Impact of Temperature and Pressure on Solar Still Using Black and White Wall Performance Assessment

Ashutosh Dwivedi[1], Dr. Anjaney Pandey [2] Dr. P.K. Shrivastav[3]

[1,2]Department of Mechanical Engineering Mahatma Gandhi Chitrakoot Gramoday Vishwavidyalaya, M.P.
[3]Department of Mechanical Engineering Government Engineering College, Rewa, M.P.

---***---

Abstract - *The goal of this study is to develop a system that can purify water from almost any source, such as rivers, lakes, and reservoirs. Much of the land is filled by salt water where fresh water is available in a low proportion and the demand for fresh water for drinking use is also rising rapidly due to the rise in population. Solar desalination is therefore a potential solution to resolve this large-scale difficulty. Desalination and mechanics are called the mechanism by which impure water is turned into clean water.*

In this research analysis, the variation of the inside still air pressure in a vapor tight solar still and the impact of inside air pressure variation on the still output was theoretically and experimentally investigated. This paper provides a detailed analysis of the impact of temperature, pressure, black inner wall and white inner wall with regard to time.

Keywords: Solar still, desalination, black inner wall, White Inner Wall

1. INTRODUCTION

Global demand for fresh water is increasingly challenging since most sources of water are contaminated.

Industrial waste, sewage and pollution from farming. In certain parts of the world, the result is an inadequate supply of water. A solar still is a precious device that can be used for drinking water purposes to purify brackish water and salt water. But the key downside is that solar output is still poor. The productivity of any solar distillation system is depends on the basin water temperature. The productivity increases with increasing temperature of water in the basin.

In the proposed work, efforts are being made to build and evaluate an improved solar system and to combine it with an auxiliary unit consisting of a sediment filter and a solar-powered UV disinfectant unit in order to obtain a solar-powered water treatment system. This unit is intended to cater to the average family's need for consumable water, preferably in rural areas where open space is plentiful, but electricity supply is insufficient and irregular.

The higher rate of growth in the world's population and industries has contributed to a major rise in demand for fresh water. A small demand can be met by the natural supply and this leads to acute fresh water shortages. Therefore, the extensive treatment of salt and polluted water into filtered water is a concern.

2. LITERATURE REVIEW

Drinking water is still a big problem in dried and remote areas. Single basin solar still is a solution for this problem. This type of solar still is capable of producing clean potable water from available salty or waste water throughout the year. Single slope still is suitable at higher latitude place.

Water and energy are two types inseparable items that govern our lives and promote civilization. Looking to the history of mankind one finds that water and civilization were also two inseparable entities. It is not a coincidence that all great civilizations were developed and flourished near large bodies of water. Rivers, seas, oases and oceans have attracted mankind to their coasts because water is the source of life. The supply of hygienic potable water is one of the major problem faced in underdeveloped and in some developed countries. Since transportation of drinking water from far-off regions is usually not economically feasible / desirable, desalination of available brackish water has been considered as an alternative approach.

Several researchers have studied the effects of various designs, operational and climatic parameters. Many designs and modifications of the solar still have been proposed in literature.

Omar O. Bad ran et. al. [2] Evaluating thermal performance of a single slope solar still.In this study, several conclusions can be obtained as follows; (a) the increase in either ambient temperature and/or the solar intensity can lead to an increase the solar productivity, (b) as the water depth decreases from (3.5 cm) to (2 cm), the productivity increases by (25.7 %), (c) The maximum efficiency occurs in early afternoon due to the high solar radiation at this time, (d) the overall heat loss coefficient increases until it reaches the maximum in the afternoon due to higher solar intensity and ambient temperature, and finally, (e) the proposed mathematical model gave good match with experimental results. Future work can be carried out using this model to enhance the design of single solar stills.

Anil kumar Tiwari et. al. studied [3] Effect of Cover Inclination and Water Depth on Performance of a Solar Still for Indian Climatic Conditions. The study leads to the following conclusions.

1. There is significant variation in convective heat transfer coefficient for different inclinations of condensing covers and different water depths. This will be useful in choosing passive solar still designs for specific applications, regions, and seasonal performance requirements.

2. Overall, 45 deg and 15 deg inclinations of the condensing cover result in maximal annual yields of similar order of magnitude. However, specific summer or winter peak performances are optimized when choosing a condensing cover inclination of 15 deg or 45 deg, respectively.

3. Lowest possible water depth produces maximum yield and efficiency throughout the entire year.

P.Vishwanath Kumar et. al. studied [4] Solar stills system design as freshwater demand is growing day by day in the present times of rapid grow distilling the saline water throughout the world. Many solar stills have been studied in detail in this review covering all the aspects of design specifications. Also the effect of design and operating parameters on the distillate productivity of various stills has been presented. The following are the conclusions that were noted from this detailed review:

In single effect passive basin stills, distillate output increases from 34%to42%bycovercoolingbycovercooling.Alsothe productivity depends on solar radiation and ambient conditions i.e., on clear and cloudy days. Particularly on sunny days, productivity was more for still with inclined flat glass cover compared to semi-sphere, bi layers hemisphere and an arch coverwithvaluesof1.25kg/m2/d, 1.1kg/m2/d, 1.2kg/m2/d and 0.83kg/m2/d respectively. Whereas on winter days, productivityincreasesby70–100%byusingreflectors.

