iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VIII **Month of publication:** August 2021

DOI: https://doi.org/10.22214/ijraset.2021.37283

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

Optimization Study of Tilt Angle for Single Slope Solar Still

Onkar Joshi[1], Siddharaj Allurkar[2], Rohit Argade[3]
[1]*DPCOE, Pune*
[2, 3]*Assistant Professor, DPCOE, Pune*

Abstract: ***Water is essential to life. The origin and continuation of mankind is based on water. The supply of drinking water is an important problem for the developing countries. The wooden box has a thickness of 8mm. It consists of a top cover of transparent glass with a tilt of 18°, 26° and is coated with black paint to absorb the maximum possible solar energy. The yield of the single basin solar still is very less and it increases considerably when the solar still was built with copper sheet. An analysis of single slope solar still has done on different tilt angle to optimizing study of tilt angle. They greatly improve the rate of evaporation and the rate of condensation on the cooler surface. The efficiency is higher for solar still made up of copper sheet and its output we have got 1.24 for 18° angle. The optimized tilt angle gave more efficiency than other tilt angle. The optimize water depth is 18mm for 18° angle. This cost-effective design is expected to provide the rural communities an efficient way to convert the brackish water in to potable water.***

Keywords: Solar still, distillate output, water depth, tilt angle

I. INTRODUCTION

Nature is carrying out the process of water desalination since ages. Oceanic water due to solar heating converts into vapors and pours down as precipitation on earth in the form of fresh water .water is the most needed substance on the earth for sustenance of life. Due to rapid expansion of population, accelerated industrial growth and enhanced agriculture production there is ever increasing demand for fresh water .demand of fresh water (potable water) has been increased .The ocean covers 71 % of the earth's surface -140 million square miles with a volume of 330 million cubic miles and has an average salt content of 35,000 ppm .Brackish /saline water is strictly defined as the water with less dissolved salts than sea water but more than 500 ppm. Potable water (fresh water) suitable for human consumption should not contain dissolved salts more than 500 ppm. For agriculture purpose, water containing salt content of 1000 ppm is considered as the upper limit. Potable water is required for domestic, agriculture, and industries Some applications in industries like cooling. Purpose sea water is feasible despite the corrosion problems while other industries use higher quality water than is acceptable for drinking water. modern steam power generation plant need water with less than 10 ppm .Potable fresh water is available from rivers, lakes, ponds, wells, etc. Underground saline water contains dissolved salts of about 2000-2500 ppm. Distillation is one of many processes available for water purification, and sunlight is one of several forms of heat energy that can be used to power that process. To dispel a common belief, it is not necessary to boil water to distill it. Simply elevating its temperature, short of boiling, will adequately increase the evaporation rate. Although vigorous boiling hastens the distillation process it also can force unwanted residue into the distillate, defeating purification. Solar distillation is by far the most reliable, least costly method of 99.9% true purification of most types of contaminated water especially in developing nations where fuel is scarce or too expensive.

A. Active Solar Still

Active methods include the use of solar collector or waste heat to heat the basin water. The use of internal and external condensers or applying vacuum inside the solar still to enhance the evaporation / condensation processes, and cooling the glass cover to increase the temperature difference between the glass and the water in the basin and hence increases the rate of evaporation.

