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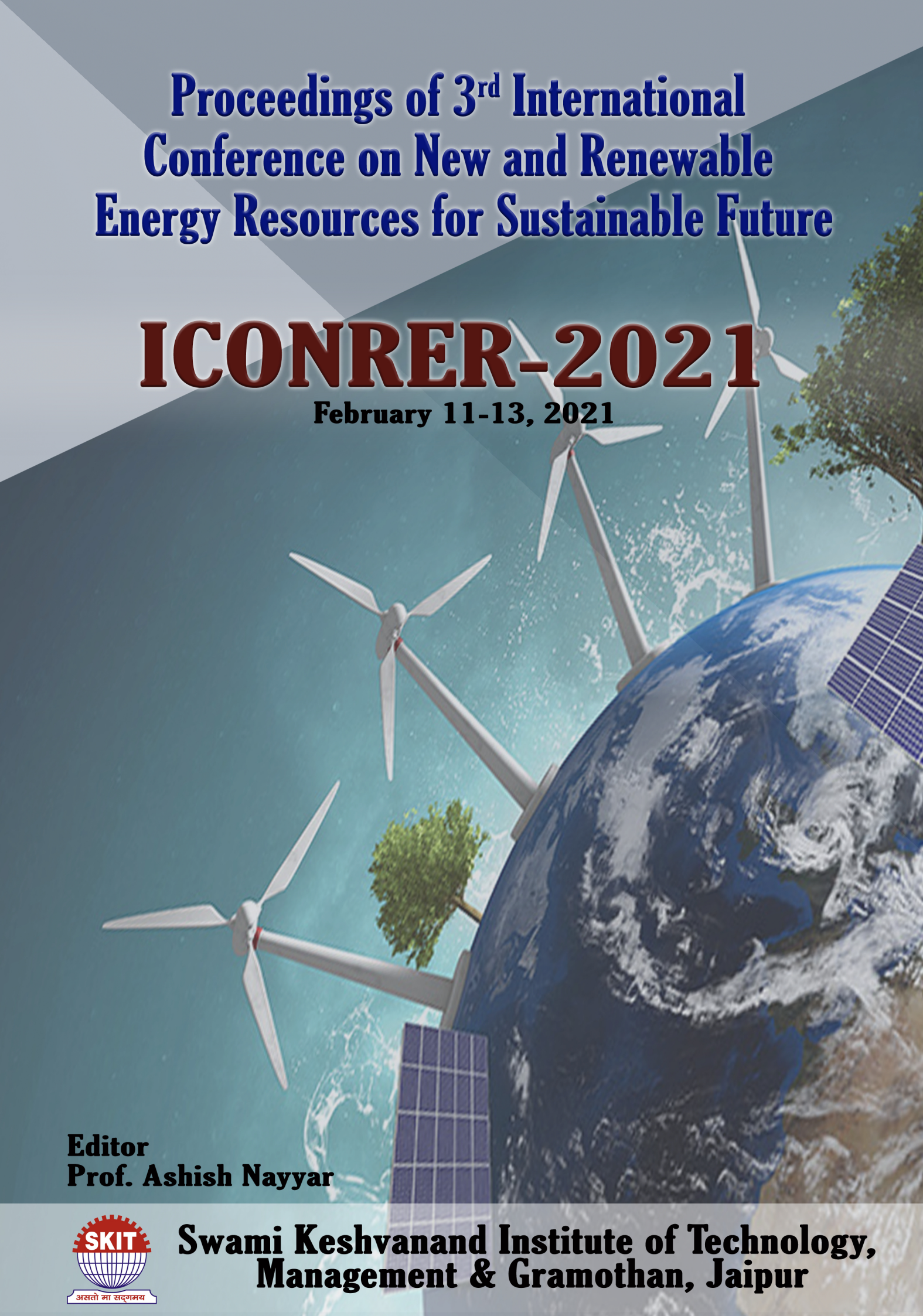

