Numerical Analysis of Solar Still for Optimum Solar Glass Surface Inclination at Different Water Level

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***Abstract* - Freshwater and energy are indispensable resources for economic and industrial developments, they are key global challenges nowadays. In recent years, the emphasis has been placed on developing the design of various solar stills in order to overcome the problem of the low yield of traditional stills. In this work, an attempt has been made to compare the performance of conventional solar still with the different inclination of glass surfaces and the different level of water in basin. The objective of the present work is to Find out the optimum solar still glass surface inclination and water level in the solar basin for maximum output of water in the Jabalpur location.**

***Index Terms* - solar still, glass, water level, etc.**

I.INTRODUCTION

1.1 Introduction

Water is one of the most important components of Earth. It is very important for the existence of human life. It is available on Earth in abundance but very less of its availability comes under human use. Fresh and potable water is the most prominent issue at present. About 71% of Earth is covered with water, out of which 96.5% is ocean water and rest exists in river and lake, in pond, in ice caps and glaciers, in the soil and in aquifers, etc. Out of all these, only less than 1%ofwater is worth for human which is fresh. Issue of potable water is growing day by day [1].

1.2 Desalination: A Solution

Water shortage is one of the toughest and threatening issues of today’s generation. More than 15% of the world’s population is deprived of fresh and potable water, out of which some are living in improper sanitation and unhygienic surroundings. To overcome this deteriorating condition, more and more water is made from seawater which is available in abundance on Earth [9]. This very process can be successful with desalination. Desalination is one of the simplest, earliest, best solutions to freshwater shortage.

The principle of hydrological cycle is followed in man-made desalination process using other sources of heating and cooling. Large amount of energy is needed to separate freshwater from brine and salty seawater. Desalination takes place by feeding saltwater into the method which gives two output streams as a result, one is freshwater stream, and another is salt-contaminated water stream. Thus, freshwater is obtained by desalinating saltwater.

Desalination process has become a major method to supply freshwater to most of the regions of the world. Desalination process is mostly taken into account at coastal regions as this process can be achieved there easily due to abundant water. The most important characteristic of this process is that it is safe for all—in other words it has no adverse effect on ecosystem. As per the survey made in the previous decade, about 75 million people all over the world are dependent on desalination process to obtain freshwater for their daily needs. There are many countries which are dependent on desalination to obtain freshwater. The top five leading nations in case desalination plant capacity are Saudi Arabia, USA, UAE, Spain, and Kuwait, with percentage coverage of 17.4, 16.2, 14.7, 6.4, and 5.8%, respectively.

1.3 Methods of Desalination

Basically, there are various methods of desalinating brackish and salty seawater. Commercially and economically out of all methods, MSFD, RO, and MED are taken into account for the desalination purpose. It has been observed that these three methods are the leading ones and in the coming future these three would be the most competitive [8]. There are various methods of desalination which are as under.

1.4 Solar Still

Water is the most important component of our planet. It covers about 75% of the Earth, but still out of that much abundant water only 1% can be used as domestic purpose, perhaps which are being contaminated by various factors like pollution, sewage disposal, etc. There is a need to obtain freshwater, and most of the water present on the Earth is brackish and salty. Desalination is one of the measures to get freshwater from brackish water. To utilize desalination as an important measure, solar still is being introduced in this developing world. Solar still is a device which is completely based on the principle of desalination.

