DESIGN, FABRICATION AND PERFORMANCE ANALYSIS OF ENERGY EFFICIENT PUMPING SYSTEM

A Project Report

Submitted by

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In partial fulfillment of the requirement in the subject of
(ME1357) Design and Fabrication Project

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BONAFIDE CERTIFICATE

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The Report of the project work submitted by the above students in partial fulfillment of the award of Bachelor of Engineering degree in Mechanical Engineering of Anna University were evaluated and confirmed to be report of the work done by them

(INTERNAL EXAMINER) (EXTERNAL EXAMINER)

ABSTRACT

Pumps are hydraulic machines which converts mechanical energy into hydraulic energy. Pump is a wonderful mechanical device which now a days occupies almost every house and commercial building in this world. It has almost become a mandatory device.

Water pumps are used regularly every where. pumps have more running and maintenance cost than the initial investment. In most of the cases pumps are not appropriately selected and the pumping system is not properly installed. The materials used for installation is not properly selected. This results in increased strain on the pump which affects the efficiency of the pump. Further it increases the maintenance cost.

Now days the unit power consumption is very important. Due to increasing demand in power, it has to be used in efficient way. Improper usage of pumping system increases the running cost i.e.; the electricity bill to a drastic extent. Also the discharge and pump rating can be decided based on requirement.

By optimizing all the above mentioned the maintenance and running cost could be brought down.

In this pumping system, the pump is selected appropriately for required head and discharge. The piping lines are installed with material of lower co-efficient of friction. The suction and discharge lines are designed such that there is minimum number of bends and joints.

The diameters of the pipes used also have great effect on the performance of the pump. The effect of under sizing and over sizing of piping are studied to optimize them. The discharge in places where constant discharge required is reduced by using a throttling device. But this reduces the head level, so instead the diameter of the impeller is reduced here. To reduce the discharge.

For increasing the efficiency of pump to great level, the surface finish of impeller, inlet, outlet and water flow paths are increased. so this reduces the resistance in flow.

By optimizing the above concepts, an energy efficient pumping system can be designed and fabricated.

ACKNOWLEDGEMENT

We thank the almighty for giving us the strength and good health from which we were able to complete the project successfully.

We are blessed to have our supervisor and mentor Mr.K.G.Maheswaran, Lecturer, Department of Mechanical Engineering, KCT, without whose guidance and help we would have not been able to complete the project successfully with such purpose.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

PUMPS:

A pump is a device used to move gases, liquids or slurries. A pump moves liquids or gases from lower pressure to higher pressure, and overcomes this difference in pressure by adding energy to the system (such as a water system). A gas pump is generally called a compressor, except in very low pressure-rise applications, such as in heating, ventilating, and air-conditioning, where the operative equipment consists of fans or blowers.

Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression.

HISTORY:

The earliest type of pump was the Archimedes screw, first used by Sennacherib, King of Assyria, for the water systems at the Hanging Gardens of Babylon and Nineveh in the 7th century BC, and later described in more detail by Archimedes in the 3rd century BC. In the 13th century AD, Al-Jazari described and illustrated different types of pumps, including a reciprocating pump, double-action pump with suction pipes, water pump, and piston pump.

CHAPTER 2 TYPES OF PUMPS

TYPES OF PUMPS:

Pumps are classified as

- Rotodynamic pumps
    1. Centrifugal pumps.
    2. Mixed flow pumps.
    3. Axial flow pumps.
- Positive displacement pumps
    1. Reciprocating pumps.
    2. Rotary pumps.

Rotodynamic pumps:

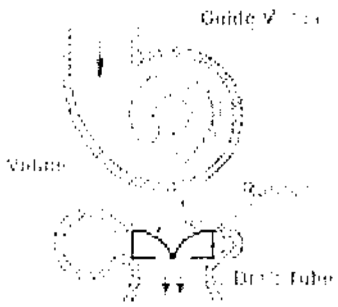
Rotodynamic pumps are based on bladed impellers which rotate within the fluid to impart a tangential acceleration to the fluid and a consequent increase in the energy of the fluid. The purpose of the pump is to convert this energy into pressure energy of the fluid to be used in the associated piping system.

Centrifugal Pumps:

Centrifugal Pumps are rotodynamic pumps which convert mechanical energy into hydraulic energy by centripetal force on the liquid. Typically, a rotating impeller increases the velocity of the fluid. The casing, or volute, of the pump then acts to convert this increased velocity into an increase in pressure. So the mechanical energy is converted into a pressure head by centripetal force, the pump is classified as centrifugal pump. Such pumps are found in virtually every industry, and in domestic service in developed countries for washing machines, dishwashers, swimming pools, and water supply.

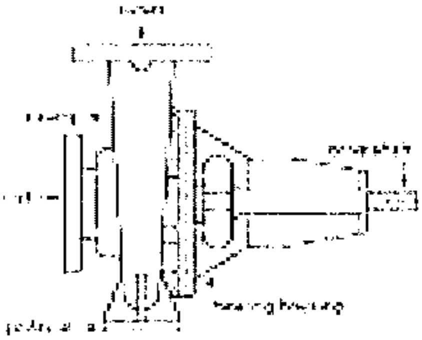
A wide range of designs are available, with constant and variable speed drives. Horizontal shafts are the most common. Single-stage pumps are usual in the smaller ratings. Pumps with up to 11 stages are in service. A demanding duty is boiler feed, and today's designs are typically 3 - 4 stage, with speeds of up to 6000 revolutions per minute.

Mixed Flow Pump:



In mixed flow pump the fluid enters the pump both in axial and radial direction to the pump impeller.

Radial Flow Pump:

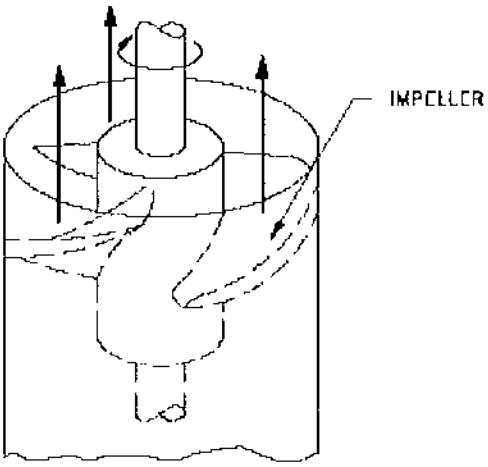


In radial flow type pump the fluid enters radially to the impeller.

Axial Flow Pump:

An axial flow pump is a common type of water pump that essentially consists of a propeller in a tube. The propeller can be driven directly by a sealed motor in the tube or by a right-angle drive shaft that pierces the tube.

The main advantage of an AFP is that it can easily be adjusted to run at peak efficiency at low-flow/high-pressure and high-flow/low-pressure by changing the pitch on the propeller.



These pumps have the smallest of the dimensions among any of the conventional pumps and are more suited for low heads and higher discharges.

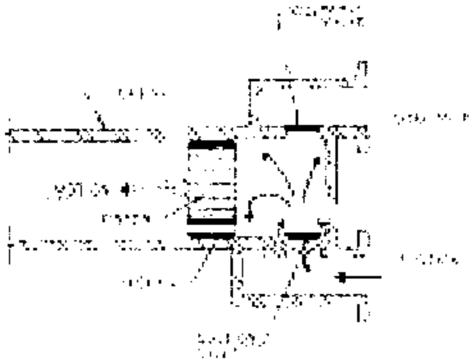
An application example of an AFP would be transfer pumps used for sailing ballast.

Positive Displacement Pumps:

A positive displacement pump causes a liquid or gas to move by trapping a fixed amount of fluid and then forcing (displacing) that trapped volume into the discharge pipe. The periodic fluid displacement results in a direct increase in pressure.

Reciprocating Pump:

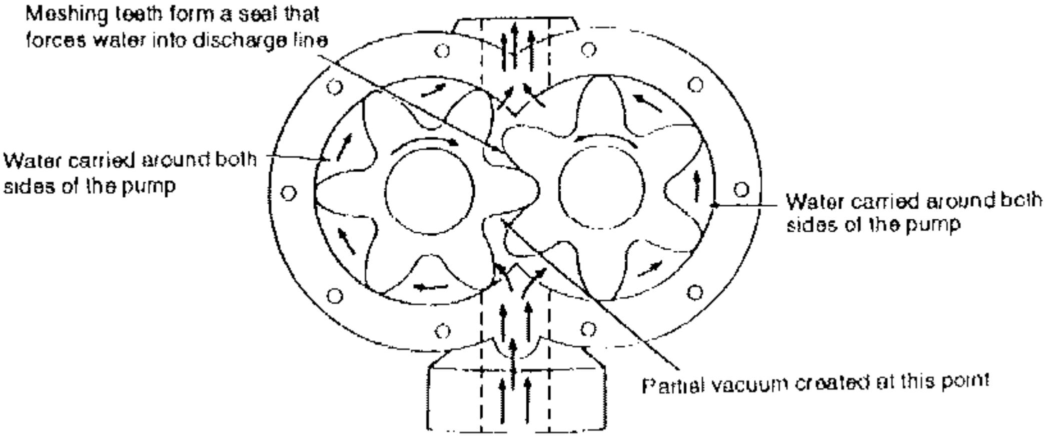
Reciprocating-type pumps use a piston and cylinder arrangement with suction and discharge valves integrated into the pump. Pumps in this category range from having "simplex" one cylinder, to in some cases "quad" four cylinders or more. Most reciprocating-type pumps are "duplex" (two) or "triplex" (three) cylinder. Furthermore, they are either "single acting" independent suction and discharge strokes or "double acting" suction and discharge in both directions. The pumps can be powered by air, steam or through a belt drive from an engine or motor. This type of pump was used extensively in the early days of steam propulsion (19th century) as boiler feed water pumps. Though still used today, reciprocating pumps are typically used for pumping highly viscous fluids including concrete and heavy oils.



