet pump behavior. Venturi diffuser angle was found to be an important geometrical parameter to characterize the maximum suction lift of the jet pump [13].

The experiment was about to study of water jet pumps with different angle of mixing nozzle. Most experimental studies on water jet pumps mainly carried out to assess the maximum efficiency. But maximum efficiency occurs when the suction lift is relatively small for a given head loss through the pump, which implies, when the suction flow rate is maximum. However, suction lift is inversely proportional to flow rate. But in the field of application there are many cases (such as drainage, dredging, well-pumping and other systems) where suction lift is more important factor than any other for water jet pumps, which gives importance to the assessment of depending factor of suction lift of water jet pumps. Three different jet pumps of one nominal diameter each of three different angle of mixing nozzle were made to carry out this experiment. The results revealed that the angle of mixing nozzle was an important parameter to characterize the suction lift of the jet pumps or not, but nominal diameter had a negligible play role [14].

The effect of operational and geometrical parameters on the jet pump efficiency were determined experimentally and numerically. Numerical investigation was held firstly to determine the effect of diffuser angle, mixing chamber length, pump area ratio and driving nozzle position on the efficiency of jet pump. Commercial computational fluid dynamics (CFD) solver ANSYS FLUENT R 15.0 using SST-turbulence model was used. The numerical results showed that jet pump efficiency increases with decreasing both of diffuser angles and mixing chamber length up to a certain value and then pump efficiency decreases. Also, jet pump efficiency increases with increasing pump area ratio up to a certain value and then pump efficiency decreases. It was found that maximum numerical efficiency is 37.8 % for pump area ratio of 0.271. In addition, the numerical results showed that the optimum relative length of mixing chamber is 5.48 and the optimum value for diffuser angle at which the efficiency is a maximum value is 5º. Experimental tests were conducted to obtain the effects of various operational and geometrical parameters on the performance of the jet pumps. A test rig was constructed using the optimum design from the numerical results. The CFD's results were found to agree well with actual values obtained from the experimental results [15].

Chapter III
Theoretical Analysis

3.1 Equations

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

$$Pb - Pw = \rho A\, g\left((Zw - Zb) + \frac{Vt^2 - Vb^2}{2g} + kt * \frac{Vt^2}{2g}\right) \qquad (3.2)$$

From A to w for liquid entering from nozzle

$$\frac{Pb}{\rho lg} + Za + \frac{Va^2}{2g} = \frac{Pw}{\rho lg} + Zw + \frac{Vs^2}{2g} + losses \qquad (3.3)$$

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

$$m.t = m.a + m.t \qquad (3.5)$$

$$\rho T\, Avz = \delta a * Aa * Vt + \rho L * Al * Vs \qquad (3.6)$$

momentum analysis of flow system

$$\sum f = \frac{d(Mv)cv}{dt} + \sum_{out} \beta m\, v - \sum_{in} \beta m\, v \qquad (3.7)$$

M=0

For no enter of forces

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

$$Pa = f$$

- W to z

$$\frac{Pw}{\rho g} + Zw + \frac{Vw\hat{}2}{2g} = \frac{pz}{\rho g} + Zz + \frac{Vz\hat{}2}{2g} + Km * \frac{Vz^2}{2g} \qquad (3.8)$$

$$Pw - Pz = \rho g(Zw - Zz) - Km\frac{Vz^2}{2g} * \rho g = \frac{\Sigma F}{A} \qquad (3.9)$$

For steady flow

$$\sum f = \sum_{out} M.v - \sum_{in} M.\ v \qquad (3.10)$$

$$= (M.a + M.l)VZ - M.a * Vt - M.l * Vs \qquad (3.11)$$

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

=

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

$$Pw - Pz =- \rho g(Zw - Zz) + Km * \frac{Vz^2}{2g} * \rho g + \left(\frac{M.a + M.p}{A}\right)VZ \qquad (3.13)$$

$$\frac{-M.a}{A}Vt - \frac{M.l}{A}Vs \qquad (3.14)$$

Z to C

$$\frac{Pz}{\rho g} + Zz + \frac{Vz^2}{2g} = \frac{Pc}{\rho g} + Zc + \frac{Vc^2}{2g} + Kd * \frac{Vz^2}{2g} \qquad (3.15)$$

$$Pz - Pc = \rho g(Zc - Zz) + \rho g\frac{(Vc^2 - Vz^2)}{2g} + Kd\frac{Vz^2}{2g} * \rho g \qquad (3.16)$$