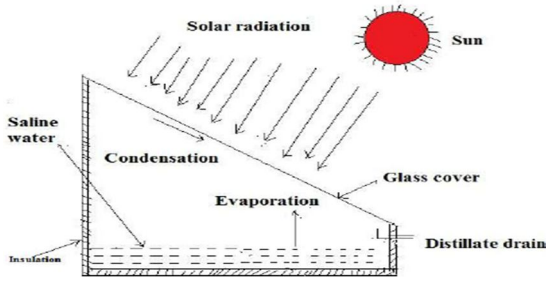

Fig:-1 Single Slope Solar Still

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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It consists of a copper basin which has effective area of 0.8 m^2.This solar still is made of wooden box with all dimensions in mm. The wooden box has a thickness of 8mm. It consists of a top cover of transparent glass with a tilt of 18º, 20°, 22°, 24°, 26º and is coated with black paint to absorb the maximum possible solar energy. This solar faces south direction .The entire assembly is made air tight with the help of rubber gasket and clamps water enters in the basin through an inlet valve .due to the several number and complexity of heat and mass transfer, included in the water still system it was seen that modeling the whole water still distillation system was too complex. The basic principal of distillation is Simple and it replicates the way of nature made rain. Sun energy increases the temperature of water, which causes the increase in the surface evaporation rate, results in formation of water vapors and condensate at the inner cover of glass as a cool surface. This process removes heavier metals, salts as well as microbiological organisms from water and provides the purest form of water as rainwater. Water from solar still should be quite pure. The slow process of distillation allows a pure form of water to evaporate from the surface and condensate at the lower surface of the inner glass surface a careful design, constructional material, and operation of a solar still will give pure water free from the harmful materials and cancer-causing substance, colorless, odorless and unfortunately tasteless also.

II. PROBLEM STATEMENT

Optimizing study of tilt angle for single slope solar still with the depth of available brackish water

III. OBJECTIVE

1) To optimize tilt angle for single slope solar still by keeping fixed water depths
2) To optimize water depth by keeping fixed optimized tilt angle

IV. BENEFITS OF DISTILLATION

A. It produces water of high quality.
B. Maintenance is almost negligible.
C. Any type of water can be purified into potable water by means of this process.
D. The system will not involve any moving parts and will not require electricity to operate.

V. LITERATURE REVIEW

Solar stills, being easy and cheap to manufacture, operate and maintain, are an attractive way to produce distilled water in remote villages or settlements that lack technological skills and cannot access expensive materials among the different varieties of solar stills, the single slope solar still hereafter called “still” is the most widely used system in this the heat collection and distillation processes take place in the same basin. Solar still performance factors depend on several factors affect the performance of a solar still which are following way.

Bhanu Pratap Singh et al. [1] solar radiation, ambient temperature, wind velocity, atmospheric pressure and humidity, and sky clearness etc.

S. Varun Raja et al.[2] (i) Absorber: Length of basin (L), material & thickness, and basin aspect ratio (=L/W)
(ii) Condenser: inclination and thickness of cover, material of cover, single or more glazing;
(iii) Insulation: type (mineral, natural and synthetic), thickness of insulation etc.; and,
(iv) Cavity Aspect Ratio (AR): distance between the absorber and cover (specific height, Hs), and distance between the front and back wall of the solar still (width of solar still, W)

Alpesh Mehta, Arjun Vyas et al.[3] The bottom surface of the still was painted black for greater absorptivity.30º angle and 0.20 m water depth maximum .as we know that output from the still gets maximum when it consists of least water depth.It is evident that as the water depth increases, the productivity will be decreased, this is due to the increase of the heat capacity of the water in the basin. Results in lower water temp in the basin leading to lower evaporation rat. The decrease of the water depth from 3.5 to 2cm increased the productivity by 26%.

Mehrzad Feilizadesh et al.[4] it is therefore essential that it must absorb solar energy hence it is necessary that the material has high absorptivity or very less reflectivity and very less Transmitivity. It is the part of the system in which the water to be distilled is kept. different black material which store greater amount of heat energy and increase the heat capacity of the basin rubber and gravel are some material having these properties we are going to use the black paint .Aluminum has minimum corrosion problem and copper has high thermal conductivity and high radiation absorptivity.

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VI. CFD ANALYSIS

A. Specification of the solar still for 18° and 26° Angle.

Table 1 Specification of the still

Sr. No	Specification	Case[1]	Case[2]
1	Front height	200 mm	200 mm
2	Back height	460 mm	590 mm
3	Angle	18°	26º
4	Transparent glass	5 mm	5 mm
5	Width	1000 mm	1000 mm
6	Length	800 mm	800 mm

Application of CFD tools for the simulation of various fluid flow problem, is gaining popularity day by day as the computational capacities have been improved with the use of digital computers. The use of CFD in engineering plays a vital role because it makes flow conditions visual within the domain. With the help of CFD tools it is easy to analyses various problems which includes turbulent fluid flow. ANSYS FLUENT allows heat transfer within the fluid and solid regions in the model. Various types of complex Problems involving convective heat transfer within a fluid or heat transfer in a composite system can be simulated with the help of ANSYS FLUENT. In this work ANSYS FLUENT software is used for simulations. Efforts have been made towards the CFD modeling of single slope passive solar still. In the CFD analysis of solar still, there are certain assumptions that have been taken under consideration during the simulation.