Rotating Pump:

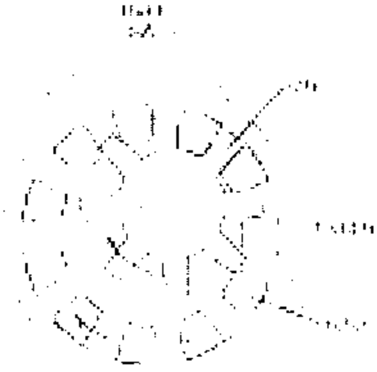
Gear Pump:

A Gear pump uses the meshing of gears to pump fluid by displacement. They are one of the most common types of pumps for hydraulic fluid power applications. Gear pumps however are also widely used in chemical installations to pump fluid with a certain viscosity. There are two main variations; external gear pumps which use two external spur gears, and internal gear pumps which use an external and an internal spur gear. Gear pumps are fixed displacement, meaning they pump a constant amount of fluid for each revolution. Some gear pumps are designed to function as either a motor or pump.



Gerotor Pump:

A gerotor is a positive displacement pumping unit. The name gerotor is derived from "Generated Rotor". A gerotor unit consists of an inner and outer rotor. The inner rotor has N teeth, and the outer rotor has N+1 teeth. One rotor is located off-center and both rotors rotate. During part of the assembly's rotation cycle, the area between the inner and outer rotor increases, creating a vacuum. This vacuum creates suction, and hence, this part of the cycle is where the intake is located. Then, the area between the rotors decreases, causing compression. During this compression period, fluids can be pumped, or compressed (if they are gaseous fluids).



Gerotor pumps are generally designed using a trochoidal inner rotor and an outer rotor formed by a circle with intersecting circular arcs. Although this design works well and is simple to define it does create gaps between the inner and outer rotor when the tooth of the inner rotor rotates into the pocket of the outer rotor. This gap seals during rotation causing inefficiency, noise and wear due to the pump attempting to compress the trapped and incompressible fluid in the gap.

Peristaltic Pump

A peristaltic pump is a type of positive displacement pump used for pumping a variety of fluids. The fluid is contained within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A rotor with a number of 'rollers', 'shoes' or 'wipers' attached to the external circumference compresses the flexible tube. As the rotor turns, the part of tube under compression closes (or 'occludes') thus forcing the fluid to be pumped to move through the tube. Additionally, as the tube opens to its natural state after the passing of the cam ('restitution') fluid flow is induced to the pump. This process is called peristalsis and used in many biological systems such as the gastrointestinal tract.

Progressive Cavity Pump:

A progressive cavity pump is also known as a progressing cavity pump, eccentric screw pump or even just cavity pump and, as is common in engineering generally, these pumps can often be referred to by using a manufacturers name, so names can vary from industry to industry and even regionally, examples; Mono pump, Moyno pump and Nemo pump.

This type pump transfers fluid by means of the progress, through the pump, of a sequence of small, fixed shape, discrete cavities, as its rotor is turned. This leads to the volumetric flow rate being proportional to the rotation rate (bidirectionally) and to low levels of shearing being applied to the pumped fluid. Hence these pumps have application in fluid metering and pumping of viscous or shear sensitive materials. It should be noted that the cavities taper down toward their ends and overlap with their neighbors, so that, in general, no flow pulsing is caused by the arrival of cavities at the

CHAPTER 3 WORKING OF CENTRIFUGAL PUMPS

outlet, other than that caused by compression of the fluid or pump components.

Working Mechanism of a Centrifugal Pump:

A centrifugal pump is one of the simplest pieces of equipment in any process plant. Its purpose is to convert energy of a prime mover (a electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being Pumped. The energy changes occur by virtue of two main parts of the pump, the impeller and the volute or diffuser. The impeller is the rotating part that converts driver energy into the kinetic energy. The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy.

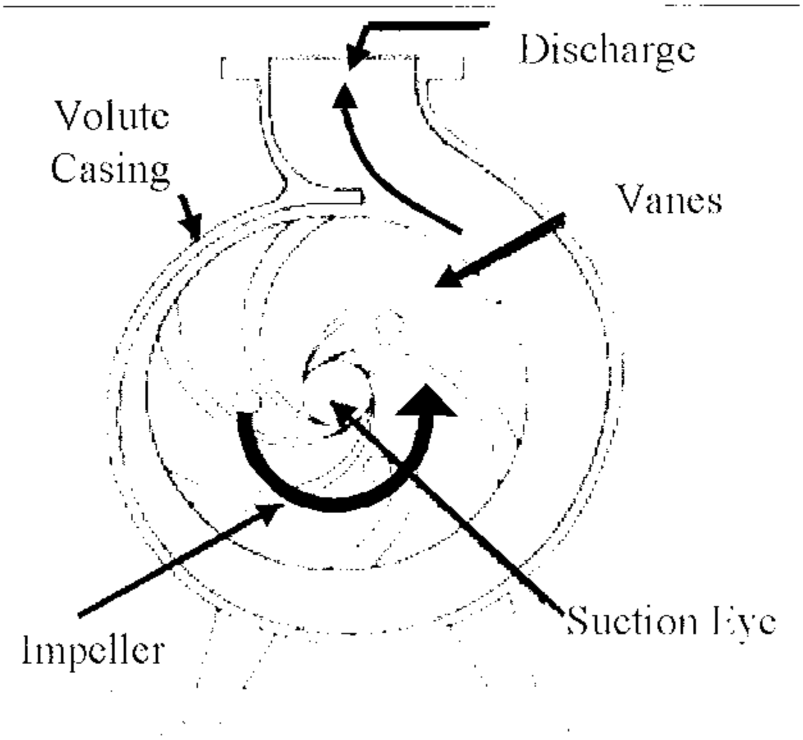
Note: All of the forms of energy involved in a liquid flow system are expressed in terms of feet of liquid i.e. head.

Generation of Centrifugal Force

The process liquid enters the suction nozzle and then into eye (center) of a revolving device known as an impeller. When the impeller rotates, it spins the liquid sitting in the cavities between the vanes outward and provides centrifugal acceleration.

As liquid leaves the eye of the impeller a low-pressure area is created causing more liquid to flow toward the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by the centrifugal force. This force acting inside the pump is the same one that keeps water inside a bucket that is rotating at the end of a string.

Figure below depicts a side cross-section of a centrifugal pump indicating the movement of the liquid.



Conversion of Kinetic Energy to Pressure Energy

The key idea is that the energy created by the centrifugal force is kinetic energy. The amount of energy given to the liquid is proportional to the velocity at the edge or vane tip of the impeller. The faster the impeller revolves or the bigger the impeller is, then the higher will be the velocity of the liquid at the vane tip and the greater the energy imparted to the liquid.

This kinetic energy of a liquid coming out of an impeller is harnessed by creating a resistance to the flow. The first resistance is created by the pump volute (casing) that catches the liquid and slows it down. In the discharge nozzle, the liquid further decelerates and its velocity is converted to pressure according to Bernoulli's principle.

Therefore, the head (pressure in terms of height of liquid) developed is approximately equal to the velocity energy at the periphery of the impeller expressed by the following well-known formula:

$H= v^2/2g$.

H= total head.

V= velocity at periphery of impeller.

g= acceleration due to gravity.

Where,

$V= (N*D)/229$

N= impeller rpm.

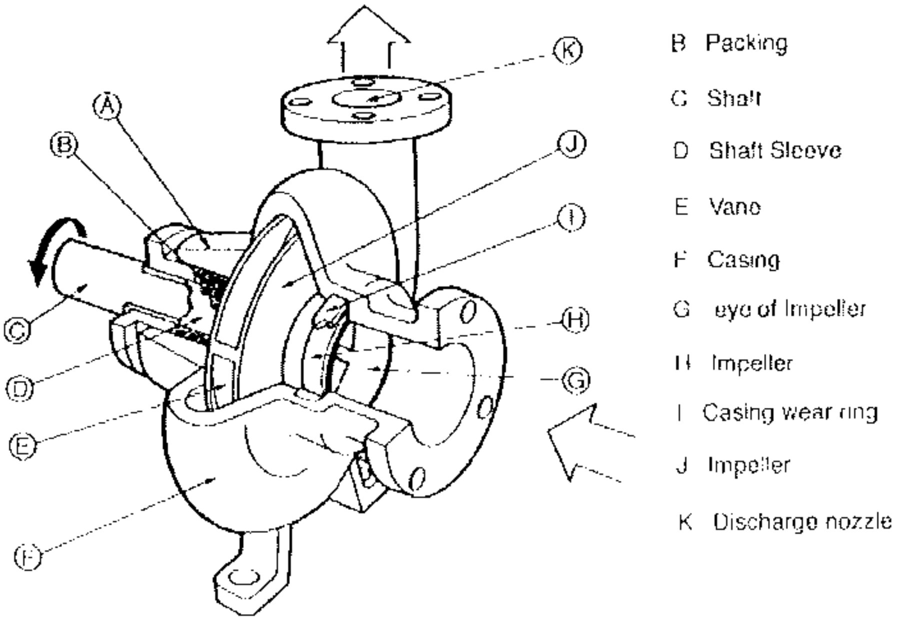
D = diameter of impeller in inches.

