A PROJECT REPORT

ON

"DESALINATION OF BRACKISH WATER BY REVERSE OSMOSIS"

Submitted by

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In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. S.V RANADE

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

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CERTIFICATE

This is to certify that the project entitled

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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APPROVAL OF DISSERTATION

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DECLARATION

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

The base RO process starts with raw water (Brackish Water) pumped from the submersible then the water is dosed with chlorine which kills bacteria and other microbes. After that multigrade sand filter comes to process in which contaminants are captured in the sand bed of filter. After this Sodium Meta Bi Sulphite (SMBS) dosing removes the excess chlorine. The activated carbon filter then removes organic particles through absorption. The antiscalent dosing further removes calcium, magnesium salts to prevent scaling of membrane. The micro cartridge filter further removes the bacteria etc having range of filtration 0.1 to 10 μm.

Then the water is passed through the high pressure pump which is reciprocating. This increases the pressure and water is passed to RO Membrane which is the heart of the system. The membrane separates the water and salt. The pure water is taken out from the outlet of Membrane.

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CHAPTER 1
INTRODUCTION

1. INTRODUCTION

Water and slightly salty water is found as surface water in estuaries. Water is the source of life, the basis of human survival and the principal material base to guarantee the economical development of any country. With increasing consumption and excessive pollution at alarming levels is posing a threat to human existence in many parts of the World. The fresh water scarcity is a growing globally, the gap between the supply and demand for water is causing problems all over the world because only 1% of earth's water is fresh water available is fit for humans to drink. The US geological survey found that 96.5% of earth's water is located in seas and oceans and 1.7% of earth's water is located in the ice caps. The remaining percentage is made up of brackish as groundwater in salty aquifers. The need for fresh water is at the top of the international agenda of critical problems, at least as firmly as climate change. India as a country has 16% of the world's population and 4% of its fresh water resources.

Due to rapid industrialization and development, there is an increased opportunity for grey water reuse in developing countries such as India. Although India occupies only 3.29million km^2 geographical area, which forms 2.4% of the world's land area, it supports over 15% of world's population. The population of India as of March 31, 2011 was 1,210,193,422 (Census, 2011). India also has a livestock population of 500 million, which is about 20% of world's total livestock. However total annual utilizable water resources of the country are 1086km^3 which is only 4% of world's water resources. Total annual utilizable resources of surface water and groundwater are 690km^3 and 396km^3, respectively. Consequent to rapid growth of population and increasing water demand, stress on water resources in India is increasing and per capital water availability is reducing day by day. In India, per capita surface water availability in the years 1991 and 2001 were2309 m^3 (6.3m^3/day) and 1980m^3 (5.7m^3/day), respectively, and these are projected to reduce to 1401 m^3 and 1191 m^3 by the years 2025 and 2050, respectively. Total water requirement of the country in 2050 is estimated to be 1450km^3 which is higher than the current availability of 1086km^3.

Pure, clean water is an absolute must for our survival. Water resources used by humans for various domestic purposes such as drinking, cooking food, washing etc. Water is also used for various industrial purposes, agricultural purposes, power generation, fishing, and so forth. The quantity of available fresh water is inadequate to meet the growing demands of human beings. The conventional water sources, like rivers, lakes, ponds, and so forth, in the form of surface water are not fully dependable because most of these are rain fed. Presently, rainfall is below normal in most of the years. This results in failure of many surface water source schemes. Similarly, due to the reasons stated already the subsurface sources also fail in certain extent. Experts estimate that over 1 billion people are without clean drinking water. Each year more than 5 million people die from water-related diseases; 4 million of them are children. Increasing demands on water and an ever-increasing population mean that water supply is becoming a serious issue.

Despite an estimated total of Rs 1105 billion spent on providing safe drinking water since the first Five-Year Plan was launched in 1951, lack of safe and secure drinking water continues to be a major hurdle and is a national economic burden. As a consequence of the growing scarcity of freshwater, the implementation of the desalination plants is increasing on a large scale. According to a report by Frost and Sullivan, with growing demand and more focus on desalination by the Indian states, the desalination capacity of India is expected to reach 1,449,942m^3/day by 2015 from 291,820m^3/day in 2008.

The crucial role groundwater plays as a decentralized source of drinking water for millions of rural and urban families cannot be overstated. However, due to rapid growth of population, urbanization, industrialization, and agriculture activities, groundwater resources are under stress. There is growing concern on the deterioration of groundwater quality due to geogenic and an anthropogenic activity.

Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies. The desalination of the available saline water has become a suitable alternative, which is widely used worldwide. The well-established seawater and brackish groundwater desalination technologies, no doubt, can be employed to produce large amounts of good-quality water at a cost which appears to be reasonably quite competitive, but the main drawback of all such processes still remaining to be resolved is the high energy consumption.

Desalination of seawater or saline water has been practiced regularly for over 50 years and is well-established means of water supply in many countries. It is now feasible, technically and economically, to produce large quantities of water of excellent quantity from desalination processes. Challenges, however, still exist to produce desalination water for relatively large communities, for their continuous growth, development, and health, and for modern efficient agriculture, at moderate costs.

Membrane processes such as Reverse Osmosis (RO), Nano-filtration (NF), and Electro-dialysis (ED) have drawn more attention because of their strong separation capabilities and exhibiting a great potential for the treatment of water worldwide. In the recent years, RO membrane technology is the leading technology for new desalination installations and has been developed for both brackish and seawater applications. Brackish water RO membranes typically have higher product water flux, lower salt rejection, and require lower operating pressures due to lower osmotic pressure. But these membrane separation processes have some problems due to the formation of polarization films and by-products which may generate bacteria and fouling.

CHAPTER 2
PROBLEM DEFINITION

2. PROBLEM DEFINITION

2.1 CHALLENGES IN RURAL AREAS:-

As water scarcity and contamination problems are more acute in rural areas, implementation of desalination and water purification technologies will help in a big way in providing safe drinking water. But, the various constraints normally encountered in rural areas pose certain limitations on the efficiency and techno-economics of desalination in general.

Power supply in rural areas is a serious concern. Availability of power varies from 8 to 10 hours a day and even the available power supply is highly erratic with crippling voltage fluctuations and sudden power cuts. Hence the total requirement of drinking water for the village needs to be produced in a short span of time when the power is usually available. Remoteness and inaccessibility of remote areas pose difficulties in case of equipment failure as skilled manpower and spare parts may not be readily available which results in considerable delay. To deal with such situations the critical moving parts are installed in standby mode and important spare parts are always kept ready.

Due to acute summer and over exploitation of the ground water, the water table goes down, thus affecting the yield and at times rise in salinity. Hence sustenance of the quality and quantity of the product is difficult. Reject water recirculation in the design is the suitable approach which takes care of conserving the ground water resource. Because of the lack of availability of skilled man power in rural areas the design should take care that minimum human interface is called for. Design should be robust and simple.

2.2 AIM:-

Our main motive or aim is to full the water tank of 10 tons per hour with drinkable water. Making a mobile desalination unit which can be mounted or installed on back of truck for example Leyland Tusker will help in treating the brackish water source not situated near the treatment plant.

* To convert the brackish water to a level nearly to drinking water or for irrigational purpose.

* To fill the tank of capacity of 5 tone in an hour.
* To build up a mobile desalination unit.
* Develop a semi permeable membrane for the purpose of treatment of water.

CHAPTER 3
LITERATURE SURVEY

3. LITERATURE SURVEY

3.1 VISIT TO KHOPOLI:-

Figure 3.1 Visit to Khopoli

By obtaining permission from our college we got to visit "MS SPARKLE TECH PVT.LTD" we got the permission from the office which is situated at Belapur CBD. After the final permission from their office we visited the plant situated at Khopoli .On 4th of March 2017we went to visit the plant .The plant was situated of the outskirts of Mumbai Pune express way. After reaching to the plant we had a brief discussion with their manager "MR NARENDRA INGALE" who gave a brief discussion on current water scenario and the crisis of water in our country and the steps taken to curb the crisis. We got to know that proper steps were not taken to curb the current crisis situation. Also he said that our country was not in the race of development of RO process with other countries. In the plant situated at Khopoli they imported various parts from other countries and assembled at their unit in Khopoli. In INDIA membrane are not made of superior quality it is imported from California. We got to know that the RO membrane was not yet developed in our country. Students of the California University have made membrane in which Nano filtration is possible it was told to us by the manager. After a brief discussion we started the visit to the plant with the manager. Firstly we saw a project of RO fitted in a cargo shipping container. The owner's requirement was of limited space and he wanted the water for the usage of his clients. That project costed a price of 1 crore. All the parts were very well fitted inside the container and it was easily accessible for 2 persons to operate the system. A piston pump was used for a pressure of 95 bars and was well fitted in the container with proper vibration isolators. And the materials which were used for the construction were very well finished. All the important controls were situated inside that cargo container from where operator could access it. A set of 20 membrane in parallel were used which was the heart of RO project. 2or 3 membranes were used coupled together and output water was taken. The water was stored and used for the drinking purpose. And that container was ready to be shipped and would be delivered to Singapore. Then we visited few similar units which used centrifugal pumps as they were of smaller capacity. We then visited their electrical control department who's in charge was "MS BHAVNA SINGH" she took us to the controls section where various equipment's were used. She perused a B.E electrical degree from Sardar Patel College of Engineering. She took us to the control sections where we saw various units installed. Then with the manager we visited the testing section they had a special equipped lab for hydro testing of the equipment's. They had a laboratory where PH value, TDS, BDS etc. were tested. The manager was the main in charge of the of the lab section. In this way our visit was concluded.

3.2 CHEMISTRY OF GROUND WATER

The downward percolating water is not inactive, and it is enriched in CO2.It can also act as a strong weathering agent apart from general solution effect. Consequently, the chemical composition of ground water will vary depending upon several factors like frequency of rain, which will leach out the salts, time of stay of rain water in the root-zone and intermediate zone, presence of organic matter etc. It may also be pointed out that the water front does not move in a uniform manner as the soil strata are generally quite heterogeneous. The movement of percolating water through larger pores is much more rapid than through the finer pores. The overall effect of all these factors is that the composition of ground water varies from time to time and from place to place. Before reaching the saturated zone, percolating water is charged with oxygen and carbon dioxide and is most aggressive in the initial stages. This water gradually loses its aggressiveness, as free CO2 associated with the percolating water gets gradually exhausted through interaction of water with minerals.

$$CO2 + H2O \longleftrightarrow H2CO3 \longleftrightarrow H+ + HCO3^{-}$$

$$H+ + Feldspar + H2O^{--} \longrightarrow Clay + H4SiO4 + Cation$$

The oxygen present in this water is used for the oxidation of organic matter that subsequently generates CO2 to form H2CO3. This process goes on until oxygen is fully consumed

$CH_2O + O_2 = CO_2 + H_2O$

(Organic matter)

3.3 GROUND WATER QUALITY SCENARIO IN INDIA:-

Groundwater is an essential and vital component of our life support system. It plays an imperative role in India's economic development. The rapid pace of agricultural development, industrialization and urbanization has resulted in the overexploitation and contamination of groundwater resources in parts of the country, resulting in various adverse environmental impacts and threatening its long-term sustainability.