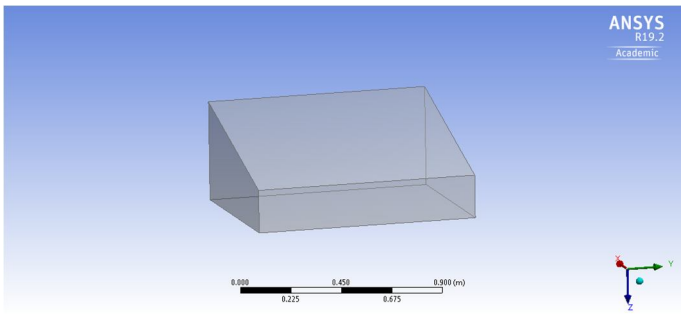

Fig2. Geometry of single slope solar still 18°.

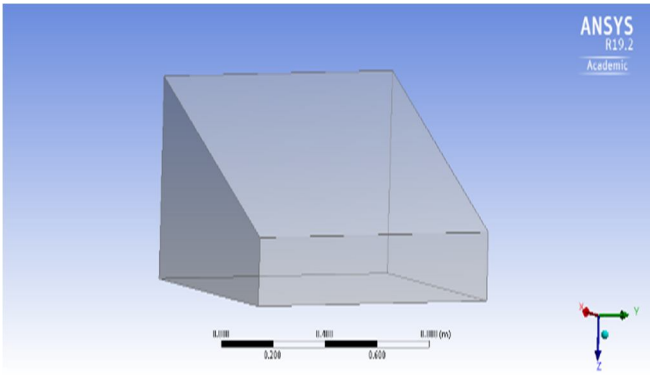

Fig: 3 Geometry of single slope solar still for 26°.

B. Temperature Profiles for 18˚ Angle

In case of solar still, temperature attained by glass cover, water in the basin and the interior of the still play vital role for the distillation of water. In general, amount of distillate produced by solar still depends upon the temperature difference between water in the basin and glass cover. Temperature contours inside the solar still are drawn at the x-y plane passing through center of the still and parallel to its side walls. Temperature profiles of interior temperature and the glass temperature are shown at different time intervals. In the temperature contours a common range from 311 K to 327 K for 18° temperature was chosen for appropriate representation of the contours

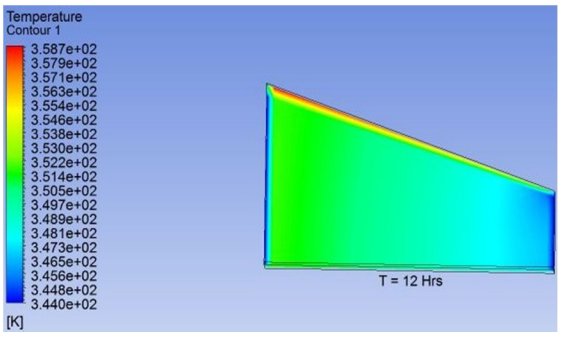

Fig: 4. Contour of interior temperature at 08:00 Hrs

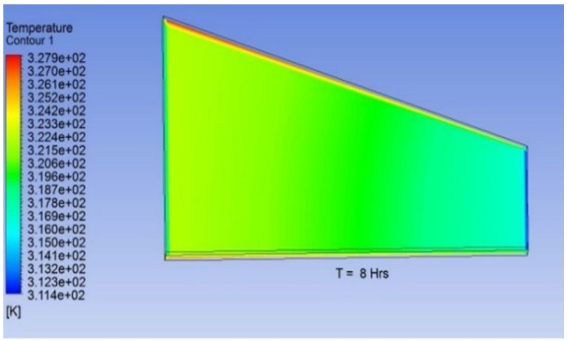

Fig: 5. Contour of interior temperature at 12:00 Hrs

C. Temperature Profiles for 26˚ Angle

In case of solar still, temperature attained by glass cover, water in the basin and the interior of the still play vital role for the distillation of water. In general, amount of distillate produced by solar still depends upon the temperature difference between water in the basin and glass cover. Temperature contours inside the solar still are drawn at the x-y plane passing through center of the still and parallel to its side walls. Temperature profiles of interior temperature and the glass temperature are shown at different time intervals. In the temperature contours a common range from 294 K to 309 K for 26° temperature was chosen for appropriate representation of the contours