CHAPTER 4 COMPONENTS OF CENTRIFUGAL PUMP

General Components of Centrifugal Pumps

A centrifugal pump has two main components:

1. A rotating component comprised of an impeller and a shaft
2. A stationary component comprised of a casing, casing cover, and bearings.



Stationary Components:

Casing:

Casings are generally of two types: volute and circular. The impellers are fitted inside the casings.

1. Volute casings build a higher head; circular casings are used for low head and high capacity. A volute is a curved funnel increasing in area to the discharge port. As the area of the cross-section increases, the volute reduces the speed of the liquid and increases the pressure of the liquid.

One of the main purposes of a volute casing is to help balance the hydraulic pressure on the shaft of the pump.

2. Circular casing have stationary diffusion vanes surrounding the impeller periphery that convert velocity energy to pressure energy. Conventionally, the diffusers are applied to multi-stage pumps.

The casings can be designed either as solid casings or split casings. Solid casing implies a design in which the entire casing including the discharge nozzle is all contained in one casting or fabricated piece. A split casing implies two or more parts are fastened together. When the casing parts are divided by horizontal plane, the casing is described as horizontally split or axially split casing. When the split is in a vertical plane perpendicular to the rotation axis, the casing is described as vertically split or radially split casing. Casing Wear rings act as the seal between the casing and the impeller.

Suction and Discharge Nozzle

The suction and discharge nozzles are part of the casings itself. They commonly have the following configurations.

1. End suction/Top discharge - The suction nozzle is located at the end of and concentric to, the shaft while the discharge nozzle is located at the top of the case perpendicular to the shaft. This pump is always of an overhung type and typically has lower NPSHr because the liquid feeds directly into the impeller eye.

2. Top suction Top discharge nozzle -The suction and discharge nozzles are located at the top of the case perpendicular to the shaft. This pump can either be an overhung type or between-bearing type but is always a radially split case pump.

3. Side suction / Side discharge nozzles - The suction and discharge nozzles are located at the sides of the case perpendicular to the shaft. This pump can have either an axially or radially split case type.

Seal Chamber and Stuffing Box

Seal chamber and Stuffing box both refer to a chamber, either integral with or separate from the pump case housing that forms the region between the shaft and casing where sealing media are installed. When the sealing is achieved by means of a mechanical seal, the chamber is commonly referred to as a Seal Chamber.

When the sealing is achieved by means of packing, the chamber is referred to as a Stuffing Box. Both the seal chamber and the stuffing box have the primary function of protecting the pump against leakage at the point where the shaft passes out through the pump pressure casing. When the pressure at the bottom of

the chamber is below atmospheric, it prevents air leakage into the pump. When the pressure is above atmospheric, the chambers prevent liquid leakage out of the pump. The seal chambers and stuffing boxes are also provided with cooling or heating arrangement for proper temperature control. Figure B.06 below depicts an externally mounted seal chamber and its parts.

Gland:

The gland is a very important part of the seal chamber or the stuffing box. It gives the packings or the mechanical seal the desired fit on the shaft sleeve. It can be easily adjusted in axial direction. The gland comprises of the seal flush, quench, cooling, drain, and vent connection ports as per the standard codes like API 682.

Throat Bushing:

The bottom or inside end of the chamber is provided with a stationary device called throat bushing that forms a restrictive close clearance around the sleeve (or shaft) between the seal and the impeller.

Mechanical Seal:

Bearing housing

The bearing housing encloses the bearings mounted on the shaft. The bearings keep the shaft or rotor in correct alignment with the stationary parts under the action of radial and transverse loads. The bearing house also includes an oil reservoir for lubrication, constant level oiler, jacket for cooling by circulating cooling water.

Rotating Components

Impeller

The impeller is the main rotating part that provides the centrifugal acceleration to the fluid. They are often classified in many ways.

Based on major direction of flow in reference to the axis of rotation

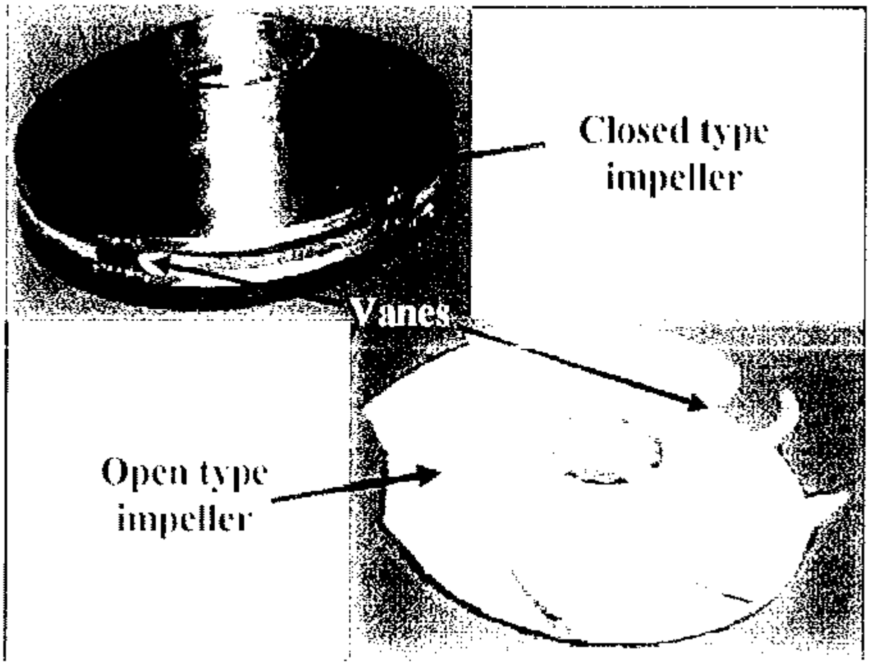
1. Radial flow Axial flow
2. Mixed flow

Based on suction type

1. Single-suction: Liquid inlet on one side.
2. Double-suction: Liquid inlet to the impeller symmetrically from both sides.

Based on mechanical construction.

1. Closed: Shrouds or sidewall enclosing the vanes.
2. Open: No shrouds or wall to enclose the vanes.
3. Semi-open or vortex type.



Closed impellers require wear rings and these wear rings present another maintenance problem. Open and semi-open impellers are less likely to clog, but need manual adjustment to the volute or back-plate to get the proper impeller setting and prevent internal re-circulation. Vortex pump impellers are great for solids and "stringy" materials but they are up to 50% less efficient than conventional designs.

The number of impellers determines the number of stages of the pump. A single stage pump has one impeller only and is best for low head service. A two-stage pump has two impellers in series for medium head service A multi-stage pump has three or more impellers in series for high head service.

Wear rings:

Wear ring provides an easily and economically renewable leakage joint between the impeller and the casing. clearance becomes too large the pump efficiency will be lowered causing heat and vibration problems. Most manufacturers require that you disassemble the pump to check the wear ring clearance and replace the rings when this clearance doubles.

Shaft:

The basic purpose of a centrifugal pump shaft is to transmit the torques encountered when starting and during operation while supporting the impeller and other rotating parts. It must do this job with a deflection less than the minimum clearance between the rotating and stationary parts.

Shaft Sleeve :

Pump shafts are usually protected from erosion, corrosion, and wear at the seal chambers, leakage joints, internal bearings, and in the waterways by renewable sleeves. Unless otherwise specified, a shaft sleeve of wear, corrosion, and erosion resistant material shall be provided to protect the shaft. The sleeve shall be sealed at one end. The shaft sleeve assembly shall extend beyond the outer face of the seal gland plate

Coupling:

Couplings can compensate for axial growth of the shaft and transmit torque to the impeller. Shaft couplings can be broadly classified into two groups: rigid and flexible. Rigid couplings are used in applications where there is absolutely no possibility or room for any misalignment. Flexible shaft couplings are more prone to selection. installation and maintenance errors. Flexible shaft couplings can be divided into two basic groups: elastomeric and non-elastomeric

Auxiliary Components

Auxiliary components generally include the following piping systems for the following services:

1. Seal flushing , cooling , quenching systems
2. Seal drains and vents
3. Bearing lubrication , cooling systems
4. Seal chamber or stuffing box cooling, heating systems
5. Pump pedestal cooling systems

Auxiliary piping systems include tubing, piping, isolating valves, control valves, relief valves, temperature gauges and thermocouples, pressure gauges, sight flow indicators, orifices, seal flush coolers, dual seal barrier/buffer fluid reservoirs, and all related vents and drains. All auxiliary components shall comply with the requirements as per standard codes like API 610 (refinery services), API 682 (shaft sealing systems) etc.

CHAPTER 5 FACTORS AFFECTING PUMP PERFORMANCE

PARAMETERS INFLUENCING PUMP PERFORMANCE

Cavitation:

The term ‘cavitation’ comes from the Latin word cavus, which means a hollow space
or a cavity. Webster’s Dictionary defines the word ‘cavitation’ as the rapid formation
and collapse of cavities in a flowing liquid in regions of very low pressure.

Specific speed:

It is defined as speed of rotation of a geometrically similar pump of such a size that it ensures a delivery of 75 litres per sec.

Net positive suction head:

This is a function of pump design.

This is the total positive head in meters absolute required at the pump suction to over come pump internal losses like, turbulence.

Type of pump selected:

The performance depends on the type of pump selected. Proper pump should be selected based on the application.

Surface roughness:

The surface roughness affects the resistance to floe to liquid. As the surface roughness increases, the head of the pump discharge.

