

Solar Energy Based Water Desalination System

Sumedh S. Malpathak¹, K.V.Bhadane², Suresh Kathe², Shyam Kadam², Manohar Shewale²

^{1,2}(Department of Electrical Engineering, Sandip Institute of Engineering and Management, Nashik, Savitribai Phule Pune University, India)

¹Corresponding Author: Email

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Abstract: There is scarcity of portable water in the world which is an essential thing. But the water should be suitable for drinking. There are many filters present in the market that can-do purification process, that make water safe to drink, but they don't reduce the saltiness, due to this the drinking water tastes salty. This desalination processes the removes the salt and other minerals from the water & makes it suitable for human consumption and industrial use. RO generally used in domestic filtration system that removes impurities. RO is needed if the Total Dissolved Solids (TDS) exceeds a certain value. The main aim of this project is to use the non-conventional source of energy to design a system which provide water for drinking purpose and mainly designed for a village/ commercial purpose that the desalination system runs on solar power.

Keywords: RO (Reverse Osmosis), TDS (Total Dissolved Solids), Desalination, Solar energy, Fresh water, AT89S52 Microcontroller.

I. Introduction

Today the world is facing water scarcities, water supply inconsistency and unbalanced demand to supply ratio on large scale in several countries and regions. It has so now become important to start converting the salt water resources into potable once. As most of the earth's surface is covered with water but the availability of fresh drinking water is only 2.6% and remaining 97% of water is in the form of saltwater or icebergs in the polar region of the earth, and less than 1% is pure fresh water available or safe for drinking purpose. This is inadequate to support life and vegetation on earth. Presently the common desalination technologies used by the developed countries are distillation, electro dialysis method and reverse osmosis.

The most commonly used desalination methods are reverse-osmosis, in this the salt is forced to pass through a membrane that allows only water molecules to pass but does not allow other molecules of salt and minerals to pass. However, conventional desalination process use excessive energy, which is mostly obtained from the non-renewable sources/ fossil fuels like coal and oil, which results in reduction in the percentage of desalination plants. This conventional energy is nonrenewable resources react upon on the surrounding environment while being used. The use of solar energy helps us keep these factors as clean as possible. Using solar-panel or solar energy-based system has its own advantages; they don't consume excess energy, no pollution, and reduce operational cost.[9]

II. Literature Survey

Basically, there are three types of desalination systems available: -

(a) Thermal or distillation processes that heat the saltwater, it collects and condenses the steam producing purified water but it can only be used for small plants; variations are multi-stage flash (MSF), multi-effect distillation (MED), membrane distillation, and vapor compression distillation (VCD). [2]

(b) Membrane technology includes reverse osmosis (RO), electro-dialysis and reversal methods. In this the saltwater is forced in a membrane with high pressure that removes the impurities, salts from the water in this it also includes a semi permeable membrane in between the high and low solute area, leaving brine behind on one side and drinkable water on the other.[19]

- (c) Hybrid source of energy is used combining wind and solar energy. Due to the use of solar and wind energy the cost of fuel is not incurred and the energy produced is almost constant and nor variable due to grid connection. The only drawback is the maintenance cost of the wind turbines and the generator used.
- (d) An efficient cost-effective battery less photovoltaic or solar powered seawater or purification RO plant works effectively only if there is ample amount of sunlight is available or only during the day time. The advantage of using battery less RO system run on solar-panel is that it saves the additional cost of batteries and also its maintenance cost. But it is not effective or efficient in night time or in the cloudy weather. [15]
- (e) For the better operation wind and solar interconnected model is used. Model Predictive Control (MPC) is used for the maximum efficiency and operation of an integrated wind- solar energy. It is used for co ordinating solar and wind system so that desalinated water can be produced from RO and enough energy is provided to battery. [3]
- (f) Seawater and brackish water purification efficiency in MSF process is 43.6% and that of RO process is 63.8%. In MSF it contains 3-4 stages and high pressure and high temperature steam is required for the purification process which is passed through an evacuated chamber and passed through number of stages. [5]
- (g) The characteristics of renewable energies plays an important role for power supply in rural areas where electricity is not available. If we use Solar energy that is readily available in nature to run desalination plant it can also save energy and also solve the water scarcity problem. Standalone solar system with RO is used for desalination purpose in this project. [6]
- (h) Capacitive deionization can be used as it is an energy efficient technology that provides a good alternative to this problem. Thin film composite electrodes of carbon or graphite are used which collect the ions and are separated by applying of DC voltage and space between them is filled with brackish/saltwater. Capacitive deionization is the application of a low DC voltage on two parallel electrodes. [7]
- (i) Solar energy-based water desalination system is done by using a flat plate collector of approx. 75 w is used to produce clean water with steady state and stable output. It is observed that productivity of clean water is increased if we use a parabolic mirror. It is found that temperature is increased using same receiver area with parabolic through and water production is increased for this system keeping the input constant.[8]