B to c

$$Pb - Pc = (Pb - Pw) + (Pw - Pz) + (Pz - Pc) \qquad (3.17)$$

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

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

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

Total energy at B

$$Eb = \frac{Pb}{\rho g} + Zb + \frac{Vb^2}{2g} \qquad (3.20)$$

Total energy at C

$$Ec = \frac{pc}{\rho g} + Zc + \frac{Vc^2}{2g} \qquad (3.21)$$

B to c

$$Eb - Ec = \frac{Pb - Pc}{\rho g} + (Zb - Zc) + \frac{Vb^2 - Vc^2}{2g} \qquad (3.22)$$

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

$$Eb - Ec = \frac{m.a + M.l}{A\rho g} - \frac{M.a}{A\rho g}Vt - \frac{M.l}{A\rho g}Vs + (Kt + 1)\frac{Vt^2}{2g} + (Km + Kd - 1)\frac{Vz^2}{2g} \qquad (3.24)$$

$$M.a = \rho a(A - Anozzle)Vt \qquad (3.25)$$

$$M.l = \rho l(Anozzle)Vs \qquad (3.26)$$

$$M.a + M.l = \rho AVz \qquad (3.27)$$

Diameter Ratio

$$\in = \frac{dnozzle}{dz} \qquad (3.28)$$

Mass flow ratio

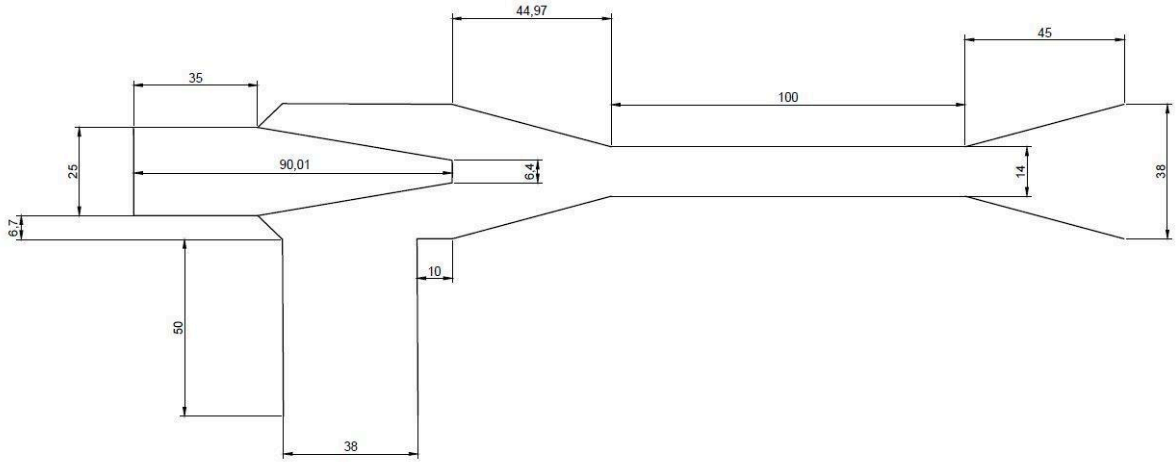
$$\mu = \frac{M.a}{M.l} \qquad (3.29)$$

Total energy ratio

$$\pi = \frac{Ea - Eb}{Ec - Eb} \qquad (3.30)$$

3.2 Schematic diagram

3.2.1Jet pump dimensions



3.3 Components

3.3.1 Stand table

In the beginning, the main component of the project is defined, which is a 1.5 millimeter-thick iron table made of a surface of 100 cm in length, 70 width and 80 height of the table, and it is designed to put two tanks and a jet pump, and part of the model is designed, which is 80 cm above its surface, which is its position The smaller tank was installed on it to measure different pressures, so the tire had a height of 175 cm, in addition to the traction wheel

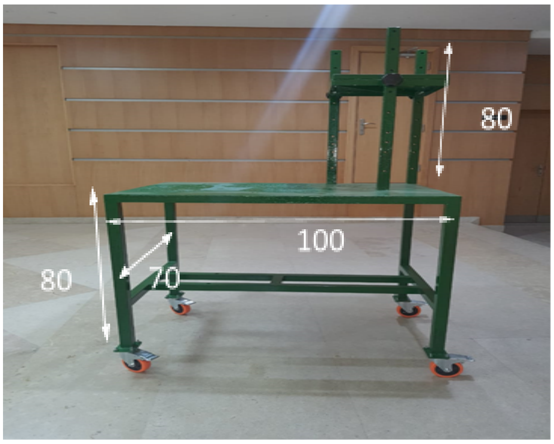


Figure 3.3.1 stand table

3.3.2 Motor stand

This part of the table is designed at a height of 30 cm from the surface of the floors and a length of 100 cm in the length of the table to place the meter on it in the middle of the table to reduce the vibrations caused by the motor and distribute it to all parts of the table so as not to affect a specific place