Impeller clearance:

Impeller clearance determines the internal leakage loss in a pump. As the clearance increases the leakage loss also increases.

Specific gravity:

It is the ratio of the density of a fluid to that of water at standard conditions.

Viscosity:

Viscosity has the following effects on the performance of a pump.

1. It reduces the capacity and head.
2. It increases the power requirement and lowers the efficiency.
3. It affects the suction head/ lift.

Pressure:

Pressure on the surface of the liquid to be pumped has a bearing on the performance of the pump. The atmospheric pressure varies as per the height of the pumping system.

Temperature:

The temperature affects the

1. Specific gravity.
2. Viscosity.
3. Vapour pressure.
4. Suction capacity.

The required NPSH is also affected due the change in vapour pressure.

Vapor Pressure:

The pressure exerted by vapour, when a state of equilibrium has reached between a liquid and its vapour at certain temperature, is called the vapour pressure of the liquid.

Water hammer:

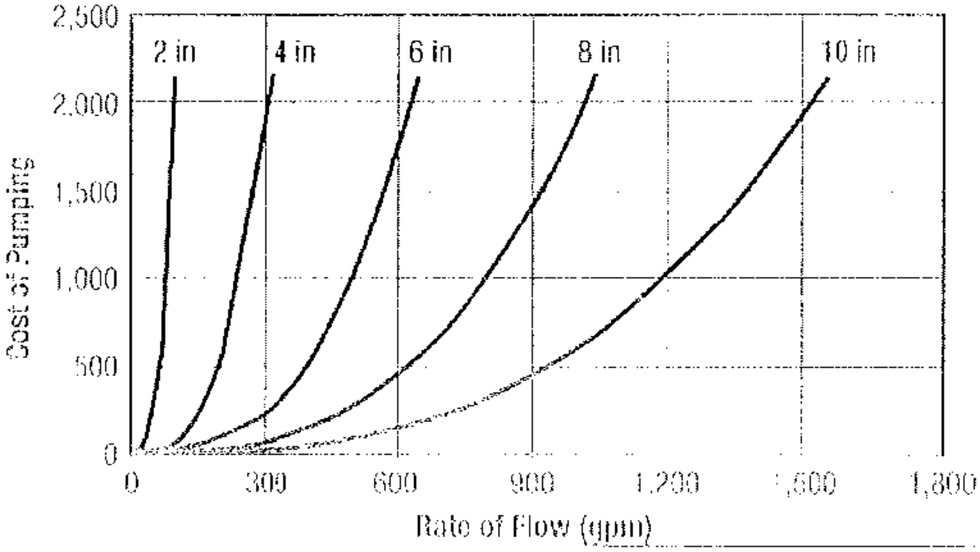
When there is sudden power failure, the kinetic energy of the rotating parts of rotating parts become very small that it cannot maintain flow against discharge head. The pump speed reduces and the pump starts to rotate in reverse direction.

Now the pump starts to behave like a turbine. This phenomenon is perceived as a series of shocks sounding like hammer blows and known as hammer blow.

Priming:

In pumps, the pressure has to be developed by the machine itself and this is possible only when the pump is completely filled initially with the liquid to be pumped. This operation is known as priming. This is essential for satisfactory operation of the pump.

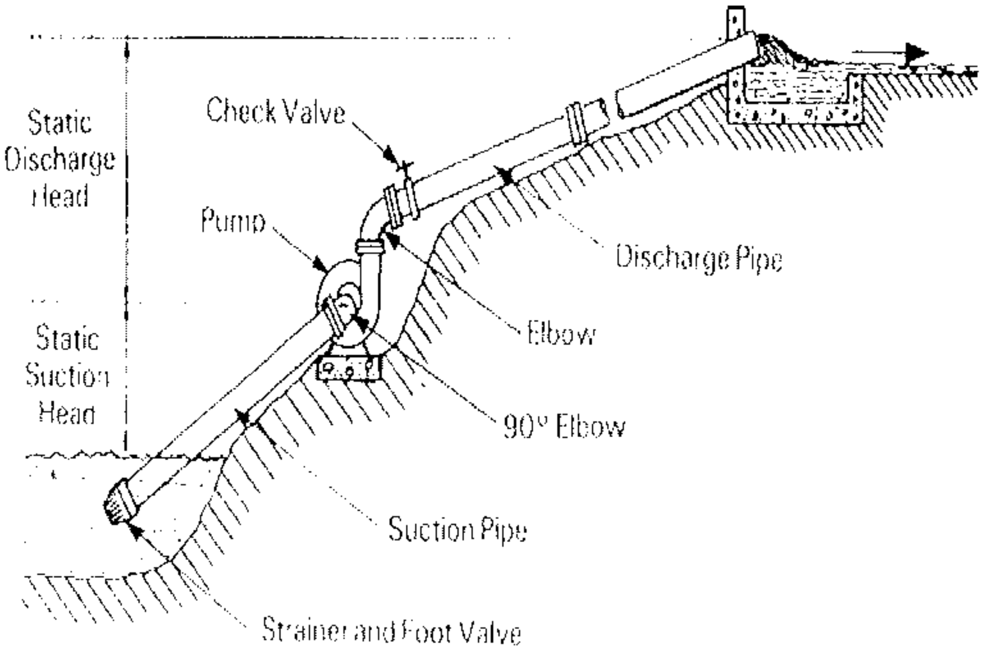
Diameter of pipes:



CHAPTER 6 PUMPING SYSTEM COMPONENTS

PUMPING SYSTEM COMPONENTS

The pumping system consists of a pump, suction line piping, delivery line piping , foot valve or strainer , control valves , check valves ,bends , reducers etc .,

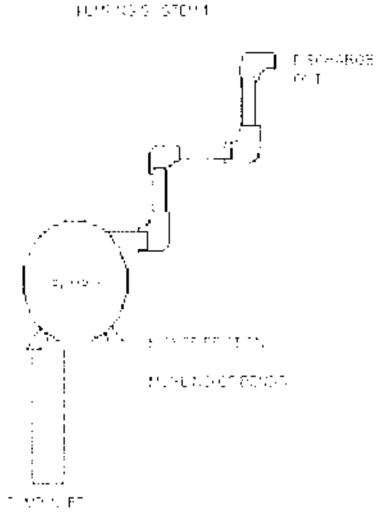


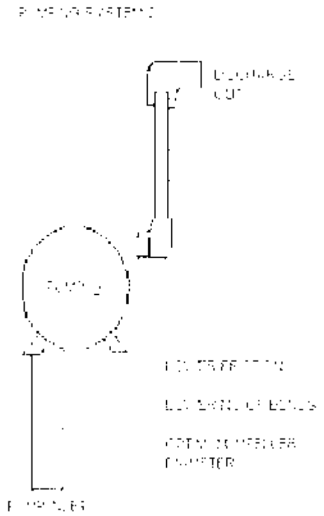
CHAPTER 7 EXPERIMENTAL SET UP

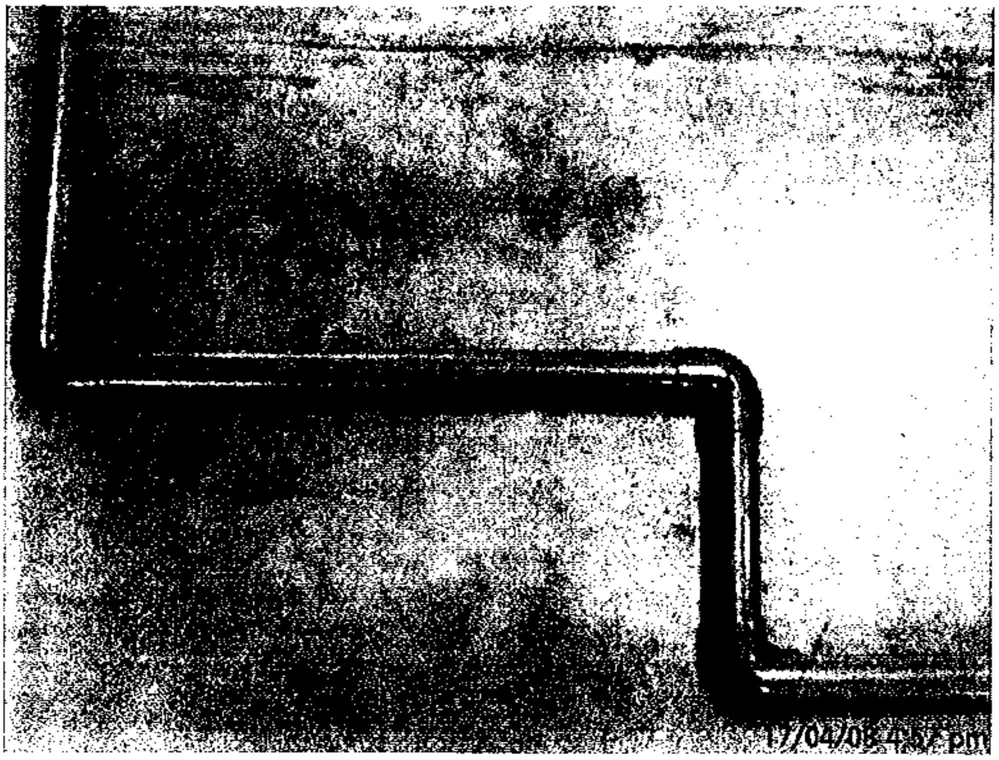
EXPERIMENTAL SETUP:

Pump installation means erecting the pump in the required site in required position.

