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Design, Thermal Analysis and Experimental Evaluation of Effect of Slope of Glass on Performance of Solar Still

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***Abstract*: - Now-a-days, encountering with lack of potable water is one of the major problems in developing as well as under-developed countries. There is a lot of saline water in earth hence to solve problem of potable water, the saline water needs to be converted into potable water. A device, which converts saline water into drinkable water, is called solar still. Solar still is a device which uses process of solar distillation. Solar distillation method is an easy, small scale and cost-effective technique for providing drinking water. It requires an energy input as heat and the solar radiation can be the source of energy. In every efficient solar still design, water temperature, distillate output, and difference between water temperature and inner glass cover temperatures are very important. Many scientists of world have worked on solar still to increase the output. There are different types of solar still designs available with different mechanical structures and performance characteristics including single slope solar still, hemispherical solar still, pyramid solar still, double slope solar still and so on.**

In this thesis, the main aspect of research is focusing on single slope solar still with single basin along with its design, requirements of components, implementation and analysis of the effect of slope of glass on performance of this design in providing drinking water from saline water. In this work, an attempt is made to develop the experimental setup to perform experiments on solar still having movable slope. Proper insulation and sealing is ensured to trap the heat in the basin without any leakage of water and heat. In-depth study of literature is done on the basis of different types of solar still, simulation done as well as designing done on them. Based on the literature, it has been decided to develop the experimental setup of single basin solar still with adjustable/ changeable slope with some modification for experimentation considering different slope angles to check effect on temperature and efficiency of solar still. An attempt will be made for experimental evaluation and cfd analysis at different slope angles to find the angle of slope at which the efficiency is more. DP-1 status involved thorough design, 3D model and parameters/ elements needed for experimentation. In MSR, the actual working model along with analysis/ reading based on experimental evaluation is carried out and in DP-2 CFD-analysis and comparison between experimental and CFD-analysis is done.[1], [2]

***Index Terms*: Solar Still, Variable Slope of Glass Cover, Experiment, Thermal Analysis, Comparison.**

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I. INTRODUCTION

In this emerging era, lack of drinking water is major problem in most of the countries. Solar still is an economical and easy method for production of pure water. Evaporation and condensation are the basic principles used in solar still. The impure water in the solar still is heated by solar radiations that penetrate through the glass cover this causes water to evaporate. Due to temperature difference between water and glass cover the water starts condensing at glass cover leaving all contaminants in the basin. This condensed purified water then runs into a collector through the pipe and then into an enclosed container. Additional water is fed into solar still to flush out concentrated waste from the basin of solar still to avoid excessive salt deposition in the basin.

The design of solar still is make from the analysis of different review paper and case study in which mostly 0.8m^2 to 1.2 m^2 of solar still used and the height increase from left to right from 1 foot to 1.5 foot so, i made a solar still of 0.81m^2 and height of increase from 0.10m – 0.30. The main modification in this solar still is the variation of angle of slope of glass and measure the effect at different angle of slope. There is a basin of 0.75 × 0.88 × 0.10m^3 and the cover of this solar still contain a glass of 4mm and the pipe in which the water come from solar still and go to the collector.

The glass collector collects waterdrops from the glass and go to the half tube type component and it place at the smaller side of the solar still at the end of cover glass. The smaller side of solar still is connected with the outer basin and variable with angle in vertical direction. At the bigger side the cover is variable with the angle from 0 - 15˚.[1], [2], [3]

II. PROBLEM IDENTIFICATION

By studying the research paper based on different type of solar still, performance of it, design, cfd analysis, mathematical modelling. The heat loss, the heat transfer coefficient and the temperature decrease in different type of solar still. For less angel of slope. the productivity is less. For higher depth of water in basin and for less thickness of water layer the productivity is lesser. So, I come on this conclusion that I will make a solar still which have cover with variable angle so we can convert this disadvantage to advantages.

OBJECTIVE

1) Cost should low and affordable.
2) Higher efficiency with less implication.