Figure 3.3.2 motor stand

3.3.3 Wheels

A wheel was used for traction from cast Artilon, and this type was chosen because it can bear a weight of more than 300 kilograms, as the total weight of the object is 260 kilograms, and this type of wheel was chosen to take into account the safety factor With a wheel mount to prevent slipping

Figure 3.3.3 wheels

3.3.4 Tubes

The total number of hoses was calculated and became 5 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 3.3.4 tubes

3.3.5 Motor tube

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 3.3.5 motor tube

3.3.6 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 length of the jet pump is 30 cm

Figure 3.3.6 jet pump

3.3.7 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

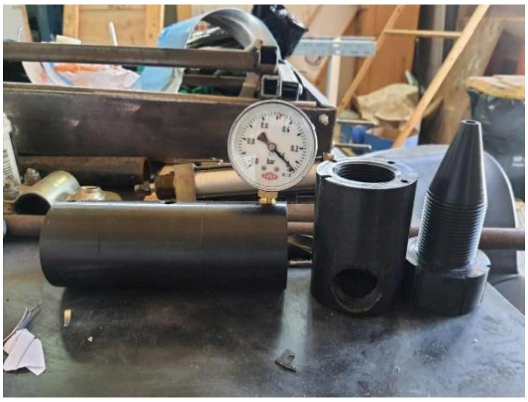


Figure 3.3.7 jet pump components

3.3.8 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 3.3.8 negative pressure gauge

3.3.9 Postive 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

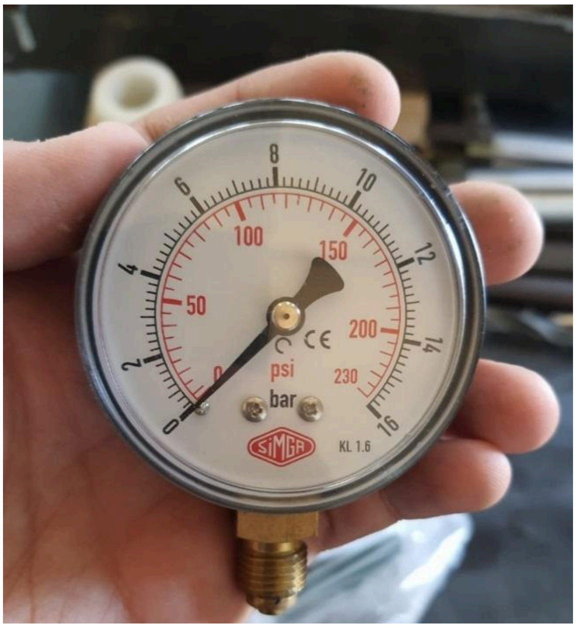


Figure 3.3.9 postive pressure gauge

3.3.10 Motor

The motor used has a power of 2 horsepower and a flow rate of 85 liters per minute .

Figure 3.3.10 Motor

3.3.11 final model

Figure 3.2.11 final model

3.4 Results

Pm : pressure inlet to jet pump

Pd: pressure outlet from jet pump

Ps : pressure of suction tube

Pr : pressure ratio

Level in (cm)	Pm	Pd	Ps	Pr=(pd-ps)/(pm-pd)
level1=25	3	1.01325	-0.0875	0.554046
level2=40	3	1.01325	-0.095	0.557821
level3=55	3	1.01325	-0.105	0.562854
level4=70	3	1.01325	-0.1375	0.579212
level5=85	3	1.01325	-0.15	0.585504