The experimental setup consists of two pumping systems. One system has a standard pump and the other has a locally manufactured pump. The pump is attached to firm bed, which can bear the vibrations produced .The pump is bolted using bed bolts. The suction and delivery piping are connected. The electrical connections for the pump is also made . The earth of the pump is properly grounded.



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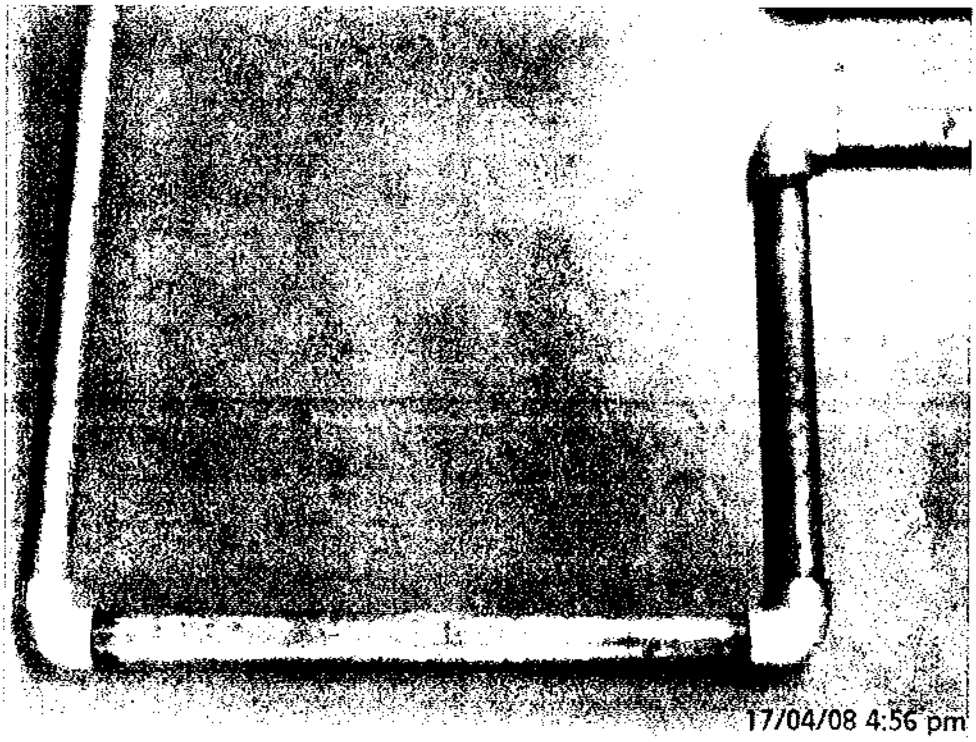
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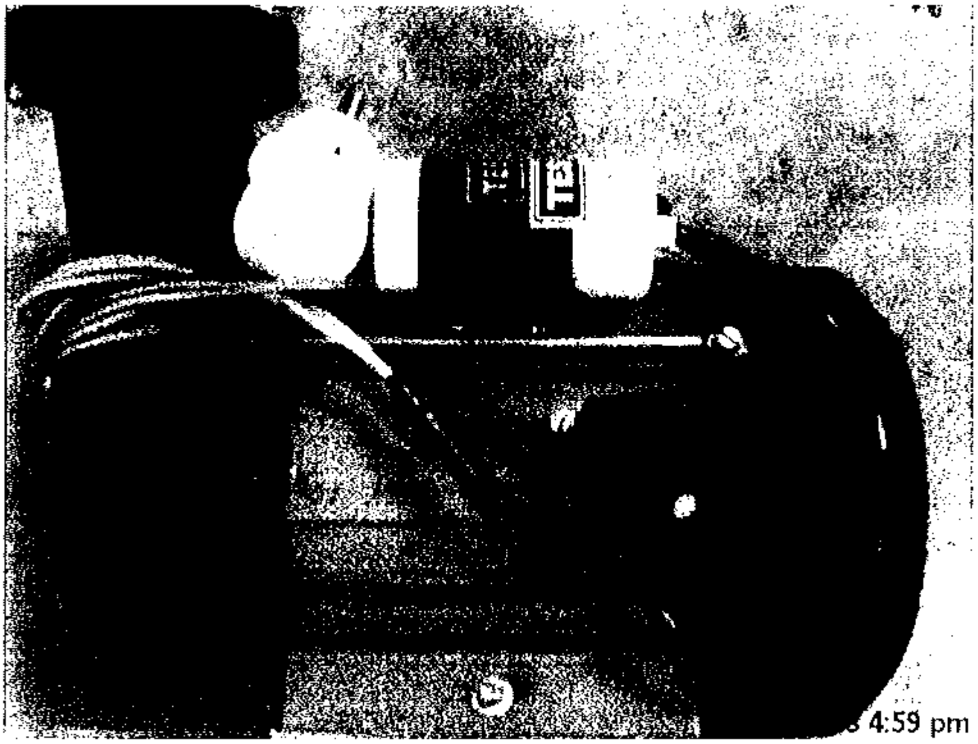
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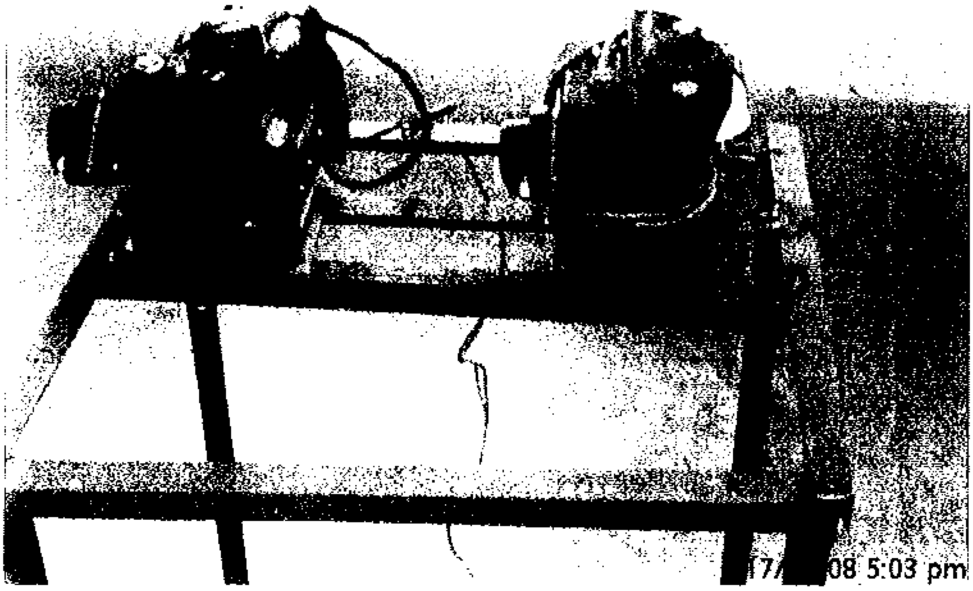
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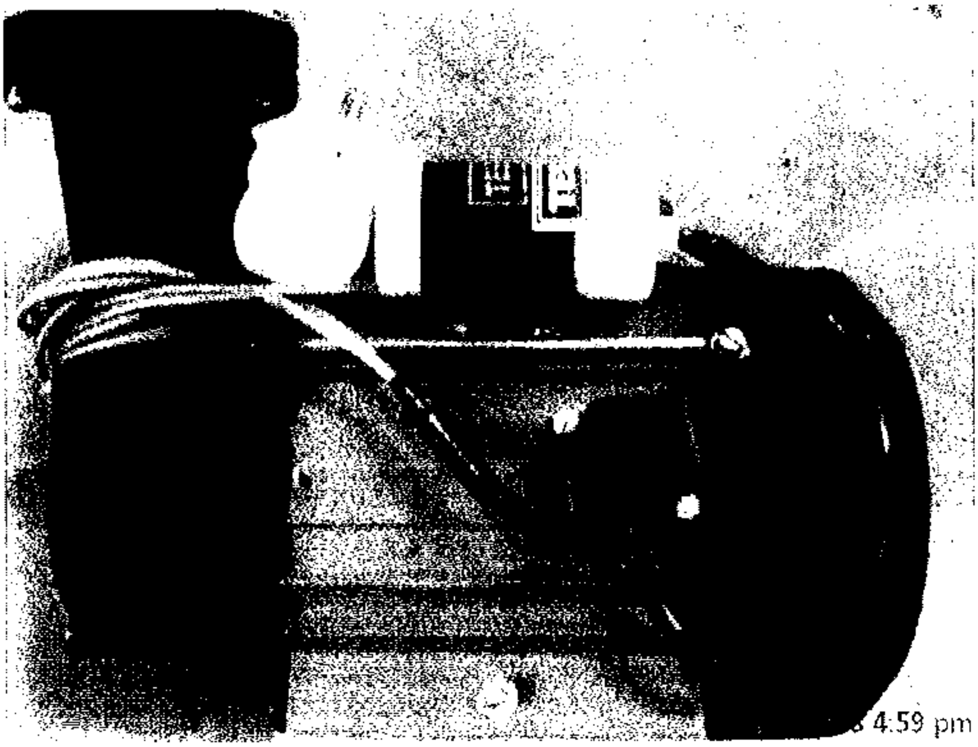

