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DESIGN & FABRICATION OF INDIGENOUS SOLAR WATER PURIFIER: A Review

Atul jain[1], Ashish Kabra[2]

[1]*Assistant Professor Department of Mechanical Engineering R.B.S. Engineering Technical Campus Agra, (U.P.), India*

[2]*Assistant Professor Department of Mechanical Engineering R.B.S. Engineering Technical Campus Agra, (U.P.), India*

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Abstract: *In today's world majorly all the population is coming under the effects of water pollution and diseases caused by it. The most affected areas are the rural one due to less availability of fresh drinking water. So as to meet the need of people in rural area a simple but effective water purifying system has been fabricated to provide the purified water to all at a very low consumption of energy. The author described the detailed information about previous research paper regarding the basic modeled prototype consisting a solar panel connected to a heating coil along with a appropriate filtration unit. The basic principle behind this is using solar energy to boil water with infected impurities and removing it by means of filtration according to the type of impurities containing by the water.*

All the previous solar based purifier has different methodology to purify different impurities but in this basic methodology is same for all kind of impurities, only the filtration unit varies according to the type of impurity to be removed

Key Words: **Solar, Water, Impurities, Filtration, Energy**

1. INTRODUCTION

Water is a natural resource that is a necessity of all living organisms. Water sources are normally brackish and contain harmful microbes such as bacteria which make water unsafe and unsuitable for drinking. Out of all available water on earth, 97% of water is saline and the reminder (3%) constitutes the entire freshwater which is unevenly distributed all over the earth in the form of rivers, streams, glaciers, etc. and unfortunately, in some areas, it has been too polluted by human activities[1]

Water and energy are fundamental resources used for economic, social and cultural development. These resources have been long presupposed as abundant. With the increase of population and the developments brought by the industrial revolution, their demand increased and scarcity is now an undeniable result. Fig. 1 illustrates the total global stock of water for human use [2]. From the global water reserve, only 2.5% is fresh water and the rest is saline. From the 2.5% the largest part is frozen in Polar Regions and 30% are also in remote aquifers of difficult access. As a result only 0.007% of the total global water is directly accessible for use. Unfortunately part of this water is polluted by industrial plants, mining, oil or gas exploration, fertilizer and pesticide residue used in agriculture. In addition, the uneven distribution of water over the globe causes even more severe water scarcity in some regions. Desalination and water reclamation are of paramount importance in water security, where desalination happens to be one of the main life supports in many arid regions.

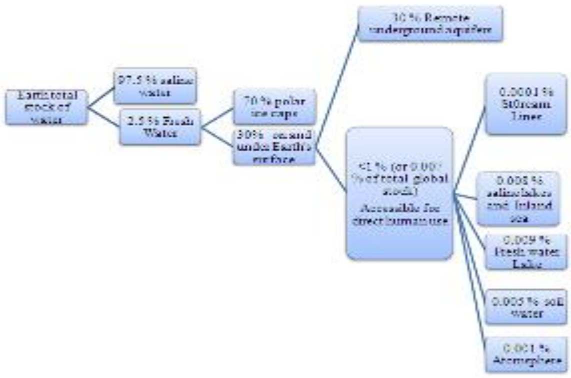

Fig: 1 The total global stock of fresh water for human use

1.1 Current Global condition of Water crises

The current global energy problem originates not only from limited fossil energy supplies, but also its environmental impacts for its entire energy lifecycle, from mining and processing to emissions, waste disposal and recycling. The indicators of energy sustainability include its price, environmental impacts and greenhouse gas emissions, availability of renewable energy sources, land requirements, water consumption and social impacts [3]. One solution to achieve energy sustainability is to develop sustainable technologies to gradually replace non-renewable fossil fuels. These include energy conversion from renewable and/or natural resources (e.g. biomass, wind, solar and water) into usable energy (e.g. electricity) and energy storage systems for long-term or remote usage.

Solar energy being a pure and renewable source of energy can be used for many purposes. Here we use solar energy to sterilize medical equipment as well as to purify water. The importance of such a device is in the rural area, where there is no proper way for sterilizing medical equipment which may lead to spreading of infections. The sun rays hitting on the parabolic trough is reflected on to the copper pipe place at the focal line of the trough. It contains impure water to be purified. The water inside is circulated. As time passes the temperature of the water inside is increased. The water passes through a pressure vessel where the equipments to be sterilized are kept. The water is converted into steam in the autoclave and it sterilizes the equipments. The steam is then passed to a heat exchanger through a copper tube using a valve. A shell and coil heat exchanger is used. The heat exchanger helps the steam to cool down and converts the steam to water. The cooled purified water can be collected [4].

