International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 338-342 www.ijaem.net ISSN: 2395-5252

On- Grid Solar Powered Ro Plant: Project Proposal for a Pv Powered Ro Filtration System

Sharvani Satpathy
Junior Officer HINDALCO Power Plant Hirakud, Sambalpur, Odisha
Corresponding Author: Sharvani Satpathy

Date of Submission: 15-08-2020 Date of Acceptance: 31-08-2020

ABSTRACT: Water is one of the most essential things for power generation in thermal power plants. Water comes to the cooling towers from the condensers, air coolers and oil coolers. In case of a captive power plant of aluminium smelting plant the water used in smelter also comes to the cooling tower. The water from the cooling tower comes to RO for filtration. The rain water is also channelized to the RO feed water. The cooling water (C.W) Pumps circulate the water through the heat exchangers and back to the cooling tower. Reverse Osmosis (RO) is used to separate the contaminants from the water used in the industry. The purified water is recycled and thus reduces the water demand for the plant. It also cuts the total cost of the raw water.

In this paper, it is suggested to run a RO plant with 294 m3/hour water treatment capacity on solar energy. The basic principle behind this project is reverse osmosis using solar energy. The solar radiations are collected by solar panels. This energy is then used by RO plant and the extra energy is transferred to the Grid and when the solar plant does not generate electricity the RO plant draws the energy from the Grid. The proposal is to install an On- Grid Power Plant of 1.2 MWP capacity to generate 4800-5000 kWh unit per/day for the RO plant.

With the increase in temperature of the solar photovoltaic (PV) panels the efficiency of (PV) panels decreases therefore the heat transfer from the panel is essential. The present paper proposes the temperature control of PV panel by Heat Pipes which collects the excess heat from the panels and heat up the feed water to reverse osmosis plant. The heat pipes recover the heat energy and improve the efficiency of the electric generation. It is a well known fact that the reverse osmosis at higher temperature results in the improvement in the flow performance of the membrane.

KEYWORDS: Reverse Osmosis, Solar Energy, On-Grid Solar Power Plant, Heat Pipe.

I. INTRODUCTION

A coal fired Thermal power plant located in Odisha is taken as the case study. The filtration of used water is done in RO plant of the company. In a coal fired thermal power plant water is required for various applications. Reverse osmosis is required pressure driven membrane process.

Boiler water supply is fully treated in RO plant and then goes to DM water plant where it is mixed with the chemical regent to water i.e cat ion &anion resin. Reverse osmosis is a pressure driven membrane separation process. That is capable of separating dissolved solutes from a solvent, usually water. The solute may be organic or inorganic in nature and range in size from 1-10 angstroms or less. The ability or reverse osmosis membrane to reject substances depends upon the molecular weight geometry of the solute and other factors. A well – designed RO system is capable of removing 90-99% or the most of dissolved organic and inorganic compounds.

Reverse Osmosis membranes are constructed from Cellulose acetate, polyamides or other polymers.

Process: When a salt solution is separated from dematerialized water by semi permeable membrane the higher osmotic pressure of the salt solution causes demine raised water to flow into the salt solution compartment (see Fig. above) water will continue to flow and rise in the solution compartment until the increase in water heights equals the osmotic pressure of the salt solution. If the pressure is exerted on the salt solution compartment water can be made to flow in the reverse direction. This is the process of reverse osmosis. The osmosis pressure is a function of the specific solute and its concentration in water and in practical terms it is the minimum pressure required to produce the first drop of pure water from a solution of solute at s' specific concentration

The membrane at a rate higher than the multivalent salts like calcium sulfate the molecular weight cut off lies in the range of 100-1000 MW for the reverse osmosis membrane. Osmotic pressure of a solution is expressed by the following equation as follows:

$$\pi = iMRT$$

π = osmotic pressure

i = van't Hoff's factor

M = Molar concentration of solution (mol/ L)

R = Ideal gas constant (0.08206 L atm mol^{-1} K^{-1})

T = Temperature in Kelvin (K)

The molar concentration is determined by dividing the number of grams of solute used to make the solution by the molecular weight of the solute.

van't Hoff's factor is a measure of the number of ions a solute will form when dissolved in water.

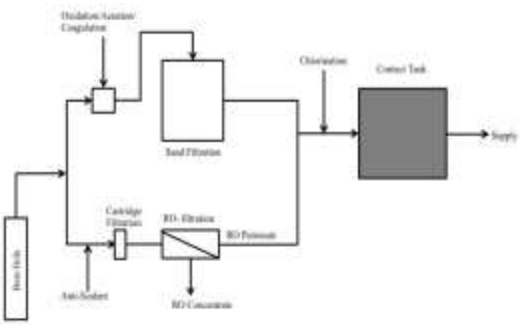

FIG 1: SCHEMATIC DIAGRAM OF RO FILTRATION SYSTEM

In its simplest design form, an RO system consists of a pump to pressurized the feedwater, an RO device, and a throttling (flow control) valve on the brine outlet to control the conversion. A typical RO plant uses this basic design in modular form to achieve the desired product flow and water quality. For large-scale RO plants, continuous monitoring is used for such factors as temperature, feed pH, feed conductivity, brine and product conductivities, feed chlorine content, energy consumption, etc.