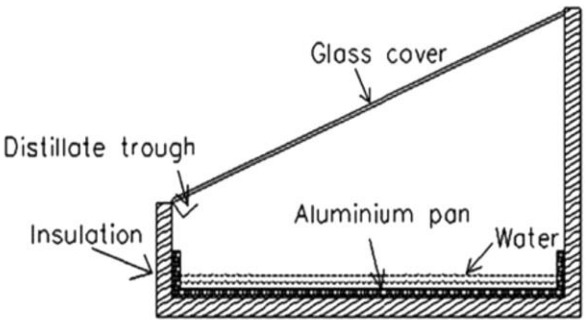

Figure 1.1 Single-basin solar still

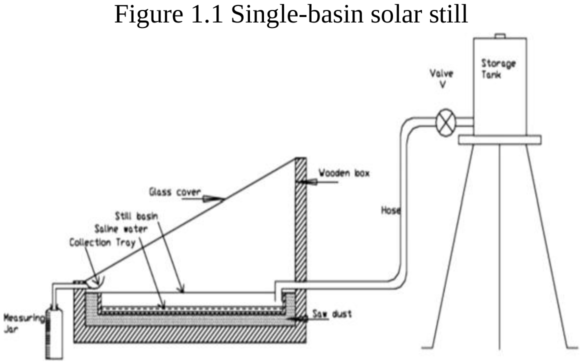

Figure 1.2 Solar still with simple basin

Working principle of solar stills

Solar distillation is the process which basically uses the heat of the sun directly for obtaining useful water from the salty brackish or sea water. The equipment or the device used is known as solar still. The solar still consists of a shallow basin blackened from the inside to absorb high amount of incident rays and is covered with a transparent glass cover. Figure 1.9 presents a schematic diagram and components of a traditional solar still built from a single basin contain saline water and covered by an inclined single glass cover. To reduce heat losses to surrounding the basin was insulated with glass-wood, fiberglass, and wood (Sahoo et al., 2008).

The working of solar stills is very simple. A sun's rays that are incident on the glass cover of a still allow the water (to be distilled) to heat up present in the basin causing the process of vaporization. When the rate of vapor production increases, it condenses on the inner surface of the glass casing and consequently condensed water vapor on the inner surface of the glass lid slowly flows through the collecting channel and is assembled into a storage bottle. During this process, salts and microorganisms are left in salt water. The useful fresh water gets collected in the measuring flask through the outlet present on the side of the still leaving behind all the impurities and the salt content.

II-LITERATURE REVIEW

Mohammed Shadi S. et al; 2016 aims to investigate the different parameters that affect solar still productivity when the solar still productivity is very low compared with other desalination systems, such as other thermal processes or membrane processes. These parameters include environmental, design and operational parameters. The results show that productivity was highly affected by environmental parameters due to the unpredictability of metrological factors. When design and operational parameters were varied, increases in productivity were observed.

Sampath kumar et al: 2010. States that various advanced technology desalination techniques using fossil fuels or electrical energy derived from fossil fuels, are used world-wide, such as reserve osmosis, electrodialysis, ozone, UV, vapor compression and active carbon filtration to obtain potable water. Although these techniques are capable of desalinating water, they directly contribute to global warming and incur high costs. Additionally, these technologies are commercially suited for large cities and have high efficiencies and productivity rates when non-natural energy sources are used. Therefore, to provide fresh water to arid and semi-arid areas where sunshine is readily available, relative to non-natural energy, these methods are not suitable.

III-RESEARCH METHODOLOGY

Thermal Modelling of Solar Still

As stated earlier, during desalination process, the energy radiated from the Sun is absorbed by the saline water kept inside the air tight enclosure which makes it to evaporate as water vapour. Then, the vapour is condensed on a glass cover. The tube is utilized to collect clean water droplets with the help of beaker. The evaporation rate depends on many parameters like temperature difference between heating source and condensing medium, velocity of wind, humidity, etc.

Heat Transfer Process in Solar Still

Simultaneous mass transfer and heat transfer is the basis for both water evaporation and its condensation in solar still. The internal or external heat transfer process is undertaken in the solar still based on its thermal energy flow into or out of the system. The internal process is mainly accountable for the evaporation and movement of fresh water vapour which leaves behind all kind of impurities in the solar still basin itself. The external process is accountable for the condensation of the fresh water vapour as distillate output. The following section briefly explains Internal Heat Transfer Process.

CFD Simulation

A two-phase model was developed in the volume of fluid (VOF) framework for liquid water and mixture of air and water vapor system at quasi steady state condition; thus, only surface evaporation of liquid occurs, and their interface should be considered for modeling. A distinct interface between vapor and liquid phases exists, hence both phases are continuous. No turbulence models were used for both phases because liquid was taken stagnant and vaporization rate is low. Energy and mass transfer have been considered in this work. For each phase, the time and volume-average continuity, energy and mass equations are numerically solved.