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Table of Contents

A REVIEW ON PERFORMANCE ENHANCEMENT METHODS FOR SOLAR STILLS

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Abstract

Solar distillation is a relatively simple treatment for purification of brackish or impure water. In this process water, evaporated using the solar energy, is converted into vapor which is further condensed as pure water. In this process salts and other impurities are removed. There are various methods to improve the efficiency of solar stills. One of the latest trend to improve the efficiency of the solar still is the use of nano-particles of metal oxides. This paper discusses the literature review to explore the different methods for improving the efficiency of the solar still. The findings state that 30º inclination of solar still and larger cover angle are two prominent ways to achieve higher daily productivity. In addition, the use of nano-particles coating on still basin also significantly increases the absorption capacity of solar still which gives higher productivity.

Keywords: Solar still, Performance enhancement, Nano-coating

INTRODUCTION

Potable water is vital for health, which relates to social development of any country. Safe drinking water is insufficient in the developing countries due to the limitation of knowledge, financial and other resources. Low quality water can be improved through the use of modern solar stills. This technology is suitable for any continent in the world and is well suited to the developing countries like India because it is cheap and requires little maintenance. But simple solar still has very low efficiency so this device for distillation is not very popular in the world. Now lots of research is done to improve the productivity of the solar still. Latest trend to improve the efficiency of the solar still is the use of nano-particles like metal oxides. Previous studies shows that use of nano-particles demonstrate better results for solar collecting devices.

Solar distillation is a relatively simple treatment of brackish water (i.e. water which contains dissolved salts). In this process water is evaporated using the energy of the sun then condensing vapour to get pure water. This process removes salts and other impurities because many impurities cannot evaporate with water. Solar distillation is used to produce drinking water or to produce pure water for lead acid batteries, laboratories, hospitals and in producing commercial products such as rose water. Some saline water may need to be added to the distilled water for making acceptable drinking water.

LITERATURE REVIEW

According to M. Boubekri et al. [1] use of reflectors in solar still shows best effect in winter season of the year and production of distilled water in night can be possible by thermal tank coupled with solar still as shown in Fig.1. Results shows the increase in the production resulting from the reflectors and much more significant in winter (72.8 %), and in spring (40.33 %) that in summer (7.54 %) The effect of the storage tank is also very significant in winter and summer.

The daily productivity of the still coupled with the tank is about 27.54%, 21 % and 23.28% respectively for the winter, spring and the summer.

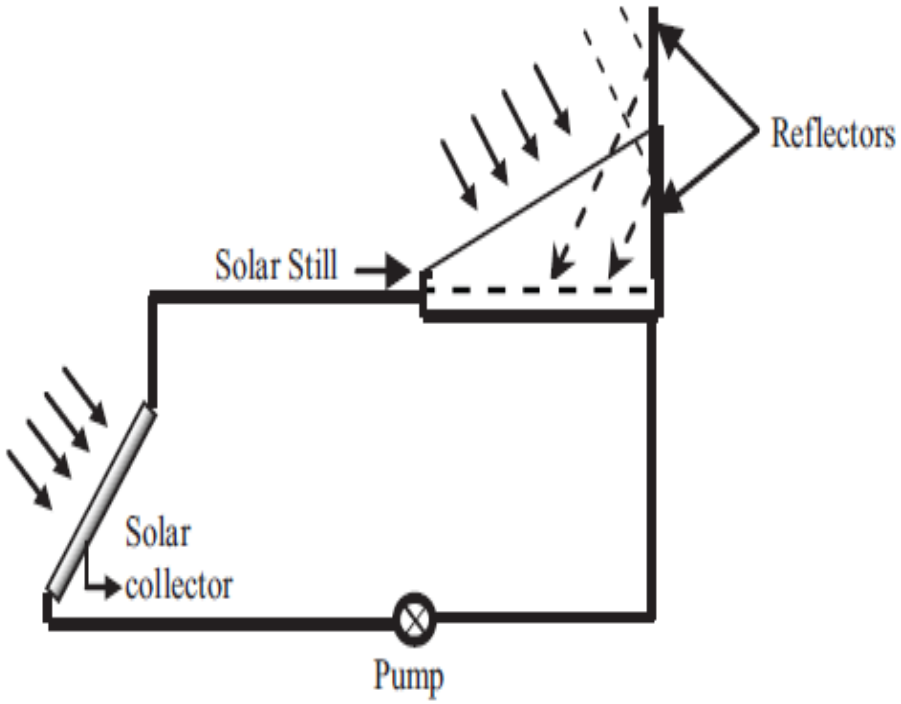


Fig. 1 Combined solar still with solar collector and mirror reflector [1]