The groundwater available in the country, in general, is potable and suitable for various usage. However, localized occurrence of groundwater having various chemical constituents in excess of the limits prescribed for drinking water use has been observed in almost all the states. The commonly observed contaminants such as arsenic, fluoride, and iron are geogenic, whereas contaminants such as nitrates, phosphates, and heavy metals owe their origin to various human activities including domestic sewerage, agricultural pesticides, and industrial effluents. Groundwater in shallow aquifers is generally suitable for use for different purposes such as drinking, agricultural, or industrial, which is mainly of calcium bicarbonate type and mixed cations and mixed anion type. However, other types of water are also available including sodium-chloride water. The average limit of the toxic contamination available in the groundwater in different states of India is shown in Table 1. It shows that the values are higher than the permissible limit as per Indian standards and World Health Organization (WHO) guidelines for drinking water.

Table 3.1: Average limit of groundwater toxic contaminants available in different states of India

Sr. No.	Indian state	Characteristic limit in groundwater (mg/L)			
		Fluoride	Iron	Arsenic	Nitrate
	Permissible Limit	**0.6–1.5 max**	**0.3–1 max**	**0.05**	**45**
1	Andhra Pradesh	1.5–3.8	1.1–8.43	NA	46–1110

2	Assam	1.52–6.72	1–10.13	0.052–0.147	NA
3	Bihar	1.7–2.62	1.12–10	0.05–1.8	48–228
4	Chhattisgarh	1.5–2.2	1.0–7.5	1.89	46–240
5	Delhi	1.58–4.42	NA	NA	47–218
6	Gujarat	1.5–6.8	1.1–3.24	NA	45–520
7	Haryana	1.5–8.84	1.1–17.78	NA	49–1200
8	Jammu and Kashmir	2.0–2.06	1.3–6.32	NA	45–150
9	Jharkhand	1.6–2.5	1.15–6.8	NA	46–230
10	Karnataka	1.5–4.4	1.0–16.2	NA	46–247
11	Kerala	2.5–5.7	1.0–9.0	NA	NA
12	Madhya Pradesh	1.5–10.7	1.0–6.0	NA	46–279
13	Maharashtra	1.5–4.01	1.06–10.1	NA	45–488
14	Orissa	1.52–4.9	1.1–13.98	NA	46–272
15	Punjab	1.54–8.33	1.0–25.0	NA	45–944
16	Rajasthan	1.5–35.15	1.0–16.5	NA	45–1005
17	Tamil Nadu	1.51–3.8	1.49–2.93	NA	45–654
18	Uttar Pradesh	1.5–2.96	1.03–6.24	0.05–0.195	46–848
19	West Bengal	1.5–9.1	1.0–17.3	0.05–3.0	46–81
20	Andaman Nicobar	NA	NA	NA	NA
21	Goa	NA	1.0–2.0	NA	NA
22	Manipur	NA	1.8–16.52	NA	NA
23	Meghalaya	NA	1.29–7.2	NA	NA
24	Tripura	NA	1.02–5.23	NA	NA
25	Himachal Pradesh	NA	NA	NA	45–65
26	Uttarakhand	NA	NA	NA	46–81

3.4 GENERAL CENCEPT OF MEMBRANE PROCESS:-

In general, membrane treatment processes use either pressure-driven or electrical-driven technologies. Pressure-driven membrane operation can be divided into four overlapping categories: reverse osmosis (RO), Nano filtration (NF), ultrafiltration (UF), and microfiltration (MF). The characteristics of applications of pressure-driven membrane processes are shown in Table 2. Reverse osmosis, and to some extent Nano filtration process, are considered effective in salt removal.

Table 3.2:- Characteristics of application of pressure-driven membrane processes.

Membrane process	Applied pressure (kPa)	Minimum particle size removed	Pollutant removal (type, average removal efficiency %)
Microfiltration	30–500	0.1–3µm	Turbidity (>99%); bacteria (>99.99%)
Ultrafiltration	30–500	0.01–0.1µm	Turbidity (>99%); bacteria (>99.99%); TOC (20%)
Nano filtration	500–1000	200–400 Daltons	Turbidity (>99%); color (.98%); TOC (>95%); hardness (>90%); sulfate (>97%); virus (>95%)
Reverse osmosis	1000–5000	50–200 Daltons	Salinity (>99%); color and DOC (>97%); nitrate (85–95%); pesticide (0–100%); As, Cd, Cr, Pb, F removal (40–98%)

Low-cost alternative to conventional technologies such as reverse osmosis (RO) process can be used for efficient purification of drinking water, which can remove all sorts of non-volatiles..

CHAPTER 4
REVERSE OSMOSIS PROCESS

4. REVERSE OSMOSIS PROCESS

4.1 R.O BASIC PRINCIPLE:-

RO is a physical process that uses the osmosis phenomenon, that is, the osmotic pressure difference between the salt water and the pure water to remove the salts from water. RO is a pressure-driven membrane process where a feed stream flows under pressure through a semipermeable membrane, separating two aqueous streams, one rich in salt and other poor in salt. Water will pass through the membrane, when the applied pressure is higher than the osmotic pressure, while salt is retained. As a result, a low salt concentration permeate stream is obtained and a concentrated brine remains at the feed side.

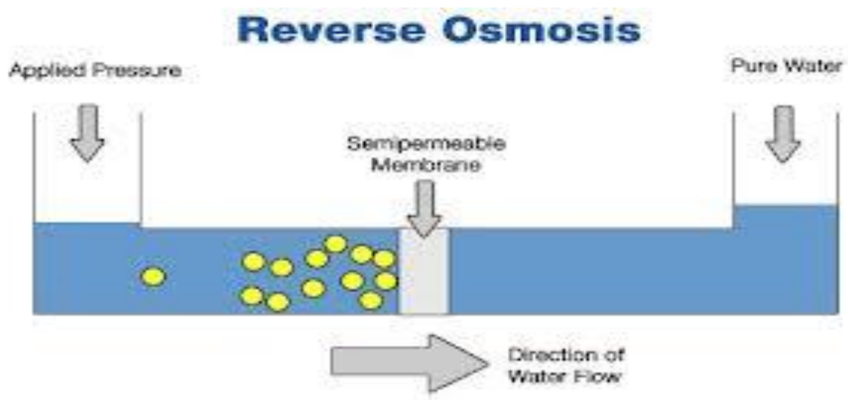


Fig 4.1- General concept of reverse osmosis

A typical RO system consists of four major subsystems: pretreatment system, high-pressure pump, membrane module, and post treatment system. Using a high-pressure pump, the pretreated feed water is forced to flow across the membrane surface. RO operating pressure ranges from 17 to 27 bars for brackish water and from 55 to 82 bars for seawater. Brackish groundwater has a much lower osmotic pressure than seawater; therefore, its desalination requires much less energy. Also, lower pressures found in brackish-water RO system permit the use of low-cost plastic components.

RO membranes do not have distinct pores that traverse the membrane and lie at one extreme of commercial available membranes. The polym8er material of membranes forms a layered, weblike structure, and water must follow a tortuous pathway through the membrane to reach the permeate side. The membrane manufacturers offer high salt rejection membranes for RO plants, and the membranes do not retain the initial salt rejection throughout the membrane's lifetime (up to 7 years with effective pretreatment). Temperature, salinity, target recovery, and cleaning methods can affect salt passage through normal membrane.

Brackish water RO plants tend to be smaller in production capacity than seawater RO plants, but a greater number of brackish water RO plants (48% of the total number of plants) are in operation worldwide than seawater RO plants (25%) as shown in Figure 4.1. The remaining desalination plants (27%) consist of other feed waters, including rivers, wastewater, and pure water.

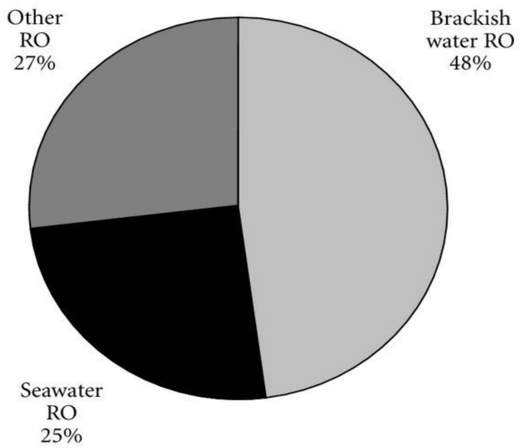


Figure 4.2: Percentage of RO desalination plant based on feed source of water in the world (other RO plant feed source: river, wastewater, and pure water

The main drawbacks of RO technology are the limited recovery and the environmental impact of rejected brines. Recovery and brine concentration are limited because increasing the brine concentration in RO would increase osmotic pressure and thus the energy consumption as well as scaling on the membrane surface. Recovery of the seawater RO plant is 35 to 45%, and brackish water RO plant is 75 to 90% reported in the literature. Hence the feed water concentration and characteristics play an important role in the RO system design. Recent innovations in brackish water RO plant design have stemmed from a combined need for inland desalination and reduced concentrate production or increased product water recovery. Increasing RO plant design size and environmental awareness have also influenced interest in alternative concentrate management. The key limiting factor to widespread use of inland desalination is the exorbitant cost of concentrate disposal. The ideal solution would be to further increase brackish water RO recovery, but membrane scaling limits RO systems. High recoveries (95–99%) typically seen in fresh water treatment plants cannot be achieved by RO plants commercially available today.

For seawater RO plants, the disposal method is usually discharge back into the same body of water, meaning that it is diluted into the large seawater body without influencing the feed water composition. In the brackish water RO plants, if the concentrate discharged to surface water, can change the salinity of the receiving water. The change in salinity can change the concentration of dissolved oxygen (DO) in the water and negatively affect aquatic life; the slandered limit for surface water discharge is a salinity difference of less than 10%. Also, the rejected brines contain the high concentration of toxic contaminants which have serious effect on the human life and agriculture. Hence, it needs to reduce the volume of the concentrate stream, ultimately to increase the recovery of the RO plant. It also affects the cost of product.