Kuldeep H.Nayi et. al. studied [7] Pyramid solar still. The study leads to the following conclusions. Pyramid solar still is one of the outcomes of such a development. The present paper reviews the development in the field of pyramid solar still as well as the various techniques to improve the performance of still. From the review on research carried out by the various researchers, it has been found that pyramid solar still is more efficient and economical in compare to conventional single slope single basin still. Thus, the review paper will assist the researchers to understand the fundamentals of pyramid solar still with the need, developments and challenges in pyramid solar still to improve its thermal performance and to make it more and more economic.

Swellam W. Sharshir et. al. [8] In this article, a review of factors affecting solar still production (climatic conditions, operations and design parameters) and enhancement techniques (wicks, internal and external condensers, internal and external reflectors, phase change materials, Stepped solar still and a new method improved the solar still yield by using nanoparticles) has been argued. Using sponge cubes in the basin water caused a significant enhancement in solar still production (up to 273%) whereas using cuprous oxide nanoparticles increased the distilled yield by 133.64% and 93.87% with and without the fan respectively.

Ravishankar Sathyamurthy et. al. [9] Concludes that the geometry in the solar still significantly influences the yield of fresh water. Following conclusions are made:

(1) The highest yield stills are the stepped with reflectors and weir cascaded solar stills, but their cost remains high.

(2) A serpentine array of tubes from automobile radiators as a solar collector may be used to increase the brine temperature. The theoretical characterization of ethylene glycol nanofluids of automobiles at minimum mass flow shows a

Higher heat transfer rate.

(3) A method for improving the yield of conventional solar still is increasing the surface area of water by adding specified dimensions of sensible heat energy storage in the basin .

(4) The use of heat exchangers from condensers in the air conditioning system will improve the inlet feed water temperature for better evaporation in the solar still.

(5) A new shape of a triangular basin single slope solar still increases the contact area of water with solar radiance by reducing the shadowing effect from the side walls during morning and evening hours.

(6) For the triangular pyramid solar still, cooling water may be circulated through the side walls, which takes away the heat which is returned as feed water into the basin.

Ali.F.Muftah, K.Sopian et. al. [10] study involved the enhancement of a stepped solar still by integrating superior design concepts into one design. The energy-balance analysis of the proposed stepped still prior to and post modification has been conducted. The performance of the proposed stepped solar still was detailed under multiple evaluation parameters. The daily productivity of the stepped solar still post modification increased from 6.9 kg/m2 to 8.9 kg/m2. Based on the results obtained from the thermal evaluation parameters and statistical test, the proposed design significantly enhanced the thermal performance of the stepped solar still

3. METHODOLOGY AND EXPERIMENTATION

Impure water is also filled inside an airtight insulated basin covered with clear glass in the solar form of basin. The rays are transmitted from the cover to the absorber surface at the bottom when the silos are exposed to the light, thereby heating the water. Then the hot water heats the air inside, leaving it unsaturated. The water evaporates and saturates the air around it, which is being circulated inside the still due to the temperature difference between the water surface and the cover lower surface.

Solar units of the single basin type are produced with certain design parameters and tested under field conditions. The basin was made of wooden block with a 1.0 m x 0.8 m base, which was positioned for support on the metal stand. In order to minimize the heat loss to the atmosphere, 5 cm thick insulation (glass wool) was provided between the wooden box and the basin. T in order to increase the absorptive of the basin surface, it is painted black . Glass of 3 mm thickness covers the single slope still with an inclination with horizontal.

Fig. 1 Experimental Setup of solar distillation system

A pyranometer was used to measure the insolation on the still. Temperatures of the following locations were recorded by means of digital type thermometer, a) at basin liner, b) inner and outer surface of glazing, c) water in basin and d) surrounding air. The accuracy of this thermometer is of the order of ±0.1 degree centigrade for the range of temperatures measured. The distillate output was measured by means of a measuring Cylinder, at half hour interval.

All the observations & readings on experimental setups are taken in the month of May -Jne .The time duration for observations of solar still is from 9:00 AM to 5:00 PM for experimental setups of arrangement of only Black Coating with reflector arrangement.

Table 1 Simulation parameters of inclined solar still

S.No.	Parameters	Symbol	Values and units
1	Mass of Solar Still	M_s	20 kg
2	Area of base	A_b	1 m^2
3	Specific heat of material	C_b	510 J/kg K
4	Absorptivity of material	α_b	0.95
5	Mass of glass	M_g	2.7 kg/m^2
6	Area of glass surface	A_g	1 m^2
7	Specific heat of glass	C_g	750 J/kg K
8	Absorptivity of glass	α_g	0.05
9	Transmissivity of glass	t_g	0.88
10	Emissivity of glass	ε_w	0.97
11	Mass of basin water	M_w	10.8 kg
12	Area of basin water surface	A_w	0.95 m^2
13	Specific heat of water	C_b	4185 J/kg K

14	Absorptivity of water	α_w	0.05
15	Emissivity of water	ε_w	0.95
16	Latent heat of vaporization for water	L_w	2430.7 KJ/kg
17	Convection heat transfer Coefficient	$h_{c(b-w)}$	135 W/m^2K
18	Overall heat loss coefficient from bottom	U_b	14 W/m^2K
19	Stefan-Boltzmann constant	σ	$5.67x10^{-8}$ W/m^2K^4
20	Thermal conductivity of absorber plate	K_b	50.2 W/mK
21	Thickness of absorber plate	tk_b	0.003 m

Table 2 Controllable parameters used in mathematical modeling of proposed solar still configurations.

