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SUSTAINABLE DESALINATION METHODS

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ABSTRACT

Sustainable desalination involves using non-conventional or renewable sources of energy to generate steam. This is done by harnessing the power of the sun, tidal waves, temperature difference in the depths of the ocean, etc. We are going to look at once such way of sustainable desalination by harnessing the power of the sun with the help of parabolic troughs.

A parabolic trough is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two, made of polished metal mirror. The sunlight entering the mirror parallel to its plane of symmetry is focused along the focal line of the parabolic trough. The tube which contains the fluid which is to be heated is present along this focal line. The angle of the parabolic trough is adjusted according to the time of the day, basically according to the location of the sun to maximize the incident sunlight. The hot fluid can be used for many purposes.

The naturally occurring focus of the parabola or the focal line of the parabolic trough on which sunlight is concentrated is the main advantage of parabolic troughs over traditional flat solar panels. .

One of the main problems of desalination by multiple effect distillation is the high consumption of power required for the inlet steam. Alternate methods like parabolic troughs

can be used as a hybrid system to reduce the amount of power generated by conventional methods. Heat recovery should be implemented wherever possible, in this case, the output steam after the nth effect.

Thus, innovative new methods can be used to make desalination a cleaner and sustainable process.

Key words: Sustainable, desalination, parabolic trough, consumption, innovative.

1. INTRODUCTION

As we know, non-renewable or traditional sources of energy such as coal, oil, and will not last forever. Moreover, desalination is done to obtain a necessity of man, water. Which means that we are using burning exhaustible sources of energy to obtain a primary resource. Burning of traditional sources of energy leads to the generation of a carbon footprint, which has long lasting effects on the environment. Therefore, we should not be generating a carbon footprint for a necessity such as water, which leads us to sustainable desalination.

Sustainable desalination involves using non-conventional or renewable sources of energy to generate steam. This is done by harnessing the power of the sun, tidal waves, temperature difference in the depths of the ocean, etc. We are going to look at once such way of sustainable desalination by harnessing the power of the sun with the help of parabolic troughs.

A parabolic trough is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two, made of polished metal mirror. The sunlight entering the mirror parallel to its plane of symmetry is focused along the focal line of the parabolic trough. The tube that contains the fluid, which is to be heated, is present along this focal line. The angle of the parabolic trough is adjusted according to the time of the day, according to the location of the sun to maximize the incident sunlight. The hot fluid can be used for many purposes.

The naturally occurring focus of the parabola or the focal line of the parabolic trough on which sunlight is concentrated is the main advantage of parabolic troughs over traditional flat solar panels.

We will also be looking at some ways of energy recover in the desalination process. Recovering energy at strategic points will help us reduce the energy input required and hence the cost of desalination.

One of the main problems of desalination by multiple effect distillation is the high consumption of power required for the inlet steam. Alternate methods like parabolic troughs can be used as a hybrid system to reduce the amount of power generated by conventional methods. Heat recovery should be implemented wherever possible, in this case, the output steam after the nth effect. [1][2]

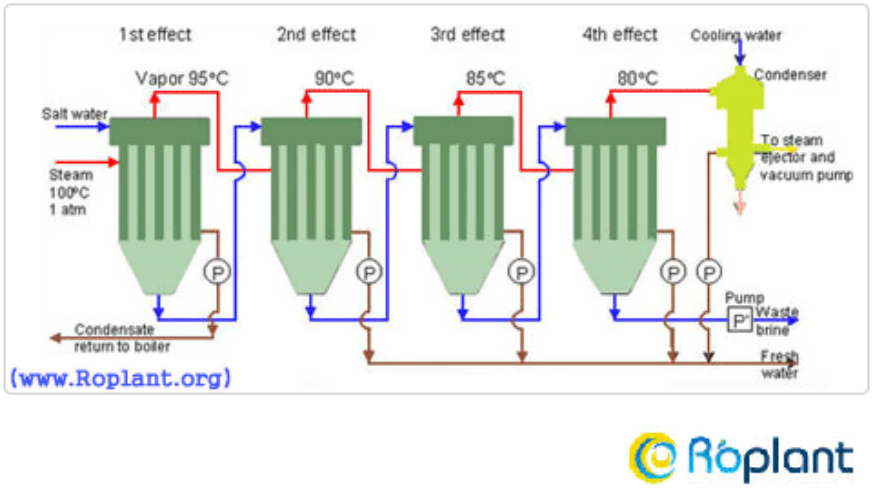


Figure 1. Typical representation of a multiple effect distillation procedure used for desalination of seawater. [4]

