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RESEARCH ARTICLE

Performance enhancements of conventional solar still using reflective aluminium foil sheet and reflective glass mirrors: energy and exergy analysis

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Abstract
Many researchers are seeking simple and successful solutions to increase the output from the solar distiller. In this research work, reflective mirrors and reflective aluminium foil sheet were fixed on inner surfaces of the single-slope solar distiller, leading to more water production. The presence of reflective mirrors and reflective aluminium foil sheet on inner surfaces of the solar distillate permits the reflection of solar radiation falling inside the basin. Experiments were carried out on three stills: the first distiller is conventional solar still with black painted walls (CSS-BPW); the second distiller is conventional solar still with reflective aluminium foil sheet walls (CSS-RAFW); and the third distiller is conventional solar still with reflective glass mirror walls (CSS-RGMW). The maximum total drinking water productions from the CSS, CSS-RAFW and the CSS-RGMW are 3.41, 5.1 and 5.54 kg/m^2, respectively. Compared to the CSS-BPW, the production of drinking water was increased by 68.57% when using the reflective glass mirrors and 48.57% when using the reflective aluminium foil sheet.

Keywords Solar energy · Reflective glass mirrors · Aluminium foil sheet · Storage energy

Introduction

Water is the main component of living organisms. It covers nearly three quarters of the earth's surface, and it is home to millions of marine organisms such as fish and other marine plants (Ghadamgahi et al. 2020). The earth surface receives tremendous solar energy from sun. It is possible to take advantage of solar energy directly or indirectly by converting it to another type of energy such as thermal, mechanical, electrical or chemical (Al-Nimr et al. 2019; Zhuang 2016; Gonzalo et al. 2019). Dependence on traditional energy sources is lower; e.g. oil and gas are reduced, because the use of such resources causes environmental problems (Manokar et al. 2018a; Márquez et al. 2018). Scientists are working on the possibility of using renewable energy in all industrial fields, including desalination. The insufficiency of safe drinking water has become the main problem that threatens people's lives (Hilarydoss et al. 2020). Therefore, desalination of saline water using solar distillation can be used for producing drinking water (Nabil and Khairat Dawood 2020; Malik et al. 2019; Thalib et al. 2020). Many researchers are working to enhance the daily output of solar distillers by

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adding heat storage materials and by changing the design of the distiller (Hassan et al. 2020b; Zouari et al. 2019). Kostić et al. (2010) and Kostic et al. (2010) studied the impacts of using aluminium mirrors on the performance of solar still. They found that using the reflectors with an angle of 66° improved the system performance. In Algeria, Tabet et al. (2014) enhanced the performance of a PhotoVoltaic/Thermal (PV/T) air collector using a plane reflector. The results show that the use of the plane reflector improves the PV/T air collector's performance. In the city of Kolkata, Naik and Palatel (2014) studied installing a mirror attached to the top with angles ranging from 85° to 100° in the hybrid solar collector. The results revealed that the solar collector efficiency was improved by using a reflective mirror. Baccoli et al. (2015) mathematically studied the effect of the external reflector on the flat solar collector. Bahaidarah et al. (2015) reported the effect of the reflective mirrors on the performance of the hybrid solar collector. The obtained results published that the efficiency of the solar collector was improved. Belhadj et al. (2016) studied the effect of position between the angles of two reflecting panels on solar cells. The researchers confirmed that this process increased the solar radiation input to the system.

Chowdhury (2016) published the influence of concentrated hybrid PV/T collector design to improve the total efficiency of the collector (see also Kabir and Chowdhury 2017). Mohd Rosli et al. (2014) studied the unglazed PV/T system to increase the thermal efficiency of a polymer collector. By using an unglazed PV/T system, the thermal efficiency of the system was augmented by 47%. Khechekhouche et al. (2020b) conducted the experiments on the conventional solar still (CSS) with a simple external mirror. The experimental results revealed that the daily production was equal to 4.84 L/m^2/day with the reflecting mirror. However, it is about 3.40 L/m^2/day in the CSS. Tanaka and Nakatake (2009) reported the impact of the inclination of the flat plate external reflector. Compared to the vertical reflector, in the case of the half-length reflector, the results revealed that the daily accumulation has increased by 15 to 27% when the oblique reflector was used. Omara et al. (2016) reported the comparative study of corrugated solar still (CrSS) using layer wick, reflectors and the CSS. The results indicated that an improvement in daily accumulation in CrSS was 145.5% higher than the CSS and the daily efficiency of the CrSS and CSS was about 59 and 33%, respectively. Omara et al. (2014) investigated the impact of internal and external reflectors in the modified stepped solar still. They concluded that the daily productivity with internal and external reflectors was 125% higher than the CSS. Abdallah et al. (2008) investigated the CSS with internal mirrors, stepwise basin and sun tracking system. In this system, the CSS performance was enhanced by 30% when using the interior mirrors, 180% when using the stepwise basin and 380% when using the stepwise basin coupled with a sun tracking system. Shanmugan et al. (2008) studied the efficiency of solar distillation with acrylic mirror supported just above the glass cover. With the possibility of adjusting the supporting mirrors, the maximum productivity was obtained according to the angle of movement of the sun. Results indicated that the output was about 4.2 kg/m^2/day; the rate increases 45% when using the mirror booster as compared to the CSS.