II. REVERSE OSMOSIS

Solvent flow through a semi-permeable membrane, from a concentrated solution to dilute solution by the driving force created by the difference in pressure between the two solutions is called Reverse Osmosis. Osmotic pressure is added to the concentrated solution side in order to stop the solvent flow through the membrane from low concentration to high concentration solvent side.

Reverse osmosis is to reverse the flow, forcing water through a membrane from a concentrated solution side i,e waste water side to a dilute solution to produce filtered water.

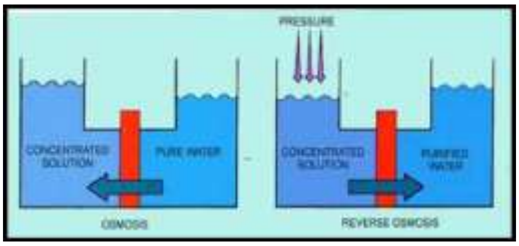

FIG 2: THE OSMOSIS PROCESS

Reverse osmosis is created when sufficient pressure is applied to the concentrated solution to overcome the osmotic pressure and to create a driving force. This pressure is provided by feed water pumps which consumes large amount of electricity. Concentrated contaminants (brine) are reduced from the high-pressure side of the RO membrane, and filtered water (permeate) is reduced from the low-pressure side. Membrane modules may be staged in various design configurations, producing the highest-quality permeate with the least amount of waste.

Typically, 95% of dissolved salts are reduced from the brine. All particulates are removed. However, due to their molecular porosity, RO membranes do not remove dissolved gases, such as Cl2, CO2, and O2.

The two most common RO membranes used in industrial water treatment are cellulose acetate (CA) and polyamide (PA) composite. Currently, most membranes are spiral wound; however hollow fiber configurations are available. In the spiral wound configuration, a flat sheet membrane and spacers are wound around the permeate collection tube to produce flow channels for permeate and feed water. This design maximizes flow while minimizing the membrane module size.

Hollow fiber systems are bundles of tiny, hair-like membrane tubes. Ions are rejected when the feed water permeates the walls of these tubes, and permeate is collected through the hollow center of the fibers. Concentrated brine is produced on the outside of the fibers contained by the module housing

III. HOW DO TEMPERATURE AFFECTS RO WATER PRODUCTION IN RO PLANT

Every year, a lot of money is wasted on unneeded membrane replacements because operators overlook the negative effects of cold water on their Reverse Osmosis (RO) system performance. Assumptions are generally made that their membranes have fouled, when in fact the temperature of the feed water has just dropped and caused the membrane production to be significantly reduced. Often, this is because the operators forget to take into consideration the lower feed water temperatures experienced during the winter season. As water gets colder it gets thicker and the flow rate out of a Thin-film composite (TFC) membrane decreases. As water gets warmer it gets thinner and the flow rate coming out of a membrane increases. All flow rates stated on reverse osmosis systems and membranes are assuming a water temperature of 77 degrees F. As the water temperature changes so will the flow rate. For every degree F lowered the temperature there is a lose about 3% of product flow. For every degree F raised temperature there is a gain about 3% product flow rate - this occurs because water with a higher temperature has a lower viscosity and higher diffusion rate, which makes it easier for the water to permeate the RO membrane. RO membranes cannot handle water temperatures over 100 degrees F.

Temperature Correction Factor (TCF): Temperature has an inverse effect on product flow through the membrane; a high temperature increases product flow, a low temperature decreases product flow. To find the membrane permeate rate at any temperature multiply the rated permeate flow of the RO membrane by the TCF shown in the table below. The result is the permeate flow at that temperature.
Example: A thin-film membrane permeate rate at 77 degrees Fahrenheit, 65 PSI = 50 gallons per day. What is the permeate flow rate at 50 degrees Fahrenheit?
Answer: Use the temperature correction factor (from table below) = 0.52.