Geometry

For the present analysis the design of solar still has been obtained by the design adopted by *Jyoti Bhalavi et al 2019*

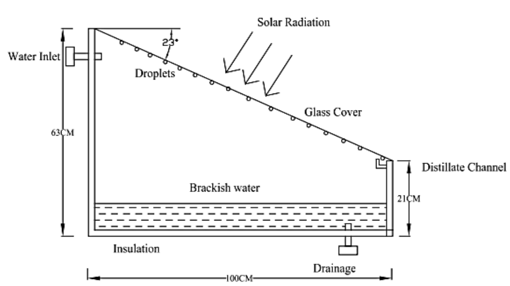

Figure 3.1 Schematic Diagram

For changing the inclination angle of glass cover the back wall height have been changed while the front wall height kept constant (i.e. 21 cm).

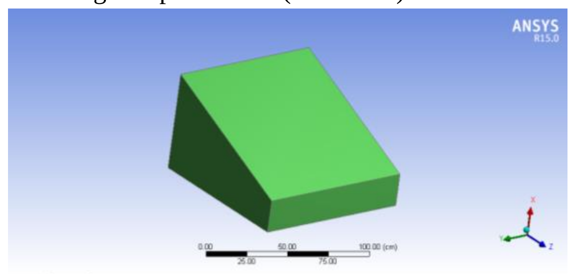

Figure 3.2 Solar Still Geometry

Meshing

Model geometry and its meshing were done using ANSYS Workbench 15. The tetrahedral meshing type was used. The number of nodes and elements for different geometries are given in table 3.1. Geometric model was created in ANSYS CAD module and imported to ANSYS meshing module for the generation of mesh.

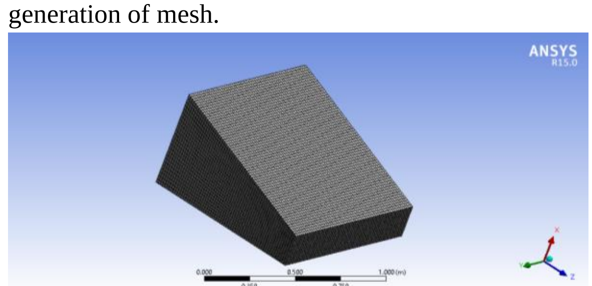

Figure 3.3 Meshed structure of the solar still for CFD simulation

IV-RESULT ANALYSIS

In this study, several numerical simulations has been performed for various water level and glass surface inclination in a typical passive type solar still. The inclination of glass surface have been changes from 20° to 35° with the cases of three different water level i.e. 3cm, 4cm, and 5 cm respectively. The following results have been obtained:

Results for 20° inclination and different water level at basin

Figure 4.1 to 4.5 shows the water volume fraction at glass surface, Turbulence Kinetic energy, velocity of fluid, vapor volume fraction and vapor mass flow for 20° inclination of glass surface and 5cm water level at basin.

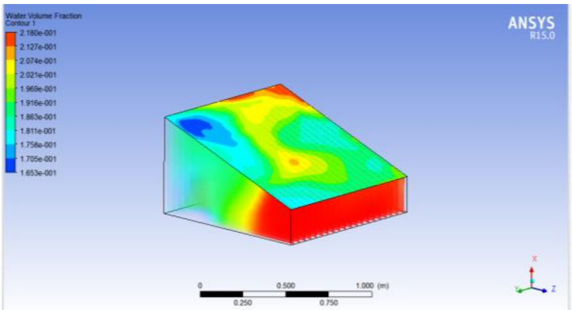

Figure 4.1 Water Volume fraction at glass surface for 20° angle and 5 cm water level

