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# Solar Water Distillation System by Using Inclined Double Basin

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**Abstract -** *To design and test the double inclined solar water distillation system and compare it with a single inclined solar water distillation system under the climate conditions. In an inclined solar water distillation system, the feeding water falls down on the bare plate through the distribution pipe. The double inclined solar water distillation system has two sections. In the lower section the feeding water falls down on the bare plate, through distribution pipe. In upper section of the double inclined solar water distillation system, the feeding water falls down on the glass, through distribution pipe. Inclined solar water distillation and double inclined solar water distillation (DISWD) systems have the ability to produce both fresh water and hot water at the same time*

## 1. INTRODUCTION

The solar desalination systems provide potable or fresh water for drinking and cooking. There are different classifications for solar desalination systems. In term of energy supply, solar desalination systems fall into two categories: passive and active solar stills. The passive solar still systems are those using solar energy as the only source of thermal energy. In the active solar stills extra thermal energy is given to the passive solar still for faster evaporation. It can also be classified according to different used techniques, phase change or thermal processes and membrane or single-phase processes. In the phase change process the distillation of sea water is achieved by utilizing a thermal energy source. The thermal energy may be obtained from a conventional fossil-fuel source, nuclear energy or from a non-conventional solar energy source. In the membrane process, electricity is used either for driving high pressure pumps or for ionization of salts contained in the sea water. In term of structure, solar desalination systems fall into two main categories, direct systems and indirect systems. The former one refer to those systems which all parts are integrated into one system which means it uses solar energy directly to produce distillate mainly on the backside of the glass cover of solar collector, while the later one refer to those which two sub-systems are employed separately, one for solar energy collection and one for desalination which means distillate mainly produce in a separate condenser. In the direct solar desalination systems, there are different kinds of solar stills like simple or conventional solar stills, double basin or regenerative solar stills, triple basin solar stills, pyramid shape solar stills, capillary film distiller stills, multi effect solar stills and etc. For the in-direct systems, there are different kinds of humidification-dehumidification systems, solar stills with outside condenser, solar stills with forced condensation and etc.

## 2. LITERATURE SURVEY

Distillation technologies were used for some years to provide fresh and potable water for labors in small industrial society in the past. After 1945, the demand for potable water was increased; this caused the increase in using distillation systems. Within recent years, the progress that have been made and also the modifications and improvements in efficiency brought down the cost of distillation systems. [1]

Solar still distillation is one of the different processes that can be applied to remove the impurities from water. Solar irradiation is the source of heat energy needed for this kind of work. In this process, the sun radiation provides heat to evaporate water and to separate the vapor from impurities that exist in the water, after that condense it as portable water under the glazing. Distillation processes simulate water evaporation and raining cycle on the earth. The sun's radiation or solar radiation heats the water in the oceans, seas and rivers. It evaporates and condenses and forms clouds, which fall on the earth as rainwater. Solar still can be classified basically in two types; active and passive solar still systems. [2]

## 3. EXPERIMENTAL SETUP

### 3.1 Double Inclined Solar Water Distillation System

Three sides of the double inclined solar water distillation system, i.e., bottom, left and right inner sides are made of galvanized steel, painted to matte black to increase the absorptive. The middle and the top of the system are covered with transparent glass having thickness of 4 mm. As it is shown in Fig, DISWD is divided into two sections; lower and upper section. The lower section has a rectangular shape; the bottom and two sides are made of the galvanized steel, the top and left and right inner sides covered by glass. The upper section of DISWD has two sides made by galvanized steel, the left and right inner sides and the bottom and top are covered with 4mm thick transparent glass. In both lower and upper sections there are pipes that have small holes on them to distribute feeding water on the plate and the glass. The channels collect and allow the condensate water vapor get collected in reservoirs. There are pipes connected to the holes to guide the remaining hot water get collected into separate tanks.