T. Arunkumar, R. Jayaprakash, et al. [2] studied that flowing of cold water on glass cover can improve efficiency of solar still. In this study 48 % increment is achieved in still efficiency. For this experiment they use semi-hemispherical type solar still as shown in Fig. 2. Results show better productivity of solar still compared with simple solar still.

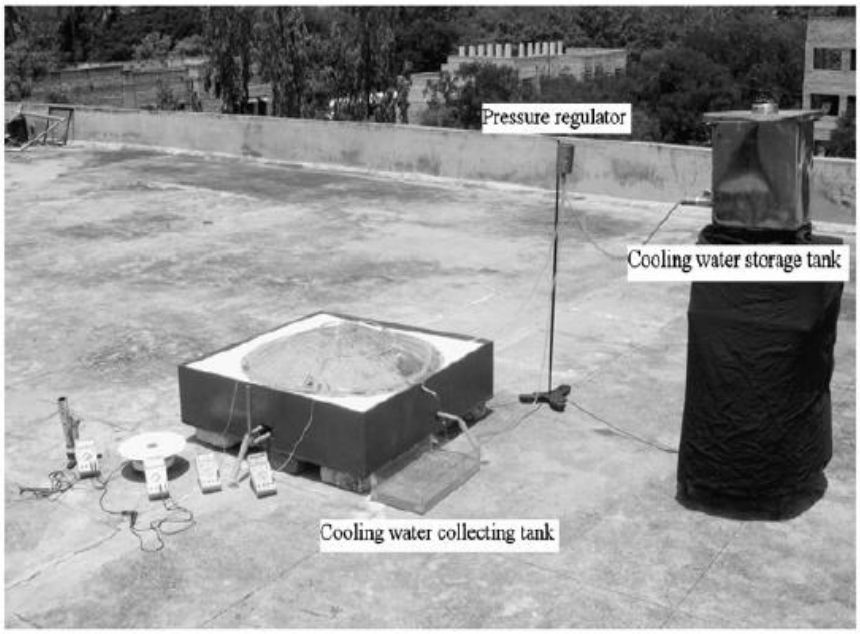


Fig. 2 Semi-hemispherical type solar still [2]

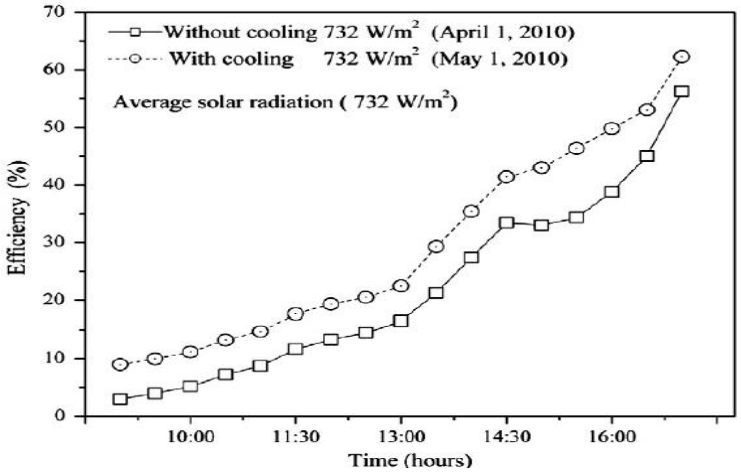


Fig. 3 Efficiency of Semi-hemispherical type solar still [2]

K. Kalidasa Murugavel and K. Srithar [3] concluded that use of black cloth covered with aluminium fins (Fig.3) can improve efficiency of solar still and other wick materials can also improve efficiency. Theoretical modeling is also validated with experimental results. It means wick materials play important role on heat transfer enhancement of solar still.