Desalination using solar energy is one of the methods for purifying water. Desalination is a process of removing various minerals and slats from water. Water desalination is done to convert salty and brackish water to fresh water which can be used for drinking and other purposes such as irrigation. Solar still is the oldest solar distillation techniques for water purification. The major disadvantage of the conventional solar still is its low productivity that can be improved by effective design modifications in the conventional solar still. Numerous research works has been done with the goal to improve the performance, productivity and efficiency of the solar stills. Various parameters that influence the productivity include depth of water, the temperature of water at the inlet to still, free surface area of water, water glass temperature difference, wind velocity and solar radiation. Researchers around the globe have worked intensively on different solar still designs. Several modifications have been implemented and studied thoroughly [5]

There are two main desalination processes: thermal based and membrane-based [6]. Thermal energy can be obtained from the combustion of conventional fossil fuels, which can be substituted with sustainable energy sources such as solar, geothermal, and nuclear. In a thermal based process, seawater is evaporated into water vapor with a thermal energy source, and the vapor is condensed to produce potable water. Some common desalination technologies that use thermal energy are multi-stage flash (MSF), multi-effect distillation (MED), humidification– dehumidification (HDH), and vapor compression (VC) [7,8]. Membrane-based processes allow water to pass through a membrane without a phase change. Representative membrane-based technologies include electro dialysis (ED) and reverse osmosis (RO) [7,8]. At present, RO is commonly used for desalination worldwide because of its low specific energy consumption, low environmental impact, and flexible capacity; it accounts for more than 60% of the installed capacity [9].

1.2 Solar desalination

Sustainable energy is an alternative solution to the decreasing reserves of fossil fuels. Solar energy is an inexhaustible resource that can be used to drive seawater desalination, mainly due to its thermal and optical effects [10]. Conventionally, there are two main methods of using solar energy: solar photovoltaics (PV) directly converts sunlight into electricity, while concentrated solar power (CSP) or concentrated photovoltaics (CPV) uses mirrors to reflect sunlight and focus it in a receiver to be transformed into thermal energy. Steam is produced to impulse a turbine engine and drive the generator to produce electric power [11]. The technologies of using solar energy have improved, which had led to the development of energy–desalination coupling schemes. These can be divided into indirect and direct processes according to whether the solar energy collection and desalination are carried out with the same device. Direct processes mainly include solar distillation (SD), solar HDH, and solar chimney (SC); solar power is collected and utilized as thermal energy, and the desalination process is carried out by the same device. In an indirect process, solar collection is separate from desalination. Solar power can be converted into heat by a solar collector or into electricity by PV power generation [12]. Indirect processes include thermally driven MSF desalination, MED, VC desalination, membrane distillation (MD), freeze desalination (FD), and adsorption desalination (AD) as well as electrically driven RO and ED.

1.3. Direct Desalination Process

Solar distillation is gradually becoming the most widely used direct process; it has a simple structure, easy and flexible operation, and low consumption of conventional energy. It boasts technical and economic competitiveness and is accessible for remote coastal areas with high solar irradiance and limited primary energy supply. Its application started in 1872, when Wilson designed the first conventional solar still in Chile [13]. SD can be divided into passive and active modes depending on whether or not a solar power collector is used [14]. By coupling solar stills with auxiliary equipment such as sponge cubes [15], condensers, concave and convex surfaces, sun tracking, flat plates, evacuated tube collectors, phase change materials (PCMs) and reflectors [16], the heat and mass transfer process inside the system can be effectively improved. In addition, the recovery and utilization (i.e., reuse) of the internal latent heat of condensation and distillate yield can be increased. SD is the subject of great interest.

1.4 Indirect desalination processes

The desalination process has a very high energy requirement. The minimum energy required for the desalination process is much greater than the theoretical value that could be acquired with the second law of thermodynamics. If RO technology is taken as an example, the minimum theoretical required energy for desalinating seawater with a salinity of 45,000 mg/L is around 1 kWh/m3 [17,18].. There is much room for further desalination technologies that are environmentally friendly and energy-efficient.

RO desalination has increased in popularity because of advances in membrane technology and its high recovery ratio (RR) and low specific energy consumption. In terms of solar-powered desalination, Solar-RO comprises 52% of indirect solar desalination plants with Solar-MED and Solar-MSF making up 13% and 9%, respectively, around the world. Solar-ED makes up 9% of the total and is suitable for brackish water desalination. Solar-MD represent 16% of the total and has seen promising developments [12].

