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Study and Prototype Design of Solar Powered Desalination

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I. INTRODUCTION

Water scarcity can be defined as a lack of sufficient water, or not having access to safe water supplies. Water is a pressing need in many areas of the world. That scarcity is spreading as water is needed to grow and process food, create energy, and serve industry for a continually growing population. Water covers 70% of our planet, and it is easy to think that it will always be plentiful. However, freshwater, the stuff we drink, bathe in, irrigate our farm fields with, incredibly rare. Only 3% of the world's water is fresh water, and two-thirds of that is tucked away in frozen glaciers or otherwise unavailable for our use. Desalination is a water supply option that is used widely around the world and involves taking the salt out of water to make it drinkable. Desalination requires significantly more energy than existing conventional water treatment processes, so it is expensive. Solar desalination is a technique to produce water with a low salt concentration from sea-water or brine using solar energy. The salt water in the desalination unit is heated by the Sun, converting the liquid to water vapour. As it is heated, the water vapour rises to the top of the unit, collects on the inside lid, and condenses back to liquid as fresh water in a separate collection container. The salt cannot change to a gas and, therefore, remains in the original unit. Direct solar desalination works well for purification but, because of the low operating temperature of the unit, does not produce a lot of water per day. The amount of drinking water produced in a direct desalination unit is proportional to the surface area of the device. The daily freshwater output per square metre of area is typically 2 to 3 litres depending on the solar still design. The typically easy-to-operate design, however, makes it ideal for small-scale needs of families in remote areas, since the average person needs about two litres of water per day to survive. The process is driven solely by solar energy, so weather conditions and variable solar intensity can negatively impact efficiency.

1.1 Need for solar desalination

There is an increasing demand for advancing conventional desalination technologies and developing novel solar powered desalination processes. The increasing demand for solar powered desalination systems is driven by the increasing cost of fossil fuels for thermal and electrical energy generation, falling cost of renewable energy technologies, need for small scale decentralized desalination systems to operate in remote areas that lack access to the electrical grid, and the concern over climate change. Solar powered desalination is especially important in remote and rural areas with low infrastructure and without connection to a grid. Small-scale stand-alone solar powered desalination systems are desirable to provide a reliable source of potable water.

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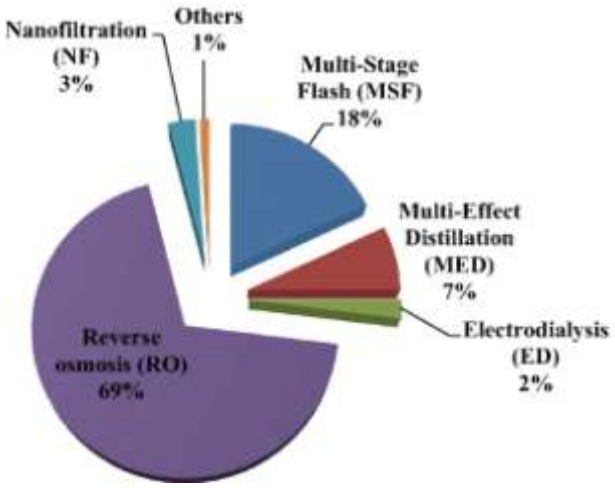

Fig 1.2 Quantity of desalinated water

1.2 Environmental Impact

Solar desalination is primarily a zero-carbon emission process and the advancements in solar technology enables overcoming previously existing problems like dust and high temperatures, which affected the efficiency of previously used solar panels.

In 2011, the Environment Agency-Abu Dhabi (EAD) tested cutting-edge solar technologies for desalinating water in the desert. The trial conducted at 30 sites in the Emirate of Abu Dhabi was said to be the largest across the globe. Each unit set at the solar desalination facilities in Sweihan and Hameem could generate 35 kW/h of energy on average and thus produce 1050 kW/h of energy on the whole. This shows that the negative impact of desalination process on the environment as well as the cost of producing water can be reduced using the solar desalination technology.

In another research carried out by Jijakli et al from the Masdar Institute of Science and Technology in 2011, three desalination-based alternatives such as a solar still, a photovoltaic (PV) powered reverse osmosis (RO) unit and water delivered from a central RO plant using truck were compared and assessed for their environmental footprint. It was found that the PV-RO unit had the lowest impact on environment. This study helps in promoting the low-carbon desalination technologies.