New permeate flow rate at 50 degrees Fahrenheit is 50 x 0.52 = 26 gallons per day.
Temperature Correction Factor (TCF) Table

Temperature F/C	Correction Factor
40/4	0.34
50/10	0.52
60/16	0.7
70/21	0.88
77/25	1
80/27	1.05
90/32	1.23
100/38	1.41

IV. COOLING OF P.V. MODULES

Solar is the most abundantly available non-conventional energy source worldwide. Sun radiation can be converted directly into electrical energy by means of photovoltaic (P·V). The P.V. has efficiency between 10 and 20%. Solar cells use an range of wavelengths from 380 to 700 nm (nanometres) for generating electricity. The high-energy photons can damage the PV cells through ionisation. The radiant energies from the Sun are converted to heat, which increases the solar cell temperature. The electrical power from the solar cells can be increased by reducing the temperature. It is a fact that P.V. panel efficiency depends on the material band gap and wavelength of the sunlight. The electrical power of solar P.V. decreases whenever the solar cell temperature becomes high. 5–20% of the sun rays incidenting on the surface of Solar cell are converted into electrical power; the remaining radiation is transmitted backwards and absorbed in the form of heat. The absorbed heat can raise temperature of P.V. cells up to 70^{o}C.

The output of the P.V. module is affected by surface temperature which is associated with the absorbed sunlight converted into heat, resulting to less production of power, efficiency, performance and life of the panel. Cooling is a potential solution to reduce heating of P.V. panels and cell temperature

In this paper Heat Pipe a passive cooling device for transferring energy from the source to the sink by evaporation and condensation of the fluid in a sealed system is recommended. Typical heat pipes are made up of a sealed pipe of high thermal conductivity material, such as copper or aluminium, at both evaporator and condenser. A Heat pipe with solar panel is shown in Figs.3 and 4.The heat pipe can convert heat from the solar panel to water and thus reduce the temperature and improve the efficiency of the P.V cell panel. A flat shape micro heat pipe arrangement with the solar panel contact can be used. Experiment have shown that the heat pipe array for P.V. cooling through air and water circulation reduces the temperature by 4.7^{0} C, and the power output rises by 8.4% for air-cooling compared to the ordinary solar panels and the temperature decreases by 8^{0}C and the output power increases by 13.9% for water-cooling.

Heat pipes can be fitted on the rear side of P.V. panels to absorb the temperature when water is used as a cooling medium to cool the cells. Waste heat from P.V. panels due to excess radiation absorption can be transferred to the circulating water. In this paper it is suggested to use the RO feed water as the circulating coolant and thus

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 338-342 www.ijaem.net ISSN: 2395-5252

increasing the feed water temperature which would

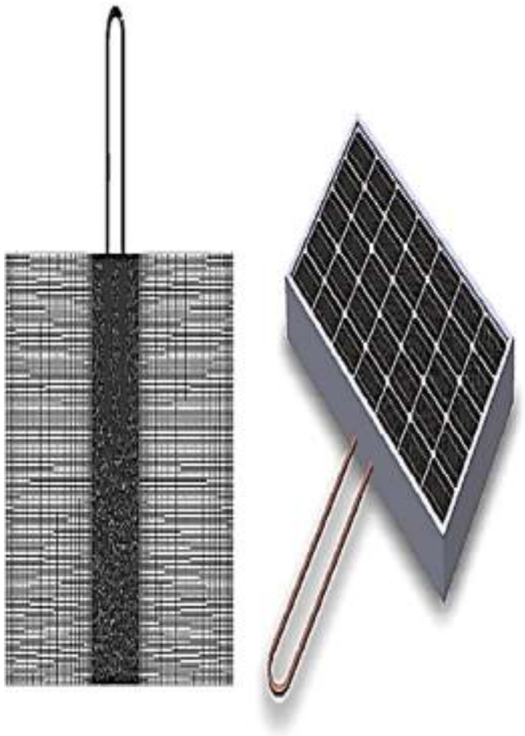

FIG. 3. P.V. PANELS WITH HEAT PIPE

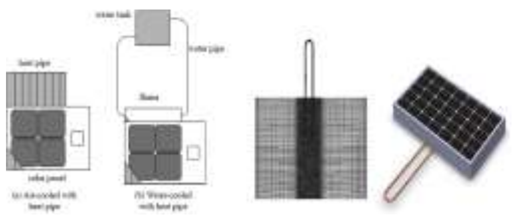

FIG.4 WATER-COOLED HEAT PIPE

V. ON- GRID SOLAR POWER PLANT

Background:

- To install 1.2MW Dual MPPT On-grid system with the objective of Green Power generation.
- Studies further show that it is necessary to adopt environment-friendly technologies along with increased efficient batter backup technology to mitigate the power shortage.
  Proposal at a Glance
- On- Grid Power Plant: 1.2 MWP capacity with respect to generate of 4800-5000 kWh unit per/day
- Daily energy need to be generated to meet the requirement:- 4800-5000 kWh/per day.

help to improve the efficiency of the RO plant.

Scope of Work:

Provision for Dual MPPT System in Hybrid mode of Power Supply with approximate 1.2 MW load ,We need 5-6 acre area

- Solar Power Plant in swing of central grid concept or String inverter concept.

