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Solar Still with Heat Pipe an Experimental Approach

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ABSTRACT: *This paper presents results that were obtained when utilizing an tube heat pipe connected to the solar still. Sensible storage materials are added to the still to increase heat carrying capacity. Experiments were conducted in various modes with and without heat pipe .The water temperature rises and reaches a maximum of 60^0 for the solar radiation input of $924W/m^2$ with distillate out put of 160ml/hr. The water temperature rises and reaches a maximum for the solar radiation input of $924W/m^2$ with distillate out put of 140ml/hr without heat pipe. For maximum for the solar radiation input of $924W/m^2$ with distillate out put with and with out sensible materials are of 240ml/hr and 140ml/hr. maximum efficiency of 68%, where as the still without heat pipe gives the efficiency of 58%.This clearly shows that the introduction of heat pipe in the still is used to improve the efficiency*

KEYWORDS *- desalination system; solar collector; heat pipe technology; solar energy; insulation material, storage materials; efficiency*

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I. INRODUCTION

It is well known that the world is suffering from shortage of potable water, pollution of the ecology and environment, scarcity of natural or fossil fuels and steadily rising energy prices. The idea of desalination of sea water as a solution to the problem of shortage of potable water has been a subject of long standing, [1]. Majority of desalination plants are using fossil fuels for fresh water production therefore this project proposal to develop a prototype to desalinate water using some of the already existing solar water heating equipment as a solution to the problem of water shortage for human needs, also addresses the problems of environmental pollution, the depletion of fossil fuels deposits, energy rising prices etc. Solar water heating for domestic use, utilizes collectors that transform solar energy into thermal energy. There are several types of solar collectors available for practical applications, such as evacuated tubes, flat plate solar collectors and parabolic dish collectors [2]. State of the art technology in solar collectors is the evacuated tubes with heat pipes. The effect of various working fluids in the heat pipe on the performance of collector has received some attention [3], a topic which will also be addressed in the future during the execution of various aspects of this project.Increasing population demands for more usable water. Scarcity of water is a major common problem. There are quite a few water purification techniques like Reverse Osmosis (RO), filtration, sedimentation, chlorination etc. These techniques are often expensive and non-eco-friendly [4]. Solar Energy is one of the most abundantly available green energy sources. It is harnessed using various techniques like solar panels, solar cells, photovoltaic cells etc.[5] As we know, the need of the hour is maximum use of clean and renewable energy sources. There is a necessity to develop a technique which uses renewable energy (solar energy) for water desalination.[6] Hence, we have come up with a solution which integrates solar energy with water purification using Compound Parabolic Concentrators with Heat Pipe[7]

II. EXPERIMENTAL SETUP

A **heat pipe** is a device that employs phase change to transfer heat between two interfaces
At the hot interface of a heat pipe, a volatile liquid in contact with a thermally conductive solid surface turns into a vapour by absorbing heat from that surface. The vapor then travels along the heat pipe to the cold interface and condenses back into a liquid, releasing the latent heat .The liquid then returns to the hot interface through either gravity and the cycle repeats. Due to the very high heat transfer coefficients for boiling and condensation, heat pipes are highly effective thermal conductors. The effective thermal conductivity varies with heat pipe length, and can approach 100 kW/(m·K) for longheatpipes,incomparisonwithapproximately 0.4 kW/(m·K) for copper. The heat pipe is partially filled with

a *working fluid* and then sealed. The working fluid mass is chosen so that the heat pipe contains both vapor and liquid over the temperature range. The stated/recommended operating temperature of a given heat pipe system is critically important. Below the operating temperature, the liquid is too cold and cannot vaporize into a gas. Above the operating temperature, all the liquid has turned to gas, and the environmental temperature is too high for any of the gas to condense. Thermal conduction is still possible through the walls of the heat pipe, but at a greatly reduced rate of thermal transfer. In addition, for a given heat input, it is necessary that a minimum temperature of the working fluid be attained ; while at the other end, any additional increase (deviation) in the heat transfer coefficient from the initial design will tend to inhibit the heat pipe action. This can be counterintuitive, in the sense that if a heat pipe system is aided by a fan, then the heat pipe operation may break down, resulting in a reduced effectiveness of the thermal management system—potentially severely reduced. The operating temperature and the maximum heat transport capacity of a heat pipe—limited by its capillary or other structure used to return the fluid to the hot area (centrifugal force, gravity, etc. Copper/water heat pipes have a copper envelope, use water as the working fluid and typically operate in the temperature range of 20 to 150 °C

.For the heat pipe to transfer heat, it must contain liquid and its vapor (gas phase). The saturated liquid vaporizes and travels to the condenser, where it is cooled and turned back to a saturated liquid. In a standard heat pipe, the condensed liquid is returned to the evaporator using a wick structure exerting a capillary action on the liquid phase of the working fluid.