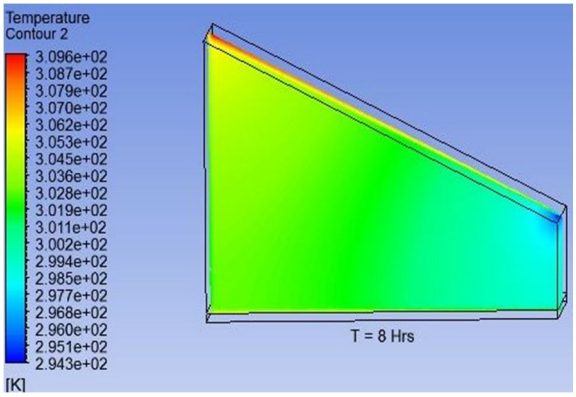

Fig: 6 Contour of interior temperature at 08:00 Hrs

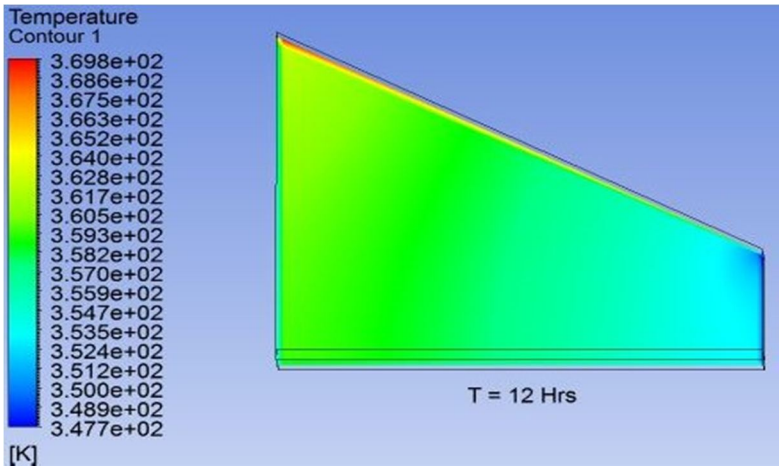

Fig:7 Contour of interior temperature at 12:00 Hrs

VII. RESULT AND DISCUSSION

Single slope solar still are designed.Analytical and CFD calculation has been done for angle 18°, 20°, 22°, 24°, 26°. In this report angle calculations are mentioned.

A. Results for 18˚ Angle

Table 2 Analytical Results for 18°

Time (Hrs)	T_w (°C)	T_g (°C)	h_c (W/m²K)	h_{ew} (W/m²K)	Output (Kg/m²/h)
08.00-09.00	27	26	0.894	5.127	7.598×10^{-3}
12.00-13.00	71	69	1.2258	23.53	0.0729

Table 3 CFD Results for 18°

Time (Hrs)	T_w (°C)	T_g (°C)	h_c (W/m²K)	h_{ew} (W/m²K)	Output (Kg/m²/h)
08.00-09.00	38	37	0.9030	4.925	7.377×10^{-3}
12.00-13.00	71	69	1.2258	23.53	0.0729

B. Results for 26˚ Angle

Table 4. Analytical Results for 26°

Time (Hrs)	T_w (° C)	T_g (°C)	h_c (W/m² K)	h_{ew} (W/m² K)	Output (Kg/m²/h)
08.00 - 09.00	27	23	1.405	4.20	0.0249
12.00 - 13.00	71	68	1.4151	29.74	0.1382

Table 5 CFD Results for 26°

Time (Hrs)	T_w (°C)	T_g (°C)	h_c (W/m²K)	h_{ew} (W/m²K)	Output (Kg/m²/h)
08.00-09.00	21	20	0.8923	2.103	3.0982×10^{-3}
12.00-13.00	75	72	1.4577	35.96	0.1679

VIII. CONCLUSION

The single slope solar still with copper collector.3D transient model helps in to get actual reading with time for clear understanding of solar still.