Parsa et al. (2019) studied the effect of height on the productivity of solar distillers. The productivity of the solar still in the Tochal Mountains summit at the height of 3964 m was higher as compared with the productivity of the solar still in Tehran, at the height of 1171 m. The results confirm that the distillate productivity in the highest Tochal Mountains was 56.17% higher as compared to the measured distillation yield in Tehran. They also concluded that the cost of distilled water produced in the mountains is more expensive than that in Tehran. Parsa et al. (2020a) examined active thermoelectric solar stills, one still on top of Tochal and the second in Tehran, with a height difference of 2793 m. The researchers concluded that productivity at the Tochal summit is higher than that in Tehran due to the decrease in pressure and wind velocity at the top of Tochal. The performance of the photovoltaic plate at the Tochal summit is better because it is cooler than Tehran. The efficiency and productivity of the solar still at the Tochal summit were improved by 27.8 and 42.5%, then the solar still at the Tehran, respectively. Parsa et al. (2020b) compared two similar active and passive solar stills in Tochal and in Tehran for a period of seven consecutive days. For active still, the system uses a photovoltaic panel with Peltier electrical heat units. The results showed that the height rise has a major impact on the efficiency of the solar still (passive and active). Parsa et al. (2020d) published the effect of the silver nanofluids on the efficiency of solar stills at the height of Mount Tochal (4000 m) and the city of Tehran. The results showed that the energy efficiency was enhanced at the Tochal site without using silver nanofluids. The addition of an external mirror to the CSS improved the distillate water productivity by 9 to 21% (Omara et al. 2017; Tanaka and Nakatake 2007; Tanaka 2009). Recently waste material/low-cost material was used as energy storage material by many researchers (Balachandran et al. 2021; Attia et al. 2020, n.d.-a, n.d.-b; El-Agouz et al. 2019; Madhu et al. 2018; Khechekhouche et al. 2020a; Ramalingam et al. n.d.).

According to the state of the art, it is found that some researchers used reflecting glass for increasing productivity. The detailed review does not consider the use of aluminium foil sheet to improve productivity. Hence, the present research aims to improve the productivity of solar distillation by using the reflective glass mirrors and reflective aluminium foil sheet on inner surfaces of the solar distillate. The presence of reflective mirrors and reflective aluminium foil sheet on inner surfaces of the solar distillate increases the water temperature due to the focusing of the sun's rays inside the basin. The manuscript is presented as follows: 'Experimentation and principle of operation of CSS' section presents the experimentation and principle of operation of the CSS; results and discussions are discussed in 'Results and discussions' section; 'Comparison of the present study with published similar works' section gives the comparison of the present study with published similar works; and finally, 'Conclusions' section shows the conclusion of the manuscript.

Experimentation and principle of operation of CSS

The CSS is a very simple device with easily available and inexpensive components. The cycle of producing distilled water uses the principle of evaporation/condensation. This simple device converts non-drinking water into drinking water in isolated areas (El-Agouz et al. 2019; Hassan et al. 2020a). Algeria has sunny areas with a higher number of sunlight hours equal to 3300 h/year (Achour et al. 2017; Nia et al. 2013; Cheniti et al. 2020). Experiments were carried out in June 2020 from 8:00 AM to 5:00 PM. The testing set-up was placed in El Oued, Algeria, with the latitude of 33.3676° N and a longitude of 6.8516° E.

In these experiments, three solar distillers were made with a basin surface area of 50 cm × 50 cm in wood with a thickness of 2.5 cm. From the horizon, the angle of the distiller is set to 10°. The front side presents 6 cm of height, and the opposite side has 14 cm of height. The basin and inside sides are painted with black silicon, considered absorbent. Reflective mirrors and reflective aluminium foil sheet are fixed on the inner walls of the distiller to reflect the maximum amount of sunlight to the basin water. One-centimetre water depth was maintained in a solar still basin using a ball floating arrangement. The water evaporates and condenses into droplets at the collector surface. Droplets are collected in a water collection tank using a PVC tube.