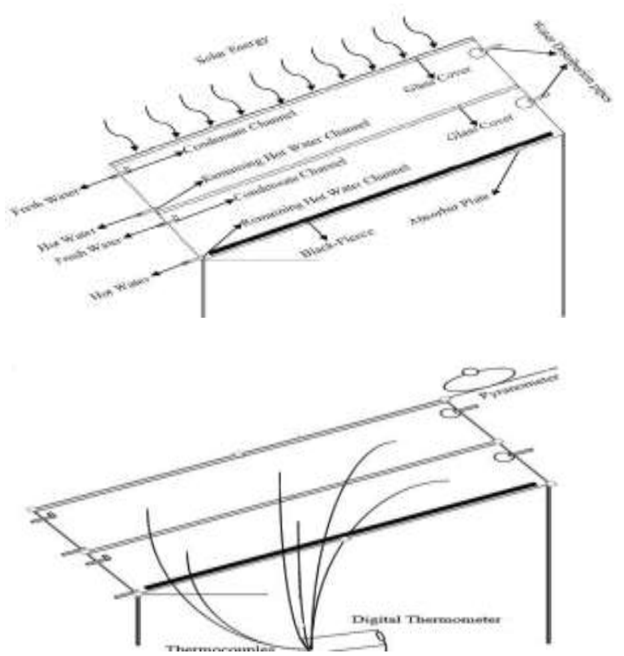


**Fig -**1: Double incline solar divided in two types.

### 3.2Energy Equation of the Absorber Plate:

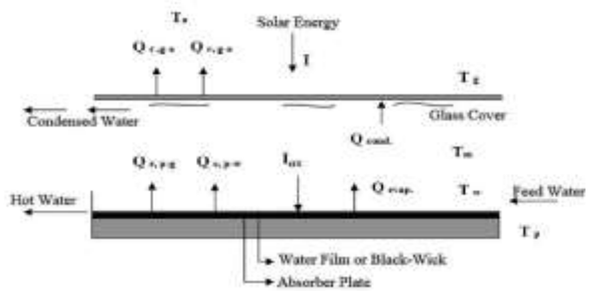


**Fig -1**: Energy Equation

The energy equation for the absorber plate can be written as-

$$M_p C_p \frac{dT_p}{d_t} = I\tau\alpha - Q_{r,p-g} - Q_{c,p-w}$$

### 3.3Humidity

There are three main measurements of humidity: absolute, relative and specific. Absolute humidity is the water content of air. Relative humidity, expressed as a percent, measures the current absolute humidity relative to the maximum for that temperature. Specific humidity is a ratio of the water vapor content of the mixture to the total air content on a mass basis.

If the relative humidity of the moist air and the water vapor density and density of the air are known, the specific humidity can be expressed as:

$$X = 0.622\varphi \frac{\rho_{ws}}{(\rho - \rho_{ws})100} \%$$

Where:

X : Specific humidity of air vapor mixture (kg/kg)

Φ : Relative humidity (%)

$\varphi_{ws}$ : Density of water vapor (kg/m3)

### 3.4 Economic Analysis:

Initial investment in desalination system utilizing solar energy is high. Therefore, an economic system evaluation is essential in decision making. Like many other systems the basis of design decisions is economics. Designing a technical system is a part of the designer's task. Equally important is the requirement that the system be economical and show an adequate return on investment. Therefore, the economic objective of this study is to design a system that has high yield i.e., low production cost.

## 4. Experimental Procedure

Inclined solar water distillation system and double inclined solar water distillation system are promising techniques to produce potable water and hot water for domestic applications. The water from the reservoir tank through the pipes distributed in to the ISWD and into the double solar water distillation system in both lower and upper sections simultaneously with different mass flow rate. The feeding water drops from the holes that are made along the pipes into the cavity and gradually flows on the bare plate on the ISWD, the bare plate of the DISWD and on the glass surface of the upper section on the DISWD unit. Sun radiates on the both systems and the water was heated and water vapors condense on the inner glass which runs down to channels that were provided to collect fresh water. The remaining water that did not become vapor gets heated and collected in a separate tank as hot water. This work has been tested by two variants, as explained the first test was with bare plate, and the second test was carried out by using black-fleece covering the surface of the plates. In inclined solar water distillation system, in the second test, some black-fleece has put over the surface of the bare plate on the bottom of the box. The black-fleece makes a thicker film of water and distribution of water became evenly. So by using black-fleece, the water kept longer time in the system and these produce in more fresh water.