3) Water should have lesser TDS than 500 ppm.
4) Insulation Should be Proper
5) Heat Loss Should Be Prevented
6) Material Selection Should be Proper in Count of Weight and Life.

By changing the angle of cover glass, changing the water layer thickness and the depth of water in basin the productivity can increase. Increase the heat transfer surface or co-efficient, conduction-convection rate the productivity can increase.by using wooden body we can reduce heat transfer to the outside surface of the solar still.

So, in this dissertation i will make the solar still in which the slope of glass of solar still is modified and the angle of glass cover with basin is varies with 0 to +15. And the basin has black plate at the bottom so the evaporation rate can be increase. And there is an insulation on the both end of solar still so we can prevent heat loss and water loss from the basin.[4], [5]

III. DESIGN OF SOLAR STILL

Table 1 – Dimension of Material

DIMENSION AND MATERIAL	
Date of Experiment	**16/02/2019 - 20/02/2019**
Place of Experiment	**Vadodara (22.3072° N, 73.1812° E)**
Maximum Temperature	**34˚**
Minimum Temperature	**15˚**
Temperature Measuring Device	**AgroDT-555 Digital Thermometer (Error = 0.5˚C)**
Maximum Radiation	**699 w/m^2**
Radiation Measuring Device	**Solarimeter (SL100)**
Material of Solar Still	**Ply-wood**
Material of Insulation	**Natural Rubber With Sulphur Contain**

This Table Contain The Date Of Experiment, Place Of Experiment, Maximum And Minimum Temperature, Information About The Temperature Measuring Device And Radiation Measuring Device, Material Of Solar Still And Insulation.

Table 2 – Dimension of Solar Still Basin

DIMENSION OF SOLAR STILL BASIN :	
Length:	**0.9 m**
Width :	**0.9 m**
Height :	**0.30 (max) – 0.10 (min) m**
Dimension of Glass :	**4 mm**
Dimension of glass Cover :	**0.9 × 0.9 × 0.05 m^3**
Dimension of Basin Tray :	**0.75 × 0.88 × 0.10m^3**
Capacity of Basin Tray :	**66 ltr**
Depth of Water In Tray :	**3 cm**
Used Volume of Water For Experiment :	**20 ltr**
Material of Basin Tray :	**Aluminium**
C-Shaped Part of Variable Angle :	**5˚, 10˚, & 15˚**

This table contain dimension of basin tray, water depth, volume, material of solar still.

IV. CASES TO BE CARRIED OUT

1) Experiment at 20˚of slope of Glass Cover
2) Experiment at 25˚of slope of Glass Cover
3) Experiment at 30˚of slope of Glass Cover
4) Experiment at 35˚of slope of Glass Cover