- **Identifying points of heat recovery:**

80° C steam leaving the last effect, which is sent to the condenser

- **Identifying source of energy typically used:**

Coal fired boilers to obtain 100 ° C steam at one atm.

2. METHODS TO MAKE DESALINATION SUSTAINABLE

2.1 Parabolic troughs

A parabolic trough is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two, made of polished metal mirror. The sunlight entering the mirror parallel to its plane of symmetry is focused along the focal line of the parabolic trough.

The tube which contains the fluid which is to be heated is present along this focal line. The angle of the parabolic trough is adjusted according to the time of the day, basically according to the location of the sun to maximize the incident sunlight. The hot fluid can be used for many purposes.

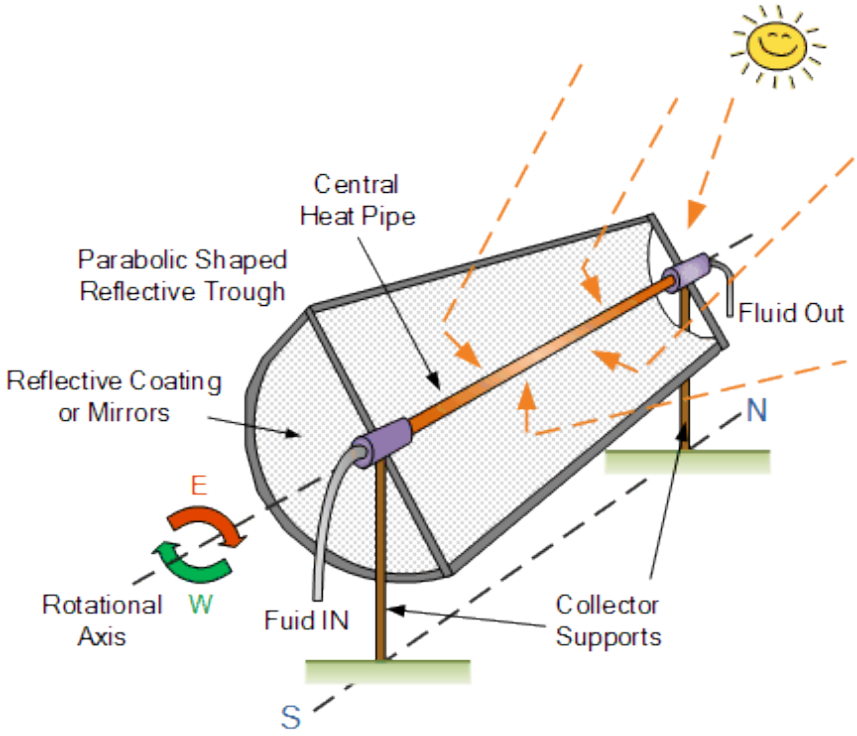


Figure 2. Parabolic Trough representation [1]

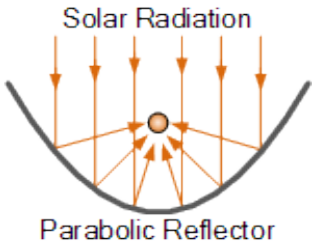


Figure 3. Focus of Parabola [1]

