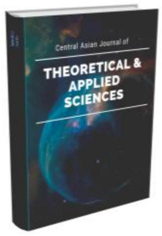

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Article

A New Solar Water Heater Design That Receives Radiation From Multiple Facets and Features a Wavy Absorption Surface, and its Performance Efficiency Has Been Tested

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Abstract: Our current work aims to improve the performance of solar water heaters through a new design that maximizes solar energy utilization by using multiple surfaces to receive and absorb radiation during daylight hours. This is achieved by comparing the old design, which has only one surface facing the sun, with the new design, in which the collector's glass panel is pentagonal, allowing it to receive solar radiation from several sides and mimicking the sun's horizontal movement. Additionally, the absorber surface is wavy To make solar radiation absorbed to the greatest extent possible.

Keywords: Solar water heater; Solar energy utilization; Pentagonal collector design; Wavy absorber surface; Thermal performance enhancement.

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Introduction

One of the important practical applications of solar energy investment is solar water heaters. It consists of two main parts: a solar collector and a tank for collecting the hot water. In our current research, we fabricated a flat-plate collector due to its ease of manufacturing, the availability of all its components, and its low cost. A conventional solar collector consists of several basic components housed within a box covered by a transparent plastic or glass lid. These include a heat absorber plate made of copper, aluminum, or an alloy of these, due to their high thermal conductivity and efficiency. Copper is also corrosion-resistant. The heat absorber plate is usually coated with a matte black paint to maximize solar energy absorption. Instead of using matte black paint, some flat-plate collectors use a selective surface coating, such as black chrome, on the heat absorber plate. Thermal insulation standards have been observed to prevent heat loss, and the water tank in this model is separate from the collector. This is the first model used in this study. The second model, designed with the same components, features a modified, pentagonal glass front panel, its sides facing the sun's rays, thus mimicking its horizontal movement. Solar collectors of all types are typically oriented perpendicular to the sun, both horizontally and vertically, to concentrate sunlight on the collector and solar water heater, thereby increasing absorption and storage and ultimately boosting their efficiency. However, studies and research projects have shown that the perpendicularity to the sun differs between summer and winter. Therefore, finding suitable solutions to achieve this alignment is necessary. One such solution is manually adjusting the collector's orientation, which requires effort and continuous monitoring throughout the system's operation. Another option is installing a motor that works with a solar sensor to rotate or change the solar system's orientation to be perpendicular to the sun, although this method is relatively expensive. Therefore, in this study, our engineering design aims to eliminate the need for direct sun alignment. This model also includes an internal tank for storing hot water, creating a solar system that utilizes natural recycling. This study compared the performance of both models under different climatic conditions in the city of Shatra, southern Iraq.

Theory:

One of the fundamental principles underlying the operation of a solar water heater is the law of conservation of energy states that the total energy of an isolated system remains constant; that is, it is conserved over time in a closed system. The total energy within the system changes only through energy entering or leaving the system. Energy cannot be created or destroyed, but it can be transformed or transferred from one form to another.

This means that a system always retains the same amount of energy unless external energy is added. This becomes confusing in the case of non-conservative forces, where energy is converted from mechanical to thermal energy, but the total energy remains constant. The only way to use energy is to convert it from one form to another. In this study, solar radiation energy is converted into thermal energy. To allow the solar radiation transmitted through the glass to diffuse onto the absorber plate, the plate must absorb an optimal amount of solar radiation while minimizing re-radiation. Prolonged exposure to radiation results in the acquisition of more thermal energy. The law of conservation of energy, or the thermal diffusion equation, applies in this process:-

$$mcpu\frac{\mathrm{d}T}{dx} = Vk\frac{d2T}{dx2} + Qout$$

$$\rho C\frac{\partial T}{\partial t} = \frac{\partial}{\partial r}\left(K\frac{\partial T}{\partial r}\right) + S$$

The theoretical analysis of the system includes calculating the amount of energy absorbed and stored within the solar collector, as well as calculating the efficiency. The amount of energy absorbed by the solar collector for each heater is calculated using the following equation:

$$Q_{abs} = I_b.A_p\,F_t.(t_{\,g}a_{\,p})\ .$$

The quantity ($\tau g\alpha p$), which represents the product of the absorbance of the absorbing plate and the transmittance of the glass cover, changes with the optical properties of the glass cover and depends on the angle of incidence and reflection of the incident solar radiation during daylight hours.

The work

Two water heater models were manufactured, as shown in the figure. The first model (hN1) consists of two separate main parts: the first part is a flat plate collector, and the second part is a hot water tank.

To improve the efficiency of the heater, since thermal efficiency is a crucial factor in determining the collector's performance and depends on the incident solar radiation, the collector's area, and the amount of heat stored, a new model was designed. This model aims to increase radiation absorption by making the absorber surface corrugated, thus increasing the amount of incident radiation. This second model is called the second heater (hN2).

It is a new design consisting of a single integrated unit, incorporating the collector and the hot water tank within the same greenhouse. The glass cover is polygonal, specifically a quadrilateral shape, giving the enclosure a curved appearance from the front. The hot water tank is placed inside this enclosure behind the corrugated absorber surface, and then the metal pipes are installed. All these components (the tank, the absorber surface, and the metal pipes) are located within the glass enclosure. The absorber surface is also designed with a corrugated pattern to increase the surface area exposed to radiation.

The two heaters were mounted on a steel base at a specific angle, and their performance was tested under the varying climatic conditions of Al-Shatra city.