Vm : volume consumed from large tank

Ve : volume of water suction

Vt : total volume of water consumed

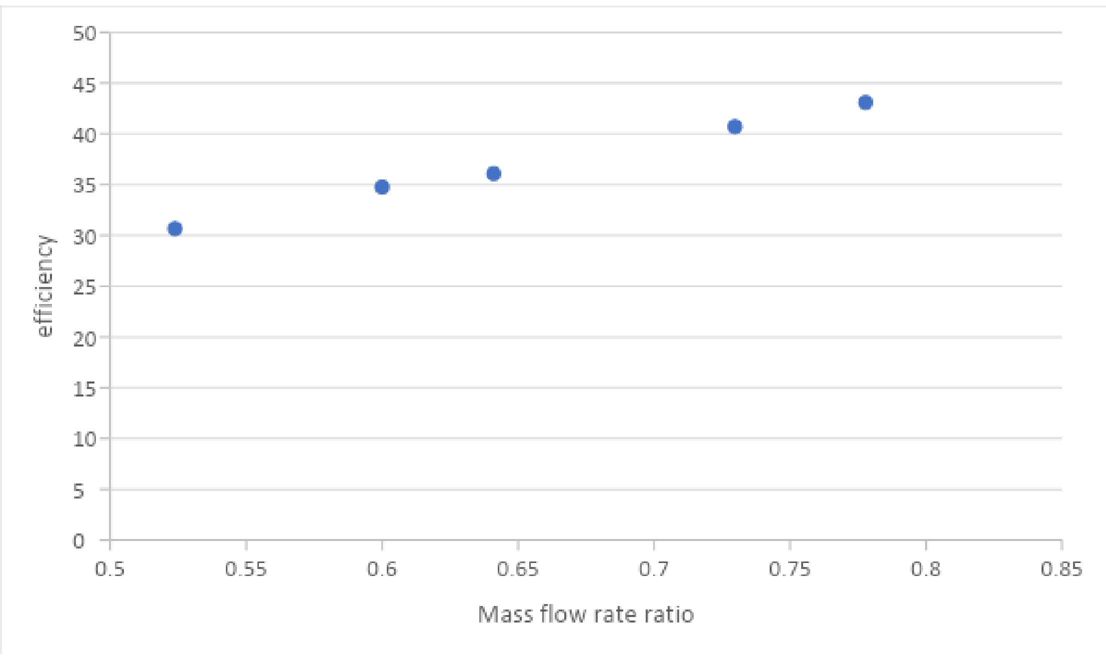
Me: mass flow rate of suction tank

Mm : mass flow rate of large tank

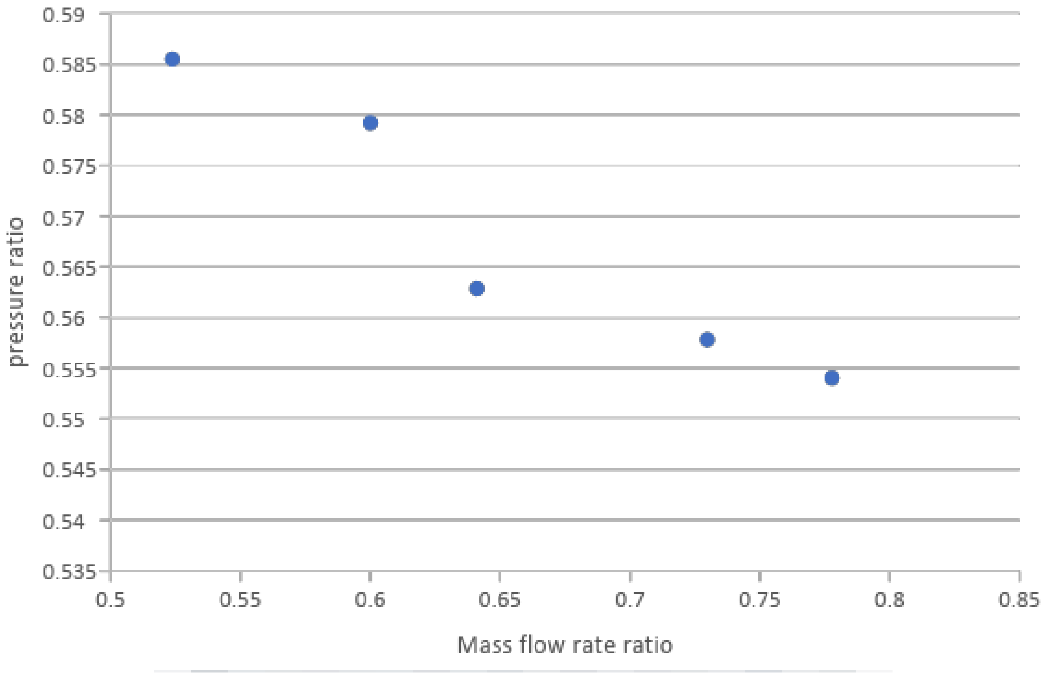
Mr : mass flow rate ratio

	Vm	Ve	Vt	time	ρ	Mm	me	Mr=me/mm	efficiency
level1=25	18	14	32	24.6	1000	731.7073	569.1057	0.777778	43.09243
level2=40	18.5	13.5	32	25.85	1000	715.6673	522.2437	0.72973	40.70582
level3=55	19.5	12.5	32	26.2	1000	744.2748	477.0992	0.641026	36.08038
level4=70	20	12	32	27.18	1000	735.8352	441.5011	0.6	34.75274
level5=85	21	11	32	27.48	1000	764.1921	400.2911	0.52381	30.66926