The thickness of the aluminium foil sheet is about 0.2 mm. Aluminium foil has a shiny side and a matte side. The inside surface is dull, which decreases both the absorption and emission of radiation, and the outside surface is shiny, which increases the reflectivity. The reflectivity of aluminium foil is 88%, and the reflectivity of the mirrors is about 99% (Hanlon and Kelsey 1998). In experiments, the aluminium foil sheet and glass mirrors are fixed onto the inner walls of the solar distillery. Figures 1 (a, b) and 2 (a, b) show the schematic and photo of the experimental set-up of solar still with the reflecting glass mirrors and reflecting sheet of aluminium foil, respectively. The experiments were conducted for a period of three days in a row: 20, 21 and 22 June 2020 for 9 h: the first distiller is a conventional solar still with black painted walls (CSS-BPW); the second is a modified solar basin with reflective aluminium foil sheet (CSS-RAFW); and the third is a modified solar still with reflective mirrors (CSS-RGMW).

Results and discussions

Hour-wise variation of solar intensity [I(t)], ambience (T_a), saline water ($T_{s.w}$) and collector cover ($T_{c.c}$) temperatures

Figure 3 (a and b) shows the hour-wise variation of I(t), T_a, $T_{s.w}$ and $T_{c.c}$ for the CSS-BPW, CSS-RAFW and CSS-RGMW on 20-6-2020 and 22-6-2020, respectively. Figure 4 (a and b) shows that I(t) hike in the sunrise hours and measured its peak value of 1008 W/m^2 at 12 PM on 20-6-2020 and 1020 W/m^2 at 12 PM on 22-6-2020. Similarly, T_a also increases in the sunrise hours and measured its peak value of 44 °C at 1 PM on 20-6-2020, and 45 °C at 1 PM on 22-6-2020. Hour-wise variations of T_a, $T_{s.w}$ and $T_{c.c}$ have trends similar to I(t) as it is the cause for changes in T_a, $T_{s.w}$ and $T_{c.c}$. Each day mean values of I(t) and T_a on 20-6-2020 are 756.6 W/m^2 and 39 °C, and on 22-6-2020 are 773 W/m^2 and 39.5°C, respectively. The highest $T_{s.w}$ of the CSS-BPW is 70 °C at 2 PM; CSS-RAFW is 75 °C at 2 PM; and CSS-RGMW is 77 °C at 2 PM on 20-6-2020. Similarly, on 22-6-2020, the highest $T_{s.w}$ of the CSS-BPW is 71 °C at 2 PM; CSS-RAFW is 76 °C at 2 PM; and CSS-RGMW is 77°C at 2 PM. The highest $T_{s.w}$ of the CSS-RAFW and CSS-RGMW is 5 and 7 °C higher than that of the CSS-BPW on 20-6-2020, and the maximum $T_{s.w}$ of the CSS-RAFW and CSS-RGMW is 5 and 6 °C higher than that of the CSS-BPW on 22-6-2020. Each day average $T_{s.w}$ of the CSS-BPW is 56.6°C, CSS-RAFW is 61.1°C and CSS-RGMW is 62.6°C on 20-6-2020, and each day average $T_{s.w}$ of the CSS-BPW is 57.6°C, CSS-RAFW is 62.2°C and CSS-RGMW is 63.2°C on 22-6-2020. Each day average $T_{s.w}$ of the CSS-RAFW and CSS-RGMW is 7.95 and 10.6% higher than that of the CSS-BPW on 20-6-2020, and each day average $T_{s.w}$ of the CSS-RAFW and CSS-RGMW is 7.98 and 9.72% higher than that of the CSS-BPW on 22-6-2020. Each day average $T_{s.w}$ of the CSS-RGMW is 2.45% higher than that of the CSS-RAFW on 20-6-2020, and each day average $T_{s.w}$ of the CSS-RGMW is 1.6% higher than that of the CSS-RAFW on 22-6-2020. Due to higher reflectivity materials in the CSS-RGMW and CSS-RAFW, the maximum and each day average $T_{s.w}$ is higher than the CSS-BPW.

Figure 3 (a and b) shows that the peak $T_{c.c}$ of 50, 51 and 52 °C were recorded on 20-6-2020, and 50, 52 and 53°C on 22-6-2020 for the CSS-BPW, CSS-RAFW and CSS-RGMW, correspondingly. Each day mean $T_{c.c}$ of the CSS-BPW, CSS-RAFW and CSS-RGMW are 42.4, 43.4 and 44.3% on 20-6-2020 and 43.3, 44.5 and 45.3% on 22-6-2020, correspondingly. The aluminium foil sheets and glass mirrors used in the CSS-RAFW and CSS-RGMW were used to augment the $T_{s.w}$ throughout the experimental days by reflecting the solar intensity on the basin saline water. Hence, the incorporation of aluminium foil sheets and glass mirrors improves the $T_{s.w}$ by