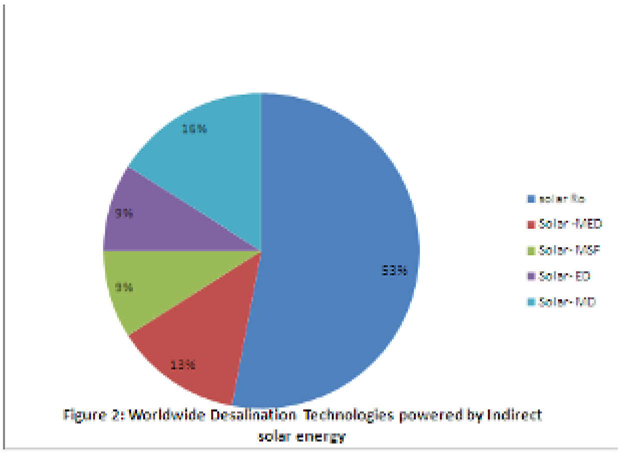

Fig: 2 Worldwide Desalination Technologies Powered by Indirect Solar Energy

1.5 Solar powered multi-effect distillation

The origins of MED can be traced back to the 1830s. However, in the early stages of MED, it was constrained by a proneness to scaling on the heat transfer surface; it was not until the 1960s that the development of low-temperature MED (LT-MED) technology eased the problems of scaling and corrosion. The MED process [19] is based on using the latent heat of steam in the first cell as a dynamic source to drive seawater evaporation and provide a heat source in the next cell; this is repeated in the following cells until the minimum temperature is reached. Horizontal-tube falling film evaporators are used to eliminate the influence of static pressure on the evaporation surface and increase the total heat transfer coefficient. This allows operation at low temperatures (top brine temperature (TBT) is 65–70 °C) and limits scale formation on the walls [18,21]. Frantz et al. [20] performed numerical simulations to systematically study the correlation of parameters in a solar-MED system. The results showed that the freshwater yield can be doubled when the steam is heated from 65 °C to 90 °C, and the yield can be increased by 50% if the surface area is augmented by 30%.

1.6 Solar-powered reverse osmosis

RO is the most common desalination technique owing to its low energy cost and installed capacity. It is a pressure-driven desalination process where feed water is forced across a semi-permeable membrane module; freshwater is collected, and the brine is drained [22-24]. The required seawater RO (SWRO) desalination productivity to meet the global water demand in 2030 is estimated to be approximately 2374 million m3/day [25]. The common energy consumption of a SWRO desalination plant is approximately 2–4 kWh/m3 and depends on the feed water salinity, RR, pretreatment, brine discharge, and electric power used within the plant [26]. Combining solar energy and RO will effectively reduce the consumption of conventional energy sources and promote the sustainable development of seawater desalination. At present, this approach can be divided into two types: PV-powered and solar thermal-powered RO desalination [27,28].

PV powered RO desalination relies on PV modules to convert heat generated by solar radiation into electricity to drive a water pump [29]. The heat can also be converted into continue mechanical energy through an organic Rankine cycle (ORC) to drive the high-pressure pump in the RO system; this is known as solar thermal-powered RO desalination. Waste heat can increase the temperature of the feed liquid, which helps increase the membrane permeate flux [30,31]. This is a cost-effective way to realize a commercial application of sustainable energy to small-scale RO desalination systems

1.7 Solar Pond

The solar pond is an energy device that acts as a large scale solar collector to absorb and store solar irradiation as low-grade heat, which can minimize current alarming environmental impacts and energy scarcity [32,33].

A solar pond with three different zones having various densities of saltwater can operate as large thermal batteries. The three zones are called the upper convective zone (UCZ), non-convective middle zone (NCZ), and lower convective zone (LCZ) [34,35]. The UCZ is the topmost layer of the solar pond and commonly consists of freshwater close to the ambient temperature; it has the functions of heat insulation and preventing the disturbance of the underlying solution. The NCZ is just below the UCZ with a gradually increasing salt concentration with increasing depth. This layer effectively prevents natural convection in the vertical direction caused by the rising temperature of the water in the lower pool, which minimizes heat losses from the highly saline bottom layer. The LCZ comprises a saturated salt solution with the highest saline density and no concentration gradient. This layer provides heat absorption and storage, and the maximum temperature can reach around 100 °C [36-39]. Solar ponds are mainly divided into two categories: convective and non-convective. A shallow solar pond is a convective solar pond; the salinity gradient solar pond (SGSP), equilibrium solar pond (ESP), solar membrane pond, and solar gel pond are non-convective [40,41]. The solar gel pond is generally more costly than the SGSP [42]. The solar pond is an energy storage technology with

1.8 Comparison of various techniques used in water purification system

Desalination improves the water quality, greatly mitigates water shortage problems, and improves the quality of life and economic status. At present, humans mainly use fossil energy. The heavy consumption of fossil fuels has caused serious ecological and environmental problems such as global warming. Moreover, the uncontrolled use of fossil fuels will exhaust the limited reserves. Therefore, demand needs to be controlled, and alternative energy sources need to be developed. So solar powered water purification system is required in this era

In a solar-powered desalination system, solar radiation is either collected by a thermal collector (e.g., MSF, MED, HDH, SC, and SD) or converted to electricity (e.g., RO, ED, and MVC)Solar thermal-driven desalination is very well-developed, while increasing focus is being given to PV cells. PV panels can easily be integrated with RO plants, which are a mature technology. The desalination cost is influenced by many factors, including the solar energy collector system, solar radiation, and desalination system energy transition efficiency. For low cost solar system with R.O system can be used

2. CONCLUSION

Fresh water scarcity is more serious problem in world. The solar – thermal based method provides stable and reliable operation and high quality water but it has high energy consumption. The membrane method has the advantages of low energy consumption, low capital costs, and greater operating flexibility, but the maintenance is high. So the solar based reverse osmosis technique is most useful for rural areas in India. As it has low powered consumption and also less maintenance cost

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