MAULANA AZAD

NATIONAL INSTITUTE OF TECHNOLOGY, BHOPAL

PROJECT REPORT

Based on Project:

"PEDAL – POWERED PISTON DRIVEN REVERSE OSMOSIS"

Under the Guidance of :

Dr. Amit Telang

Professor, Mechanical Department

MANIT Bhopal

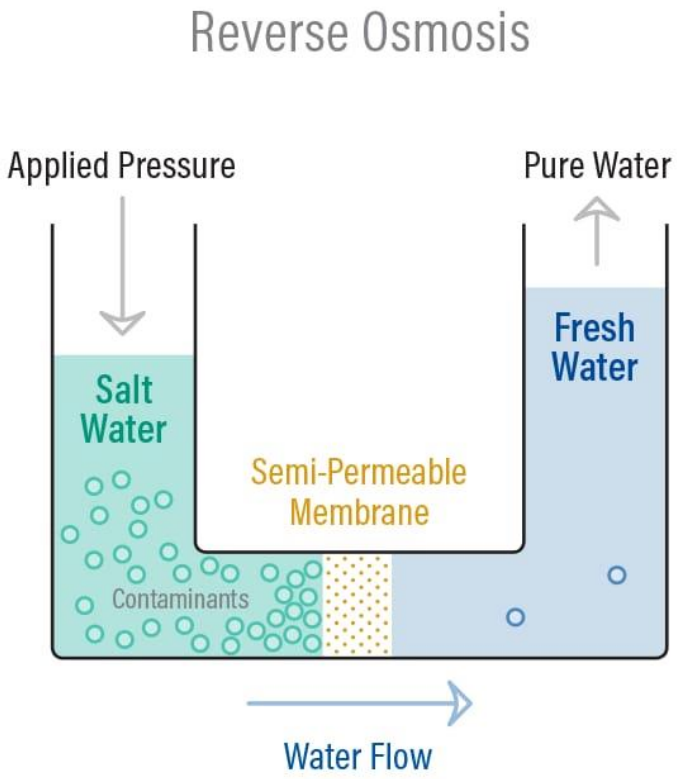
Mukti Choudhary	Mohammad Aman	Riddhi Dixit	Prince Choudhary
2211601242	2211601230	2211601206	2211601142

INDEX

1. Introduction

1.1 Reverse Osmosis:

Reverse osmosis (RO) is a water purification process that uses a partially permeable membrane to remove ions, molecules, and larger particles from drinking water. It works by applying pressure to the water, forcing it through the membrane, which allows only the water molecules to pass through while contaminants are left behind. This process is commonly used in households, industries, and desalination plants to produce clean, potable water.



1.2 RO Water Purification System

A reverse osmosis (RO) water purifier is a device that utilizes reverse osmosis technology to filter water and remove impurities. The working of RO water purifier is as follows :

1. **Pre-filtration**: Before reaching the RO membrane, the water often passes through pre-filters to remove larger particles, sediment, chlorine, and other substances that could potentially damage or clog the membrane.

2. **Reverse Osmosis**: The pre-filtered water is then pressurized and forced through a semipermeable membrane in the RO module. This membrane allows only water molecules to pass through, while contaminants such as dissolved salts, minerals, heavy metals, bacteria, and viruses are left behind and flushed away as waste.

3. **Post-filtration**: After passing through the RO membrane, the water may go through additional filters or treatments to further improve its quality and taste. This can include activated carbon filters to remove any remaining odors, tastes, or residual chemicals.

4. **Storage and Dispensing**: The purified water is stored in a separate tank within the RO system until it is needed. When a user opens the tap or dispenser, the purified water is released for consumption.

5. **Reject Water**: During the filtration process, a portion of the water is rejected and flushed away as waste along with the

contaminants. This reject water helps to maintain the effectiveness of the RO membrane by carrying away accumulated impurities.

1.3 Components of a RO Water Purifier

A typical reverse osmosis (RO) water purifier consists of several key components:

1. **Sediment Pre-filter**: This filter removes larger particles, sediment, and debris from the water before it enters the RO membrane, helping to prevent clogging and prolonging the lifespan of the membrane.

2. **Carbon Pre-filter**: Often, there's a carbon pre-filter which removes chlorine, organic compounds, and other chemicals that could damage the RO membrane or affect the taste and odor of the purified water.

3**. Reverse Osmosis Membrane**: The heart of the system, the RO membrane, is a semipermeable membrane that allows only water molecules to pass through while blocking contaminants such as dissolved salts, minerals, heavy metals, bacteria, and viruses.

4. **Post-carbon Filter**: After the water passes through the RO membrane, it may go through another activated carbon filter to further improve its taste and odor by removing any residual impurities.

5. **Storage Tank**: Purified water is collected and stored in a storage tank until it is needed. These tanks vary in size depending on the system's capacity and can typically hold several gallons of purified water.