Fig 1 – Solar Still

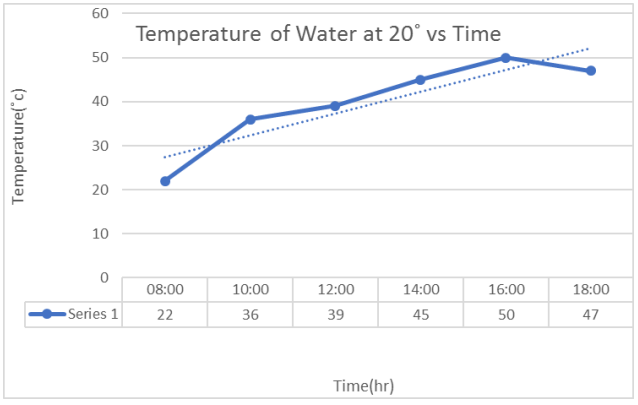


Fig 2 – Temprature of Water vs Time at 20˚

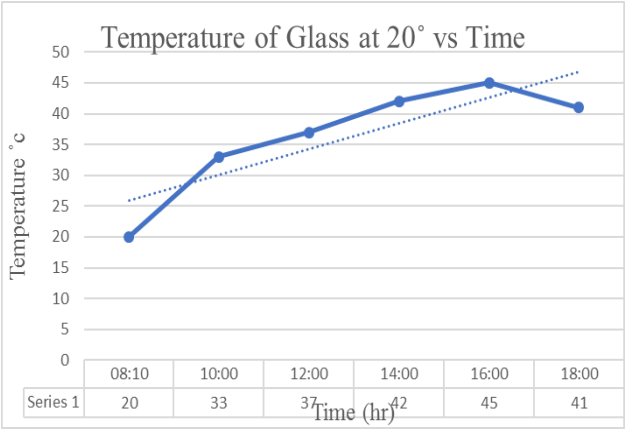


Fig 3 - Temperature of Glass vs Time at 20˚

- In this case angle of slope 20˚(Base Angle) And the Maximum Radiation of the date 16/FEB/2019 is 6.91 W/m^2 and the yield output is 1.99 ltr.

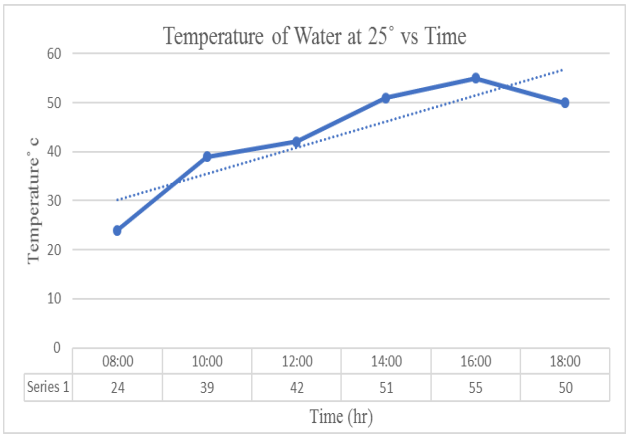


Fig – 4 Temperature of Water vs Time at 25˚

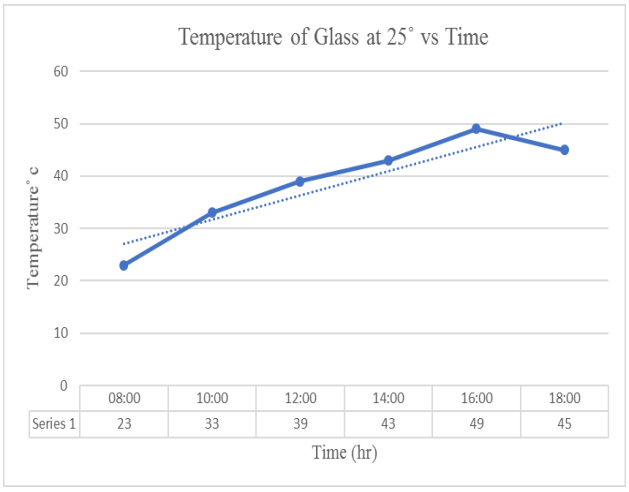


Fig – 5 Temperature of Glass vs Time at 25˚

- In this case. for angle of slope 25˚ And the Maximum Radiation of the date 19/FEB/2019 is 6.99 W/m^2 and the yield output is 2.33 ltr.
  CFD-Analysis result of vapor fraction and water fraction is shown below and the output is 3.16 ltr.