4.2 BLOCK DIAGRAM:-

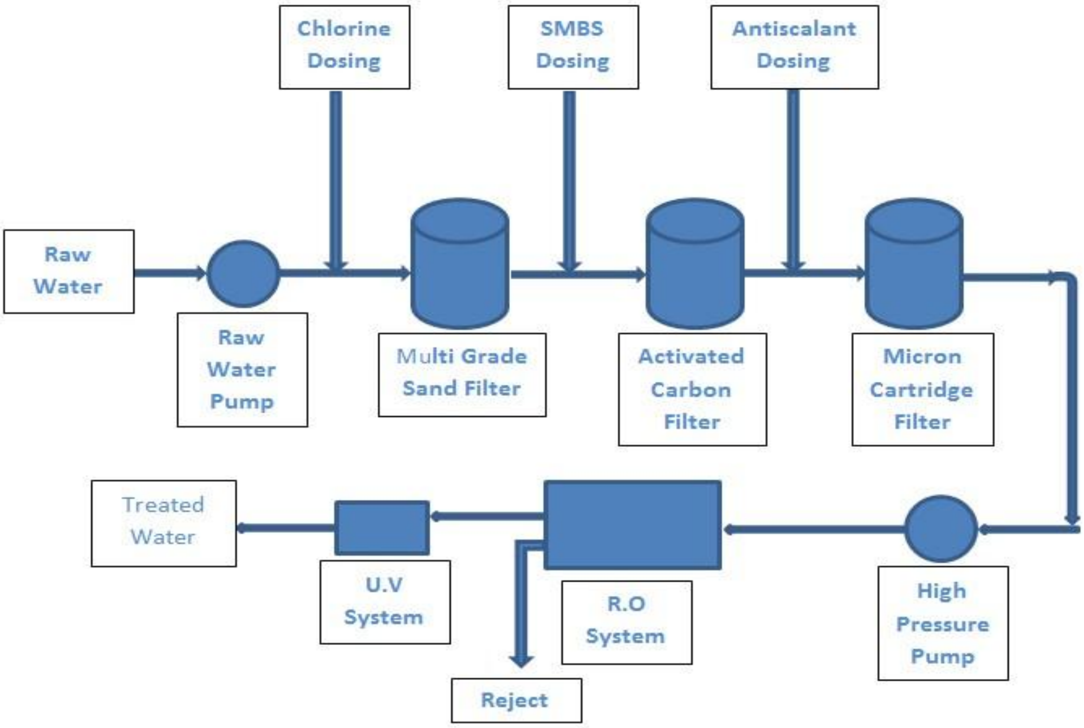


Figure 4.3:- Block Diagram of R.O Process

CHAPTER 5
PUMP USED IN R.O PROCESS

5. PUMP USED IN R.O PROCESS

5.1 INTRODUCTION:-

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps.

Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

Single stage pump - When in a casing only one impeller is revolving then it is called single stage pump.

Double/ Multi stage pump - When in a casing two or more than two impellers are revolving then it is called double/ multi stage pump.

The positive displacement principle applies in these pumps:

- Rotary lobe pump
- Progressive cavity pump
- Rotary gear pump
- Piston pump
- Diaphragm pump
- Screw pump
- Gear pump
- Hydraulic pump
- Rotary vane pump
- Peristaltic pump
- Rope pump
- Flexible impeller pump

5.2 RECIPROCATING PUMP:-

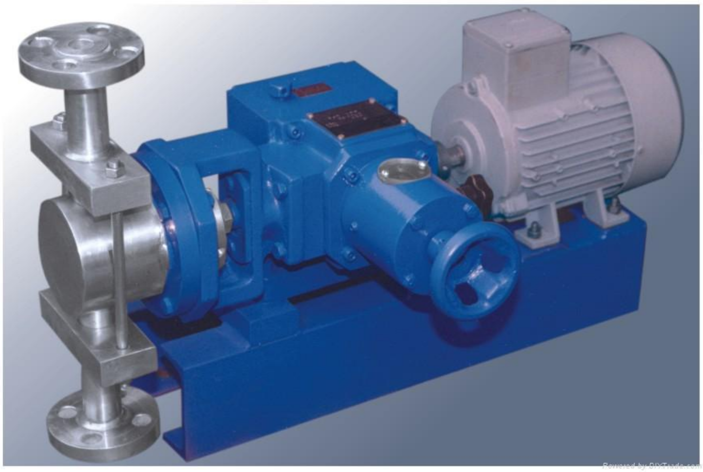


Figure 5.1: Reciprocating Pump

5.2.1 PRINCIPLE:-

Reciprocating pump operates on the principle of pushing of liquid by a piston that executes a reciprocating motion in a closed fitting cylinder.

5.2.2 DIAGRAM:-

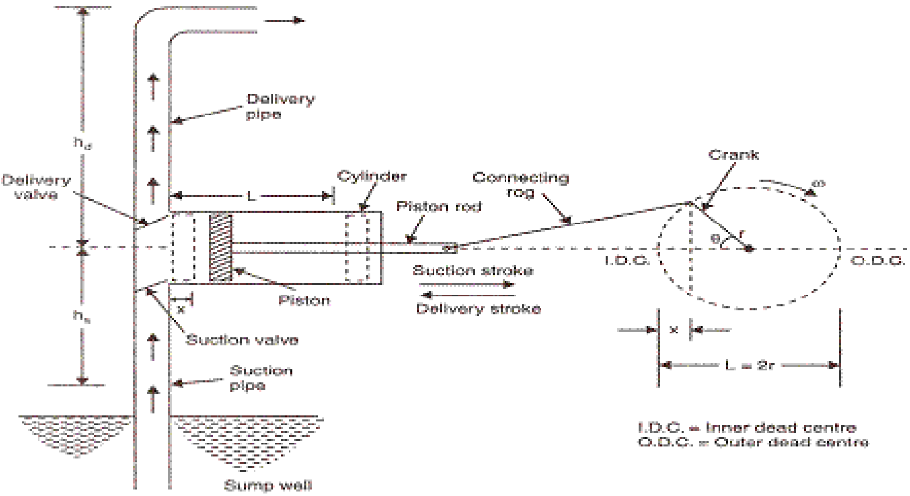


Figure 5.2: Reciprocating Pump Line Diagram

5.2.3 COMPONENTS OF RECIPROCATING PUMP:-

a) Piston or plunger:- a piston or plunger that reciprocates in a closely fitted cylinder.

b) Crank and Connecting rod:- crank and connecting rod mechanism operated by a power source. Power source gives rotary motion to crank. With the help of connecting rod we translate reciprocating motion to piston in the cylinder.

c) Suction pipe:- one end of suction pipe remains dip in the liquid and other end attached to the inlet of the cylinder.

d) Delivery pipe:- one end of delivery pipe attached with delivery part and other end at discharge point.

e) Suction and Delivery valve:- suction and delivery values are provided at the suction end and delivery end respectively. These values are non-return values.

5.2.4 WORKING OF RECIPROCATING PUMP:-

Operation of reciprocating motion is done by the power source (i.e. electric motor or I.C engine, etc). Power source gives rotary motion to crank; with the help of connecting rod we translate reciprocating motion to piston in the cylinder (i.e. intermediate link between connecting rod and piston). When crank moves from inner dead centre to outer dead centre vacuum will create in the cylinder. When piston moves outer dead centre to inner dead centre and piston force the water at outlet or delivery value.

Some Advantages of Piston Pumps

- Reciprocating pumps will deliver fluid at high pressure (High Delivery Head).
- They are 'Self-priming' - No need to fill the cylinders before starting.

Some Disadvantages of Piston Pumps

- Reciprocating pumps give a pulsating flow.
- The suction stroke is difficult when pumping viscous liquids.
- The cost of producing piston pumps is high. This is due to the very accurate sizes of the cylinders and pistons. Also, the gearing needed to convert the rotation of the drive motor into a reciprocating action involves extra equipment and cost.

- The close fitting moving parts cause maintenance problems, especially when the pump is handling fluids containing suspended solids, as the particles can get into the small clearances and cause severe wear. The piston pump therefore, should not be used for slurries.
- They give low volume rates of flow compared to other types of pump.

5.3 SUBMERSIBLE PUMP:-

Figure 5.3: Submersible Pump

A submersible pump (or sub pump, electric submersible pump (ESP)) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between pump and the fluid surface. Submersible pumps push fluid to the surface as opposed to jet pumps having to pull fluids. Submersibles are more efficient than jet pump.

5.3.1 WORKING PRINCIPLE:-

The submersible pumps used in ESP installations are multistage centrifugal pumps operating in a vertical position. Although their constructional and operational features underwent a continuous evolution over the years, their basic operational principle remained the same. Produced liquids, after being subjected to great centrifugal forces caused by the high rotational speed of the impeller, lose their kinetic energy in the diffuser where a conversion of kinetic to pressure energy takes place. This is the main operational mechanism of radial and mixed flow pumps.

The pump shaft is connected to the gas separator or the protector by a mechanical coupling at the bottom of the pump. When fluids enter the pump through an intake screen and are lifted by the pump stages. Other parts include the radial bearings (bushings) distributed along the length of the shaft providing radial support to the pump shaft turning at high rotational speeds. An optional thrust bearing takes up part of the axial forces arising in the pump but most of those forces are absorbed by the protector’s thrust bearing.

5.4 DOSING PUMP:-

Figure 5.4: Dosing Pump

A dosing pump is a small, positive displacement pump. It is designed to pump a very precise flow rate of a chemical or substance into either a water, steam or gas flow. A dosing pump will deliver this precise flow rate of chemical or other product by a number of different methods but it generally involves drawing a measured amount into a chamber and then injecting this volume of chemical into the pipe or tank being dosed. Dosing pumps are used in a variety of applications from agriculture, industry, manufacturing to medicine.

A dosing pump is generally quite small and is powered by either a small electric motor or air actuator. They are controlled either by an external control system or more commonly an internal pump controller that can alter the flow rate, the on/off function and also things like alarms and warnings for run dry, degassing and low product levels.