6. **Faucet or Dispenser**: A dedicated faucet or dispenser is installed at the point of use (usually the kitchen sink) to dispense the purified water for drinking and cooking.

7. **Automatic Shut-off Valve**: This valve stops the water flow to the RO system once the storage tank is full, preventing wastewater and ensuring efficient operation.

8**. Flow Restrictor**: This component regulates the flow of water through the RO membrane, optimizing filtration efficiency and maintaining proper pressure within the system.

9. **Check Valve**: Prevents backward flow of purified water into the RO membrane, ensuring that only treated water is dispensed from the faucet.

10. **Pressure Gauge**: Some systems include a pressure gauge to monitor the water pressure and ensure optimal performance of the RO system.

1.4 Types of RO Water Purifier

There are several types of reverse osmosis (RO) water purifiers available, each designed to meet specific needs and preferences. Some Common types of RO water purifiers are:

1**. Under-sink RO Systems**: These are installed under the kitchen sink and are connected to a separate faucet for dispensing purified water. They are suitable for households with space constraints or those who prefer a discrete installation.

2**. Countertop RO Systems**: These units sit on the countertop and are connected directly to the kitchen faucet. They are portable and easy to install, making them ideal for renters or people who frequently move.

3. **Wall-Mounted RO Systems**: Similar to under-sink systems, but these are mounted on the wall instead of being placed under the sink. They save under-sink space and are often used in commercial settings or where under-sink installation is not feasible.

4. **Whole-House RO Systems**: These systems are installed at the point where water enters the house, providing purified water to every faucet and appliance in the home. They are suitable for large households or areas with poor water quality.

5**. Portable RO Systems**: These compact units are designed for outdoor activities, camping, or travel. They are lightweight,

easy to carry, and can be used to purify water from various sources, such as rivers, lakes, or tap water.

6. **Commercial/Industrial RO Systems**: These systems are designed for high-volume water purification in commercial settings, such as restaurants, hospitals, laboratories, and manufacturing facilities. They are larger, more powerful, and capable of handling larger capacities of water.

7. **Customizable RO Systems**: Some manufacturers offer customizable RO systems that allow users to select specific components or add-ons based on their preferences and requirements. This allows for greater flexibility in designing a system that meets unique needs.

1.5 Contaminants Removed By RO Purifiers:

Reverse osmosis (RO) water purification systems are highly effective at removing a wide range of contaminants from water, including:

1. **Dissolved Solids**: RO membranes are capable of removing dissolved solids such as salts, minerals, metals (like lead, arsenic, mercury, and copper), and other impurities that contribute to water hardness.

2. **Suspended Particles**: RO membranes can filter out suspended particles and sediment, including sand, silt, rust, and other fine particles, providing clearer and cleaner water.

3. **Microorganisms**: RO systems can effectively remove bacteria, viruses, and protozoa, providing microbiologically safe drinking water. However, it's essential to note that while RO membranes can filter out these microorganisms, it's recommended to combine RO filtration with disinfection methods like UV sterilization for comprehensive microbial control.

4. **Chlorine and Chloramines**: RO systems can remove chlorine and chloramines, which are commonly used as disinfectants in municipal water treatment. These chemicals can affect the taste and odor of water, and RO helps improve the overall quality and taste of drinking water.

5. **Pesticides and Herbicides**: RO membranes can effectively remove many pesticides, herbicides, and other organic contaminants from water, providing a significant reduction in exposure to these potentially harmful substances.

6. **Industrial Chemicals**: RO filtration is also effective at removing various industrial chemicals and pollutants, including volatile organic compounds (VOCs), pharmaceuticals, endocrine disruptors, and other synthetic organic compounds.

1.6 Advantages of RO Water Purifiers:

Reverse osmosis (RO) water purifiers offer several advantages for producing clean, purified water:

1. **Removal of Contaminants**: RO systems effectively remove a wide range of contaminants from water, including dissolved salts, minerals, heavy metals, bacteria, viruses, pesticides, and other harmful substances. This ensures that the water is safe and clean for drinking and cooking.

2. **Improved Taste and Odor**: By removing impurities and contaminants, RO water purifiers can significantly improve the taste, odor, and overall quality of the water. Many people prefer the fresh and clean taste of RO purified water compared to tap water or water from other filtration methods.

3. **Health Benefits**: Consuming clean, purified water from an RO system can contribute to better overall health by reducing the intake of potentially harmful substances. It provides peace of mind, especially for households concerned about water quality and safety.

4. **Convenience and Accessibility**: RO systems provide a convenient and accessible source of purified water directly from the tap or a dedicated faucet. There's no need to purchase bottled water, which is not

only costly but also generates plastic waste. This makes RO water purifiers environmentally friendly and cost-effective in the long run.