S.No	Type of Proposed solar stills	Controllable parameters with units					
		A_w	A_b	A_g	M_w	M_b	M_r
		M^2	M^2	M^2	Kg	Kg/m^2	kg/s
2.	Inclined still with Base Black Color	0.85	1	1	6.1	9.6	0.00083
3.	Conventional basin still	0.27	0.3	0.3	4	2.34	-

4. RESULTS AND DISCUSSIONS

Numerical calculations for the stills on a typical May day in Satna were performed (MP). The calculated ambient Ta temperature and data on solar radiation used for numerical calculations are presented. It is seen from the results that the incident of solar radiation on the still cover I achieves maximum and average daily values of 760 and 650 W/m2, respectively. Comparisons are summarized between the temperatures of the different elements for the same region exposed to solar radiation in the black and white inner liner stills. As the solar radiation increases, the temperatures of the stills elements increase until they reach their maximum values around the noon period and then decrease with the decrease of solar radiation I and ambient temperature Ta. It is also shown that the temperatures of the white inner liner elements are still higher than those for the traditional still because of the increased amount of solar radiation reflected by the white inner liner that causes the water glass-temperature differences to increase.

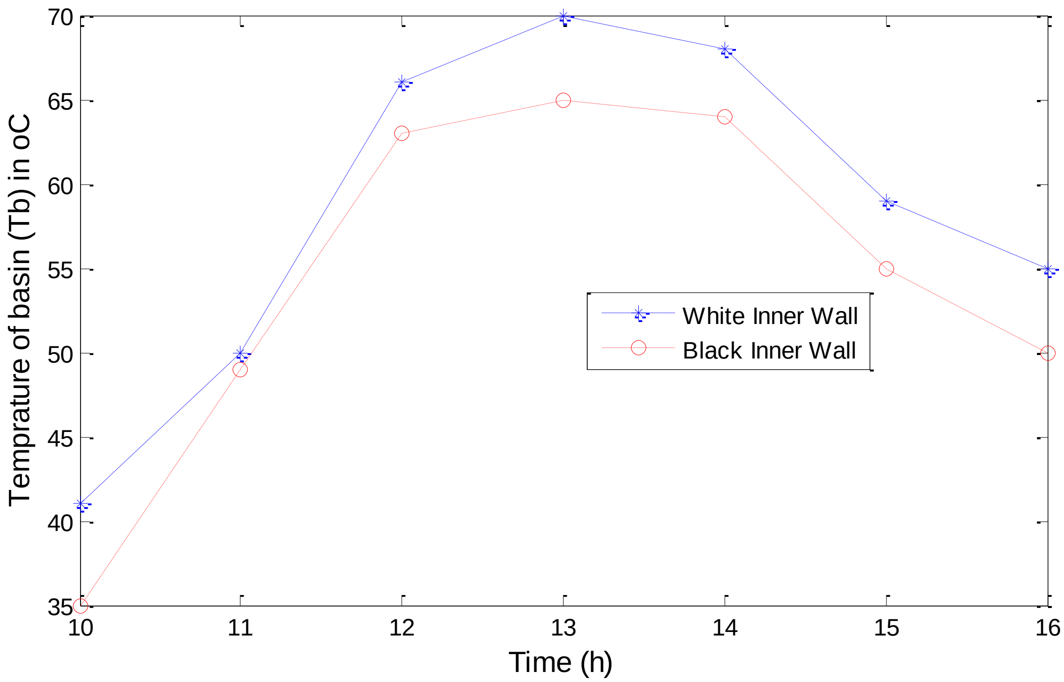

Fig 1 Hourly Variation Of Temperature of basin for Black Inner Wall and White inner wall solar still for a typical day of month May-June 2014