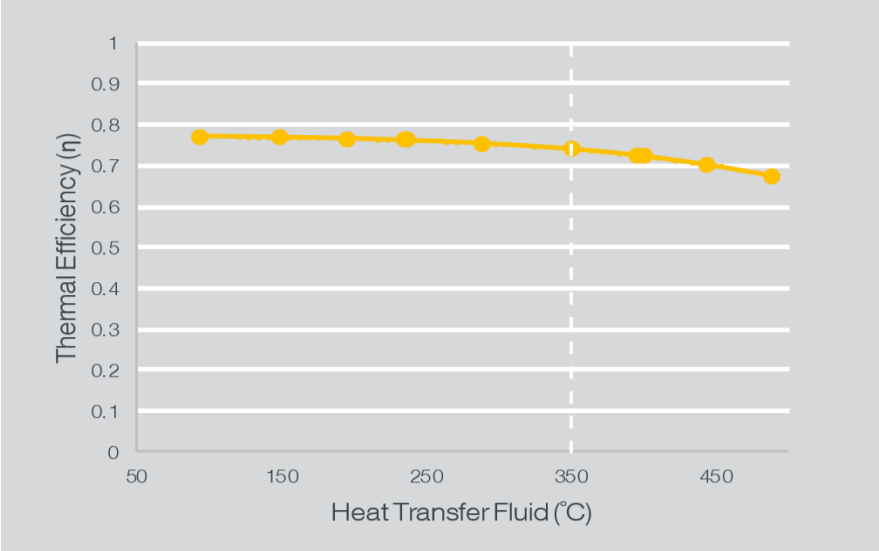


Figure 4: Efficiency of Trough at different Temperatures [4]

The outlet steam will be about 60-70 °C varying in each case. For low temperature processes, the effects will occur under vacuum with an operating pressure ranging from 0.3 bar to 1 bar. For high temperature processes, the pressure is above 2 bar. Depending on the outlet steam pressure, suitable method for heat recovery can be used. Let us look at some of these methods.

2.2 Heat recovery by condensation

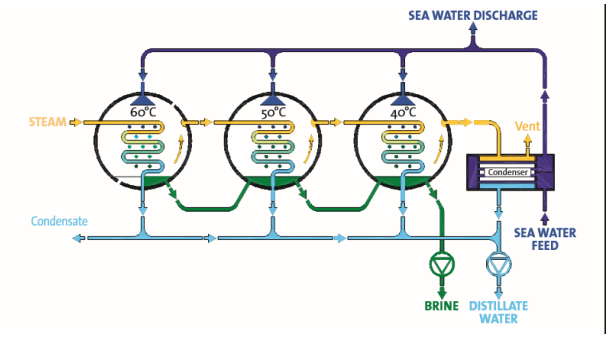


Figure 5. Heat recovery by condensation

In this case, the temperature of the outlet steam is utilized to pre-heat the sea water to a certain temperature. This in turn will reduce the heat required for distillation by some amount. It facilitates condensation of the steam while providing temperature elevation for feed sea water. Effectiveness reduces when temperature difference between outlet steam and sea water feed is low.

2.3 Steam recycling by thermo compression

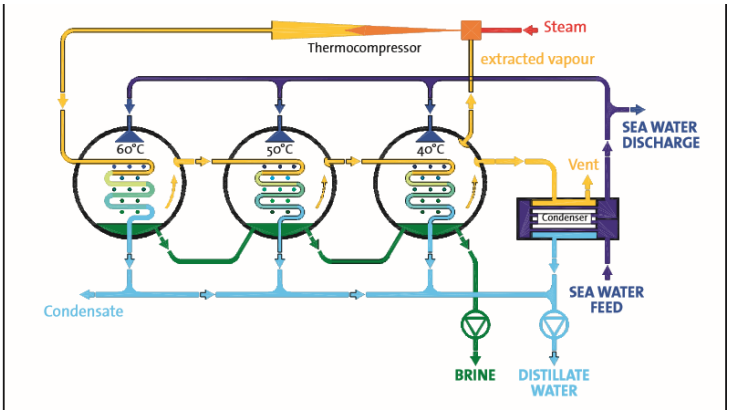


Figure 6. Steam recycling by thermo compression

Using Low pressure (0.3-1 bar) or Medium Pressure (2 bar) steam this static compressor will take a part of the vapor raised in one of the cells and recycle it into higher pressure vapor to be used as heating media for the first one. Thus, a part of the exhaust steam can be used again by increasing its pressure to the operating pressure. As a result, the energy in the exhaust steam will be utilized [3].