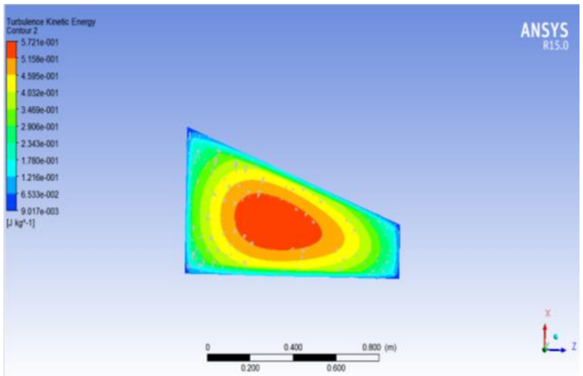

Figure 4.2 Turbulence Kinetic Energy for 20° angle and 5 cm water level

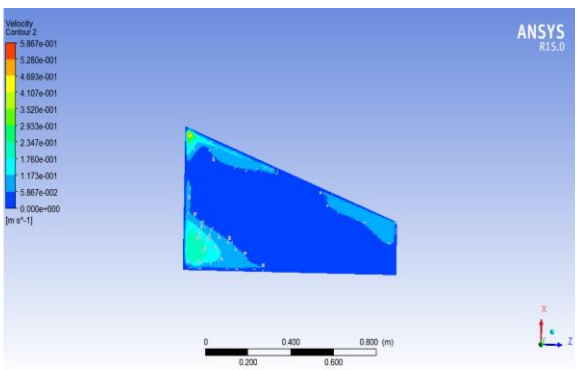

Figure 4.3 Velocity of fluid for 20° angle and 5 cm water level

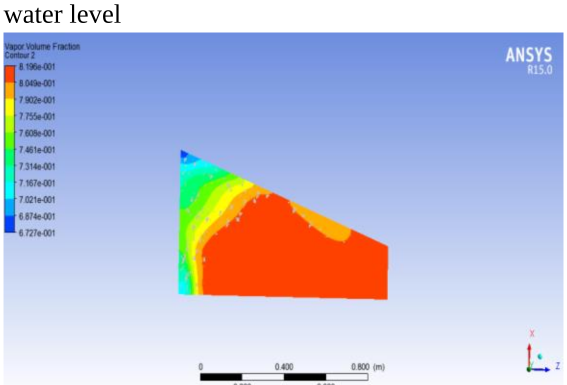

Figure 4.4 Vapor Volume Fraction of fluid for 20° angle and 5 cm water level

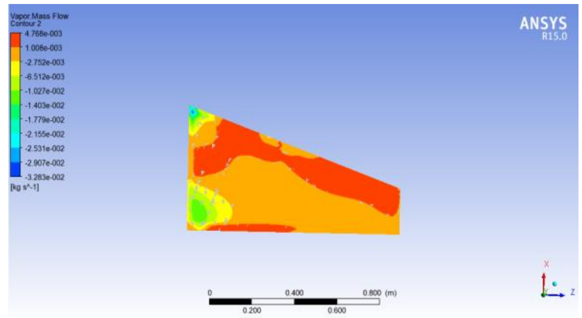

Figure 4.5 Vapor Mass Flow of fluid for 20° angle and 5 cm water level

Discussion

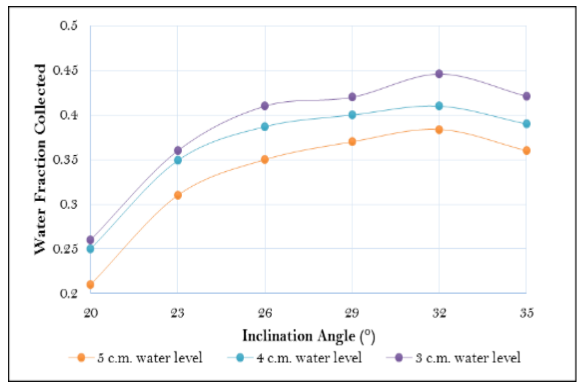

Figure 4.6 Water Fraction Collected on the Glass Surface with respect to Inclination Angle at Different Water Level

V-CONCLUSION AND FUTURE SCOPE

The performance of passive solar still is numerically evaluated under the weather conditions at Jabalpur, India. The two basic variables considered for the study are water level and glass surface inclination in a typical passive type solar still. After the result analysis following conclusions can be made:

- The amount of water collected is maximum for the solar still having the angle 32° of inclination.
- When the water level considered the maximum amount of water collected for 3c.m. water level for all the angle of inclinations.

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