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Performance enhancement of a single basin single slope solar still using agitation effect and external condenser

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HIGHLIGHTS

- The conventional still is modified with basin water agitating system, fan and external condenser.
- A shaft coupled with a dc motor and exhaust fan used for agitatiing of water and extracting vapor to external condenser.
- The agitation of basin water breaks the boundary layer of water and increaes the area of contact with air.
- The exhaust fan and external condens enhances the circulation of air and vapor condensation.
- The productivity was enhanced by 39.49% as compared with conventional still.

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ABSTRACT

Solar still is one of the best solutions to solve water scarcity. The major drawback of the still is its low productivity. Improving the evaporation and condensation rate will increase the productivity of the still. In this work, a conventional and a modified single basin single slope solar stills were used for experimental analysis. Two single basin single slope solar still of same dimensions were fabricated. One of the still was attached with a provision to give agitation effect and external condensation. Agitation effect was given by a shaft coupled with a dc motor and an exhaust fan was used to extract the vapor from still to external condenser. Experimentation was carried out to compare the performances of conventional still and the modified still under same atmospheric conditions. The agitation effect breaks the surface boundary layer of water and increases the area of contact between the water and air. The exhaust fan and external condenser enhanced the circulation of air and condensation of vapor. The experimental result shows that the modified still enhanced the distillate productivity by 39.49% as compared to the conventional still. Also modified still is more economical than the conventional still.

1. Introduction

In arid and remote areas, water is scare, impure and saline, not suitable for drinking and requires treatment. Basin type solar still is the sustainable solution for this problem. It is very simple device, can be fabricated using locally available cheaper materials and require no skill to operate and maintain. Due to low productivity, this still has not been familiarly used. To improve the production and to make it economical, lot of researches have been progressing in improving the performance of both passive and active solar stills [1–6].

The productivity mainly depends on depth of water, evaporation area, radiation absorption capacity of the basin, transmittance of the cover, volumetric heat capacity of the basin, thermal properties of the basin and water, circulation of air inside the still and heat loss through the bottom and side walls of the still [1]. Maintaining minimum depth increases the production rate during day time [7–9], however the still with higher depth yields more production during night time and in consecutive days [10]. Use of wick and porous materials in the basin enhances the evaporation area [8,11], use of sensible and latent heat storing materials enhances volumetric heat capacity of the basin [9,12,13], use of dye materials improves the radiation absorption of basin [1].

Thermal properties of the water used in the still greatly affects the still performance. Thermal behavior of the still significantly depends on the thermal conductivity of the water used in the still. This property can be increased by converting the water into water nanofluid by adding suitable nano particles. Kabeel et al. [14,15] and Elango et al. [16] conducted experiment experiments with different water nanofluids in basin and compared their performances. Lovedeep and Tiwary [17] claimed, solar still with Al_2O_3 water nanofluid enhanced the production by 12.2% while Omara et al. [18] achieved 255% higher production using same nanofluid under vacuum condition.

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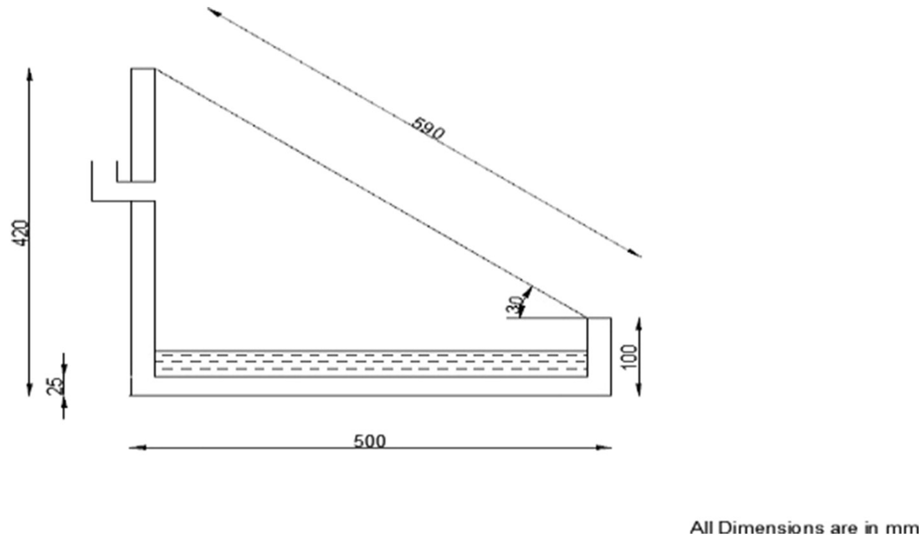

Fig. 2.1. Schematic diagram of conventional solar still.

