Experimental study of solar water distillation by parabolic collector

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Abstract
A parabolic solar collector system is used for water distillation. In the rural areas of developing countries, boiling is the means most often used for purifying water for food preparation and drinking. However, boiling is relatively expensive, consumes substantial amounts of fossil energy and the associated wood gathering contributes to depletion of forests. Among available alternatives, solar water distillation is one of the most promising approaches for an energy-efficient, cost-effective, robust and reliable solution to these problems. Purification of water by solar distillation a parabolic solar collector system is used. Parabolic collector provides high concentration of solar radiation in a small area and temperature rise is easily attended. In this system distilled water found in the range of potable water. A nominal cost is associated with this system. A onetime setup cost and marginal maintenance cost is associated with this system.
Keywords: *Solar water purification; Water distillation; parabolic collector.*

1. Introduction

Utilization of renewable energy sources are the need of present era. Increasing demand and price hiking of energy, depletion of fossil fuels and their harmful effect on the environment and humankind makes the researchers to think on exploring the renewable energy sources mainly the solar energy for various application of life. Solar energy is clean, abundantly available and most accessible natural resource all over the world. It is a natural gift to the countries which lie on the solar belt. Along with energy, lacking of fresh water is also one of the hindrances in the socioeconomic development of a nation. Impure water is the reason for millions of death and many incurable diseases. Waterborne pathogens in developing countries cause several billion cases of disease and up to 10 million deaths each year, at least half of which are children (Burch and Thomas, 1998). Energy and water are two natural, fundamental, closely interrelated resources that play important roles in national security and the economy. Energy for water refers to energy consumed in the construction, operational, and maintenance phases of the water sectors. The water sector is a large consumer of energy, because in the operational and maintenance phases of the water use cycle, energy consumption is directly related to both the quantity and desired qualities of the supplied water/treated wastewater required by consumers.
Many researchers pointed out the need of fresh water along with renewable energy integrated water purification techniques [1–3]. Solar distillation is a thermal energy based technique used for the removal of contaminants from brackish/impure water using solar energy. Depending on the way of harnessing the solar energy, solar distillation technique is classified into two ways,

namely, passive solar distillation and active solar distillation. Passive solar distillation technique uses direct solar energy for its operation whereas active solar distillation utilizes some external thermal energy sources (thermal collector, photovoltaic panels, hybrid system, etc.) along with direct solar radiation for the process to be carried out [4]. Radhwan [5] analyzed the transient performance of stepped solar still with built in phase change material. The efficiency of the still was observed to be increased by 57% with a total daily yield of 4.6 l/m2. El- Sebaii et al. [6] investigated the thermal performance of single slopesingle basin solar still with different mass of phase change material (PCM). Daytime productivity of still was observed to decrease with the increased mass of PCM, but the overall productivity was increased. Tabrizi and Sharak [7] experimentally studied the performance of basin solar still integrated with a sandy heat reservoir. With the use of heat reservoir, total yield was observed to increase by 75% than conventional solar still. Tabrizi et al. [8] investigated the performance of weir type cascade solar still at different flow rates and with and without use of PCM. Solar still performance without PCM was observed higher than the still with PCM in sunny days and reverse was observed in cloudy days. In sunny days, maximum distillate of 4.85 and 5.14 kg/ m2 was observed at a minimum flow rate of 0.055 kg/min for the designed solar still with and without PCM respectively. Dashtban and Tabrizi [9] studied the performance of weir type cascade solar still with and without PCM. Effect of water level on the absorber plate and distance between water and glass surface on the performance of the still was investigated. The productivity of the still was observed to increase by reducing the water level and air gap in the still. With the use of PCM, still gave 31% higher yield than the still without PCM. Ansari et al. [10] numerically investigated the influence of three kinds of PCM of a different melting point on passive solar still performance. It was concluded from the result that PCM increases the efficiency of the system and choice of PCM was in accordance with basin water temperature. Sathyamurthy et al. [11] studied the effect of heat storage material on the performance of triangular pyramid solar still. Paraffin wax was used as storage material and observed that productivity increases up to 35% in comparison to still without storage. Arjunan et al. [12] studied the effect of different energy storage materials on the performance of a single slope single basin solar still. Use of energy storage material is concluded as low cost improvement modification in solar still.

Experimental Setup

A parabolic type reflector is being used to harness energy from solar radiations using low cost set-up. This can be used in rural areas of India. A concentrating primary reflector tracks the movement of the Sun, focusing sunlight on a fixed place. The focused light is used to heat a large vessel, which can be used for heating, steam generation, water distillation, baking breads, and cooking food. The system has one insulated water storage tank which absorbs solar radiations as well as preserves heat of water. The experiments were performed with a sample of 3 lit tap water and observations were taken in duration 12.30 PM to 2.30 PM in each half hour period. Water collection rate by condensation of steam in observed for three different days. The vessel has been painted by non-reflective black color to maximize the absorptivity.