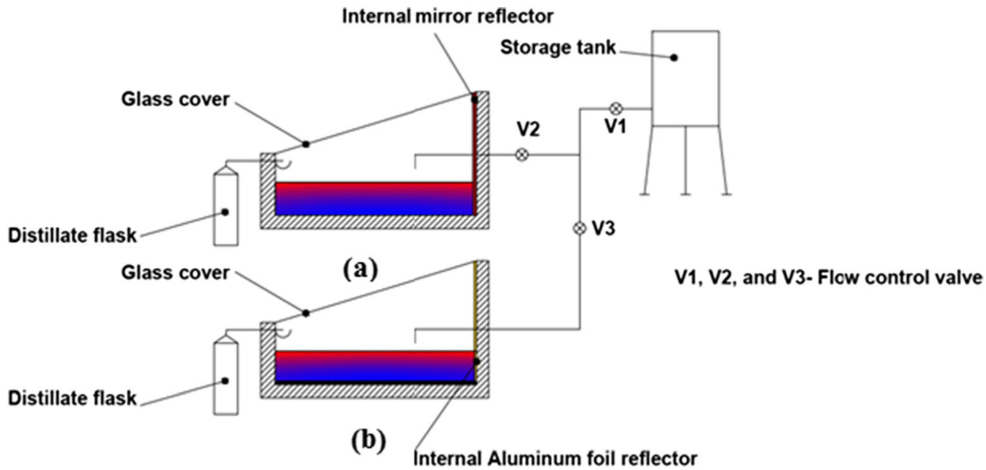

Fig. 1 Schematic of solar still with (a) reflective glass mirrors and (b) reflective aluminium foil sheet

adding some extra heat energy input to the basin saline water, whereas in the CSS-BPW, heat energy was absorbed by the wall surfaces; therefore, it has a minimum heat energy input to the $T_{s.w}$.

Hour-wise variation of evaporative heat transfer coefficient and hourly potable water yielding

Figure 4 (a and b) shows the hour-wise difference of evaporative heat transfer coefficient (EHTC) and hourly production of potable water from the CSS-BPW, CSS-RAFW and CSS-RGMW on 20-6-2020 and 22-6-2020, respectively. The highest calculated EHTC of the CSS-BPW, CSS-RAFW and CSS-RGMW are 36.94, 45.06 and 48.75 W/m^2 K on 20-6-2020 and 38.46, 46.81 and 48.86 W/m^2 K on 22-6-2020, respectively. Each day average EHTC of 22.75, 27.96 and 29.48 W/m^2 K were calculated on 20-6-2020, and each day average EHTC of 23.74, 29.25 and 30.55 W/m^2 K were calculated on 22-6-2020 for the CSS-BPW, CSS-RAFW and CSS-RGMW, respectively. Each day average EHTC of the CSS-RGMW is higher than the CSS-BPW and CSS-RAFW

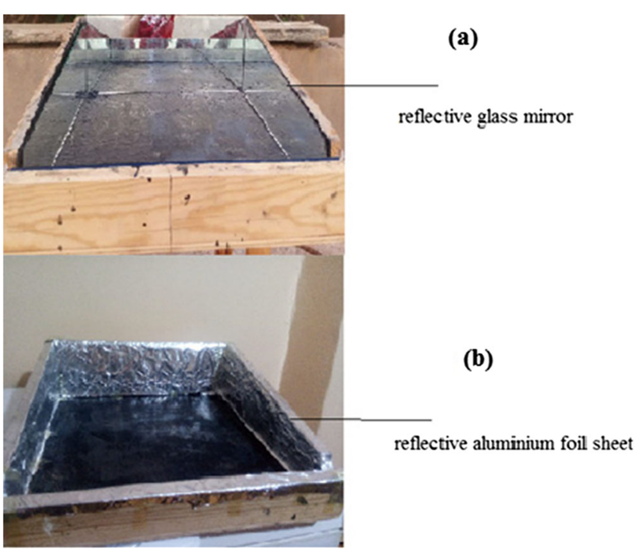

Fig. 2 Photo of a solar still with (a) reflective glass mirrors and (b) reflective aluminium foil sheet