CHAPTER 6
R.O MEMBRANE

6. R.O MEMBRANE

6.1 HISTORY:-

The first recorded synthetic membrane was prepared in 1867 by Moritz Traube19. His most successful membrane was a precipitated film of copper ferrocyanide which he used to study osmosis. His initial success spawned several decades of investigations into the theory behind the thermodynamics and kinetics of the diffusion process. In 1963, Loeb and Sourirajan demonstrated asymmetric cellulose acetate membranes which exhibited relatively high flux and good salt rejection. A membrane is a thin, film-like structure that separates two fluids. Membranes are the largest single consumable cost factor in RO desalination Therefore; increasing membrane life will contribute significantly to lowering operating cost. Membranes most often require replacement because of reduced capacity, which in most cases is attributable to colloidal and/or biological fouling. Fouling is a direct result of either an inadequate feed source or pretreatment equipment.

The ideal membrane has the following characteristics:

- High water flux rate
- High salt rejection
- Tolerant to chlorine and other oxidants
- Resistant to biological attack
- Resistant to fouling by colloidal and suspended material
- Inexpensive
- Easy to form into thin films or hollow fibers
- Mechanically strong, e.g. tolerates high pressure
- Chemically stable
- Able to withstand high temperature

6.2 REVERSE OSMOSIS MEMBRANE COMPOSITION:-

6.2.1 CELLULOSE ACETATE MEMBRANE:-

The original cellulose acetate membrane was made from cellulose diacetate polymer. Current CA membrane is usually made from a blend of cellulose diacetate and triacetate. The membrane is formed by casting a thin film acetone-based solution of cellulose acetate polymer with swelling additives onto a non-woven polyester fabric. Two additional steps, a cold bath followed by high temperature annealing, complete the casting process. During casting, the solvent is partially removed by evaporation. After the casting step, the membrane is immersed into a cold water bath which removes the remaining acetone and other leachable compounds. Following the cold bath step, the membrane is annealed in a hot water bath at a temperature of 60 - 90°C.The annealing step improves the semi permeability of the membrane with a decrease of water transport and a significant decrease of salt passage. After processing, the cellulose membrane has an asymmetric structure with a dense surface layer of about 1000 - 2000 A (0.1 - 0.2 micron) which is responsible for the salt rejection property. The rest of the membrane film is spongy and porous and has high water permeability. Salt rejection and water flux of a cellulose acetate membrane can be controlled by variations in temperature and duration of the annealing step.

Cellulose acetate has a higher flux and a smaller area of membrane is therefore required. It is also resistant to small concentrations of free chlorine and may therefore be kept free of bacteria and also produce a product with residual chlorine in it to prevent subsequent re-growth.

Advantages

1. Low purchase cost
2. tolerant of chlorine in feed water

Disadvantages

1. Hydrolysis by acids and alkalies can lead to poor rejection.
2. Membrane susceptibility to biodegradation, so chlorine feed is often required.
3. Inferior salt rejection.
4. Narrow pH range (4-8).
5. Narrow temperature limits (0-35°C).
6. Subject to structural compaction and high operating pressures.
7. Lower permeability requires higher pressures and resulting operating costs.

6.2.2 COMPOSITE POLYAMIDE MEMBRANES :-

Composite polyamide membranes are manufactured in two distinct steps. First, a polysulfone support layer is cast onto a non-woven polyester fabric. The polysulfone layer is very porous and is not semipermeable; that is it does not have the ability to separate water from dissolved ions. In a second, separate manufacturing step, a semipermeable membrane skin is formed on the polysulfone substrate by interfacial polymerization of monomers containing amine and carboxylic acid chloride functional groups. This manufacturing procedure enables independent optimization of the distinct properties of the membrane support and salt rejecting skin. The resulting composite membrane is characterized by higher specific water flux and lower salt passage than cellulose acetate membranes. Polyamide composite membranes are stable over a wider pH range than cellulose acetate membranes. However, polyamide membranes are susceptible to oxidative degradation by free chlorine, while cellulose acetate membranes can tolerate limited levels of exposure to free chlorine. Compared to a polyamide membrane, the surface of cellulose acetate membrane is smooth and has little surface charge. Because of the neutral surface and tolerance to free chlorine, cellulose acetate membranes will usually have a more stable performance than polyamide membranes in applications where the feed water has a high fouling potential, such as with municipal effluent and surface water supplies.

The polyamide membrane can be used at a higher temperature (35 ^{o}C) than cellulose acetate (30^{o}C), it cannot tolerate chlorine but is not attacked by bacteria whereas some bacteria which can occur in surface water actually destroy cellulose acetate.

Advantages

1. Excellent hydrolytic resistance for greater membrane stability and membrane life.
2. Superior rejection of salts.
3. Superior organics rejection.
4. Strong membrane structure for durability.
5. Excellent membrane flux for higher productivity and lower pressures.
6. Compaction-resistant sub layers.
7. Wide operating pH range (2-11).
8. Wide operating temperature range (0-45°C).

Disadvantages

1. Limited tolerance to chlorine. Continuous chlorination causes attack on the polyamide barrier layer.

6.3 REVERSE OSMOSIS MEMBRANE MODULES:-

Membrane equipment for industrial scale operation of reverse osmosis is supplied in the form of modules. The area of membrane contained in these basic modules is in the range 1–20 m2. The modules may be connected together in series or in parallel to form a plant of the required performance. The most common types of membrane modules are shown in bellow.

6.3.1 HOLLOW FIBER MEMBRANE:-

The same basic spinning process is used for the preparation of hollow fiber membranes, which have an outer diamter of 50 to 100 µm. In hollow fiber membranes, the selective layer is on the outside of the fibers, which are installed as a bundle of several thousand fibers in a half loop with the free ends potted with an epoxy resin in a pressure tube.Its production is very cost effective and hollow fiber membrane modules can be operated at pressures in excess of 100 bars.

When operated with liquid solutions the modules do not tolerate any particals, macromolecules or other materials that may easily precipitated at the membrane surface. Therefore, an extensive pretreatment is required when hollow fiber membranes are used for the treatment of liquid mixtures. The main application of the hollow fiber module is today in reverse osmosis desalination of sea water and in gas separation. Both application require high operating pressures and low cost membranes which have a long useful life. In reverse osmosis, of sea water an extensive pretreatment of the sea water is required.

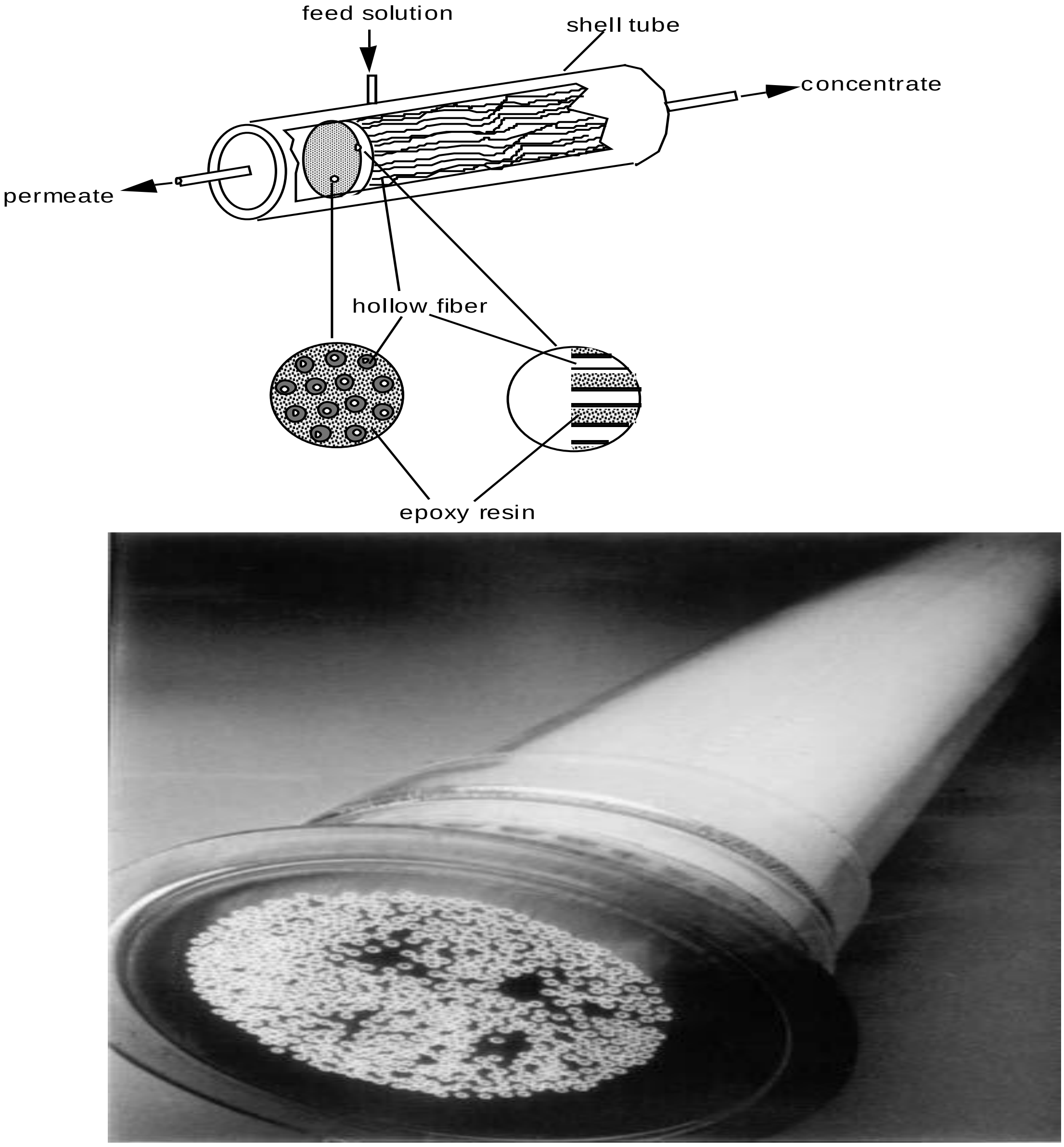


Fig 6.1: Schematic drawing illustrating the construction of a hollow fiber module

6.3.2 OPERATION:-

Hollow fiber devices operats by introducing the pressurized feed into the center tube, where it is distributed along the entire length of the permeator and flows radially outward around the outside of the fibers. The product water permeates through the fiber walls into the bore and exist through the tube sheet into a permeate port. The brine flows between the outside of the fiber bundle and the inside wall of the pressure vessel to a brine port. The permeate exits at low pressure, but the brine undergoes a minimal pressure drop and is available to feed successive stages for additional recovery and greater system capacity.