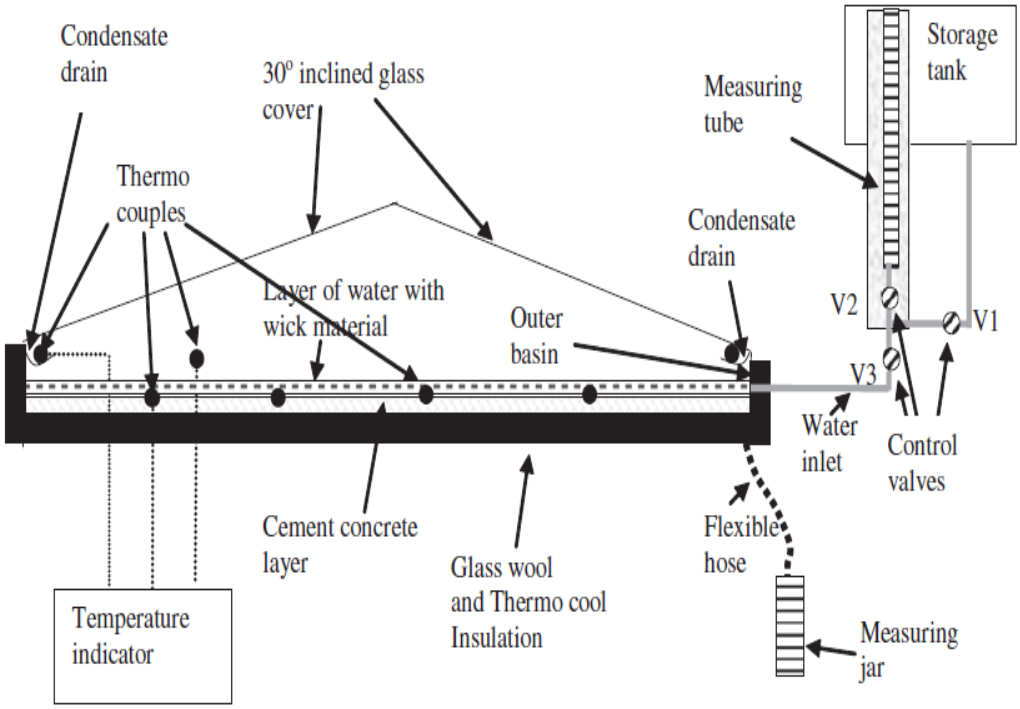


Fig. 4 Single basin double slope solar still [3]

According to Rahul Dev, Sabah A. et al. [4] the maximum optimized water depth can be taken as 0.03 m for the IASS (Inverted Absorber Solar Still) at which the addition of reflector under the basin does not affect its performance considerably in comparison to that of the SS. The theoretical results are in fair agreement with the experimental results for the IASS at water depths 0.01, 0.02 and 0.03 m only for the daytime operation as shown in Fig. 4.

The daily yield obtained from the IASS is 6.302, 5.576 and 4.299 kg/m^2-day at water depths 0.01, 0.02 and 0.03 m respectively. At same respective water depths, the daily yield obtained from the SS is 2.152, 1.931 and 0.826 kg/m^2-day respectively, lower than that of the IASS. On the basis of economic analysis of IASS, Maximum temperature achieved during experiment was 94^{o}C.

M. Koilraj Gnanadason, P. Senthil Kumar et al. [5] used CNT for their experiment on solar still (as shown in fig.5) and in their results 60% increase in efficiency was found when copper basin is used in place of cast iron basin. Metallic or non-metallic nano-particles changes the heat transfer characteristics of fluid and increases temperature of water, finally improve efficiency of still 50%. Overall Efficiency is increased 150% when compared with single basin solar still.