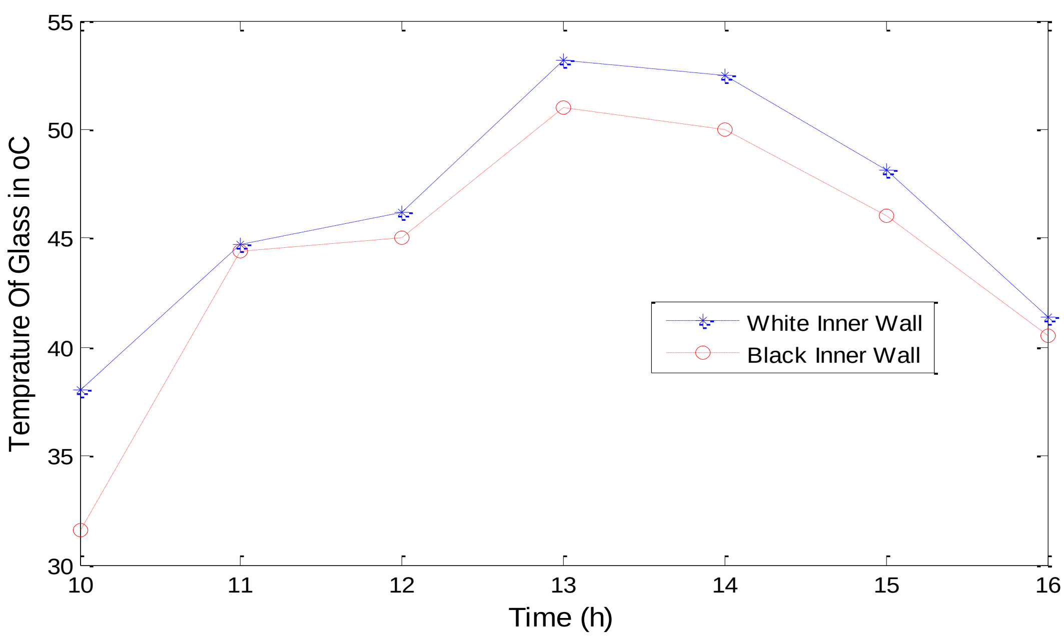

Fig 2 Hourly Variation of Temperature of Glass for Black Inner Wall and White inner wall solar still for a typical day of month May-June 2014

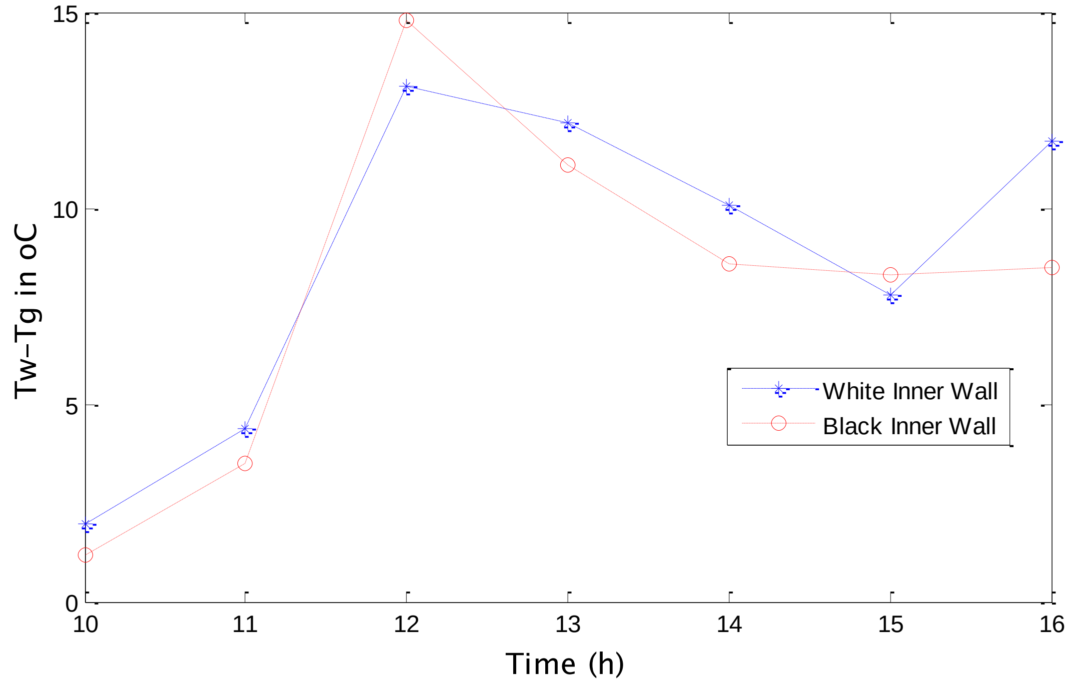

Fig 3 Difference between Water Temperature and Glass Temperature (T_w-T_g) with respect to time for Black Inner Wall and White inner wall solar still for a typical day of month May-June 2014