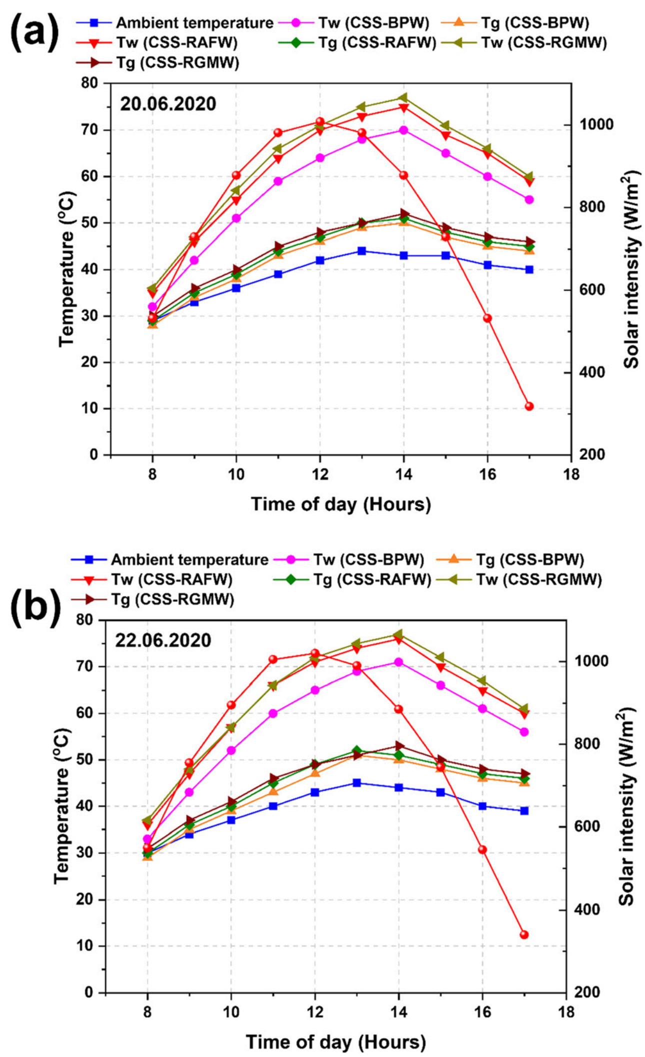

Fig. 3 Hour-wise variation of I(t), T_a, $T_{s.w}$ and $T_{c.c}$ for the CSS-BPW, CSS-RAFW and CSS-RGMW on (a) 20-6-2020 and (b) 22-6-2020

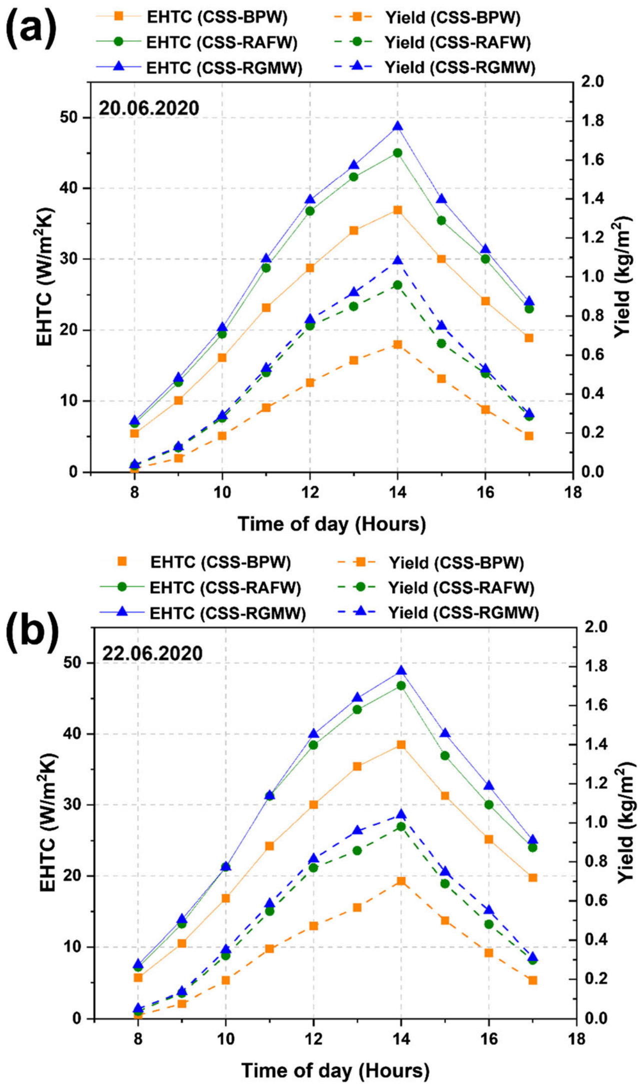

Fig. 4 Hour-wise variation of EHTC and yield from the CSS-BPW, CSS-RAFW and CSS-RGMW (a) on 20-6-2020 and (b) on 22-6-2020

due to the higher reflective materials at the inner sidewalls of the solar still. Each day average EHTC value of the CSS-RAFW and CSS-RGMW is 23.21 and 28.68% higher as compared to each day average EHTC of the CSS-BPW, and the daily average EHTC value of the CSS-RGMW is 4.44% higher as compared to the CSS-RAFW. In the CSS-RGMW, glass mirrors enhance the saline water temperature, and so it has maximum hourly and each day average EHTC than the CSS-RAFW and CSS-BPW.