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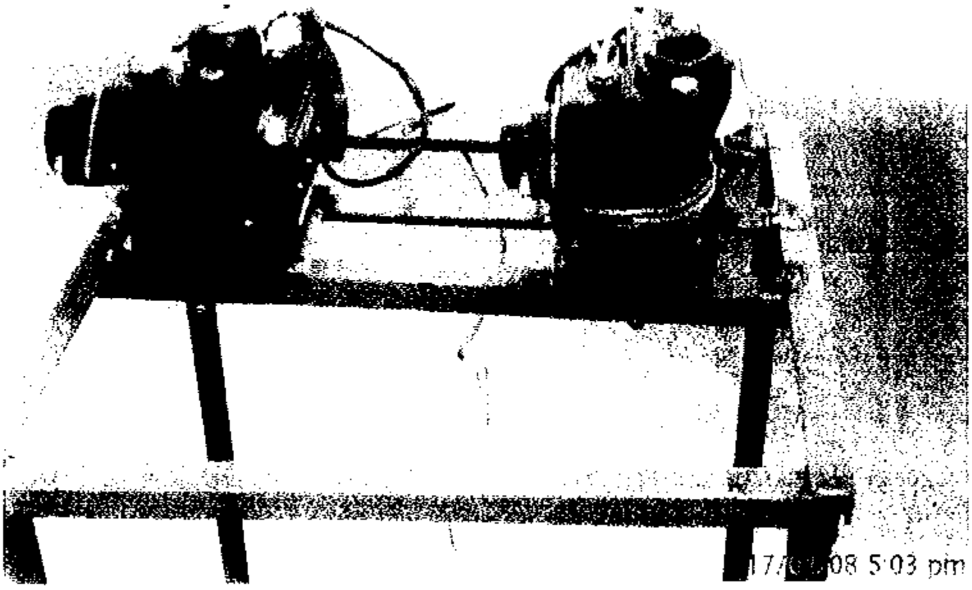

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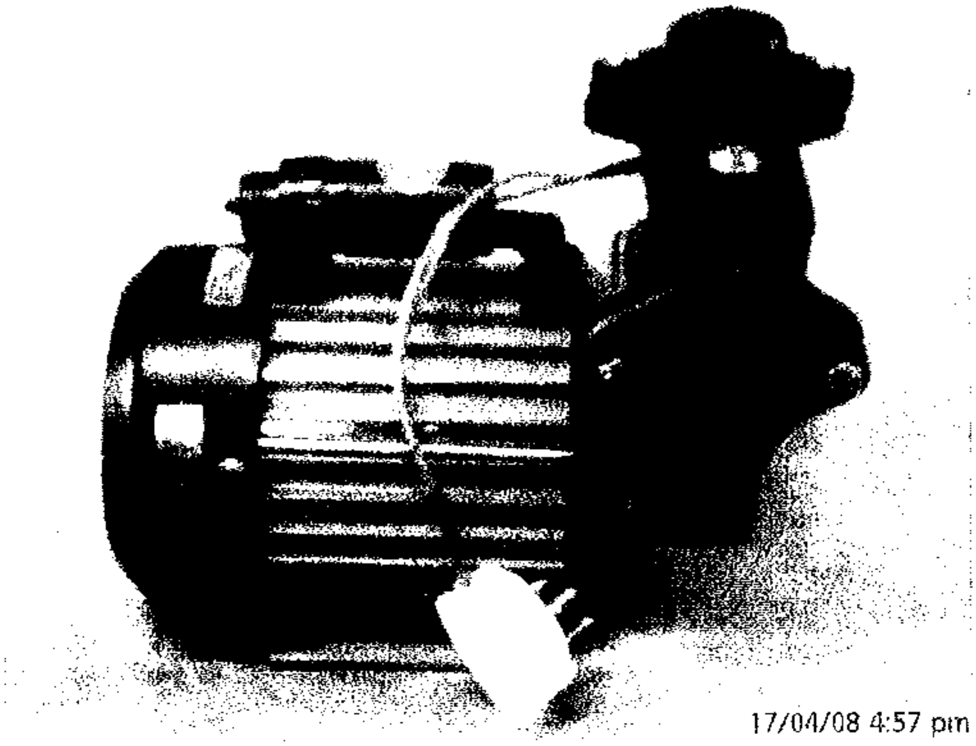

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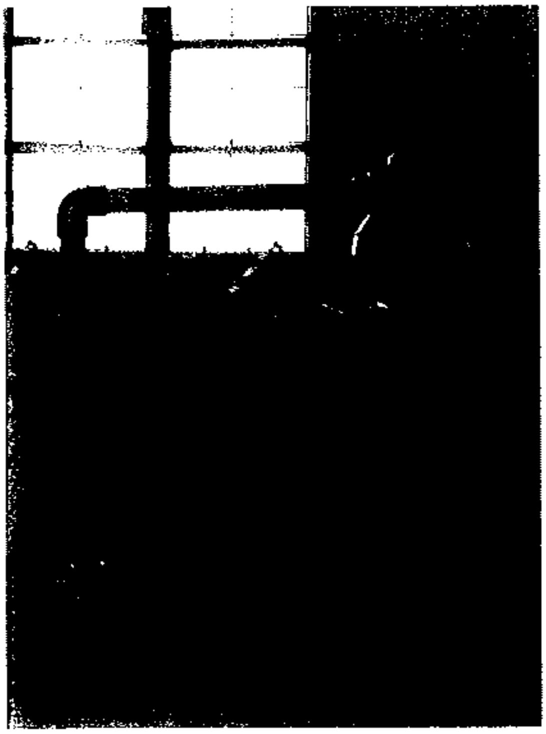

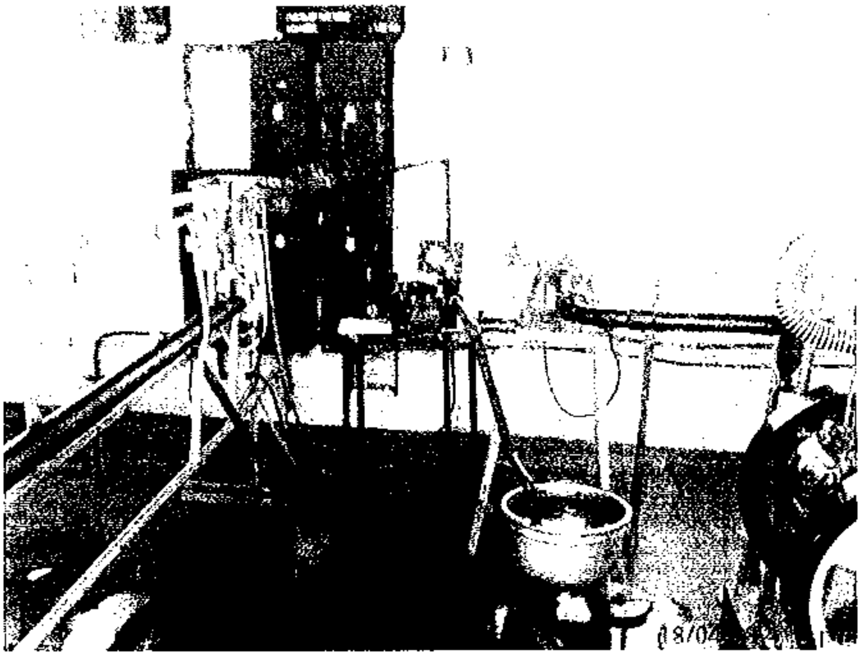

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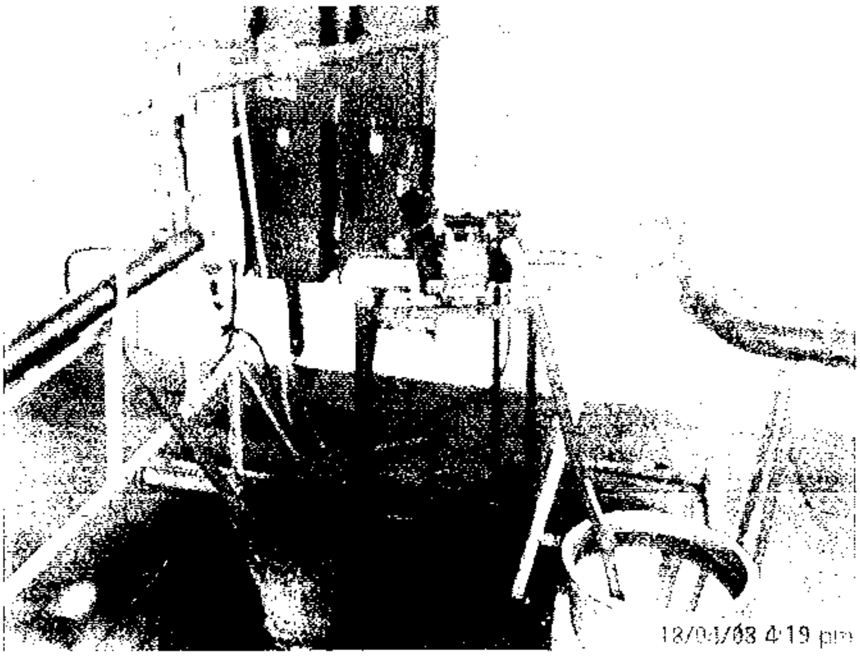