A. Reverse Osmosis

In the traditional osmosis process, the solvent is moved from an area of low solute concentration, through a membrane, to high solute concentration by application of high pressure. By applying external force or pressure to reverse the flow of water or solvent is known as reverse osmosis. However, there are key differences between reverse diffusion or osmosis and filtration. The main removal of impurities in membrane is called straining or size reduction, so the process can achieve perfect removal of salts and solid particles on paper regardless of operational parameters such as inappropriate pressure and concentration.[11]

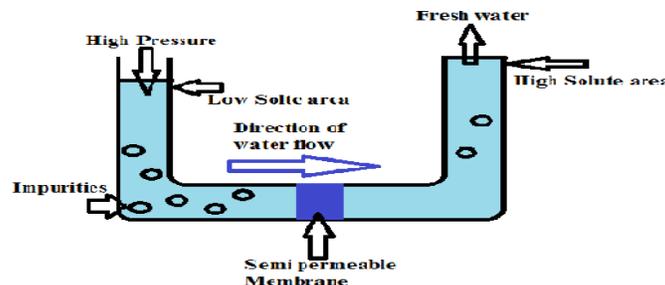


Fig. 2.2 Reverse Osmosis process [18]

Reverse diffusion, however, involves a scattering mechanism so that separation efficiency is dependent on solute concentration, pressure, and water flow rate. Reverse osmosis is mostly used for purification of brackish water, saltwater or water with high ph values. This process removes impurities from the water to make it drinkable. [11]

B. RO System Design

The standard method for designing a RO system is to use methodology provided by manufacturers that provide water recovery, salt rejection and purified water. A membrane system should be designed to operate within the recommended ranges to minimize the rate of the mechanical damage to the system. Membrane operating conditions are limited by the maximum membrane recovery, operating pressure, feed water flow rate, and concentrate flow rate. The designing process starts by estimating the volume or quantity of water required per day and amount of water to be purified at every hour. Since the most of system are designed to run all day and provide water for 24 hrs., design processing are required in manufacturing to use for the periodic operation of the system.[11]

C. Solar PV System Consideration

For systems operating in remote conditions and there is no access to the grid electricity directly. The energy which is required to run or power the desalination plant can be produced using the solar energy which is readily and abundantly available in nature. Therefore, the PV system is designed accordingly to supply power to RO system. [14]

While determining the system capacity one must take into account the available solar energy, the light incident on the panels and conversion efficiency to electricity. The rating of solar panels required for a desalination plant depends mainly on the pumping requirements of RO plant and solar radiance throughout the day.[12]

The charge controller will moderate the power sent to the pump. Over sizing the PV panels may produce more water during low-light conditions but may be wasted capacity during peak and also overall increase in the system cost. The PV panel capacity should be confirmed after sizing the RO pump to ensure that the power estimated required to the RO pump is sufficient enough and also not wasted in case of peak sunlight. To avoid the wastage of electricity produced from the solar panel batteries can be used to store the excess energy.

III. Proposed Plan

The thermal purification plants use fossil fuels, which increases global warming. It harms marine life like algae, coral reefs, salt marsh, mangroves in the water. MSF and MEB processes include various stages at decreasing temperature and pressure. There are many companies that are installing their designs but they are dependent on conventional grid-powered. These systems are of little use when operating off the grid and are costly too. Causing problem to remote & disconnected villages as the resources required to set up these plants is high and also their maintenance cost is high due the use of fossil fuels. The many countries that suffer a shortage of water, over 80% of the fresh water consumed is used for agriculture use. In this project, pH sensor and microcontroller based system will provide a direct and convenient way to monitor water quality and impurities. It is connected to a level sensor and microcontroller provides feedback signal to RO if availability of water is not there. [15]