Following are the components of experimental setup and are shown in Fig. 1, 2, 3 and 4.

- Rotating Support
- Reflector
- Cross bar
- Centre bar
- Frame
- Adjustments
- Distillation place
- Heating Vessel
- Insulated Storage tank

Results and discussions

Experiments were performed with a sample of 3 liter tap water and the afternoon time 12.30 PM to 2.30 PM was selected for taking observations. Water collection and temperature profile for the selected duration for three different days observed and results shown in form of graph by Fig. 5 and 6 respectively. Water distillation rate depends upon the temperature, as temperature increases vaporization rate also increases. The maximum temperature of vessel was observed116^{o}C and maximum water collected was 1200ml in duration of 2 hrs. by the designed setup. From the above experiments it was found out that by increasing the reflector size and exposure time water distillation rate can be increased.

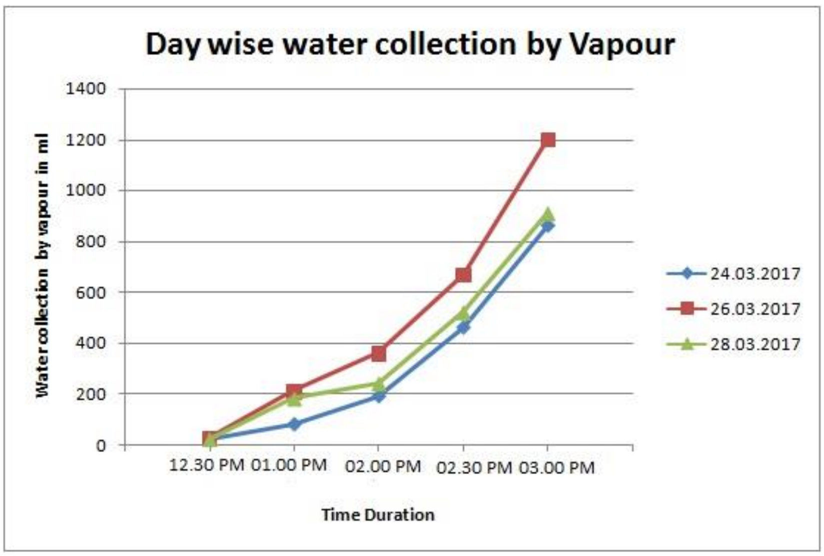

Fig.5: Day wise water collection by vapour for observed duartion

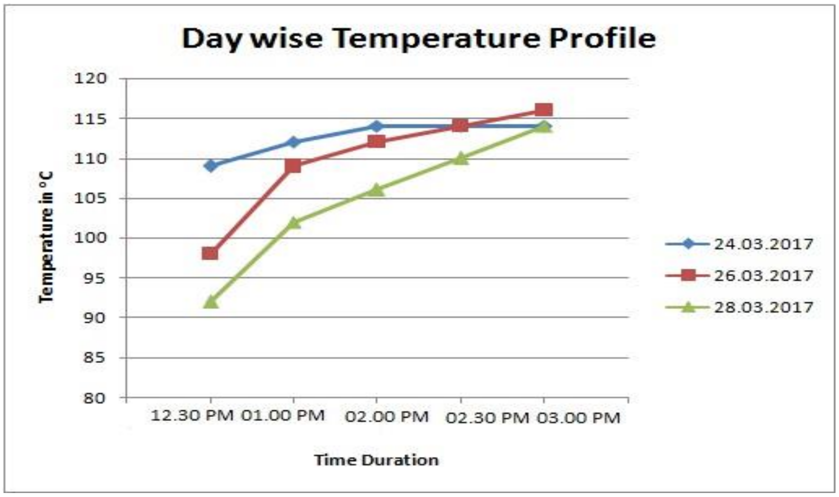

Fig.6: Day wise temperature profile for observed duration

Conclusion:

Solar water distillation process is an effective way to provide clean water in the rural areas of India. The proposed equipment can give better results with material with high heat conductivity and with a thick base, to prevent setup at the centre, where the intensity of heat is maximum. The solar intensity varies day to day basis, during afternoon period maximum energy can be harnessed for the distillation process. Evacuated tube method can also be combined with the given system to increase distillation rate in order to meet the demand of drinking water. The solar water distillation systems develop for community cooking applications provide an eco-friendly solution to the increasing energy demand of the community kitchen/cooking.

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