System Description:

The Photovoltaic (PV) ON-Grid system consists mainly of 3 components: The PV array, Module Mounting Structure and the Power conditioning Unit (PCU). The PV array converts the light energy in to sunlight to direct current (DC) power. The Module mounting structure is used to hold the module in position. The DC power is converted to alternating current (AC) power by the PCU, which is connected to the utility power grid.

FIG:5 SYSTEM SCHEMATIC (EXCESS POWER NEED TO BE FEED TO GRID SYSTEM

The PV installation comprises of 330Wp modules. The system voltage – 38.49 V nom, 330 Wp multi crystalline modules used are grouped in an optimum number of strings with module-to module cable connections.

The modules are held fixed on structures made of galvanized steel structures. The modules are inclined at 20/25 deg to horizontal facing due south.

Proposed Systems (OEM):

- SPV Module:- Jakson Solar/UTL Solar/ Vikram Solar
- Power control unit (MPPT/IGBT):-UTL/ JAKSON/DELTA

DC Distribution:

The DC power output from the PV array is fed to the inverter. The DC power flow is as below:

- Solar modules are grouped into parallel strings with modules in series.
- The DC output from the modules is fed to Array Junction Boxes and the strings areparalleled at Sub Main & Main Junction Boxes.

- The output of the main junction box is fed to DC distribution board (DCDB) 1000 Volts.
- The DC power output from the DCDB feeds the Central inverter (PCU)

AC Distribution:

Power conditioning unit installed in a control room converts DC energy produced by the solar array to AC energy. The AC power output of the inverter shall be fed to the AC Distribution Board with bus bars, different feeders and energy meter. The 240V AC output is fed to the loads directly connected to the system.

RO PLANT
Capacity: 294 m3/hour.
Power consumption: 160 Kwh / hour.
Hence power consumption/ m3 of water is 0.53 kwh.

Total Project Cost: INR 38,052,540.00 (Rupees Three Crore Eighty Lakh FiftyTwo Thousand Five Hundred Fourty Only)

Provision for Dual MPPT System in Hybrid mode of Power Supply with approximate 1.2 MW load requires 5-6 acre area. For the RO plant to run uninterruptedly by Solar Power a solar power generation unit of 1.2 MW is required to compensate the lean period of solar radiation from morning 6AM to 9 AM and evening 3PM to Sunset and also to non generation of power during night time.

VI. CONCLUSION

In RO filtration the concentration of ions in the product solution decreases with increasing operating pressure and with increasing feed flow rate. Increasing operating pressure are necessary to overcome the osmotic pressure and the driving force will be higher, therefore, TDS decreases. Feed flow temperature is to be maintained properly since temperature has an inverse effect on product flow through the membrane; a high temperature increases product flow, a low temperature decreases product flow. For a RO plant of nearly 300 m^3/ hour water filtration the power consumption per hour is 160 Kwh so to run the RO plant we need a solar power station of 1.2 MW. Solar is the cleanest and most abundantly available source of energy. It is green energy and reduces the carbon footprint. Power plants have also the need to fulfil the **Renewable Purchase Obligations (**RPO) requirement as decided by the Government, so an installation of a solar power plant will meet both the requirements of producing green energy, its utilization and meeting the regulatory dorms of the Government.

REFERENCES

[1]. Ahmed F., 2000 “Study of factors affecting the efficiency of reverse osmosis process” MSc.Thesis, University of Baghdad.

[2]. Amjad Z. and Zibrida J., 1998, Reverse Osmosis Technology: Fundamentals and Water Applications. Association Water Technologies, Inc. Annual Convention, Washington, DC.

[3]. B. Koteswararao, K. Radha, P. Vijay, N. Raja, Experimental analysis of solar panel efficiency with different modes of cooling 8 (3) (2016) 1451–1456.

[4]. M. Hasanuzzaman, Global advancement of cooling technologies for P.V. systems: a review, Sol. Energy 137 (2016) 25–45. [7] D. Du, J. Darkwa, G. Kokogiannakis, Thermal management systems for pho-tovoltaics (P.V.) installations: a critical review, Sol. Energy 97 (2013) 238–254

[5]. M.A. Bashir, H.M. Ali, K.P. Amber, M.W. Bashir, A. Hassan, S. Imran, M. Sajid, Performance investigation of photovoltaic modules by back surface water cooling, Therm. Sci. (2016) 1–110.

[6]. Sharvani Satpathy., 2020 “A Solar Powered Reverse Osmosis Treatment of Used Water for Industrial Reuse in Power Plant ” Master of Science in Engineering Thesis in Chemical Engineeing, Crown University International Chartered Inc, Delaware, USA.