3.4.1 Efficiency Curve



3.4.2 Pressure ratio curve



Chapter IV
Conclusion

Conclusion

The motor draws water from the large tank and directs it to the jet pump. The jet pump draws petroleum materials or ground water through the suction section through the vacuum, and this happens through the exit of the motive fluid from the nozzle. And 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 the time with stop watch until the tank full over then calculate the mass flow rate M = density of water * Q . we have 3 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 , we 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 .

References

1--A.H. HAMMOUD, “Effect of design and operational parameters on jet pump performance”, Proceedings of the 4th WSEAS International Conference on Fluid Mechanics and Aerodynamics, Elounda, Greece, January 2006

2--Alaa El-Shaikh , Imam El-Sawaf , Nabiel El-Menshawy and Nageh Gad El-hak, “DREDGING WATERWAY CHANNELS BY MOVABLE/ STATIONARY JET PUMP” ,Tenth International Water Technology Conference, 2006

3--Yukitaka yamazaki, Tomonori nakayama, Tadashi narabayashi, Hidetoshi kobayashi and Toshihiko shakouchi , “Effect of Surface Roughness on Jet Pump Performance”, JSME International Journal Series B ,Nov.4 2006

4--Yamazaki Y, Yamazaki A, Narabayashi T,Suzuki J and Shakouchi, "Studies on mixing process and performance improvement of jet pumps (Effect of nozzle and throat shapes)", Journal of Fluid Science and Technology, T (2007).

5-El-Sawaf, I. A., M. A. Halawa, M. A. Younes, and I. R. Teaima, "Study of the Different Parameters That Influence on the Performance of Water Jet Pump", Fifteenth International Water Technology Conference, Alexandria, Egypt, (2011).

6--Tarek Meakhail and Ibrahim Teaima, "Experimental and numerical studies of the effect of area ratio and driving pressure on the performance of water and slurry jet pumps", J Mechanical Engineering Science, November 29, 2011

7--El-Sawaf, I. A., M. A. Halawa, M. A. Younes, and I. R. Teaima, "EXPERIMENTAL STUDY OF THE EFFECT OF MIXING CHAMBER LENGTH AND DIFFUSER ANGLE ON THE PERFORMANCE OF DREDGING JET PUMP", Sixteenth International Water Technology Conference, (2012).

8--Ibrahim R. Teaima, "A CENTRAL-TYPE JET PUMP MODEL FOR WHEAT GRAINS REMOVING FROM WATER CHANNELS", Sixteenth International Water Technology Conference, IWTC 16 2012

9--Tarek A. Meakhail, Ibrahim R. Teaima, "A Study of the Effect of Nozzle Spacing and Driving Pressure on the Water Jet Pump Performance" , International Journal of Engineering Science and Innovative Technology (IJESIT), September 2013

10--Kemal Aldas, & Yapıcı, R, "Investigation of Effects of Scale and Surface Roughness on Efficiency of Water Jet Pumps Using CFD", Engineering Applications of Computational Fluid Mechanics, March 2014

11--C. PRABKEAW, K. OGOSE and K. AOKI, "STUDY ON THE OPTIMUM MIXING THROAT LENGTH OF THE CENTRAL JET PUMP", JRAME, (2015)

12--C. H. Zou, H. Li, P. Tang & D. H. Xu, "Effect of structural forms on the performance of a jet pump for a deep well jet pump", WIT Press, 2015

13--Mr. Brijesh R. Naik, Mr. Sagar M. Patel, "The Effect of Venturi Design on Jet Pump Performance", Journal for Research, June 2016

14--S. R. Pandhare, A. K. Pitale, "Study the Performance of Water Jet Pump by Changing the Angle of Mixing Nozzle", IJSRST,27 April 2017.

15--A. A. A. Sheha, M. Nasr , M. A. Hosien and E. M. Wahba, “Computational and Experimental Study on the Water-Jet Pump Performance, Journal of Applied Fluid Mechanics”, January 13 2018