Heat pipes contain no mechanical moving parts and typically require no maintenance, though non-condensable gases that diffuse through the pipe's walls, that result from breakdown of the working fluid, or that exist as original impurities in the material, may eventually reduce the pipe's effectiveness at transferring heat.

Heat pipe materials and working fluids

Heat pipes have an envelope, a wick, and a working fluid. Heat pipes are designed for very long term operation with no maintenance, so the heat pipe wall and wick must be compatible with the working fluid. Some material/working fluids pairs that appear to be compatible are not. For example, water in an aluminum envelope will develop large amounts of non-condensable gas over a few hours or days, preventing normal operation of the heat pipe

BASIC COMPONENTS OF BASIN STILLS

A basin still consists of the following basic components: (1) basin, (2) a support structures, (3) glazing, (4) a distillate through, and (5) insulation.

The section that follows describes these components, the range of materials available for their construction, and the advantages and disadvantages of some of those materials.

The Basin; The basin contains the saline (or brackish) water that will undergo distillation. As such, it must be waterproof and dark (preferably black) so that it will better absorb the sunlight and convert it to heat. It should also have a relatively smooth surface to make it eas

Support Structures; Support structures form the sides of the still as well as the basin, and support the glazing cover. ier to clean any sediment from it.

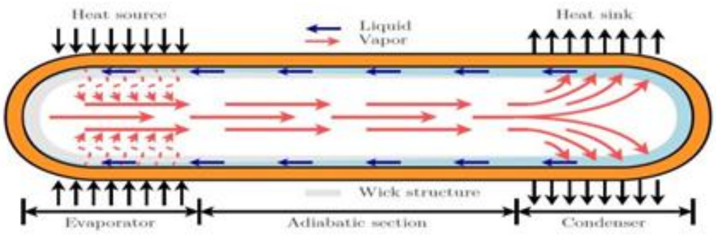
Glazing Cover; After the pan, the glazing cover is the most critical component of any solar still.

Distillate Trough; The distillate trough is located at the base of the tilted glazing.

Ancillary Components; Ancillary components include insulation, valves, sealants, piping, fixtures, pumps, and water storage facilities. In general, it is best to use locally available materials, which are easily replaceable

Insulation; Insulation, used to retard the flow of heat from a solar still, increases the still's performance.

Sealants; Although the sealant is not a major component of a solar still, it is important for efficient operation