## 5. RESULT AND DISCUSSION

The efficiency of the system can be calculated using the following equation.

$$\eta = \frac{\dot{m}_f \times h_{fg}}{Radiation\left(\frac{W}{m^2}\right) \times Area(m^2)}$$

Where:

$m_f$: Mas flow rate of fresh water

$h_{fg}$: Latent heat of evaporation

**Table -1:** Hourly average of efficiency of ISWD and DISWD of Test#1 and Test#2

| ISWD (bare plate) Test#1 | DISWD (bare plate) Test#1 | ISWD (black-fleece) Test#2 | DISWD (black-fleece) Test#2 |
|---|---|---|---|
| 9.48% | 19.97% | 29.44% | 38.54% |
| 9.73% | 20.32% | 26.35% | 35.90% |
| 10.40% | 22.16% | 25.26% | 36.50% |
| 10.11% | 21.72% | 28.62% | 38.91% |
| 10.16% | 22.07% | 27.92% | 39.07% |

## 6. Simple Payback Period (SPP)

The Simple Payback Period is employed to find out for how long the distillation systems will pay back the money invested. The average of fresh water productivity of the inclined solar water distillation system with black-fleece during the summer season it is about 1.8 L/day and for the winter season is 1.16 L/day. The average of fresh water productivity of the double inclined solar water distillation system with black-fleece during the summer season it is about 2.3 L/day and for the winter season is 1.5 L/day. The average of fresh water productivity for the whole year for the inclined solar water distillation system is about 1.48 L/day. The average of fresh water productivity for the whole year for the double inclined solar water distillation system is about 1.9 L/day. The sale price of a 20 liters water bottle is 5.0 TL. The SPP is calculated as follows.

**For ISWD:**

Daily (saving) = litters produced × price/litter

Therefore, the daily savings is 0.37 TL

Net savings/day = Daily savings - Running cost

The net savings are estimated to be 0.37 TL

**For DISWD:**

Daily (saving) = litters produced × price/litter

Therefore, the daily savings is 0.475 TL

Net savings/day = Daily savings - Running cost

The net savings are estimated to be 0.475 TL

The investment cost of the systems are 560 TL this includes all the equipment and other parts in the distillation systems.

The Simple Payback Period is calculated for ISWD and DISWD by the following equation.

$$Simple\ Paybac\ Period = \frac{\text{Investment Cost}}{\text{Income Per Day}}$$

The Simple Payback Period for ISWD is calculated to be 1514 days (i.e., 4.15 years) and the Simple payback period for DISWD is calculated to be 1179 days (i.e., 3.2 years). The Simple Payback Period is not acceptable for time span greater than 10 years. As the Payback Period is less than 10 years for both ISWD and DISWD, the method is acceptable.

## 3. CONCLUSION

The present work proposes an experimental study to distill the brackish water by using ISWD and DISWD systems with two different variants (bare plate and black-fleece). One of the most important factors that affect the productivity of an inclined solar water distillation system and double inclined solar water distillation system is solar radiation. As the solar radiation increased the productivity of fresh water also increases. According to the results obtained from the first test, the average of the highest amount of fresh water produced by ISWD and DISWD were measured as 83.7 ml/h and 140.8 ml/h respectively. In the first test, the highest hourly average efficiency for ISWD and DISWD systems were evaluated as 10.40% and 22.16% respectively. Since, the fresh water production rate and the efficiency of DISWD system were greater than ISWD system, DISWD was the preferred system. According to the results obtained from the second test, the average of the highest amount of fresh water produced by ISWD and DISWD were measured as 166.4 ml/h and 222.18 ml/h respectively. In the second test, the highest hourly average of efficiency for ISWD and DISWD systems were evaluated as 29.44% and 39.07% respectively. Since, the fresh water production rate and the efficiency of DISWD system were greater than ISWD system, DISWD was the preferred system.

## REFERENCES

1) E. Kabeel, and S. A. El-Agouz, "Review of researches and developments on solar stills," Desalination, vol. 276, no. 1-3, pp. 1-12, 2011.

2) H. Ş. Aybar, F. Egelioğlu, and U. Atikol, "An experimental study on an inclined solar water distillation system," Desalination, vol. 180, no. 1-3, pp. 285-289, 2005

## BIOGRAPHIES

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