Advantages

1. High membrane surface area to volume ratio
2. High recovery in individual permeators
3. Easy to troubleshoot
4. Easy to change bundle in the field

Disadvantage

1. Sensitive to fouling by colloidal and suspended material

CHAPTER 7
PRE-TREATMENT

7. PRE-TREATMENT

An excessively advanced pretreatment system significantly increases the installation cost. Conventional pretreatment typically consists of acid addition, coagulant/flocculent addition, disinfection, media filtration, and cartridge filtration. Although conventional pretreatment has been widely used for seawater and brackish water RO plants, variation feed water can cause variation in conventional pretreatment effectiveness. Often, colloids and suspended particles pass through conventional pretreatment and contribute to remove RO membrane fouling.

Below are some pre-treatment solutions for RO systems that can help minimize fouling, scaling and chemical attack.

7.1 MULTI GRADE SAND FILTER (MGF):-

A Multi Grade Sand Filter is used to help prevent fouling of an RO system. A MGF typically contains three layers of media consisting of anthracite coal, pebbles, sand and garnet, with a supporting layer of gravel at the bottom. These are the Medias of choice because of the differences in size and density. The filter media arrangement allows the largest dirt particles to be removed near the top of the media bed with the smaller dirt particles being retained deeper and deeper in the media. This allows the entire bed to act as a filter allowing much longer filter run times between backwash and more efficient particulate removal.

A well operated Multi-Grade Sand Filter can remove particulates down to 15-20 microns. A Multi Grade Sand Filter that uses a coagulant addition (which induces tiny particles to join together to form particles large enough to be filtered) can remove particulates down to 5-10 microns. To put this in perspective, the width of a human hair is around 50 microns. A multi Grade Sand filter is suggested when the Silt Density Index (SDI) value is greater than 3 or when the turbidity is greater than 0.2 NTU. There is no exact rule, but the above guidelines should be followed to prevent premature fouling of RO membranes. It is important to have a 5 micron cartridge filter placed directly after the MGF unit in the event that the under drains of the MGF fail. This will prevent the MGF media from damaging downstream pumps and fouling the RO system.

7.1.1 WORKING PRINCIPLE:-

The MGF works on principle of retention and removal of physical impurity in a graded manner through Voids of the filtering media.

7.1.2 ADVANTAGES OF MULTI-GRADE SAND FILTER:-

- Flow rates: 15-30 m/h for treating water containing 50-25 ppm suspended solids
- Higher specific flow rate than conventional down flow filters thereby saving on Space & cost.
- Filtrate with less than 5 ppm can be obtained
- High specific velocity
- Raw water back-washes the filter
- Low maintainability

7.2 MICRON CARTRIDGE FILTER (MCF):-

The 5 micron cartridge filter is the most versatile and least expensive filter cartridge in industry application from drinking water to pre-treatment for high purity water system.Micron cartridge filter are essentials end filters, to get a super clarity & extra sparkle to water that is already filtered by a conventional sand filter. Very fine suspended impurities, colloidal matter, chlorine traces sand particles etc. which escape entrapped in sand filter, are easily separated in these filters. They will not remove bacteria and viruses, because these are smaller than the pore size available. In addition simple filtration will not remove dissolved contaminants such as color or dissolved metals. These would need to be removed by a different process, such as reverse osmosis or Nano, Ultra, micro filtration. Micron Cartridge Filters are in line units capable of working at a maximum line pressure of 5 kg./sq. cm. and maximum recommended temperature is 100F.

7.2.1 WORKING:-

Water is admitted in the fitter, chamber as indicated & surrounds all cartridges .Through very fine apertures of cartridges, it seeps into the interior of each cartridge & then descends down to collecting chamber, from which it goes out. It is necessary to clean the cartridges of the accumulated impurities after certain interval of time. For this, by opening the top lid, all the cartridges are to be physically taken out a brushed carefully using soft brush or cloth under flow of water.

7.3 ACTIVATED CARBON FILTER (ACF):-

ACF is used for both removing organic constituents and residual disinfectants (such as chlorine and chloramines) from water. ACF media is made from coal, nutshells or wood. Activated carbon removes residual chlorine and chloramines by a chemical reaction that involves a transfer of electrons from the surface of the ACF to the residual chlorine or chloramines. The chlorine or chloramines ends up as a chloride ion that is no longer an oxidizer.

The disadvantage of using a ACF before the RO unit is that the ACF will remove chlorine quickly at the very top of the ACF bed. This will leave the remainder of the ACF bed without any biocide to kill microorganisms. An ACF bed will absorb organics throughout the bed, which is potential food for bacteria, so eventually a ACF bed can become a breeding ground for bacteria growth which can pass easily to the RO membranes. Likewise, a ACF bed can produce very small carbon fines under some circumstances that have the potential to foul an RO.

CHAPTER 8
POST-TREATMENT

8. POST-TREATMENT

8.1 ULTRAVIOLET SYSTEM:-

UV disinfection of municipal water and waste water is becoming increasing popular for a variety of reasons. UV radiation from ultraviolet water systems alone is not suitable for water with high levels of suspended solids, turbidity, color, or soluble organic matter. These materials can react with UV radiation, and reduce disinfection performance. Water turbidity makes it difficult for the ultraviolet radiation to penetrate water. UV is installed after reverse osmosis system. Ultraviolet radiation can be used as a polishing step to sterilize and disinfect water.Sunlight has long since been known to kill micro-organisms. The rays from the sun contain the UV *spectrum used in Ultraviolet Water Treatment Systems although at much lower intensities. It is also referred to as either the Germicidal Spectrum or Frequency. The frequency used in killing micro-organisms is 254 nanometers (nm). The UV lamps used are designed specifically to have the highest amount of UV energy at this frequency.The UV disinfection process is a non-chemical method for destroying microorganisms by altering their genetic material, and rendering them unable to reproduce.

The advantages of UV disinfection have been realized and the technology successfully employed worldwide for decades. The primary advantage of being able to effectively control all types of microorganisms, including those which are chlorine-resistant, without chemicals has numerous benefits for municipal, industrial, commercial and aquatics customers. In addition to disinfection, UV is also very effective for TOC removal, destruction of chlorine, chloramines and ozone.

1. No known toxic or significant nontoxic by-products
2. No danger of overdosing
3. Does not require storage of hazardous material
4. Adds no smell to the final water product
5. Requires very little contact time

CHAPTER 9
DESIGN CALCULATION

9. DESIGN CALCULATION

9.1 DESIGN PARAMETERS:-

- **Pressure (P) = 50 bar**
- **Discharge(Flow Rate) (Q_a) = 6 m^3/hr**
- **Velocity of Flow (V) = 1.5 m/s**

9.2 DESIGN OF HIGH PRESSURE PUMP (RECIPROCATING PUMP):-

P = 50 bar

P = ρ g h

$50\times10^5=1025\times9.81\times H$

H=500m

9.2.1 SUCTION AND DELIVERY PIPE:-

Q_a = 6 m^3/hr

Q_a =$1.722\times10^{\wedge-3}$ m^3/sec

V =1.5m/sec

$\eta_v = Q_a/Q_t$

$Q_t = 1.79\times10^{-3}$ m3/sec

$Q_t = A\times V$

D = 0.039 m = 39.02mm

Selecting standard pipe

OD = 42.16mm

ND = 40mm

Schedule = 80

$\eta_o = \eta_m\times \eta_{mano}\times \eta_{vol}$ (all efficiency 96% assumption)

η_o = 0.884

$\eta_o = \rho \times g \times Q_t \times H$ / power

Power = 10.14 KW

Power = 11 KW

Speed=1000 rpm (PSG 5.126)

9.3 DESIGN OF RECIPROCATING/PISTON PUMP:-

9.3.1 DESIGN OF CYLINDER:-

CYLINDER LINER:-

BORE AND LENGTH (D & L):-

Pi = Pm×L×A×N×K

K = 1

N =1000rpm

$Q = (\pi/4) \times d^2 \times L \times (N/60)$ (L=D Assume)

D = L = 55mm

BP = 11 KW = 15 HP (input power to pump)

η_m = IP / BP

IP = 10.45 KW

IP = P_m×L×A×N×K

P_m = 58.05 bar = 5.8mpa

LINER THICKNESS:-

$t_l = \frac{D}{2}\left(\left(\frac{Sd+0.4Pm}{Sd-1.3Pm}\right)^{\frac{1}{2}} - 1\right)$ (Sd=90 mpa FOR CARBON STEEL)

t_l =5mm

Checking pressure stress criteria

$Sx = (Pm \times D) / (2 \times t_l)$ (Sx = 80 to 100 mpa for steel)

Sx=31.9 mpa <100 mpa Safe

DESIGN OF CYLINDER BLOCK:-

Inner Dia of cylinder

Di=D+2Ti = 65mm

Outer Dai of cylinder

Do=Di+2Ti = 75mm

Swept Volume = 1.306×10^-4

r_c = Vs+Vc/Vc

Vc = 1.451×10^-5 m3

Total Length of liner

$L = Lc+L_l+L$ = 7+7+55 = 69mm

Length of cylinder = 69 mm

9.3.2 DESIGN OF PISTON:-

THICKNESS OF PISTON CROWN OR HEAD:-

t_c = 0.032D+1.5 = 3.26 = 5mm

Checking $t_c = D(3/16 \text{ x } 5.8/Sd)^{1/2}$

Sd = 131.58 mpa <150 mpa safe

PISTON RING:-

Radial thickness of piston ring $t_r = D(3Pw/Sd)^{1/2}$

t_r = (0.04 -0.045)D (empirical relations)

t_r = 2.2mm

Checking for t_r

Sd = 45.937 < 150 mpa design is safe

NO OF PISTON RING:-

$n = 0.4\sqrt{D}$ n = 3

AXIAL THICKNESS OF PISTON RING:-

t_a =(0.6 – 1 tr) t_a = 2.2mm

PISTON SKIRT LENGTH:-

0.8D = 44 mm

PISTON BARREL:-

max thickness of piston barrel = t_{b1} = 8.75 mm

piston wall thickness t_{b2} = 2.625mm

Total length of piston 50 mm

DESIGN OF PISTON PIN:-

Length of piston pin = 49.5 mm

length of pin in connecting rod = 16.5mm

outer dia of pin = 19.25mm

Inner dia of pin = 11.55 mm

9.3.3 DESIGN OF CONNECTING ROD:-

Gas pressure

$Fg = (\pi /4) \times D^2 \times Pm$

Fg = 13.799 kN

Inertia force

$Ft = W_e \times w^2 \times Rc \times (1+1/n)$

We = (W1+W2+W3) × Ap (W1 =W2 =W3 = 300 kg/m^2)