2.4 ELECTRICITY GENERATION BY LOW PRESSURE STEAM

On one side we have low pressure steam at about 60-70 °C which would heat up ammonia in a heat exchanger. Boiling point of ammonia is -33 °C so we would be getting high pressure vapor at temperatures like 50-60 °C. This vapor will be used to drive a turbine which will in

turn generate electricity. The ammonia will be cooled by the sea water to complete a closed ammonia cycle.

3. RESULTS

Table 1. Power input from parabolic trough

Power input from Parabolic Trough per unit area		
Average Incident Solar Power	1000	W/m^2
Working Temperature of fluid (water)	100	°C
Efficiency of Design Parameters	0.75	
Heat transfer rate to working fluid	750	W/m^2

The average incident solar rays lead to an incident power of 1000 Watts per meter square of the earth's surface. Looking at the efficiency chart of the parabolic troughs, for our working temperature, we can see that at 100 C, we get an efficiency of 0.75. This means that we will be getting about 750 Watts per meter square of the parabolic trough used. [4]

COSTING

Table 2. Costing of Trough

Costing per m^2 of Parabolic Trough		
Space frame	3430	Rupees per m^2
Reflectors	2940	
Receivers	1050	
Drive and Controls	1330	
Torque Plates	700	
Pylons and foundations	420	
Reflector Supports	350	
Electrical Cabling	350	
Receiver supports	280	
Transport	140	
Site equipment	70	
Total	**11060**	

Adding up all the costs of material, installation, transportation, etc. we get a total of 11,000 Rupees per meter square of the parabolic trough. [5]

CAPACITY

Table 3. Capacity of Parabolic Trough

Capacity per unit area of parabolic trough		
Temperature change	30 to 100	°C
Heat required to convert water to steam at 100°C	2522	KJ/Kg
Average productive running time	6	hours/day
Heat transfer rate per day	16200	KJ/m^2
Capacity to produce steam per day	**6.42**	**Kg/m^2**

We require a temperature change from 30C to 100C for desalination. The heat required will be the sensible heat to heat water from 30 C to 100 C and the latent heat of vaporization. This is about 2522 KJ per Kg of water. Not all 24 hours of the day are suitable to run the solar trough. For optimal performance it has been found out that solar panels, troughs, etc. should be run for 6 hours. Which means that we get a heat transfer of 16200 KJ per meter square of the parabolic trough in a day. This leads to a steam generation capacity of 6.42 Kg per meter square of the parabolic trough per day.

4. DISCUSSION

One of the main problems of desalination by multiple effect distillation is the high consumption of power required for the inlet steam. Alternate methods like parabolic troughs can be used as a hybrid system to reduce the amount of power generated by conventional methods. Heat recovery should be implemented wherever possible, in this case, the output steam after the nth effect. Thus, innovative new methods can be used to make desalination a cleaner and sustainable process.

5. REFERENCES

[1] Hamid Rezvani Datsgerdi, Hui Tong Chua, Thermo-economic analysis of low-grade heat driven multi-effect distillation based desalination processes, Desalination, Volume 448, 15 December 2018, Pages 36-48, https://www.sciencedirect.com/science/article/pii/S0011916418310610

[2] Mousa Abu-Arabi, Mohammad Al-harahsheh, Hasan Mousa, Zobaidah Alzghoul, Theoretical investigation of solar desalination with solar still having phase change material and connected to a solar collector, Desalination, Volume 448, 15 December 2018, Pages 60-68, https://www.sciencedirect.com/science/article/pii/S0011916418311986

[3] Sky fuel http://www.skyfuel.com/products/sky trough/

[4] RO Plant http://www.roplant.org/

[5] Wikipedia Parabolic Trough https://en.wikipedia.org/wiki/Parabolic trough