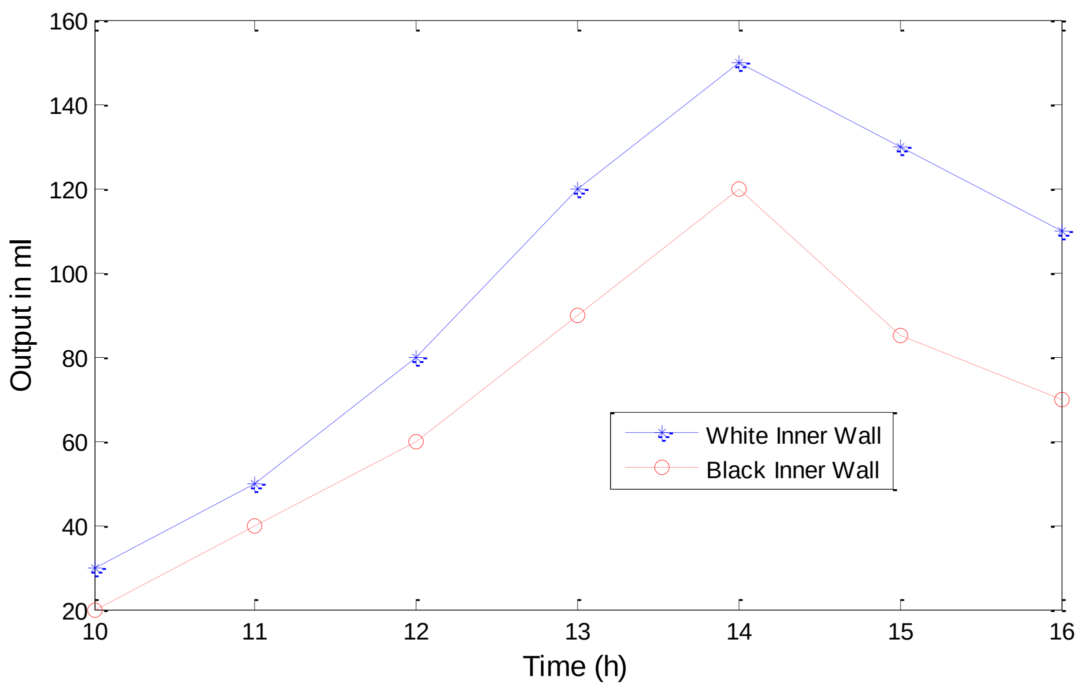

Fig 4 Fig Hourly Variation Of Output of Black Inner Wall and White inner wall solar still for a typical day of month May-June 2014

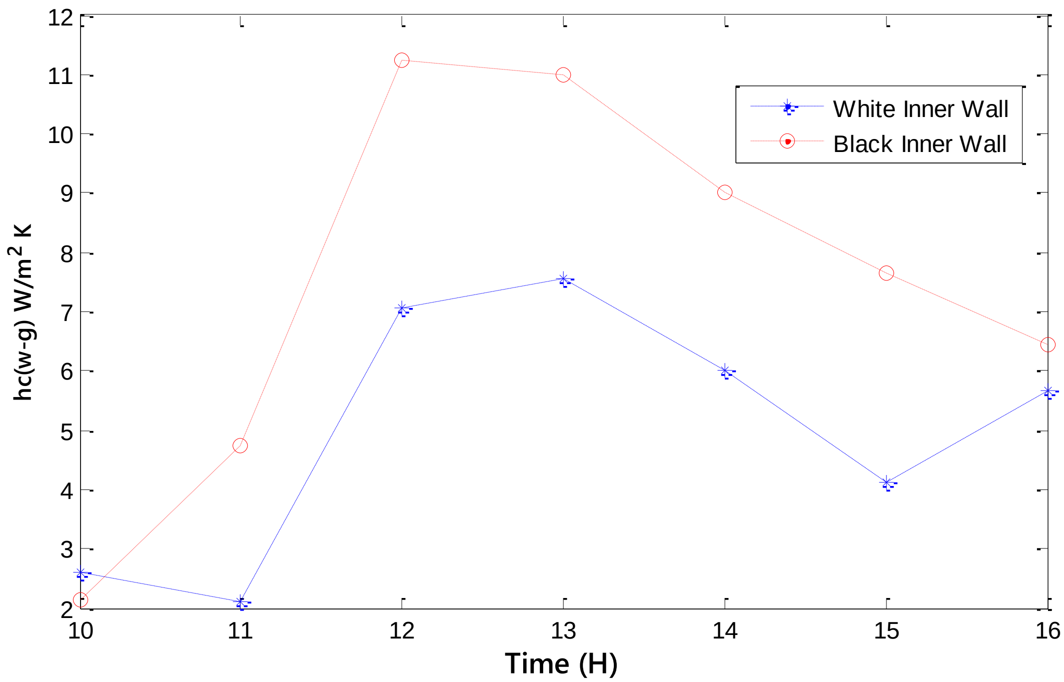

Fig. 5 variation of convective heat transfer coefficient between water and glass with respect to time for white and black inner wall

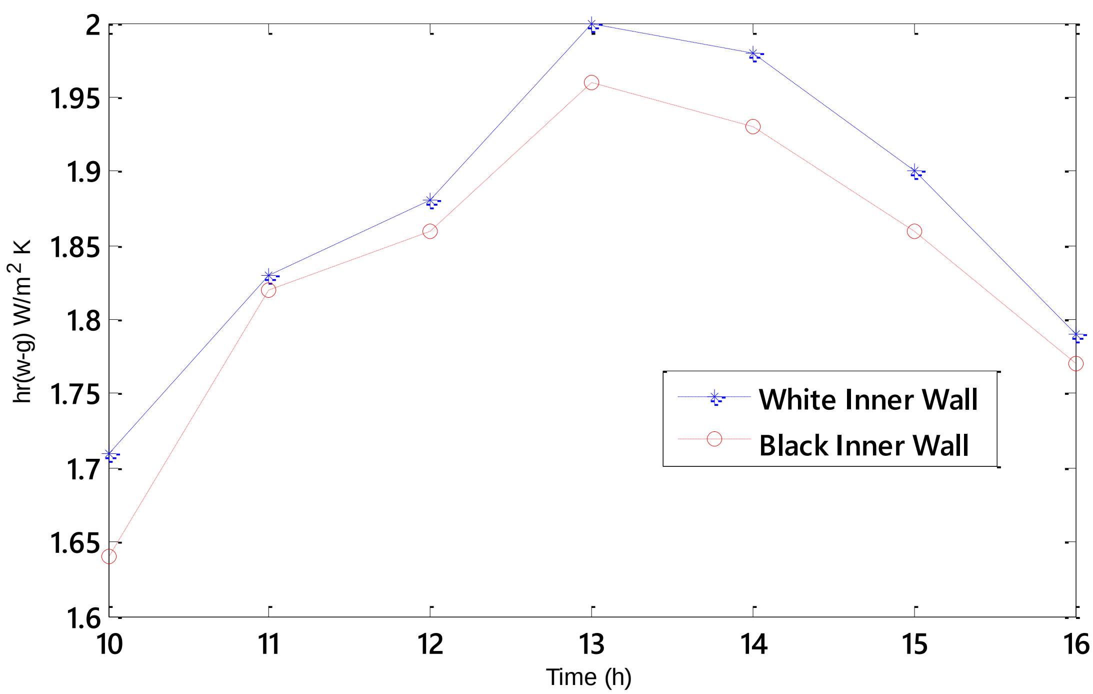

Fig. 6 variation of radiative heat transfer coefficient between water and glass with respect to time for white and black inner wall