We = 2.138 kg

Crank radius Rc = stroke / 2 = 27.5 mm

n = length of connecting rod / crank radius

L_{cr} = 110 mm

w = (2×π ×N) / 60

w = 104.72 rad/ sec

Fi = 805.95 N

Normal force acting on connecting rod

Fn = Fg – Fi

Fn =12.993 KN

Critical load for buckling

Fcr = Fc×Fs

Fcr = 63.495 kN

Cross section of connecting rod

Fcr = Sd×As / 1+1/a×(Lc/k)^2

thickness of connecting rod = t=10mm

DIMENSIONS OF SMALL EYE END:-

Inside dia of small eye end = 19.25 mm

Length of small eye end = 16.5 mm

Bush dia (d_b) = 23.25 mm

Outer dia of small end = 34.875 mm

BIG EYE END DIMENSIONS:-

Dia of crank pin = 38.5 mm

length of crank pin = 44 mm

Dia of bush = 42.5 mm

Outside dia of big eye end = 56.5 mm

Span of big eye end 74.5 mm

flange thickness = 6 mm

Checking bearing stress

σ_{br} = Fmax/ A = 8.14 mpa < 20 mpa safe

9.3.4 DESIGN OF CRANK SHAFT:-

Dia of crank shaft = 3805 mm

Length of crank shaft = 74.5mm

Height = 9.625 mm

Width = 46.5 mm

Dm = 45mm

Length of main shaft = 70 mm

9.4 DESIGN OF COUPLING:-

Selecting muff coupling

D = 2×dia of shaft

D = 2×45 = 90 mm

L = 3.5 × dai of shaft

L = 157.5 mm

Material cast iron

σ_u = 60 Mpa

σ_t = 30 Mpa

τ = 15 Mpa FOS = 2

$T = (\pi / 16) \times \tau \times (D^4 - ds^4 / D)$

$P = (2\times\pi\times N\times T) / 60$

T = 105.04 N.m

$\tau = 0.512\ N/mm^2 < 15$ mpa design is safe

9.5 SELECTION OF BEARING:-

Radial load acting on bearing

Fr = P / Vm

Vm = πDN /60

Vm = 2.356 m/sec

Fr = 466.8 KN

Equivalent load

Assuming pure radial load

$P_{eq} = V\times Fr\times S\times Kt$

P_{eq}= 700.2 Kgf

Life of bearing

Assuming a life of 3 years

$(L90)_{hrs}$ = 14400 hrs

$(L90)_{mr}$ = 864 million rev

Dynamic load carrying capacity

C = 6668.98 kgf

NOW SELECTING STANDARD BEARING PSG 4.12

BEARING NO 6024

CHAPTER 10
COMPONENT DETAILS

10. COMPONENT DETAILS

10.1 RAW WATER STORAGE TANK:-

Manufacturer	Sintex
Model	CCWS-500.01
Capacity	5000 liters
Diameter	78.7 inches (1.998 m)
Length	76.3 inches (1.938 m)
Manhole Diameter	37 inches (0.939 m)
Price	**₹ 46339**

Table 10.1 Raw Water Storage Tank

10.2 SUBMERSIBLE PUMP:-

Manufacturer	Tsurumi
Model	80SFQ 21.5 Series
Flow Rate	Upto 70.8 m^3/hour
Maximum Head	Upto 24.6 m
Maximum Temperature	40 ^{0}C
Motor Power	1.5 kw
Weight of Pump	36 kg
Price	**₹ 123740**

Table 10.2 Submersible Pump

10.3 FLANGE:-

Model	BS 4504 PN64 DN40 Flange
Nominal Diameter	40 mm
Outer Diameter	130 mm
Thickness	16 mm
P.C.D	100 mm
No. of holes	4
Bolt size	M12
Bolt Length	55 mm

Table 10.3 Flange

10.4 BEARING(D.G.B.B) :-

Bearing No.	SKF6024
Series	60
Diameter of Bearing	120mm
C_o (Static Load Carrying Capacity)	6700 kgf
C (Dynamic Load Carrying Capacity)	6550 kgf
Mass of Bearing	2.12 kg

Table 10.4 Bearing

10.5 COUPLING(MUFF COUPLING):-

Diameter	90 mm
Length	157.5 mm

Table 10.5 Coupling

10.6 HIGH PRESSURE RECIPROCATING PUMP:-

Manufacturer	Vino Technical Services
Pressure	Upto 100 bars
Capacity	500 to 30000 LPH
Motor Speed	1450
Motor Power	11 KW
Price	**₹ 50,000**

Table 10.6 High Pressure Pump

10.7 TRUCK:-

Manufacturer	Ashok Leyland
Model	3118L 5200/COWL
Width	2432 mm
Length	9745 mm

Table 10.7 Truck

10.8 MEMBRANE:-

	Membrane Element	ESPA2-LD
Performance:	Permeate Flow:	10,000 gpd (37.9 m^3/d)
	Salt Rejection:	99.6 % (99.5 % minimum)
Type	Configuration:	Spiral Wound
	Membrane Polymer:	Composite Polyamide
	Membrane Active Area:	400 ft^2 (37.1m^2)
	Feed Spacer:	34 mil (0.864 mm)
Application Data	Maximum Applied Pressure:	600 psig (4.16 MPa)
	Maximum Chlorine Concentration:	< 0.1 PPM
	Maximum Operating Temperature:	113 F (45 C)
	pH Range, Continuous (Cleaning):	2-11 (1-13)*
	Maximum Feedwater Turbidity:	1.0 NTU
	Maximum Feedwater SDI (15 mins):	5.0
	Maximum Feed Flow:	75 GPM (17.0 m^3/h)
	Minimum Ratio of Concentrate to Permeate Flow for any Element:	5:1
	Maximum Pressure Drop for Each Element:	10 psi

Table 10.8 Membrane

CHAPTER 11
COST CALCULATION

11. COST CALCULATION

11.1 TOTAL CAPITAL INVESTMENT:-

Component	Cost(₹)	Quantity	Total Cost(₹)
Submersible Pump	1,23,740	1	1,23,740
Storage Tank	46,339	1	46,339
Multi Grade Sand Filter	35,500	1	35,500
Chlorine Dosing Pump	10,000	1	10,000
SMBS Dosing Pump	10,000	1	10,000
Activated Carbon Filter	45,000	1	45,000
Antiscalent Dosing Pump	10,000	1	10,000
Dosing Tank	1400	3	4200
Micron Cartridge Filter	400	1	400
High Pressure Pump	50,000	1	50,000
Pressure Gauge	900	2	1800
Flow Meter	5255	5	5255
Total			3,63,000
RO Membrane	31,160	5	1,60,000
Total			5,23,000

Table 11.1: Total Capital Investment

Working capital is 20 % of total equipment cost = 0.20 X 523000

= 1,04,600 /-

Total capital investment = equipment cost + working capital

= 523000 + 104600

= **6,27,600 Rs /-**

11.2 PRODUCTION COST:-

11.2.1 MEMBRANE DEPRECIATION:-

Straight line method

$$\text{Depreciation} = \frac{\text{cost} - \text{scrap value}}{\text{No of year}}$$

Scrap value for membrane is zero and generally life of membrane is 3 to 5 year

Depreciation = 160000 / 3

= **53,333 Rs /-**

11.2.2 OTHER EQUIPMENT DEPRECIATION:-

Straight line method

$$\text{Depreciation} = \frac{\text{cost} - \text{scrap value}}{\text{No of year}}$$

Scrap value is 10 to 15 % of capital cost of equipment, life of equipment is 10 to 15 year and rate of interest is 10 %

Scrap value = 0.10 X 363000

= 36,300 /-

$$\text{Depreciation} = \frac{(363000 - 36300)}{10}$$

= **32670 Rs/-**

Total depreciation = 53333 + 32670

D = **86,003 Rs /-**

11.2.3 ANNUAL LABOUR COST:-

There are 2 person are working on this plant, per person salary is around 10,000 Rs /- per month.

Annual labor cost = 2 X 10000 X 12

= **240,000 Rs /-**

11.2.4 MAINTENANCE COST:-

Maintenance cost is 10 % of other equipment total cost excluding membrane cost.

Maintenance cost = 0.10 X equipment cost

= 0.10 X 363000

= **36300 Rs /-**

11.2.5 CHEMICAL COST:-

Chlorine (lit) per day = 3.1

Chlorine per year = 3.1 x 365 = 1131.5

Sodium hypochlorite (NaoCl) density = 1 kg/lit

Chlorine per year = 1131.5 x 1

= 1131.5 kg / yr

Annual cost of chlorine = chlorine per year x cost per kg

= 1131.5 x 20

= **22630 Rs/-**

HCL calculation is same as chlorine calculation; HCL density is 1.19 kg/lit

HCL per year = 273.75 x 1.19

= 325.7625 kg / yr

Table 11.2: shows the detail cost calculation of chemicals used in R.O.

Sr. no	Chemicals	Chemical per day	Chemical per year	Cost per kg	Total cost per year
1	Chlorine	3.1	1131.5	20	22630
2	Antiscalant	0.75	273.75	240.45	65823.19
3	SMBS	0.76	277.4	60	16644
4	HCL	0.75	273.75	8	2606.1
5	NAOH	0.24	87.6	60	5256
	Total cost	____________	__________	________	1,12,959.28

Annual cost of chemicals is = **1,12,595.28 Rs /-**

11.2.6 CONSUMABLE COST:-

Consumable used in R.O. plant are Activated carbon and four different types of sand. sand prize is same for all four types of sand 4.3 Rs/- per kg. And carbon is 47 Rs/- per kg. We had already calculated required sand and carbon.

Activated carbon = 272.76 kg

Annual cost of activated carbon = 272.76 x 47

= 12819.72 /-

Total sand required = 714.1478 kg

Annual cost of sand = 714.1478 x 4.3

= 3070.83554

Annual cost of consumable = carbon cost + sand cost

= 12819.72 + 3070.83554

= **15,890.556 Rs /-**

11.2.7 ELECTRICAL COST:-

One unit = 10 Rs/-

Table 11.3: show the total kilowatt power required per element

Sr. no	Electric consumable elements	KW power consumed per element
1	Raw water pump	1.5
2	High pressure pump	11
3	Dosing pump (4)	0.2
	Total KW consumed	12.7

Total working hours per year = 20x300

= 6000 hours

Annual KW power required = 12.7 x 6000

= 76200

Annual electrical cost = 76200 x 10

= **7,62,000 Rs /-**

11.3 TOTAL ANNUAL PRODUCTION COST

Table 11.4: show total production cost

Sr. no	Elements	Annual cost
1	Membrane depreciation	54,000
2	Other depreciation cost	33,000
3	Labor cost	2,40,000
4	Chemical cost	1,12,000
5	Electrical cost	7,62,000
6	Consumable cost	16,000
7	Maintenance cost	36,500
	Total	12,53,500/-

Total annual production cost = **12,53,500 Rs /-**

Total annual production

Flow rate per m3= 4 m^3 / hr

Flow rate per year = 4 x 6000

= 24,000 m^3/year

Total annual production = **32, 000 Rs/-**

Water cost per m3 = $\frac{\text{Annual production cost}}{\text{Annual production}}$

= $\frac{12,53,500}{24000}$

= **52.22 Rs /-**

Water cost per lit = **0.052 Rs /-**

= 5.2 paise/lit

Water cost for this project is 6 paisa/lit.