5. **Versatility**: RO systems can be used in various settings, including homes, offices, schools, hospitals, restaurants, and industrial facilities. They are available in different sizes and configurations to meet different needs and usage requirements.

6. **Customization**: Some RO systems offer customization options, allowing users to add additional filters or features to address specific water quality concerns or preferences. This flexibility ensures that the system can be tailored to meet individual needs effectively.

1.7 Disadvantages of RO Water Purifiers

Reverse osmosis (RO) water purifiers have some disadvantages:

1. **Wastewater Generation**: RO systems produce a significant amount of wastewater during the purification process, typically around 3-4 times the amount of purified water produced. This can lead to water wastage, especially in regions facing water scarcity.

2. **Removal of Essential Minerals**: RO systems can remove not only harmful contaminants but also essential minerals like calcium and

magnesium from water. Drinking demineralized water over the long term may lead to mineral deficiencies in the body.

3. **Energy Consumption**: RO purification requires energy to operate the system, particularly for the water pressure needed to push water through the semi-permeable membrane. This energy consumption can contribute to overall household energy usage.

4. **Initial Cost and Maintenance**: RO systems often have a higher initial cost compared to other water purification methods. Additionally, they require regular maintenance, including filter replacements and membrane cleaning, which can add to the overall expense.

5. **Slow Process**: RO systems typically have a slower purification process compared to other methods, due to the intricate filtration process. This can result in a slower flow rate of purified water, especially if the system is undersized for the household's water demand.

6**. pH Imbalance**: RO water tends to be slightly acidic due to the removal of minerals. Some people prefer water with a more balanced pH level for drinking, and additional steps may be needed to adjust the pH of RO water.

7. **Environmental Impact**: The production and disposal of RO membranes, as well as the energy consumption during operation, contribute to the environmental footprint of RO systems.

2. Performance and Calculations:

2.1 Salt Rejection %:

This equation tells how effective the RO membranes are removing contaminants. A well-designed RO system with properly functioning RO membranes will reject 95% to 99% of most feed water contaminants (that are of a certain size and charge).

Salt Rejection % = (Conductivity of feed water – Conductivity of Permeate water)/ Conductivity of Feed * 100

The higher the salt rejection, the better the system is performing. A low salt rejection can mean that the membranes require cleaning or replacement.

2.2 Salt Passage % :

It is the amount of salts expressed as a percentage that are passing through the RO system. The lower the salt passage, the better the system is performing.

Salt Passage % = (1 – Salt Rejection %)

2.3 Recovery % :

Percent Recovery is the amount of water that is being 'recovered' as good permeate water. The higher the recovery % means that less water is been sent to drain as concentrate and saving more permeate water. However, if the recovery % is too high for the RO design then it can lead to larger problems due to scaling and fouling.

Recovery % = (Permeate Flow Rate (gpm) / Feed Flow Rate) * 100

For example, if the recovery rate is 75% then this means that for every 100 gallons of feed water that enter the RO system, you are recovering 75 gallons as usable permeate water and 25 gallons are going to drain as concentrate. Industrial RO systems typically run anywhere from 50% to 85% recovery depending the feed water characteristics and other design considerations.

3.RO Using Piston Cylinder

In piston cylinder RO system, instead of a pump we exert pressure using a piston cylinder. When we peddle, the force moves the piston forward creating a pressure sufficient enough to purify water.

4. Calculations For Piston Cylinder RO

Force * distance travel = Torque * angle of rotation

F*b = T* 2pie

F= 2*pie*T / b

Pressure = Force / Area

Area= F/P

Pie* a^2= F/P

a^2=2*pie*T/bP

where

a= radius of piston

b= pitch of threads
F =Force applied
T= Torque

5. Conclusion

Using a piston-cylinder arrangement in an RO water purifier instead of a pump can offer some advantages, depending on the specific application and context:

1. **Simplicity:** A piston-cylinder arrangement may have fewer moving parts and be simpler in design compared to a pump, potentially reducing maintenance requirements and increasing reliability.

2. Energy Efficiency: In certain situations, a piston-cylinder arrangement powered by human effort (such as pedaling) could be more energy-efficient than an electric pump, especially in off-grid or low-resource settings.

3. Cost: Depending on the materials used and the scale of production, a piston-cylinder arrangement may be more cost-effective to manufacture and maintain compared to a pump, particularly in regions where pumps are expensive or difficult to obtain.

4. Versatility: A piston-cylinder arrangement may be more adaptable to different power sources, such as manual operation, solar power, or alternative energy sources, providing flexibility in deployment.

5. Environmental Considerations: Using human power to operate the piston-cylinder arrangement can have environmental benefits by reducing reliance on electricity and minimizing carbon emissions.

6. Emergency Situations: In emergency situations where access to electricity or mechanical pumps is limited, a piston-cylinder RO water purifier could provide a reliable source of clean water using locally available resources.