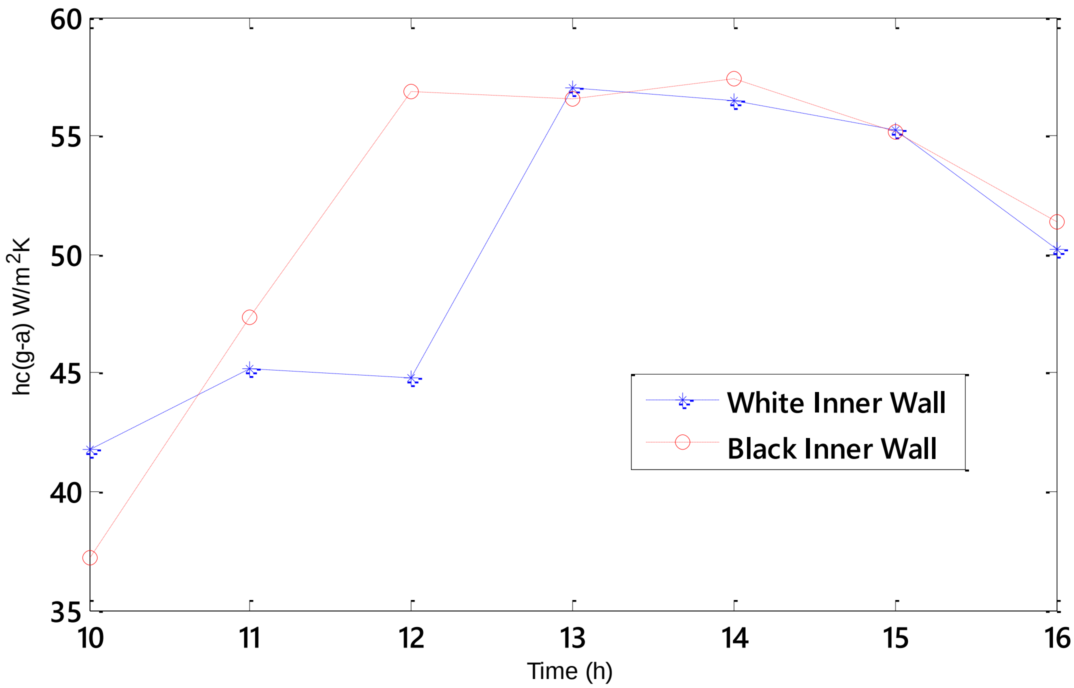

Fig 7 variation of convective heat transfer coefficient between water and air with respect to time for white and black inner wall

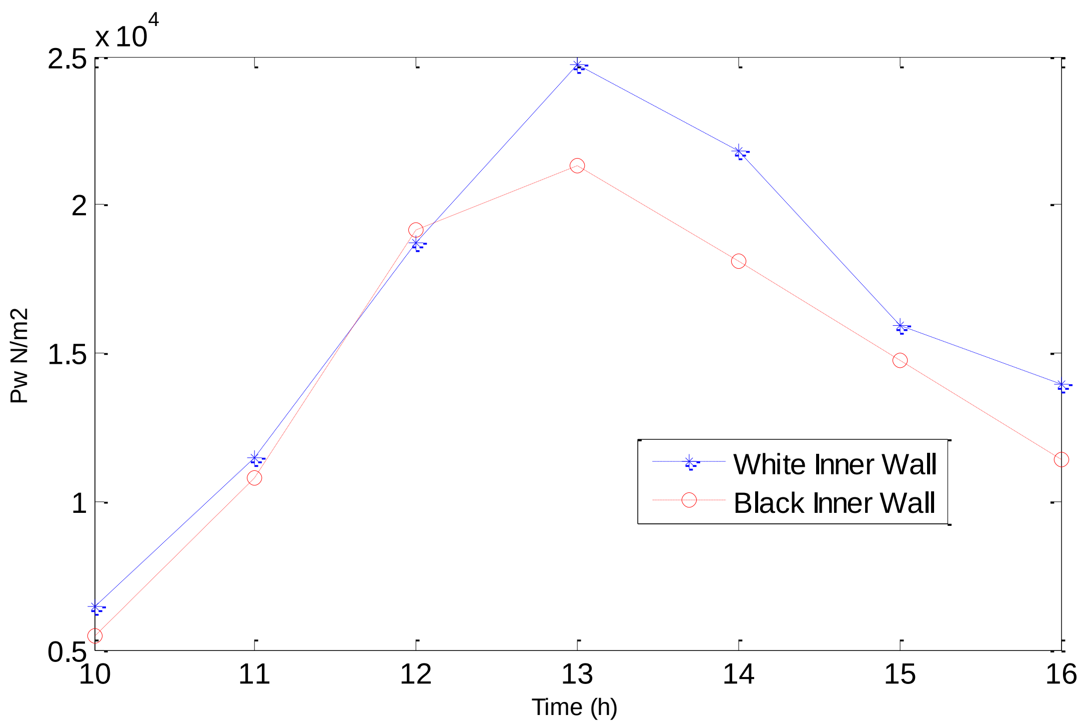

Fig 8 Variation of pressure at water surface with respect to time for white and black inner wall