CHAPTER 12
FUTURE SCOPE

12. FUTURE SCOPE

- The ground water reverse osmosis technology would be further improved by the development membrane element that are less prone to fouling, operate at lower pressures, and require less pre-filtration and by introduction of highly efficient energy recovery technologies that are simpler to operate than the existing technologies.

- Future work can also be done on brine (high TDS) disposal of Reverse Osmosis Process which is harmful for and aquatic life when is send to sea water or lack.

- Energy recovery from disposed water

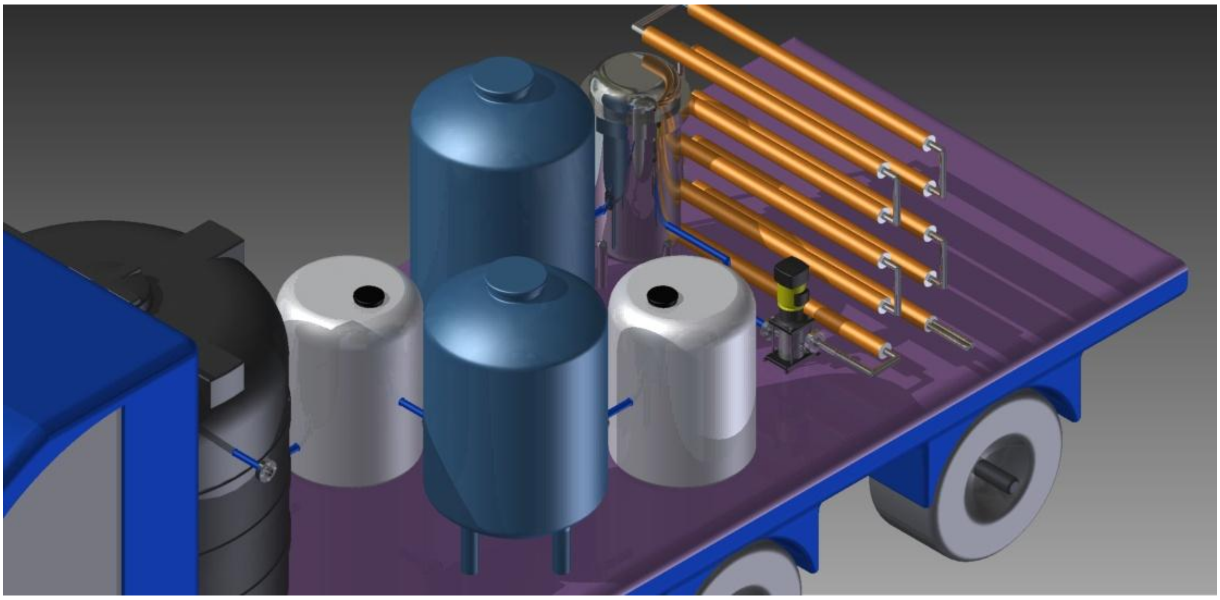
- Membrane development for Indian condition & sturdy membrane development.

- Development of membrane element that operate at lower pressures, and require less pre-filtration.