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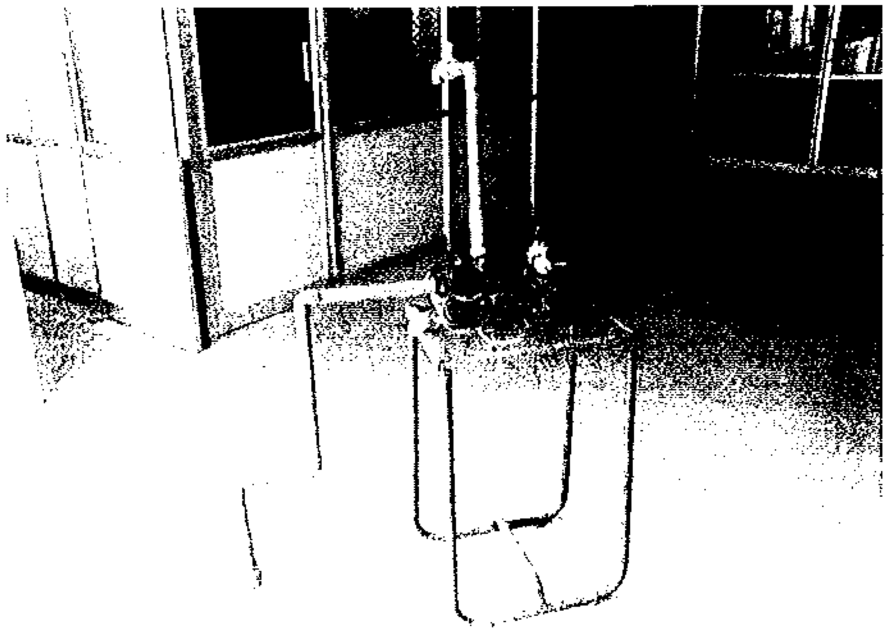

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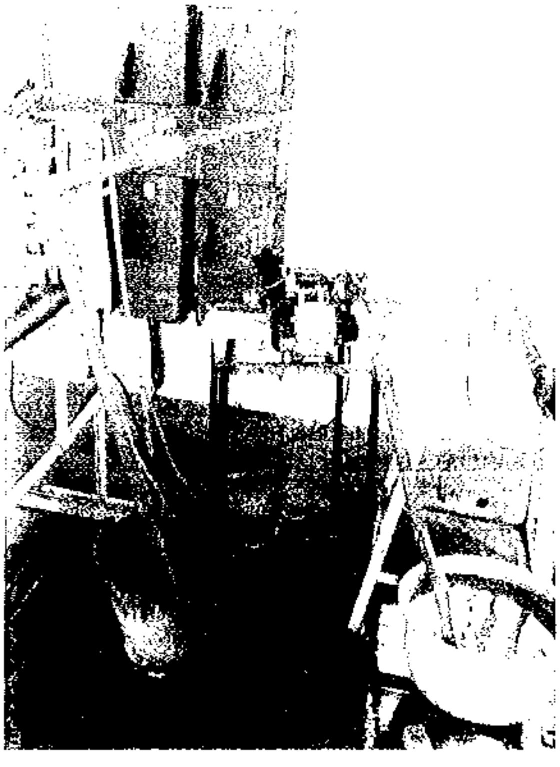


CHAPTER 8 COMPARISON OF TWO SYSTEM

TEST INSTALLATION INFORMATION

Inlet pipe size : 0.025 m

Outlet pipe size : 0.025 m

Pipe material : PVC

Inlet pipe length : 1.43 m

Outlet pipe length: 1.24 m

Suction head : 0.82 m

Delivery head : 0.42 m

Speed of pump : 2800 rpm

TESTING WITH 1" PIPE :

SYSTEM – I – STD PUMP

VALVE POSITION	VOLTAGE V	AMPERE I	DISCHARGE Q	POWER P	EFFICIENCY %
Fully open	198.6	0.17	2.88	0.063	60.4
Partially open 1	198.8	0.15	1.95	0.07	36.8
Partially Open 2	199.3	0.14	1.714	0.0073	31.2

SYSTEM – II – LOCAL PUMP

VALVE POSITION	VOLTAGE V	AMPERE I	DISCHARGE Q	POWER P	EFFICIENCY %
Fully open	200.5	0.25	2.4	0.072	44
Partially open 1	201.7	0.17	1.76	0.079	29.4
Partially Open 2	208.9	0.15	1.6	0.096	22

TESTING WITH 3/4" PIPE :

SYSTEM – I – STD PUMP

VALVE POSITION	VOLTAGE V	AMPERE I	DISCHARGE Q	POWER P	EFFICIENCY %
Fully open	209.6	0.11	3	0.81	48.9
Partially open 1	210.4	0.12	2.57	0.88	38.5
Partially Open 2	211.8	0.12	2.25	0.99	30.5

SYSTEM – II – LOCAL PUMP

VALVE POSITION	VOLTAGE V	AMPERE I	DISCHARGE Q	POWER P	EFFICIENCY %
Fully open	214.1	0.17	2.57	0.094	36
Partially open 1	215.9	0.14	2.4	0.125	25.4
Partially Open 2	216.8	0.11	2	0.186	14.2

CALCULATIONS

EFFICIENCY

η_{pump} = (Q x H x P) / 102 x P x 0.92

Time = 1.5 sec for 1 litre flow

Q in m^3/ s = (3600 / t) x 10^{-3} = 2.4 m^3/s

Q = 2.4 m^3/s

H = 1.24 m

P = 1000 kg / m^3

P = 0.063 x 10^3 W

η_{motor} = 0.92

η_{pump} = (Q x H x P) / 102 x P x 0.92

= (2.4 x 1.24 x 1000) / (102 x 0.063 x 10^3 x 0.92)

= 0.503

= 50.3 %

FRICTION LOSS

1" PIPING

$$\mathbf{H_f = (4 \times f \times L \times v^2) / (2 \times g \times D)}$$

f = 0.3

Equivalent length

Delivery: 0.42 + 0.82 + 1 elbow + 1 ball valve

= 0.42 + 0.82 + 0.8 + 8.2

= 10.24 m

Suction: 0.41 + 0.51 + 0.22 + 0.3 + 1 foot valve + 3 elbows

= 0.41 + 0.51 + 0.22 + 0.3 +2.3+ (3x0.8)

= 5.84 m

L = (10.24 + 5.84) m

V= 0.58 m/s

D = 0.025 m

$H_f = (4 \times 0.3 \times 16.08 \times 0.58^2) / (2 \times 9.81 \times 0.025)$

= 1.34 m

3/4" PIPING

$$H_f = (4 \times f \times L \times v^2) / (2 \times g \times D)$$

f = 0.3

Equivalent length

Delivery: 0.42 + 0.82 + 1 elbow + 1 ball valve +1 reducer

= 0.42 + 0.82 + 0.8 + 8.2 +0.6

= 10.84 m

Suction: 0.41+0.51+0.22+0.3+1 foot valve + 3 elbows+2 reducers

= 0.41 + 0.51 + 0.22 + 0.3 +2.3+ (2x0.8) + (3x 0.6)

= 7.14 m

L = (10.84 + 7.14) m

V= 0.095 m/s

D=0.02 m

$$H_f = (4 \times 0.3 \times 17.98 \times 0.095^2) / (2 \times 9.81 \times 0.02)$$

= 3.5 m

CHAPTER 9 PERFORMANCE OF TWO SYSTEM

PERFORMANCE OF TWO SYSTEMS

REDUCING HEAD LOSS DUE TO FRICTION ACROSS FOOT VALVE, H_{fv}

A good foot valve design should have a co-efficient of friction of < 0.8 and should confirm to IS: 10805. The foot valve should have a bell-mouth profile. This will reduce the entrance losses and H_{fv} substantially .

A typical total head rating of an agricultural pump is 16m. This head comprises of:

- Static head on suction side , $H_{ss} = 8$ m
- Static head on discharge side , $H_{sd} = 5$ m
- Head loss due to friction across foot valve , $H_{fv} = 0.5$ m
- Friction losses across suction and discharge piping ($H_{fs} + H_{fd}$) = 2.5 m

The use of bore well submersible pumps is increasing with the depletion of ground water tables . These pumps have no foot valves. Hence. this savings on account of H_{fv} , are not applicable to these pumps .

REDUCING FRICTION ACROSS SUCTION PIPING, H_h

The reduction of H_h can result in the following benefits:

- Reduction of total system head (H)
- Cavitation - free operation
- Energy efficient performance

The friction loss across pipes is given by:

$$H_f = (4 \times f \times L \times v^2) / (2 \times g \times D)$$

Where f = coefficient of friction pipe

L = equivalent length of pipe, in m

V = velocity of flow, in m/s

D = Diameter of pipe, in m

G = acceleration due to gravity, in m/s^2

The above expression shows that to reduce, H_h, the diameter of pipe should be as large as possible . Friction losses across bends are derived, by taking account the equivalent length. Bends, wherever unavoidable, should be of long radius. The 'f' is less, in case of PVC pipes.

But for identical nominal size, a PVC pipe may have smaller D, as compared to that of a G.I. pipe. The suction pipe has to be selected, to have minimum value of F/D. The H_h will reduce drastically ,as G.I. pipes corrode when compared to PVC pipes .

REDUCTION IN STATIC HEAD ON DISCHARGE SIDE , H_{sd}

H_{sd} will be high, if water is pumped to an overhead reservoir. But H_{fd} will be less in this case , as compared to pumping directly into the entire piping network .

REDUCING STATIC HEAD ON SUCTION SIDE, H_{ss}

The pump should be as near as to the level of water in the well. to reduce. The scope of reducing is dictated by site conditions and the type of pump used. The effects on cost of foundation ease of maintenance and repairs and cost of maintenance have to be taken into account.

The need for more than one foundation and for shifting of the pump can be avoided with open well submersible pumps. Care should be taken to keep the pump safe from silt. With submerged pump, there is no need for priming and there being no foot valve, H_{fv} is zero.