Another novel method of enhancing the evaporation is physically stirring, agitating or spraying of basin water using external energy. During these processes, water mass split into small particles which increases the surface area contact between air and water in turn helps in diffusing the water particles into vapor. Mohammed and Zhao [19] used a small wind turbine to stir water using impeller. Khaled [20] designed and demonstrated a new still with vibrator to vibrate the still which agitated the basin water leading to the increase of production rate from 3.4 to 5.8 l/m^2 day.

Significant parameters affecting the condensation are cover area, cover thickness, cover material, cover temperature and ambient conditions. When a still is activated for evaporation process, cover area available will not be sufficient to cool the air and to condense maximum mass of vapor present in the still air. Providing additional condensing area with the help of external condenser is the best solution for this problem. Recently, Kabeel et al. [21] presented a detailed review on solar still with external condensers.

In this work, two new single slope single basin solar stills have been fabricated. One is conventional still. In another still, agitator is provided in the basin to agitate the basin water. An external condenser is also provided to collect part of the humid air from the still and to condense the vapor. Experiments were conducted to study the comparative performance of the modified still with conventional still under same climatic condition.

2. Experimental setup and procedure

In this work, two basin stills were designed, fabricated and constructed to compare the performance of the solar desalination system. One of them is a conventional type and the other is the modified basin still as shown in Figs. 2.1, 2.2 and 2.3. The conventional still is made from galvanized iron sheet (1.5 mm thick) with a basin area of 0.25 m^2 (500 mm × 500 mm). The low-side wall height is kept at 100 mm and the high side wall depth is 420 mm for 30° inclination. The inner walls of the basin are coated with black to improve the absorptivity. The still is insulated at the bottom and side walls with thermocole of 25 mm thickness to reduce the heat loss from the still to ambient. The basin is covered with glass cover of 4 mm thickness. The gaps between the glass cover and the still was coated with silica gel to prevent leakage to the atmosphere.

The modified basin still has the same dimensions and construction of conventional still. In addition to that a shaft coupled with a dc motor of 4 W capacity for agitation effect and an exhaust fan of 0.45 W capacity is attached. The shaft was attached 20 mm above the bottom surface of basin along the centre of side wall. Five blades of length 15 mm height were used to disturb the water surface. The exhaust fan was fixed in the top corner of same side wall of the basin The output duct of exhaust fan is extended to an external condenser in cylindrical shape (400 × 300 × 300 mm) made of GI sheet and insulated using

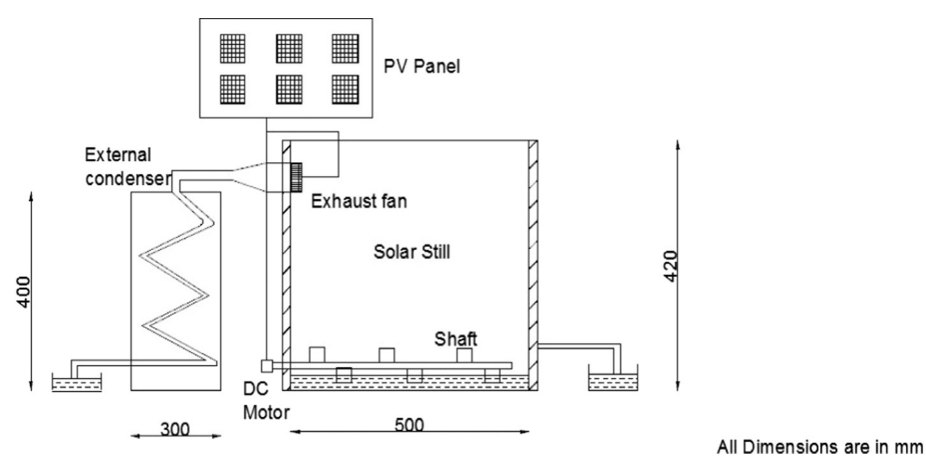

Fig. 2.2. Schematic diagram of modified solar still.