IV. Working Methodology

In this project we have designed a power sensor which is connected to solar panel of 75watts and further connected to the microcontroller AT89S52 which is connected to the LCD display which gives a fault indication for the motor protection for dry run of the ro motor and will eventually turn it off the power sensor is connected to the AC supply and in case no solar energy is available the batteries will be able to charge on AC supply as well and can be further used as our RO module is installed with a AC to DC converter we will be able to run ro module on AC mains as well. To achieve the 24v input supply and provide backup two 12v batteries are connected in series and no inverter circuit is used so as to reduce the inversion losses. To restrict the flow of reverse current at night and also avoid overcharging, overeating of the batteries we have designed a solar charge controller of 24v,2A for the same purpose.

A. RO System

In a reverse osmosis process the water is passed through many filters the salts or impurities. This feed water should be passed through the RO membranes at very high pressure. Here the power for this HP pump is provided by the solar panels, the RO module requires 24v as input. Water is passed through a high pressure membrane called as semi permeable membrane and passed to low solute concentrate by applying a external pressure. Before passing it to the semi permeable membrane the prefiltration is done in which large solutes or contaminants are removed and the rest of the water is then passed to the high solute area for further purification process to take place in which the Total dissolved solids are removed and the Ph level of water is maintained to the drinking level.

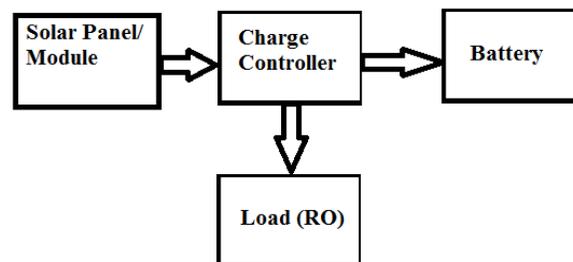


Fig. 3.1 Block diagram of Reverse Osmosis Plant using solar

B. pH Sensor

A pH electrode sensor has 2 parts: A Measuring electrode called as the glass electrode and Reference electrode is a common electrode. When pH sensor is dipped in purified water it takes continuous value of pH level of water.

C. Solar Panel

The solar panel is connected with battery to provide supply to RO system & motor to drive filtration plant. The solar energy is converted into electric energy & provided to motor of RO water purifier system. The RO system then starts to purify water and remove salt from it.



Fig. 3.1 75w Solar panel

D. Calculation

Ampere hours capacity

Voltage Rating of load = 24

Total Hours Required = 8

Maximum Current = 3.79 A

Ah Capacity of battery = Maximum current × Total Hours

Ah Capacity of battery = 3.79×8

= 30.2 ~ 30 Ah (Approx.)

Here we use two battery having 12v, 12 Ah rating connected in series. As the RO requires 24v for operation we connect two batteries in series to achieve the same.

E. Testing before finalizing the Solar RO unit

Apparatus used: - 1. Multi meter for measurement purpose.

Battery requires 3-amp current for charging that is $1/10^{\text{th}}$ of the Ah rating

The system uses DC voltage and output of solar panel is DC as to reduce the inversion losses we do not make use of inverter, a charge controller is used to regulate the voltage of solar panel to the battery which varies in day due to position of sun and also avoid the flow of reverse current from battery to solar panel at night.

F. AT89S52 Microcontroller

The **AT89S52** is a low-power, high-performance Complementary Metal-Oxide Semiconductor (CMOS), it is the technology used for building low power integrated circuits, mainly used in microprocessors, microcontrollers, and logic circuits, AT89S52 is an 8-bit **microcontroller** with 8K bytes of inbuilt programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set. It is used for controlling the motor operation for the level sensor circuit which we have designed for our project. [17]



Fig 3.3 AT89S52 Board

G. Battery

As the solar energy is only available in day time the batteries are used as a backup power supply for the RO system/module. Here we have used two 12v,12Ah batteries which are connected in series to achieve 24v power input to the ro.



Fig. 3.4 Two batteries connected in series

V. Result

Working of the designed system consists of following 2 stages: Solar RO System: Water is purified by Reverse Osmosis process using solar energy. In Ro Process salt level is reduced and water is purified so that it becomes safe for drinking. The cost of energy is also reduced and can be used for in commercial applications as well.

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