1.3 Benefits of Solar Desalination

Some of the key benefits of solar desalination include the following:

- It uses free solar energy for operation.
- Solar desalination plants are inexpensive, light in weight and easy to transport.
- The plants can be set up easily either onshore or offshore.
- Low maintenance costs.
- Environment-friendly

1.4 Disadvantages of Solar Desalination

- **Cost:** The initial cost of purchasing a solar system is fairly high. This includes paying for solar panels, inverter, batteries, wiring, and the installation.
- **Whether dependent:** Although solar energy can still be collected during cloudy and rainy days, the efficiency of the solar system drops. Solar panels are dependent on sunlight to effectively gather solar energy. Therefore, a few cloudy, rainy days can have a noticeable effect on the energy system. Also, solar energy cannot be collected during night.
- **Solar Energy Storage Is Expensive:** Solar energy has to be used right away, or it can be stored in large batteries. These batteries, used in off-the-grid solar systems, can be charged during the day so that the energy is used at night. This is a good solution for using solar energy all day long but it is also quite expensive.
- **Uses a Lot of Space:** The more electricity you want to produce, the more solar panels you

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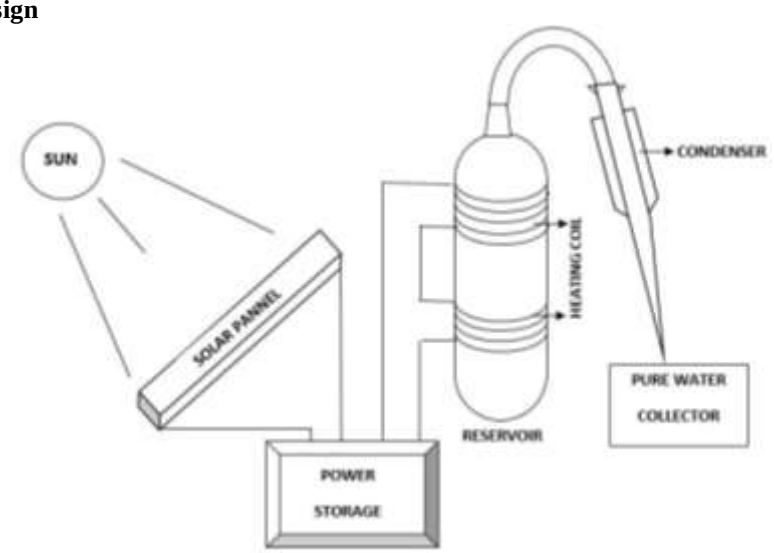
will need, as you want to collect as much sunlight as possible. Solar PV panels require a lot of space.

- **Associated with Pollution:** Although pollution related to solar energy systems is far less compared to other sources of energy, solar energy can be associated with pollution. Transportation and installation of solar systems have been associated with the emission of greenhouse gases. There are also some toxic materials and hazardous products used during the manufacturing process of solar photovoltaic systems, which can indirectly affect the environment. Nevertheless, solar energy pollutes far less than other alternative energy sources.

II. SOLAR POWERED DESALINATION

2.1 Conceptual design



2.2 Main parts in the design are;

- Boiler
- Heating coil
- Copper tube
- Condenser
- Solar power unit

2.2.1 Boiler

Reservoir is used to store and boil the saline water. In the early stages carbon steel is used in the preparation of reservoir. Carbon steel is relatively inexpensive, readily available and possesses engineering properties that have been understood and used for decade. Another feature of carbon steel that is largely understood is its tendency to corrode, so stainless steel is used as the material for reservoir.

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Fig 7.2 Boiler

2.2.2 Heating coil

Nickel-chromium alloy is used as heating coil. These alloys are especially characterized by high resistivity and high resistance to oxidation and chemical corrosion. They are suitable for making high-value electrical resistors, heating wires, heating cords and cables. Nichrome is consistently silvery-grey in colour and has a high melting point of about 1,400°C (2,550°F)

Fig 7.3 Heating coil

2.2.3 Copper tube

Copper tube is used to collect the water vapour and guide it into the condenser.

Fig 7.4 Copper tube

2.2.4 Condenser

Shell coil Condenser is used to condense the water vapour. The water vapour formed in the container passes through the condenser coil, the saline water is used as the coolant, and the heat from the vapour is absorbed by this saline water.

Fig 7.5 Condenser

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2.2.5 Solar power unit

Solar power unit consist of solar panel & battery. A solar panel, or photo-voltaic module, is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy to generate direct current electricity. A collection of PV modules is called a PV panel, and a system of panels is an array. Battery will store the electricity generated by the solar panel