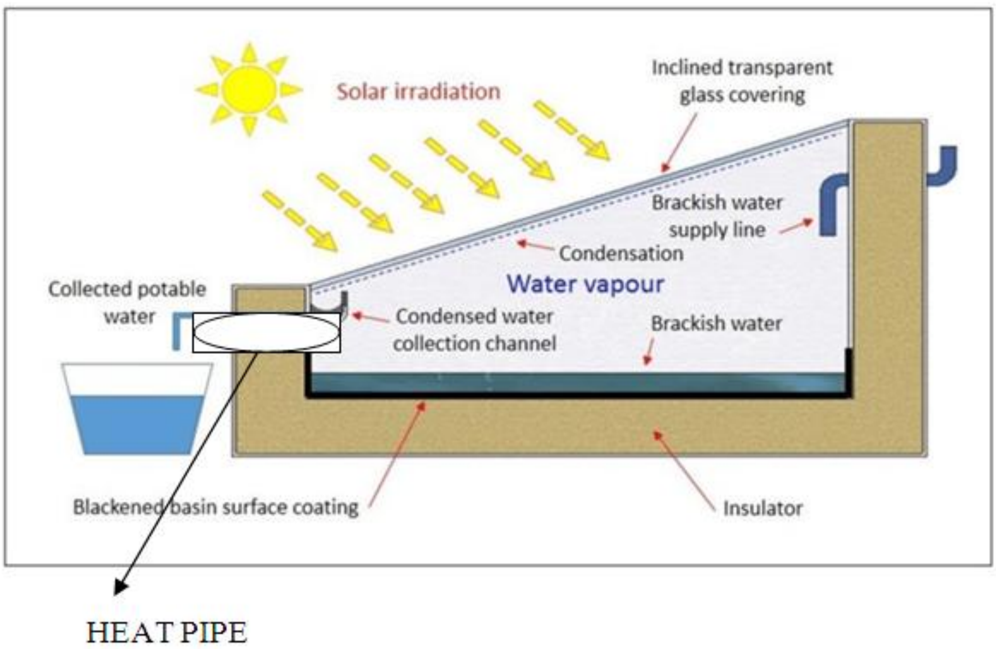


Fig.1 EXPERIMENTAL SETUP

III. RESULTS AND DISCUSSION

i.Variation of temperature with heat pipe

The fig 2 shows the variation of water temperature in the still when heat pipe is connected with the still. The solar radiation increases the temperature of the fluid in the heat pipe as a result the heat is transferred to the still. The water temperature rises and reaches a maximum of 60^0 for the solar radiation input of $924W/m^2$.The solar radiation is directly proportional to heat pipe fluid ,water temperature.

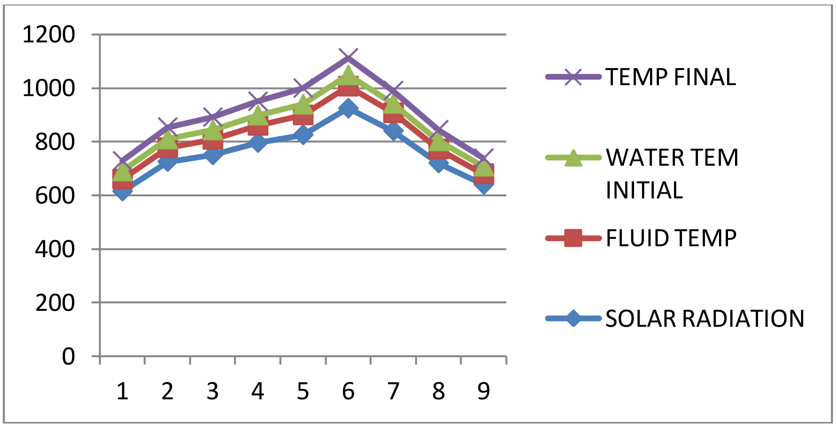


Fig.2 Variation of temperature with heat pipe

ii. Variation of temperature with heat pipe and output from still

The fig 3 shows the Variation of temperature with heat pipe when heat pipe is connected with the still. The solar radiation increases the temperature of the fluid in the heat pipe as a result the output distillate also increases. The water temperature rises and reaches a maximum for the solar radiation input of 924W/m^2 with distillate out put of 160ml/hr.

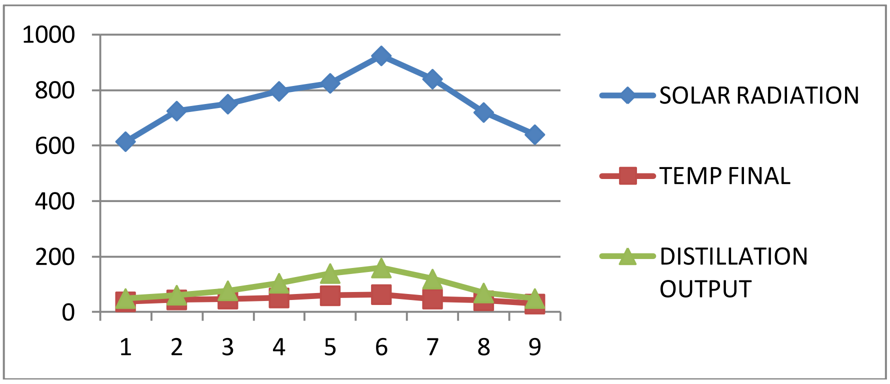


Fig.3 Variation of temperature with heat pipe and output from still

iii.Variation of temperature without heat pipe and output from still

The fig 4 shows the Variation of temperature without heat pipe when heat pipe is not connected with the still. The solar radiation is the only source to increase the temperature of the still as a result the output distillate also decreases. The water temperature rises and reaches a maximum for the solar radiation input of 924W/m^2 with distillate out put of 140ml/hr

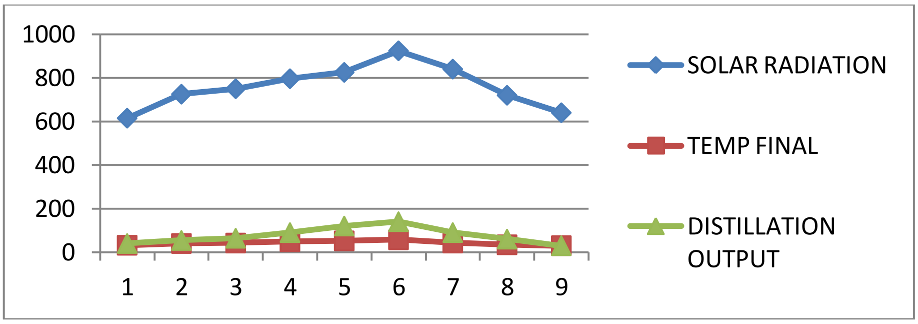


Fig.4 Variation of temperature without heat pipe and output from still

iv.Variation of temperature with heat pipe and sensible materials with output from still