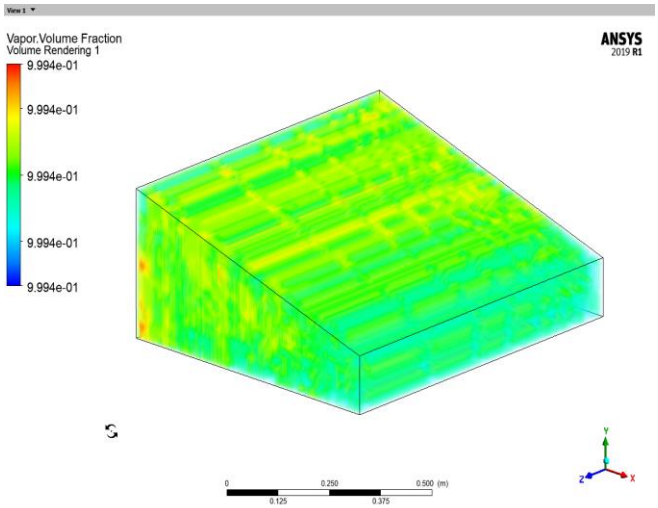


Fig – 6 Vapor Volume Fraction Rendering For 25˚

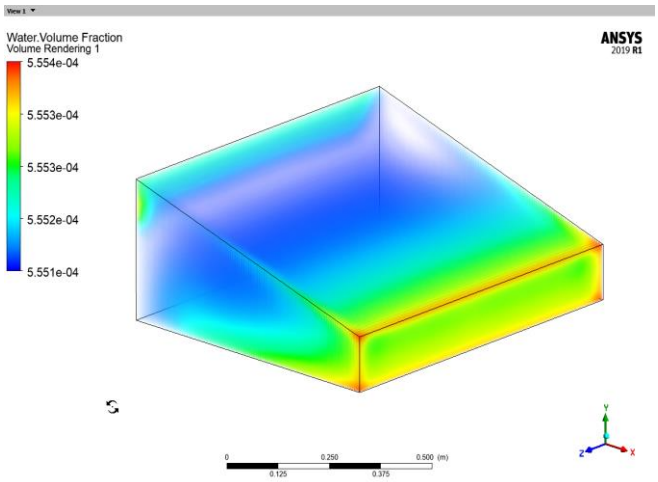


Fig – 7 Water Volume Fraction Rendering For 25˚

- In this case The angle of slope 30˚ And the Maximum Radiation of the date 17/FEB/2019 is 6.93 W/m^2 and the yield output is 2.29 ltr.