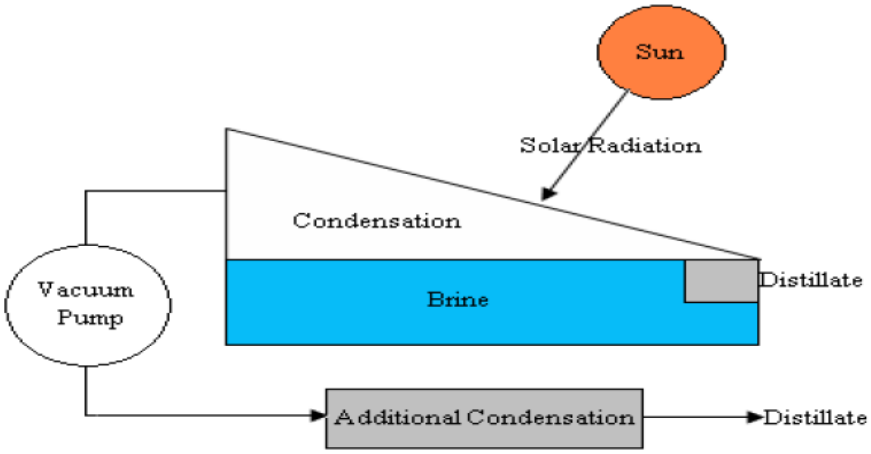


Fig. 5 Solar still with vacuum pump and use of CNT [5]

Amimul Ahsan, Kh. M. Shafiul Islam et al. [6] performed experiments as shown in fig. 6 on two types of Tubular Solar Still (TSS). First one was made of vinyl chloride sheet as a transparent tubular cover where as the second model was replaced by plastic transparent sheet as shown in figure 2.7 and 2.8. A set of laboratory experiments was carried out using a special technique to investigate the evaporation, condensation and distilled water production performance independently and simultaneously on the second model.

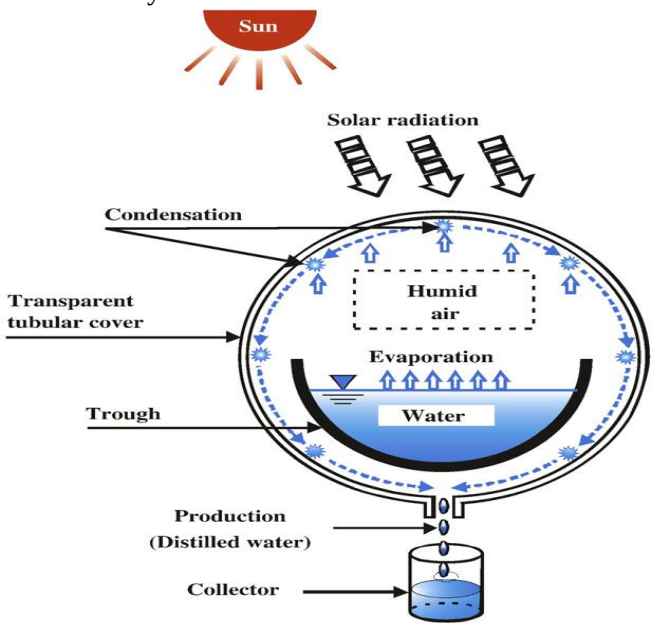
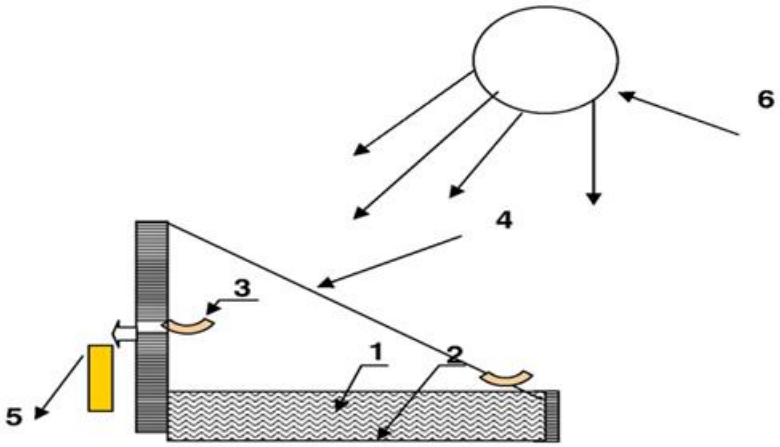


Fig. 6 Design principle of tubular type solar still [6]

It was discovered that the hourly evaporation, condensation and production fluxes were proportional to the humid air temperature and relative humidity fraction. Consequently, an empirical equation was proposed based on this relation to predict the hourly production flux.