Fig 7.6 Solar power unit

2.3 Orthographic View

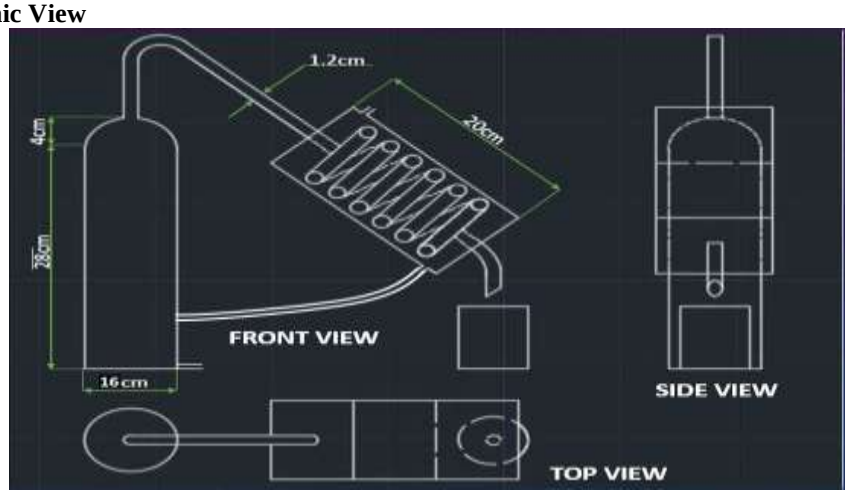

Fig 7.7 Orthographic View

2.3.1 3-Dimensonal View of boiler

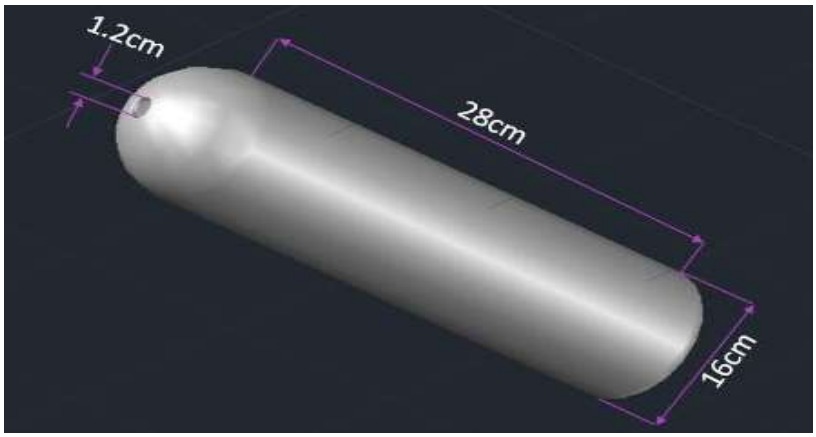

Fig 7.8 3D view of boiler

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2.3.2 3-Dimensonal View of condenser

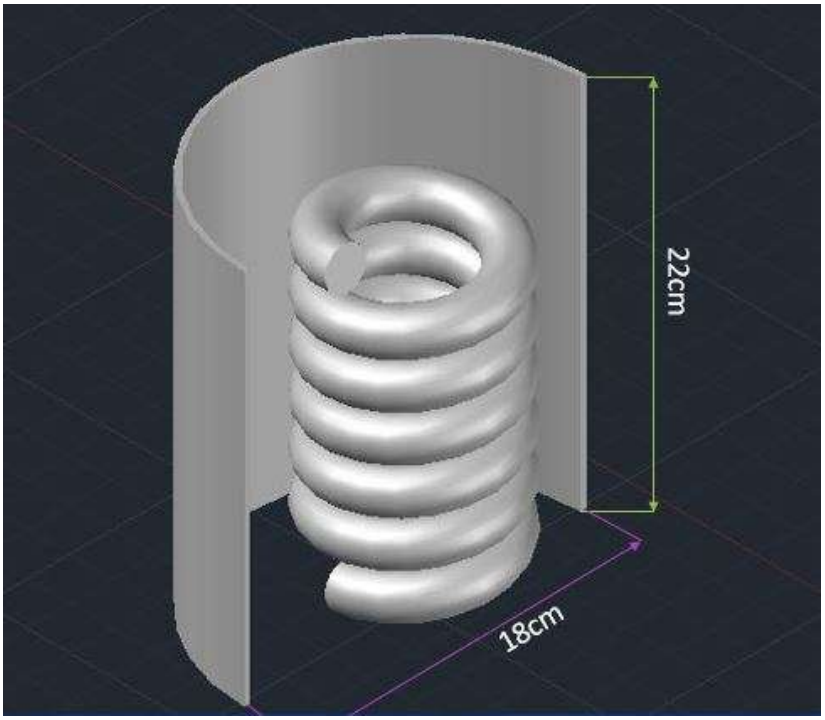

Fig 7.9 3D view of condenser

2.4 Calculations

Heating coil power = 200 Watts

Heating coil power supply for 24 hrs = 200✕24 = 4800 Watts

Ah of battery = 4800/12 = 400 Ah

By considering the factor of safety we can use 450Ah battery (3✕150)

Total power stored by the battery = 450✕12 = 5400 Watts

$$\text{Power of solar panel} = \frac{\text{Total power we required}}{(\text{Efficiency of panel}) \times (\text{no.of hours})}$$

$$= \frac{5400}{(0.8 \times 7)} = 964.2 \approx 1000 \text{ Watts}$$

2.5 Solar power rating use according to calculation

Watts	No.
100	10
200	5
500	2

Table 8.1 Power rating of solar panel.

III. CONCLUSION

The project deals with design of solar powered desalination. Fuel conception is main problem generating during the existing desalination. It is understood that existing energy source can replaced by solar energy. Studies on solar energy harvesting methods shows that solar energy harvesting using solar panel is more convenient.

Design is done on a 5 litres of solar desalination plant. Power supply is done by a 600-watt solar panel and a 200Ah battery. Evaporation of saline water is done by to heating coil each of 200 watts. Condenser used to condense the desalinated vapour is shell and coil Condense.