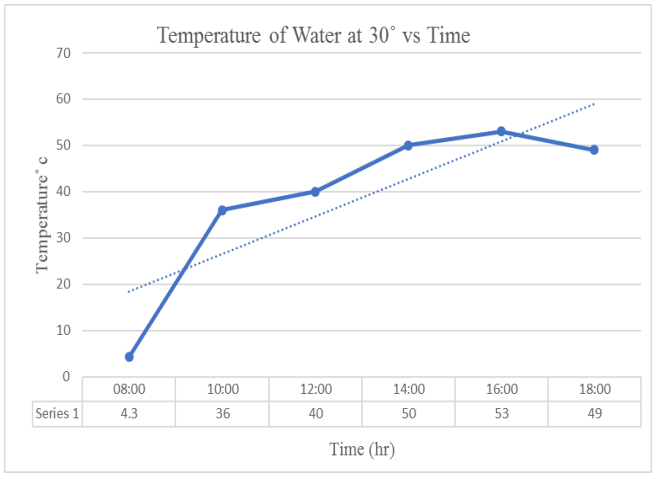


Fig – 8 Temperature of Water vs Time at 30˚

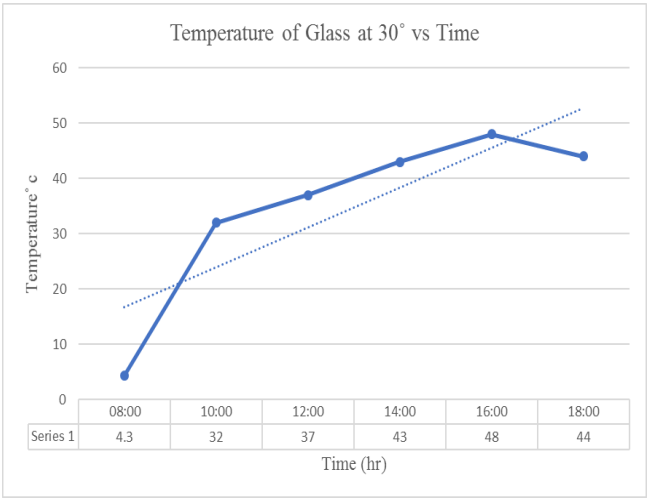


Fig – 9 Temperature of Glass vs Time at 30˚

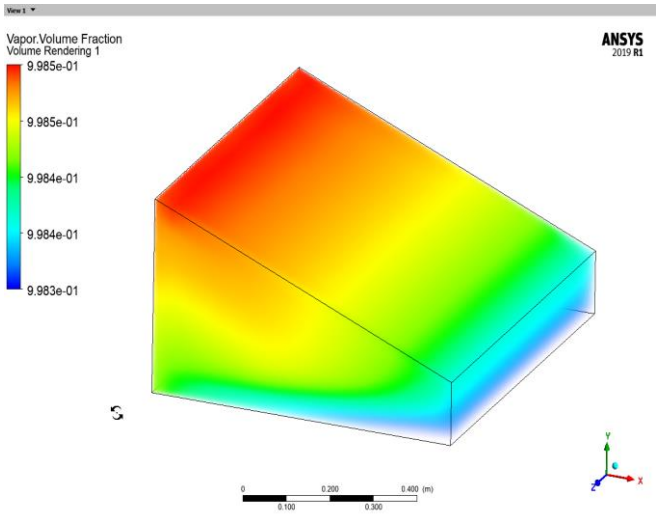
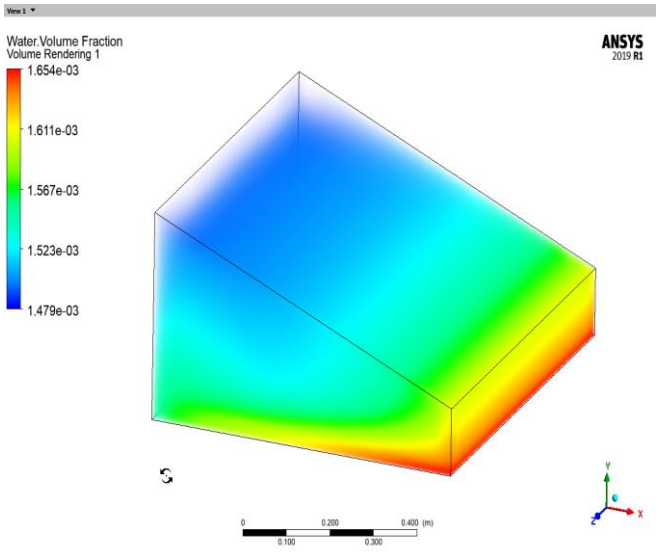


Fig – 10 Vapor Volume Fraction Rendering For 30˚



˚

Fig – 11 Water Volume Fraction Rendering For 30˚

- In this case The angle of slope 35˚ And the Maximum Radiation of the date 20/FEB/2019 is 6.97 W/m^2 and the yield output is 2.13 ltr.