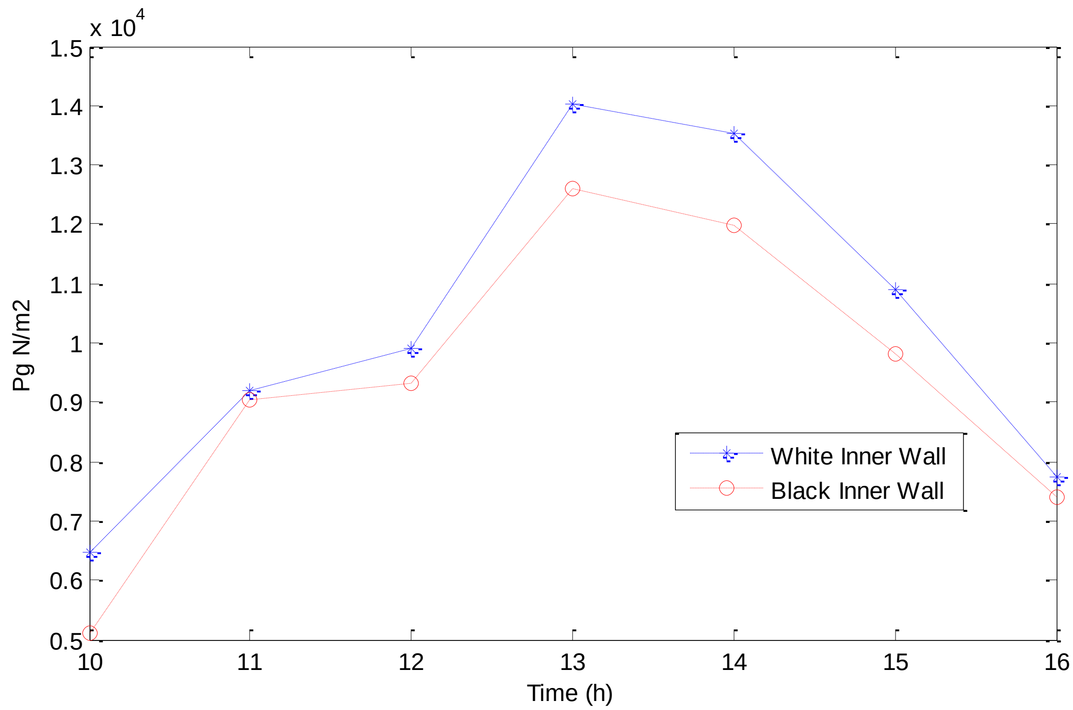

Fig 9 Variation of pressure at glass surface with respect to time for white and black inner wall

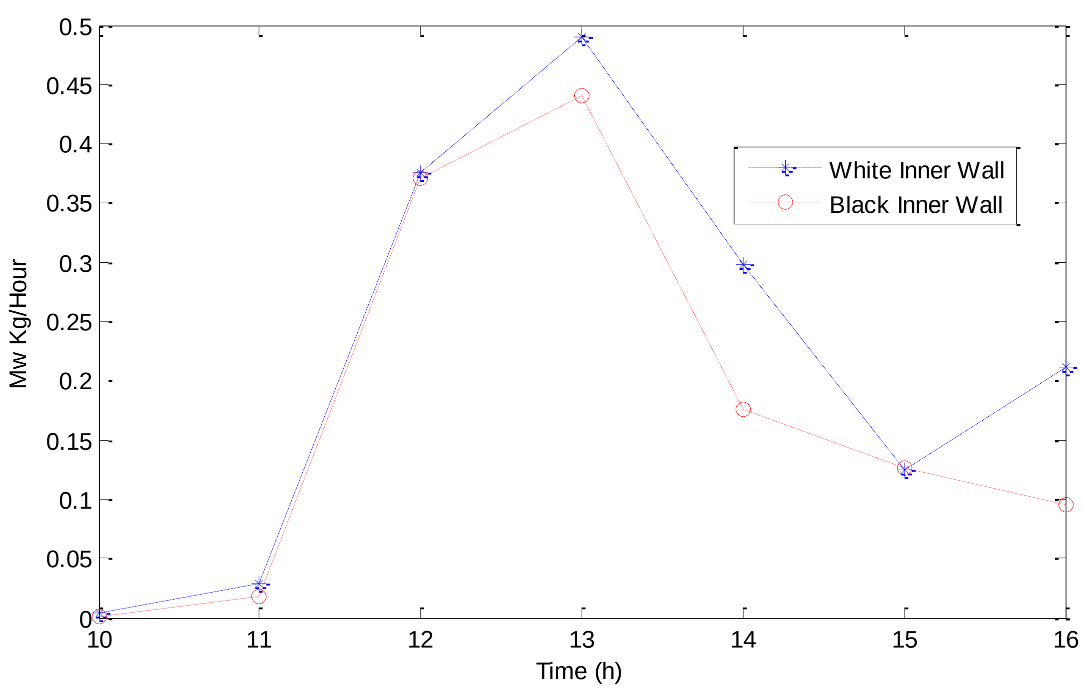

Fig 10 Variation of pressure at water surface with respect to time for white and black inner wall

5. CONCLUSION

To enhance the daily yield and performance of the still, the still fitted Solar is to be built and manufactured. It is also important to research the impact of different parameters such as glass cover pressure variation, flow rate, production variation with respect to time. The following inference is drawn from the test.