The standard orientation of solar still is assumed to be south to receive maximum amount of solar insolation. The efficiency for different tilt angle has different. Low tilt angle has more efficiency than higher tilt angle. On Depth of solar still of 18 mm we have got 1.24 liter output for low tilt angle. Copper sheet found to be the best basin material to improve absorption, storage and evaporation effects. For solar stills with the glass cover angles 18°, 26° have got output 1.24, 0.89.The optimize tilt angle is 18° which gives more efficiency than other tilt angle.

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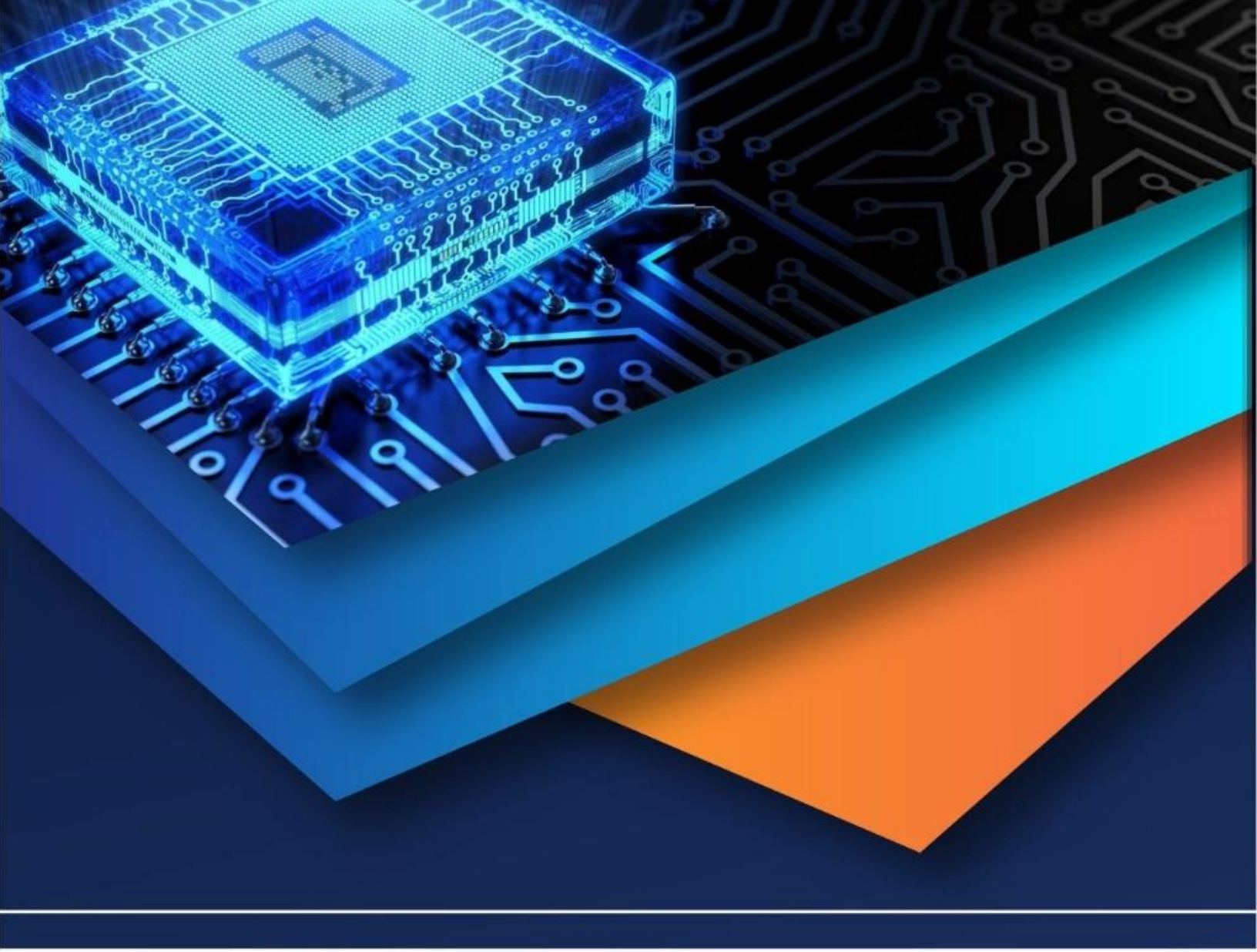

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