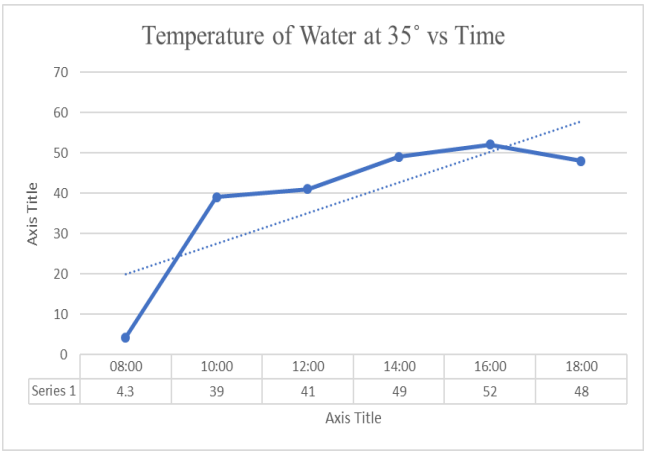


Fig – 12 Temperature of Water vs Time at 35˚

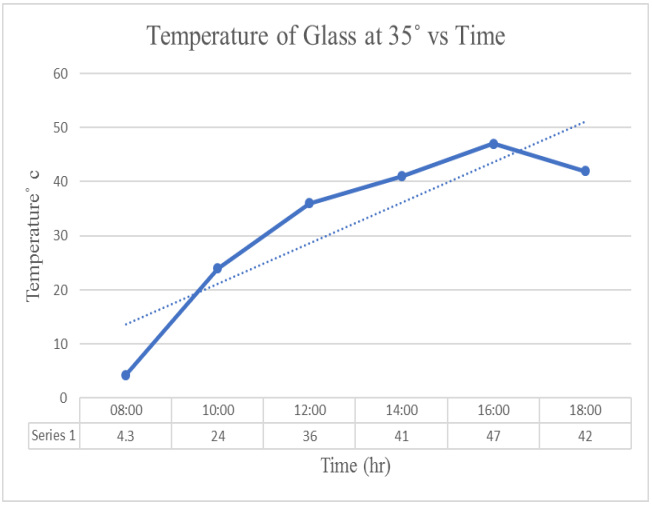


Fig – 13 Temperature of Glass vs Time at 35˚

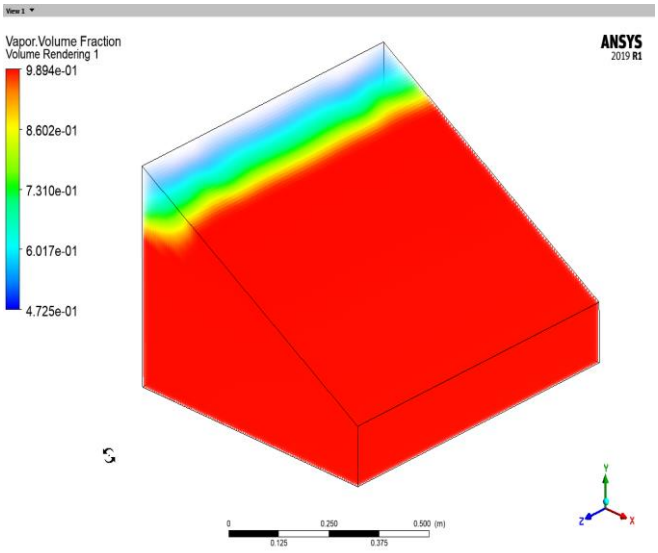


Fig – 14 Vapor Volume Fraction Rendering For 35˚

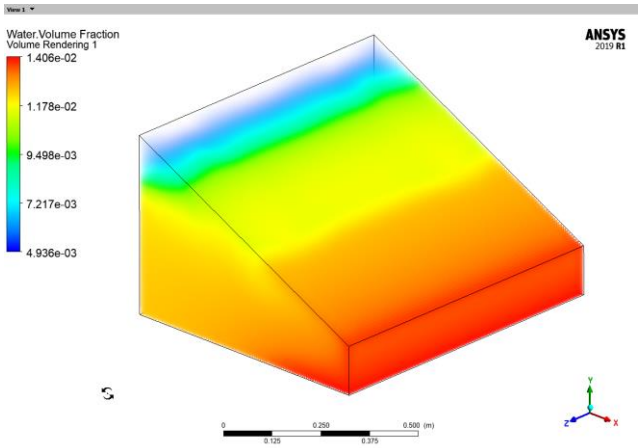


Fig – 15 Water Volume Fraction Rendering For 35˚

V. COMPARISON

Table 3 Comparison of Results

Angle	20˚	25˚	30˚	35˚
Output of CFD-Analysis (in ltr)	**2.74 ltr**	**3.16 ltr**	**3.11 ltr**	**2.98 ltr**
Output of Experimental (in ltr)	**1.99 ltr**	**2.33 ltr**	**2.29 ltr**	**2.13 ltr**

VI. CONCLUSION

As we can see the result is far good for increasing the angle of slope of glass cover but its limited to 30˚ because after that both experimental result and cfd-analysis result both show that the productivity decrease after the increasing the slope of glass cover from 30˚.

For the both results the output of 25˚ is more than 30˚ because the radiation of the date of experiment of 25˚ is more than 30˚.

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