Since there is no suction piping, the friction loss in suction piping is limited to the friction in strainer. The total head of the system (H) reduces by the depth of submergence, which reduces the static head on suction side (**H_{SS}**).However the efficiency of submersible motors is less than that of surface motors .

CONCEPT OF ENERGY LOSS DUE TO EXCESS CAPACITY IN PUMPS

Generally, pumps are designed for the maximum flow and process conditions. Therefore, it is very important to obtain accurate calculations of desired flows and pressures through the system, to ensure correct selection of equipment.

Consider a pump of 100 m3/h capacity, has a head of 50m. A pump designer uses an additional safety factor of 15m head, to ensure the pump reaches the operating point "A". This results in the pump having a total head of 65m.

Assuming that the user needs a pump to operate 100m3/h at 65m, the pump manufacturer selects a pump with the curve D, B, C. The pump curve intersects the system curve at point B, the best efficiency point of the pump.

Adding safety factor to system calc will never make certain the desired conditions are obtained. Safety factors will unnecessarily increase energy consumption.

IMPROVING EFFICIENCY OF PUMP

Ground water source is characterized by low yield and high total head. This results in low specific speed of pump and hence low pump efficiency. Multistage construction is common in bore well submersible pumps, to take care of the design specific speed.

In agricultural pumping, the flow rate will not be constant, due to seasonal variations and draw down .At high or low, efficiency of pump is low. Good design pumps, have a top efficiency characteristics, so that any reduction in efficiency away from the 'Best Efficiency Point (BEP) 'is small.

The efficiency of a pump and flat top nature of the characteristic curve are affected by good design and manufacturing practices. Norms for minimum efficiency for a whole matrix of Q-H design ratings are specified in most BIS standards on agricultural pumps. Some of them are:

- IS – 9079 : for mono sets
- IS 6595 : for coupled pumps
- IS 8034 : for bore-well submersible pumps

HOW TO QUANTIFY SAVINGS POTENTIAL IN PUMPS?

The savings potential in pumps can be estimated by measuring the pressure drop across the valves.

The pressure at the three points has to be measured.
Then

- The pressure drop across the valve is $P_2 - P_3$
- The total pressure rise of the pump is $P_2 - P_1$
- Energy saving potential is $(P_2 - P_3)/(P_2 - P_1)$ x (input KW)

SPEED REGULATION

The latest method of capacity control is speed regulation of centrifugal and positive displacement pumps. The speed of the pump can be varied, to achieve different operating capacities. The devices used to achieve speed regulation in pumps are variable speed drives, such as, variable frequency drives (VFD), variable fluid coupling (VFC) and eddy current drives.

The use of variable speed drives will help achieve speed variation. exactly matching the process requirements and minimize the power requirements. The variable speed drives could be mechanical, magnetic, hydraulic, as well as AC and DC drives. However, the use of variable speed drives is limited by the cost economics of the particular application.

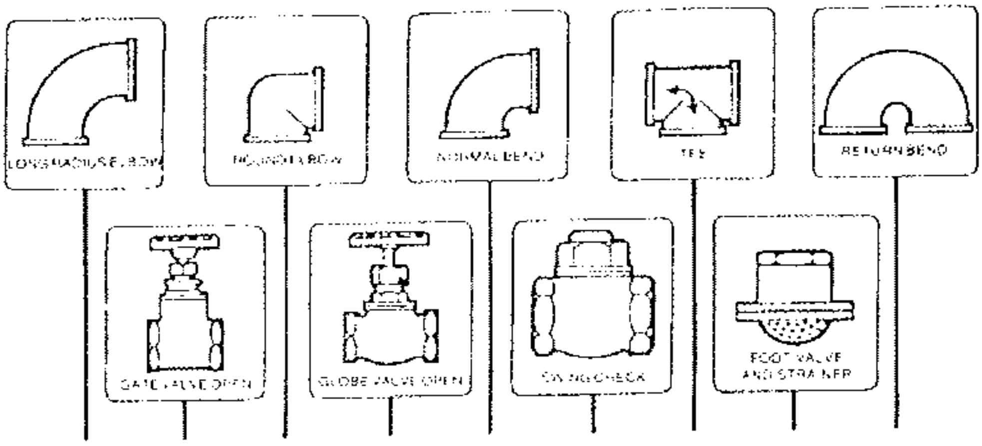
CONCEPT OF LOSS OF ENERGY IN THROTTLING

For example a pump is designed for 300 m3/h capacity with 40 m head. The required capacity is 200m3/h with a head of 30 m. The pump can be controlled with valve throttling. The pump can be controlled with valve throttling. The operating point shifts from the design point A towards left (from A to B).

In the new operating condition the pump actually develops 48m head, where as the required is only 30m. Hence the excess pressure developed by the pump has to be dropped across the control valve. In other words, nearly 18m head is lost across the valve. equivalent of BC in the curve.

The power consumption of the pump is proportional to BD whereas the corresponding power consumption for a correct size pump is CD. The difference between BD to CD (i.e.) BC is the energy lost across the throttled valve.

EQUIVALENT LENGTH OF COMPONENTS



Pipe size mm	Equivalent length of straight pipe in metres, for calculating friction loss							
20	0.3	0.3	0.6	6.7	0.5	1.5	1.5	1.5	1.5
25	0.3	0.3	0.8	8.2	0.5	2.0	1.8	2.3	2.0
32	0.3	0.6	0.9	11.3	0.8	2.6	2.4	2.7	2.6
40	0.4	0.6	1.1	13.4	0.9	3.1	2.7	3.4	3.1
50	0.5	0.8	1.4	17.4	1.1	4.0	3.4	4.6	4.0
65	0.6	0.9	1.7	20.1	1.4	5.2	4.3	5.5	4.6
80	0.8	1.1	2.1	26.0	1.5	6.1	5.2	6.7	5.5
100	1.1	1.5	2.7	34.0	2.1	8.2	6.7	8.8	7.3
125	1.2	1.8	3.7	43.0	2.7	10.0	8.2	11.0	9.5
150	1.5	2.1	4.3	49.0	3.4	12.2	10.0	14.0	11.0
200	2.1	3.1	5.5	67.0	4.3	16.5	13.4	18.0	15.0
250	2.4	3.7	7.3	85.4	5.5	20.0	16.5	22.0	19.0
300	3.1	4.3	8.5	98.0	6.7	24.4	20.0	27.4	23.0

LOSSES IN PUMPS:

Various losses occur in a pump, they are broadly classified into the following.

1. Frictional losses
2. Internal leakage
3. Mechanical losses
4. Electrical losses.

Efficiency:

The efficiency of the pump can be defined as the ratio of power output to power input.

$$\eta = P_o/P_i$$

The different efficiencies are

Manometric or Hydraulic efficiency:

It is defined as the ratio of manometric head developed by the pump to the head imparted by the impeller to the liquid.

Volumetric Efficiency:

It is defined as the ratio of liquid discharged per sec from the pump to quantity passing per second through the impeller.

Mechanical Efficiency:

It is defined as the ratio of power actually delivered by the impeller to the power supplied to the shaft by the prime mover.

CHAPTER 10 BILL OF MATERIALS

BILL OF MATERIALS

PARTS	QUANTITY	COST (Rupees)
STD. PUMP	1	2000
LOCAL PUMP	1	1100
1" PVC PIPE	10 FEET	90
3/4" PVC PIPE	10 FEET	70
1" G.I. PIPE	6 FEET	90
3/4" G.I. PIPE	6 FEET	70
1"-¾"REDUCER(PVC)	8	64
1"- ¾" REDUCER(G.I)	8	160
1" ELBOW (PVC)	6	48
3/4" ELBOW (PVC)	6	36
1" ELBOW (G.I)	6	120
BALL VALVE	1	65
FOOT VALVE	1	25
PVC GLUE	1	15

G.I. GLUE	1	20
ELECTRICAL WIRES	12 MTS	120
3 PIN TOP	2	30
FLEX BOX	1	65
TPFE TAPE	2	20
INSULATION TAPE	1	10
BED BOLTS (1/4"x3")	8	16
WASHERS	16	16
NUTS	8	16
ANGLE	9 FEET	450
CHANNELS	12 FEET	300
IRON RODS	5 FEET	100

TOTAL COST = Rs.5116 .00

CHAPTER 12 CONCLUSION

CONCLUSION

Pump is a device which is used everywhere .In this current scenario efficient usage of resource is very important. So this kind of energy efficient pumping system is much important.

This project of designing and fabricating the energy efficient pumping system could help in achieving it. The testing and its system procedures show how to select a particular type pump and install its piping and various components.

These tests could also lay a path towards high efficient mechanical system

By optimizing the design the installation cost, running and maintenance cost will be reduced drastically.

REFERENCES

REFERENCES:

"Rotodynamic and Positive displacement Pumps", 2^{nd} edition, 2006, G.K.Sahu.

"Fluid Mechanics and Hydraulic Machines", seventh edition, 1998, R.K. Bansal.

"Trouble shooting Process Operations", 3rd Edition 1991, Norman P.Lieberman, PennWell Books

"Centrifugal pumps operation at off-design conditions", Chemical Processing April, May, June 1987, Igor J. Karassik

"Understanding NPSH for Pumps", Technical Publishing Co. 1975, Travis F. Glover

"Centrifugal Pumps for General Refinery Services", Refining Department, API Standard 610, 6th Edition, January 1981

"Controlling Centrifugal Pumps", Hydrocarbon Processing, July 1995, Walter Driedger