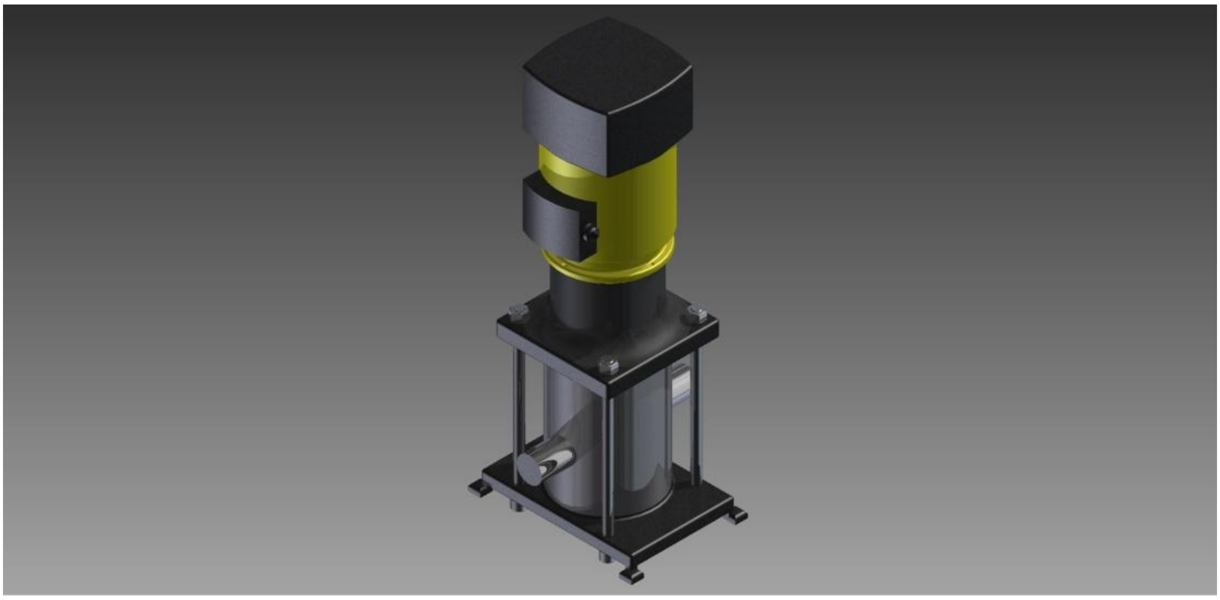
CHAPTER 13
MODELING

13. MODELING

13.1 RO PLANT:-

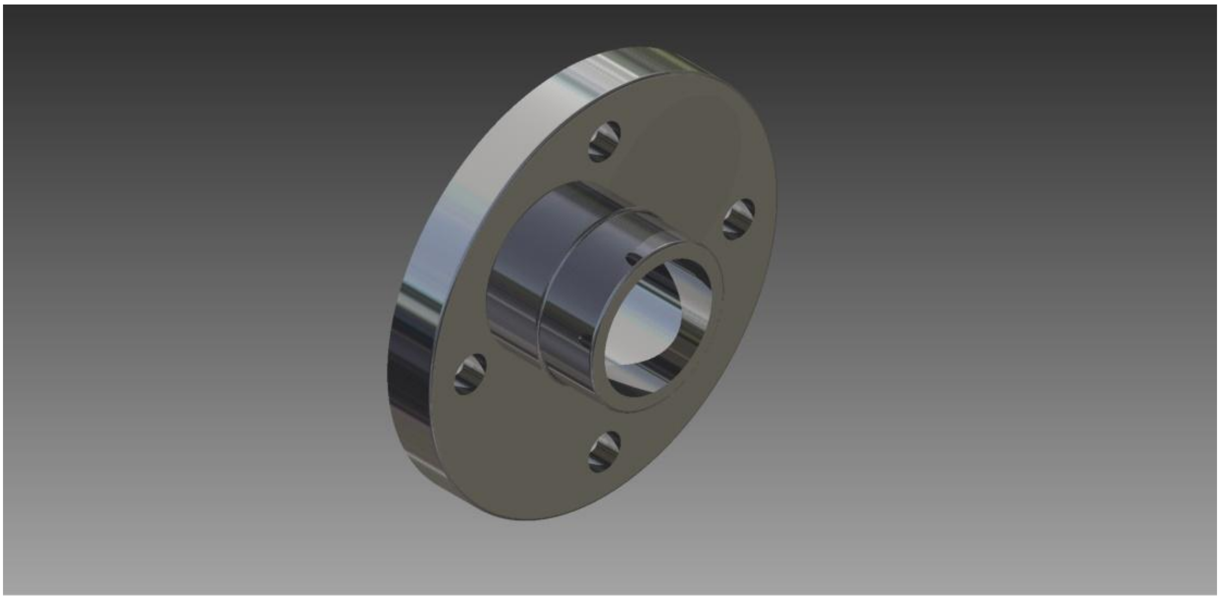


13.2 HIGH PRESSURE PUMP:-

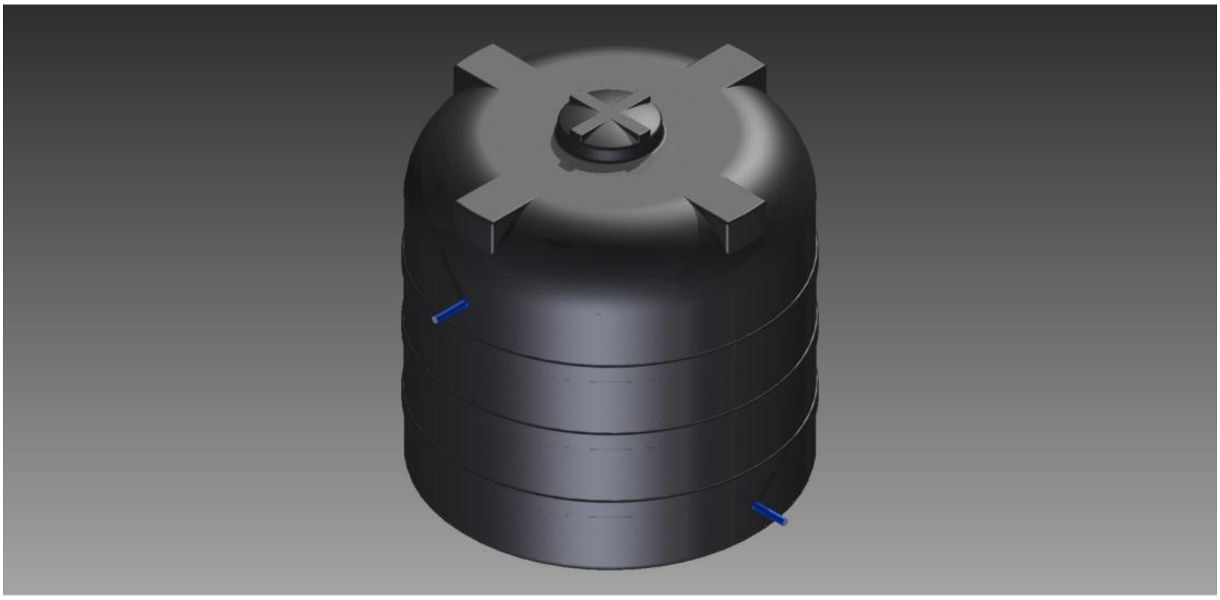


13.3 SUBMERSIBLE PUMP:-

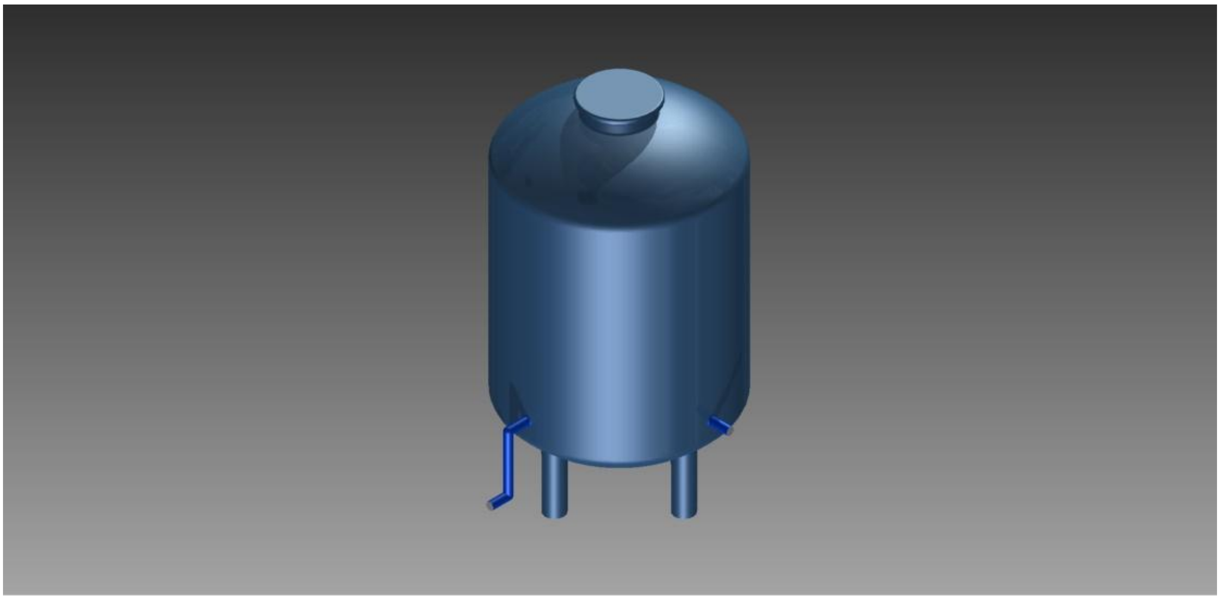
13.4 FLANGE:-



13.5 TANK:-

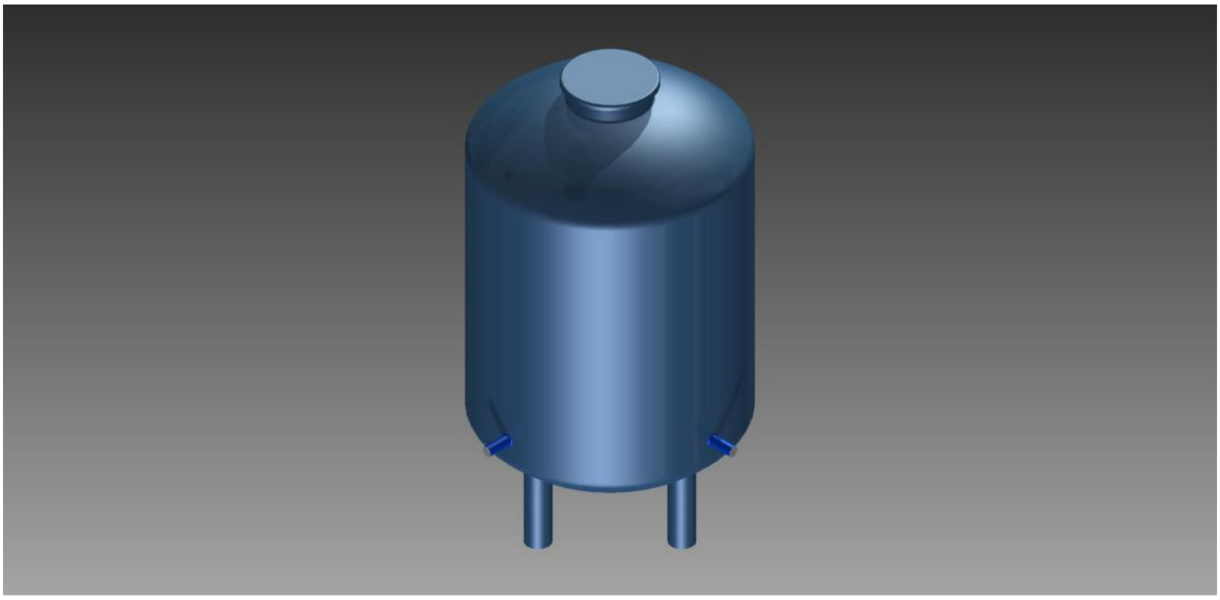


13.6 ACTIVATED CARBON FILTER:-

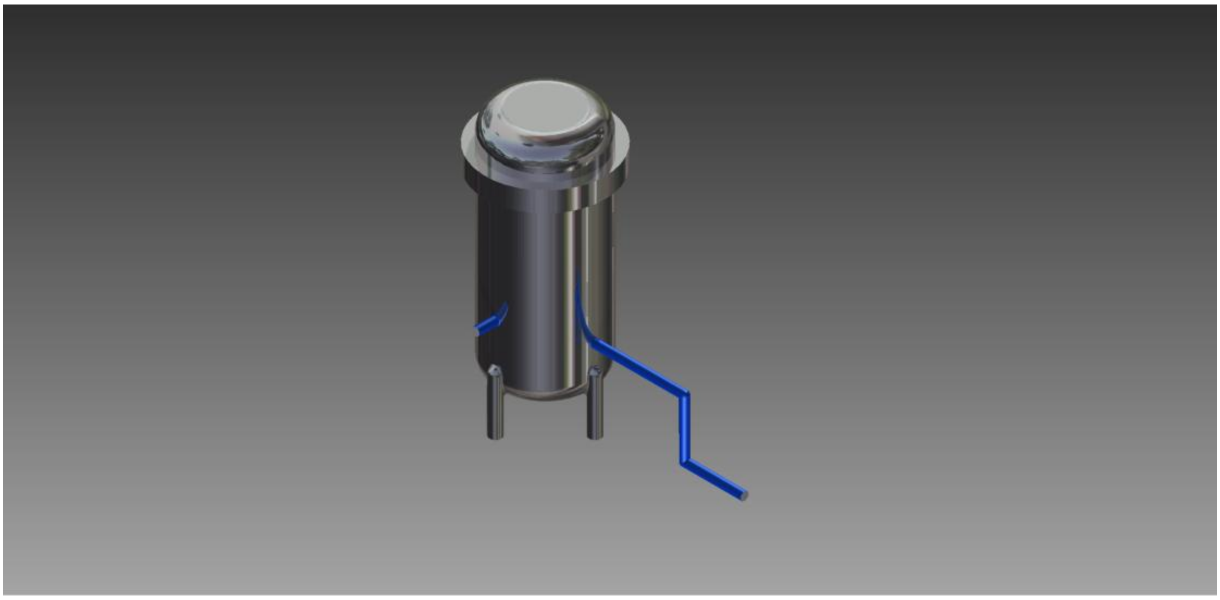


13.7 DOSING TANK:-

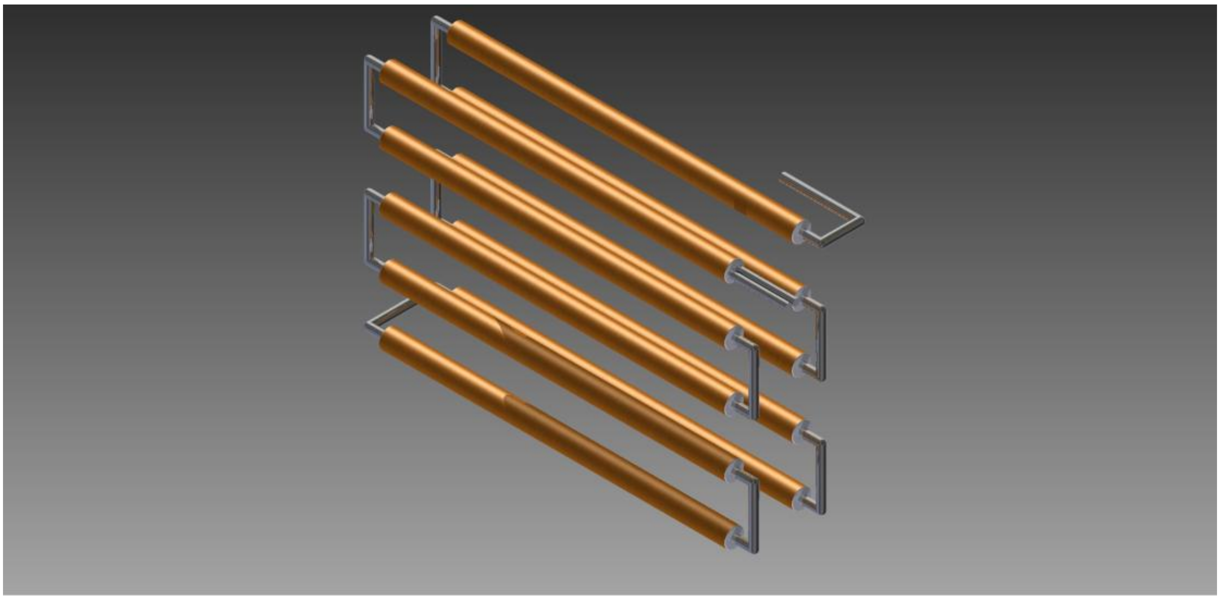
13.8 MULTI GRADE SAND FILTER:-



13.9 MICRON CARTRIDGE FILTER:-



13.10 MEMBRANE:-



CHAPTER 14
REFRENCES

14. REFRENCES

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