1. The temperature of rise in Black solar still shows the Black solar still and White solar still experimental results still as opposed to the White solar still.

2. The Black solar still and white solar still experimental findings indicate that the rate of distillation in Black solar is still higher compared to the White solar still.

3. The efficiency of black solar is still higher than that of white solar..

4. The rise in ambient temperature and/or solar intensity can lead to an increase in solar productivity,

REFERENCES

1. wikipedia.org/wiki/Solar_still
2. **Omar O. Badran Æ Mazen M. Abu-Khader (2007) "**Evaluating thermal performance of a single slope solar still" Heat Mass Transfer 43:985–995
3. **Anil kumar Tiwari & G N Tiwari (2008)** "Effect of Cover Inclination and Water Depth on Performance of a Solar Still for Indian Climatic Conditions." Journal of Solar Energy Engineering, Vol. 130 / 024502-1
4. **P.Vishwanath Kumar, Anil Kumar, OmPrakash, Ajay Kumar Kaviti (2015)** "Solar stills system design." Renewable and Sustainable Energy Reviews, Vol. 51 153–181
5. MODELING AND ANALYSIS OF THERMAL PERFORMANCE OF SINGLE BASIN SINGLE SLOPE SOLAR STILL, PARAKASH M.
6. **K.R. Ranjan, S.C. Kaushik and N.L. Panwar (2016)** "Energyandexergyanalysisofpassivesolar distillationsystems ." International Journal of Low-Carbon Technologies, 11, 211–221
7. **Kuldeep H.Nayi Kalpesh V.Modi (2018)** "Pyramid solar still: A comprehensive review" Renewable and Sustainable Energy Reviews Volume 81, Part 1, Pages 136-148
8. **Swellam W. Sharshir , Guilong Peng,Abd Elnaby Kabeel (2016)** "Factors affecting solar stills productivity and improvement techniques." Applied Thermal Engineering Vol. 100 267–284
9. **Ravishankar Sathyamurthy, D.G. Harris Samuel, P.K. Nagarajan & T. Arunkumar (2016)** "Geometrical variations in solar stills for improving the fresh water yield-A Review." Balaban Desalination Publications 1944-3986
10. **Ali.F.Muftah, K.Sopian, M.A.Alghoul (2017)** "Performance of basin type stepped solar still enhanced with superior design concepts." Desalination Vol.435 198-209
11. Experimental and theoretical investigations on the performance of inclined type solar stills,Samuel hansen R
12. **Chirag Rabadia (2015)** "Factors Influencing the Productivity of Solar Still." (IJRASET, Volume 3 No. 10
13. **Akash A. Lokhande, S. M. Shaikh (2018)** "Performance Investigation of Single Basin Double Slope Solar Still With and Without Phase Change Material and Effect of Reflector and Fins". IRJET, Volume: 05 No. 08 1686-1693
14. **Hrushikesh Kulkarni1, Chinmay Kute2, (2018) "**Experimental investigation and performance evaluation of solar still using phase change material" IRJET, Volume: 05 No. 05 1109-1118
15. **Kamarulbaharin Z. A., Safie M. A., Azmi A.M., Singh B. S. B. (2018)** "Experimental Investigations on the Performance of a Single Slope Solar Still Coupled With Flat Plate Solar Collector under Malaysian Conditions" International Journal of Engineering & Technology, Vol. 7 (4.26) 159-162
16. **Subhash Chandra, Devendra Singh** (2018) "Experimental investigations on a single basin double slope solar still" IRJET, Volume: 05 No. 06 2780-2786
17. chika Saini †Department of Mechanical Engineering, Jabalpur Engineering College, Jabalpur-482011, India
18. **Shyam Verma, Devendra Singh, Dr. Ajay Kumar Sharma** (2018) "Experimental investigations on a single slope solar still IRJET, Volume: 05 No. 06 2658-2662
19. **Dr .K. Arumugam, , Dr.R.Anbazhagan (2018)** "Experimental analysis on single slope double basin solar assisted still coupled with heating coil for desalination of brackish water. TAGA JOURNAL, Volume: 14 No. 06 2306-2311

20. **Ketan Takawade, Sandesh Patil, Akash Kore (2018)** "Experimental study of different solar still with effect of pcm and reflector mechanism IRJET, Volume: 05 No. 03 2232-2236
21. Hitesh N. Panchala,⁎, Sanjay Patel (2017) "An extensive review on different design and climatic parameters to increase distillate output of solar still. Renewable and Sustainable Energy Reviews 69 750–7580..