The fig 5 shows the Variation of temperature with heat pipe and sensible storage materials. when heat pipe is connected with the still. The solar radiation increases the temperature of the fluid in the heat pipe as a result the output distillate also increases. The water temperature rises and stores this heat as sensible heat .some of the common materials such as iron pieces, charcoal powders are used in the still as storage materials. For maximum for the solar radiation input of 924W/m^2 with distillate out put with and with out sensible materials are of 240ml/hr and 140ml/hr.

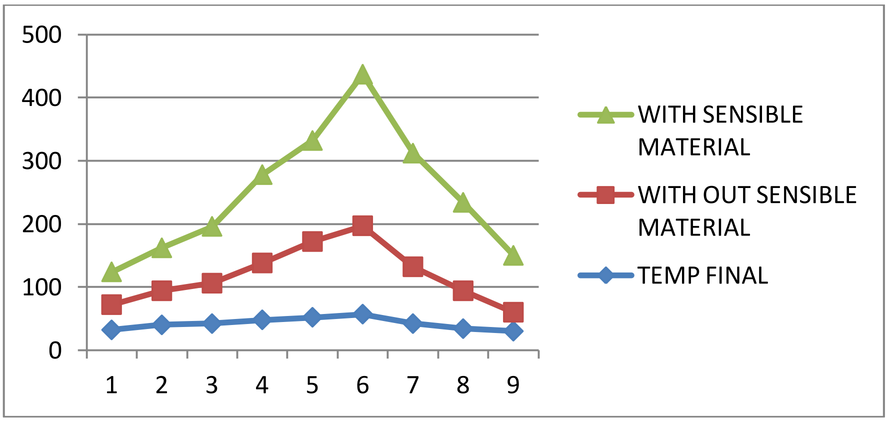


Fig.5 Variation of temperature with heat pipe and sensible materials with output from still

v.Effect of efficiency with and without heat pipe

The fig6 shows the effects of heat pipe introduction in the still on efficiency of the still.It was clearly noticed that the efficiency increases from starting and reaches the maximum value at 825w/m^2 at 1pm with maximum efficiency of 68%, where as the still without heat pipe gives the efficiency of 58%.This clearly shows that the introduction of heat pipe in the still is used to improve the efficiency.

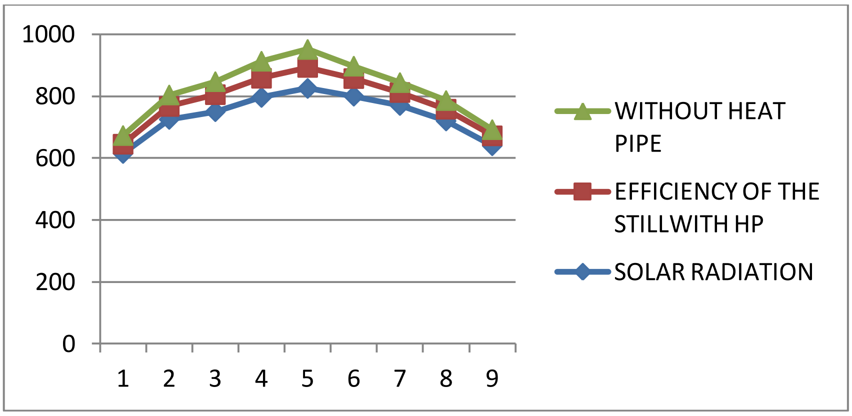


Fig.6 Effect of efficiency with and without heat pipe

IV. Conclusion

Heat pipe connected to solar still for desalination gives the following informations. Sensible storage materials are added to the still to increase heat carrying capacity. Experiments were conducted in various modes with and without heat pipe .The water temperature rises and reaches a maximum of 60^0 for the solar radiation input of 924W/m^2 with distillate out put of 160ml/hr and distillate out put of 140ml/hr without heat pipe. For maximum for the solar radiation input of 924W/m^2 the distillate out put with and with out sensible materials are of 240ml/hr and 140ml/hr. maximum efficiency of 68%, where as the still without heat pipe gives the efficiency of 58%.This clearly shows that the introduction of heat pipe in the still is used to improve the efficiency

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