Khaoula Hidouri, Romdhane Ben Slama et al. [7] wanted to improve the thermal efficiency of simple solar still by applying heat pump.

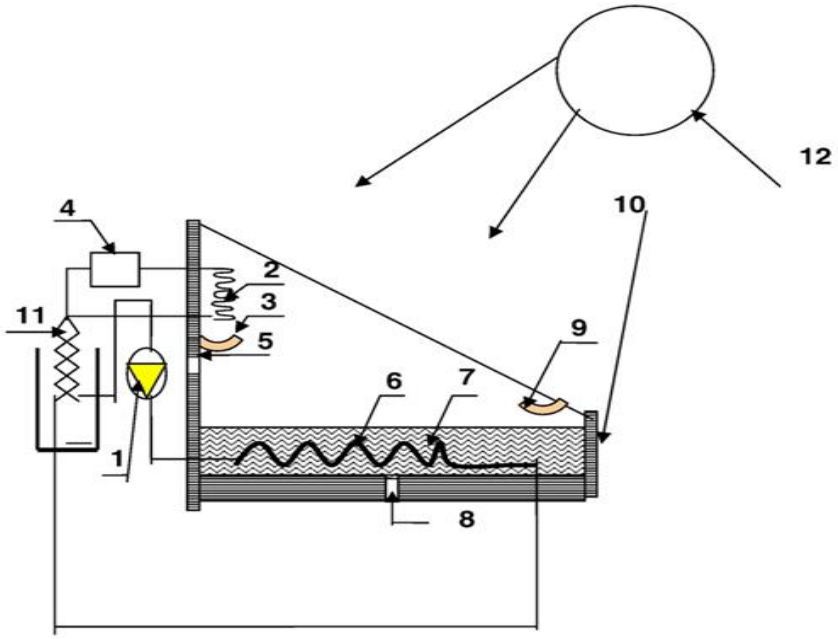


1- Brackish water, 2- Basin, 3- Distilled water gutter,

4- Glass cover, 5- Distilled water, 6- Sun

Fig. 7 Green house type simple solar still (SSS) [7]

They conducted an experimental work and modeling of a simple solar still (SSS, fig. 7), green house type a symmetrical and a hybrid system of a solar still connected to a heat pump (SSSHP, fig. 8). Data obtained from their experimental research are used to determine convective and evaporative heat transfer coefficients such as the experimental and theoretical efficiencies. Conclusion from their study was that daily output increased from 2 l/m^2 for the SSS up to 12 l/m^2, for the HSSHP and average efficiency increased from 20% to 80%.



1- Compressor, 2- Evaporator, 3- Distilled water gutter,
4-Expending valve, 5- Input brackish water, 6- Condenser,
7- Brackish water, 8- Brackish water, 9- Distilled water gutter,
10- Insulation, 11- Heat exchanger, 12- Sun

Fig. 8 Hybrid solar distillation system [7]

Abdul Jabbar N. Khalifa et al. [8] performed an experimental investigation on the productivity of a single basin type solar still with internal and external mirror reflector tilted at angles of 0°

(vertical), 10°, 20° and 30° for still cover angles of 20°, 30° and 40°. A simple still equipped with internal and external reflectors is investigated in winter at latitude angle of 33.3° N. It was found that the daily productivity is greater for a still with a larger cover angle at any reflector angle.
The daily productivity of the still with no reflectors would remain almost the same at any glass cover angle. The benefit of the vertical external reflector in winter is decreased as the cover angle exceeds 40°. The most productive solar still in winter is a solar still that has a cover plate angle of 20° and an internal and external reflector inclined at 20° it's productivity will be around 2.45 times that of simple solar still with no mirror reflectors. The conclusions of this study validated the trend of some of the theoretical results cited in the literature at 30° latitudes.