Figure 4 (a and b) shows the hourly potable water production from the CSS-BPW, CSS-RAFW and CSS-RGMW on 20-6-2020 and on 22-6-2020, respectively. Hourly productivity from the solar stills is increasing during the sunrise hours and decreases during sunset hours. The highest hourly yields of 0.65, 0.96 and 1.08 kg were produced on 20-6-2020, and the highest hourly yields of 0.70, 0.98 and 1.04 kg were produced on 22-6-2020 from the CSS-BPW, CSS-RAFW and CSS-RGMW, respectively. Each day water production from the CSS-BPW on 20-6-2020 is 3.28 kg and on 22-6-2020 is 3.41 kg; from the CSS-RAFW on 20-6-2020 is 4.95 kg and on 22-6-2020 is 5.1 kg; and from the CSS-RGMW on 20-6-2020 is 5.34 kg and on 22-6-2020 is 5.54 kg. When using the reflective glass mirrors at the surface of the wall of the CSS, water production was increased by about 63.15% and 7.94% on 20-6-2020 and water production was increased by about 62.53 and 8.57% on 22-6-2020 as compared to the CSS-BPW and CSS-RAFW, respectively. In the CSS-RGMW, due to the reflective material properties, it reflects maximum heat energy to the saline water and thus enhances the water temperature, so water yielding from the CSS-RGMW is maximum as compared to the CSS-BPW and CSS-RAFW.

Hour-wise variation of energy and exergy efficiency

Hour-wise variations of energy and exergy efficiency of the CSS-BPW, CSS-RAFW and CSS-RGMW on 20-6-2020 and 22-6-2020 are shown in Figure 5 (a and b), respectively. The energy efficiency of the CSS-BPW, CSS-RAFW and CSS-RGMW was increasing during the morning and reached the highest value at 2 PM, and then it decreases. The energy efficiency of the CSS-BPW starts at 2.30% at 8 AM and has a rising tendency and reached 50.7% at 2 PM, and then it has a declining tendency up to 5 PM (35.52%). Also, the energy efficiency of the CSS-RAFW starts at 4.36% at 8 AM and has an increasing tendency and reached 69.46% at 2 PM, and then it has a declining tendency up to 5 PM (50.94%). Similarly, the energy efficiency of the CSS-RGMW starts at 7.57% at 8 AM, has an enhanced tendency and reached 73.61% at 2 PM, and then it has a declining tendency up to 5 PM (57.32%). Each day average energy efficiencies of the CSS-BPW, CSS-RAFW and CSS-RGMW are 27.68, 40.47 and 47.7% on 22-6-2020, respectively. The energy efficiency of the CSS-RGMW is 72.35 and 17.87% higher than that of the CSS-BPW and CSS-RAFW on 22-6-2020, respectively. The presence of glass mirrors in the CSS-RGMW augments $T_{s.w}$, EHTC and production of freshwater, and consequently, it produced higher energy efficiency than the CSS-RAFW and CSS-BPW since the energy efficiency of the stills is directly proportional to the production of freshwater and radiation.

The exergy efficiency of the CSS-BPW, CSS-RAFW and CSS-RGMW was rising in the sunrise hours and reached the highest value at 2 PM, and then it has a decreasing trend. The exergy efficiency of the CSS-BPW starts at 2.3% at 8 AM and has a rising tendency and reached a maximum value of 4.08% at 2 PM, and then it has a decreasing tendency up to 5 PM (1.92%). Also, the exergy efficiency of the CSS-RAFW starts at 0.09% at 8 AM and has a rising tendency and reached the maximum value of 7.25% at 2 PM, and then it has a decreasing tendency up to 5 PM (3.72%). Similarly, the exergy efficiency of the CSS-RGMW starts at 0.11% at 8 AM and has a rising tendency and reached 7.97% at 2 PM, and then it has a