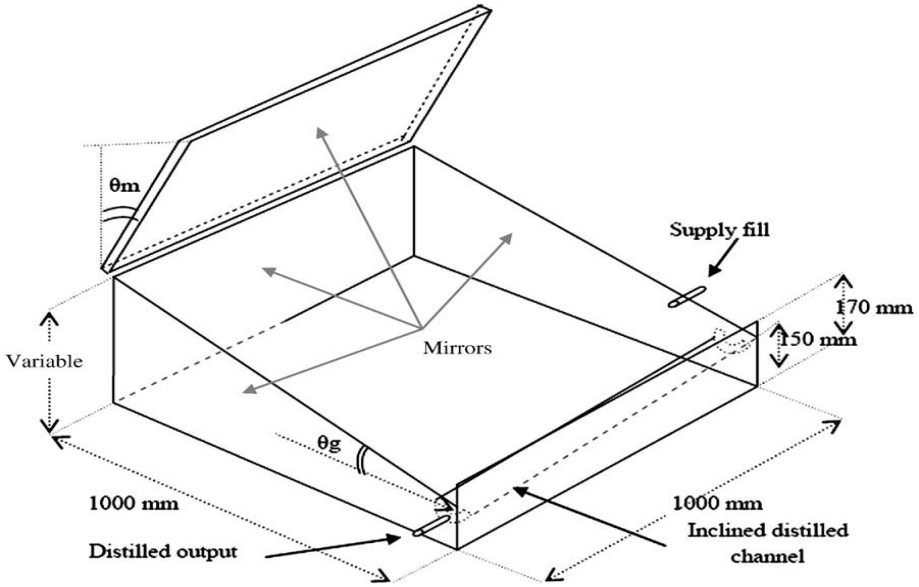


Fig. 9 schematic diagram of the basin type solar still [8]

N Hitesh Panchal, Shah P. K. [9] found that a lower glass cover thickness increases the distillate water output, water temperature, evaporative heat transfer coefficient, convective heat transfer coefficient as well as efficiency of solar still. Hence, 4 mm glass cover thickness is most suitable thickness for experiment.
Dinesh Kumar, Patel Himanshu, Zameer Ahmad [10] investigated the single slope solar still for effect of depth of water and inclination of tilted glass on water output. The investigation is carried out for 30^o and 23^o inclination, based on this investigation it is concluded that 30^o inclination of solar still is more efficient and effective.
Wasil Jamal, Prof. M. Altamush Siddiqui [11] observed that the average water mass temperature remains high for low water depths due to faster rate of heating of the shallow water mass. For almost all the water depths, the distillate output is more for the North-South orientation of the solar still Results show that the yield is maximum for shallow water depth in the basin.

Fig. 10 Solar still at different inclined angles [10]

CONCLUSIONS

The study shows that the yield from the solar still (active or passive solar still) depends upon meteorological, and design and operational parameters. Due to nature constraints, meteorological parameters cannot be controlled by human beings. Many researchers framed mathematical expressions, conducted experiments and validated the outcome from the various types of solar stills by varying the design and operating parameters. The literature review reveals valuable insights into the design of single slope solar still and ways to achieve high efficiency.

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Renewable energy and sustainable development are the key technologies to offer solutions to the ever-increasing environmental pollutions and depleting conventional fuel reserves. With an aim to discuss the state of art technologies pertaining to the renewable energy domain, RTU (ATU) TEQIP III Sponsored 3rd International Conference on New and Renewable Energy Resources for Sustainable Future (ICONRER-2021) was organized by the Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur in collaboration with Rajasthan Technical University and Department of Mechanical Engineering, Assiut University, Assiut (Egypt) from February 11 to 13, 2021. ICONRER is a series of the conference started in 2017 and it was 3rd event of that series.

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