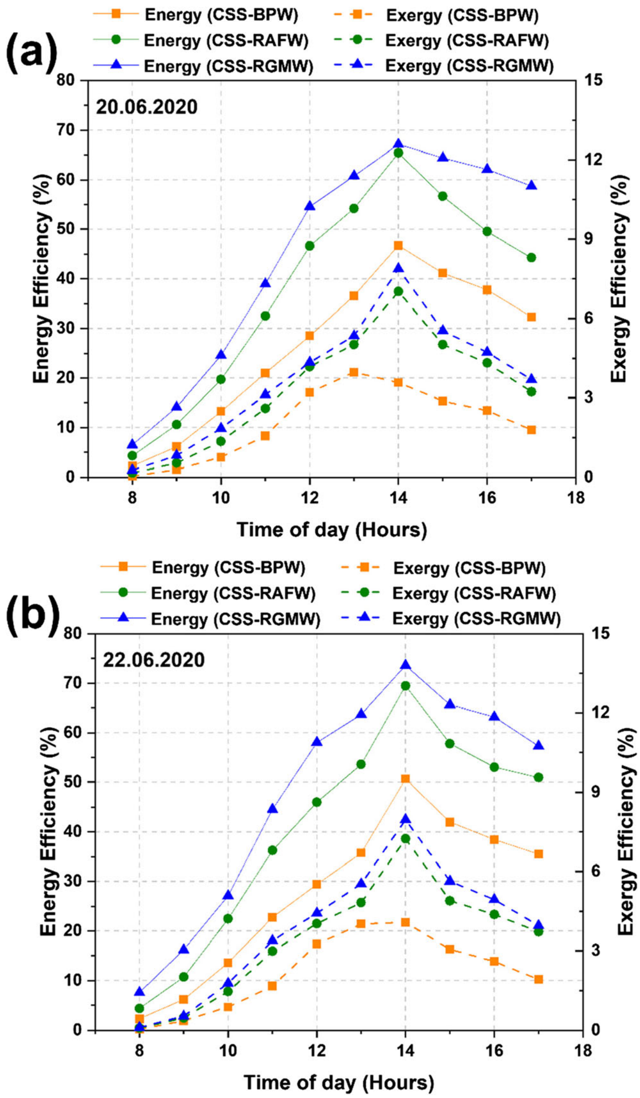

Fig. 5 Hour-wise changes of energy and exergy efficiency of the CSS-BPW, CSS-RAFW and CSS-RGMW (a) on 20-6-2020 and (b) on 22-6-2020

decreasing tendency up to 5 PM (3.96%). Each day exergy efficiencies of the CSS-BPW, CSS-RAFW and CSS-RGMW are 2.19, 3.41 and 3.82%, respectively, on 22-6-2020. The exergy efficiency of the CSS-RGMW is 74.73 and 12.16% higher than that of the CSS-BPW and CSS-RAFW, respectively, on 22-6-2020. The maximum and daily average exergy efficiencies of the stills are maximum in the cases of CSS-RGMW and CSS-RAFW since exergy efficiency is directly related to water yield production and solar intensity available. During the sunset moment, the difference between $T_{s.w}$ and $T_{c.c}$ is maximum, so the exergy efficiency of the stills during the evening is higher as compared to that during the morning. Also, it is found that reflecting the solar intensity on the saline water surface has produced better performance than the CSS-BPW.

Comparison of the present study with published similar works

The comparison of present results with published similar works has been provided in Table 1. Through the results, it has been noted that the cumulative yield of a solar still containing reflective glass mirrors increases the productivity by 68.57% compared to the CSS-BPW, and cumulative yield increases by 48.57% when using reflective aluminium foil sheet. Thus, the reflective glass mirrors greatly enhance the productivity of solar distillation. Table 1 shows that the productivity improvement of 'V' type solar still with mirror has a minimum value of 11.92% (Kumar et al. 2008). However, the double solar still with finned corrugated basin, black granite, wick and reflector has the maximum value of 171.43% (Omara et al. 2016). The present study produced maximum daily productivity of 5.54 and 5.1 kg/m^2 using reflective glass mirrors and reflective aluminium foil sheet, respectively.

Conclusions

This experimental work highlights the impact of reflective glass mirrors and reflective aluminium foil sheet on the yield produced from conventional solar distillers. This simple technique involves placing a mirror and reflective aluminium foil sheet on the inner walls of the solar distillate. This technique is simple, inexpensive and effective. Moreover, it has no negative impact on the environment. This newly proposed solution provides significant productivity improvement rates as compared to other researches. The obtained conclusions can be written as follows:

- The glass mirrors with 99% of reflectivity and the aluminium foil sheet with 88% of reflectivity enhance the yield and efficiency of the solar stills. The glass mirror material is much better than using aluminium foil sheet.
- The daily distilled water production from the CSS-BPW is equal to 3.41 kg/m^2. However, it is equal to 5.54 kg/m^{2}for the CSS-RGMW and 5.1 kg/m^2 for the CSS-RAFW.
- Compared to the CSS-BPW, the daily accumulation was improved by 68.57 and 48.57% by using the reflective glass mirrors and the reflective aluminium foil sheet, respectively.
- The energy efficiency of the CSS-RGMW is higher than those of the CSS-RAFW and CSS-BPW. The highest energy efficiencies of the CSS-BPW, CSS-RAFW and CSS-RGMW were noted as 50.7, 69.46 and 73.61%, respectively.
- The highest exergy efficiencies of the CSS-BPW, CSS-RAFW and CSS-RGMW were noted as 4.08, 7.25 and 7.97%, respectively.

Table 1 Comparison between the productivity

S.N°	Author name	Type of solar still	Enhancement techniques	Improvement in productivity
1	Tanaka and Nakatake (2005)	Vertical multiple-effect diffusion-type solar still	Flat-plate mirror	50%
2	Kumar et al. (2008)	'V' type solar still	Mirror	11.92%
			Mirror and charcoal	14.11%
3	Gnanaraj and Velmurugan (2019)	Double slope solar still	Reflector	93.39%
			Finned corrugated basin, black granite, wick and reflector	171.43%
4	Omara et al. (2013)	Stepped solar still	Internal reflectors	75%
5	Abdullah et al. (2020)	Trays solar still	Internal reflectors	58%
			External reflectors	75%
6	Parsa et al. (2020c)	Double-slope condenser	Nanofluid and condenser	100.5%
			Condenser	50.8%
7	Our results	Single slope solar still	Reflective glass mirrors	68.57%
			Reflective aluminium foil sheet	48.57%

- The amount invested is recovered in the distiller as a conventional solar still with black painted walls in 38 days. However, this period is equal to 23 days for the CSS-RGMW and 26 days for the CSS-RAFW.
- The productivity of the distillate with the mirrors is much better than that of the distillate with an aluminium foil sheet. From the economic study, it has been noted that the cost recovery period is very close in both cases. This fact is due to the price of the glass mirrors being about 40 times more than the price of the aluminium foil sheet.

Appendix 1. Error analysis

The variable parameters are measured using thermocouples, pyranometer and graduated beaker. All the errors are recorded in Table 2.

Appendix 2

1. The EHTC from $T_{s.w}$ to $T_{c.c}$ (Manokar et al. 2018b):

$$h_{e,w-g} = 16.273 \times 10^{-3} x h_{c,w-g} \left[\frac{P_w - P_{cc}}{\mathrm{Tb.w} - \mathrm{T_{c.c}}} \right]$$

Table 2 Standard uncertainties

Instrument	Accuracy	Range	Standard uncertainty
Solar power metre	±10 W/m^2	0–1999 W/m^2	5.72 W/m^2
Thermocouple	±0.1°C	−100–500°C	0.07°C
Graduated cylinder	±1 ml	0–550 ml	0.6 ml

2. Convective heat transfer coefficient from $T_{s.w}$ to $T_{c.c}$ (Manokar et al. 2018b):

$$h_{c,w-g} = 0.884 \left[\left(T_w - T_g \right) + \frac{(T_w + 273.15)\left(p_w - p_g \right)}{(268900 - p_w)} \right]^{1/3}$$

3. Partial vapour pressure at the $T_{s.w}$ (Manokar et al. 2018b):

$$P_w = exp\left(25.317 - \left(\frac{5144}{273 + \mathrm{Tb.w}} \right) \right)$$

4. Partial vapour pressure at the $T_{c.c}$ (Manokar et al. 2018b):

$$P_{gi} = exp\left(25.317 - \left(\frac{5144}{273 + \mathrm{T_{c.c}}} \right) \right)$$

5. The energy efficiency of the CSS-BPW, CSS-RAFW and CSS-RGMW (Manokar et al. 2018b):

$$\frac{\eta_{passive} = \sum \dot{m}_{ew} L}{\sum I(t) A_s \times 3600 \times 100}$$

6. The exergy efficiency of the CSS-BPW, CSS-RAFW and CSS-RGMW (Manokar et al. 2018b):

$$\eta_{overall,exe} = \frac{\sum Ex_{\mathrm{output}}}{\sum Ex_{\mathrm{input}}}$$

7. The hourly exergy output of the CSS-BPW, CSS-RAFW and CSS-RGMW (Manokar et al. 2018b):

$$Ex_{\text{output}} = \frac{m_{ew}L_{fg}}{3600} \times \left[1 - \frac{T_a}{T_w}\right]$$

8. The hourly exergy input of the CSS-BPW, CSS-RAFW and CSS-RGMW (Manokar et al. 2018b):

$$Ex_{\text{input}} = A_w I^{'}(t) \times \left[1 - \frac{4}{3}\left(\frac{T_a}{T_s}\right) + \frac{1}{3}\left(\frac{T_a}{T_s}\right)^4\right]$$

Nomenclature CrSS, corrugated solar still; CSS-BPW, conventional solar still with black painted walls; CSS-RAFW, conventional solar still with reflective aluminium foil sheet walls; CSS-RGMW, conventional solar still with reflective glass mirror walls; EHTC, evaporative heat transfer coefficient; [I(t)], solar intensity; T_a, ambience temperature; $T_{s.w}$, saline water temperature; $T_{c.c}$, collector cover temperature

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Declarations

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