Fig (1) :-Heater hN1

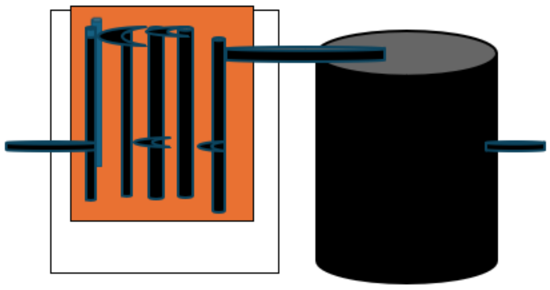

Fig (2) :-Heater hN2

Results and Discussion

The tests were conducted on different days during January and February 2026. The two heaters, or prototypes, were installed in an elevated location, side by side, in Al-Shatra, southern Iraq (31°24'35"N - 46°10'18"E), under identical conditions (same orientation and tilt angle, 45°). Each heater was placed on a steel base. Hourly readings were recorded for all measured variables for both prototypes (temperature of the stored chilled water, ambient temperature, and the temperature of the water entering and exiting the heater).

The practical steps were divided into two parts. The first part involved testing the performance of the heaters without a load (i.e., without water being drawn in).

The second part involved comparing the performance of the two water heaters under load (i.e., with water drawn) and with equal quantities of water in each model's tank, as evidenced by the data obtained. Before taking readings, the tanks of both heaters were filled with fresh water, and the glass covers were cleaned each time before measurements were taken.

The temperature was then represented as a function of daylight hours under different weather conditions, from 8:30 AM to 2:30 PM, as shown in Figures (3) and (4) over two days, one day was sunny with clear skies, and the other day was partly cloudy, as shown in the figure, where the green line represented hN2 and the red line represented hN1 the blue line represented the cold-water temperature. The second heater hN2 clearly performed slightly better because the ripple we created on the absorption surface increased the absorption area, even though the total area it occupied was the same.

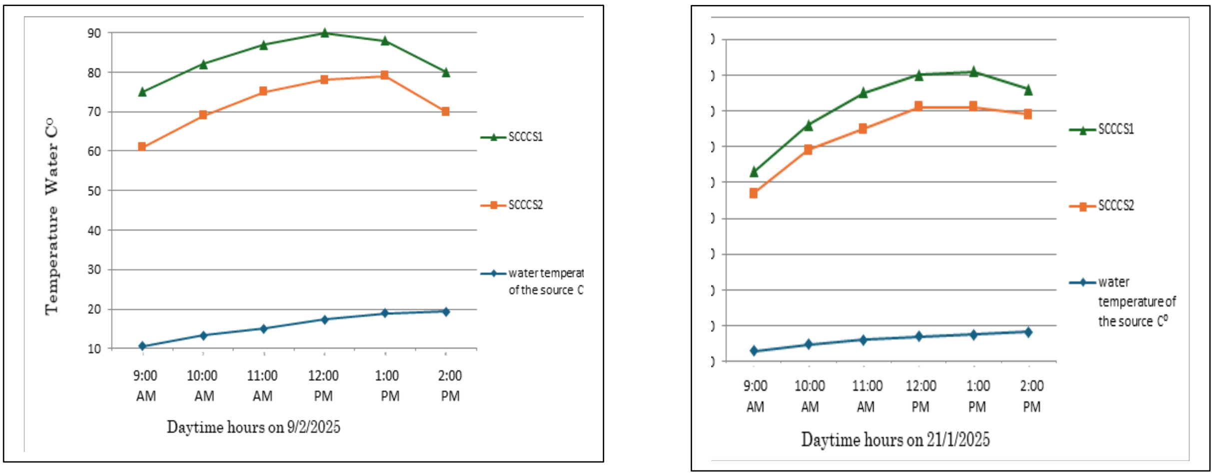

Figure 2. Variation of water temperature with daytime hours for the two solar water heater models (SCCS1 and SCCS2) compared with the source water temperature under clear-sky conditions.

Table 2. Illustrative comparison of thermal behavior between the conventional heater (hN1) and the proposed heater (hN2).

Time	H N1	H N2
08:30	20	20
09:30	25	27
10:30	31	34
11:30	37	41
12:30	43	48
13:30	47	53
14:30	50	57

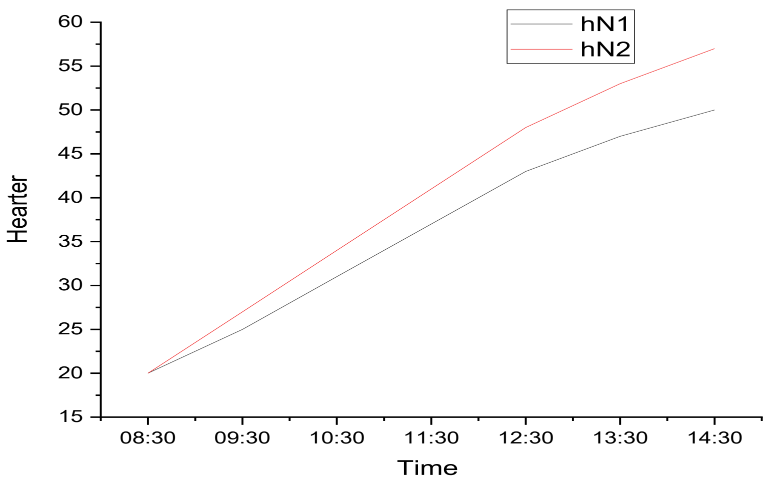

Figure 3. Variation of stored water temperature with daylight hours for the conventional heater (hN1) and the proposed heater (hN2).

Table 1. Illustrative comparison of the mechanisms contributing to enhanced thermal performance.

Factor	Impact
Multi-faceted glass	35
Corrugated absorber	40
Better tube exposure	15
Reduced thermal losses	10

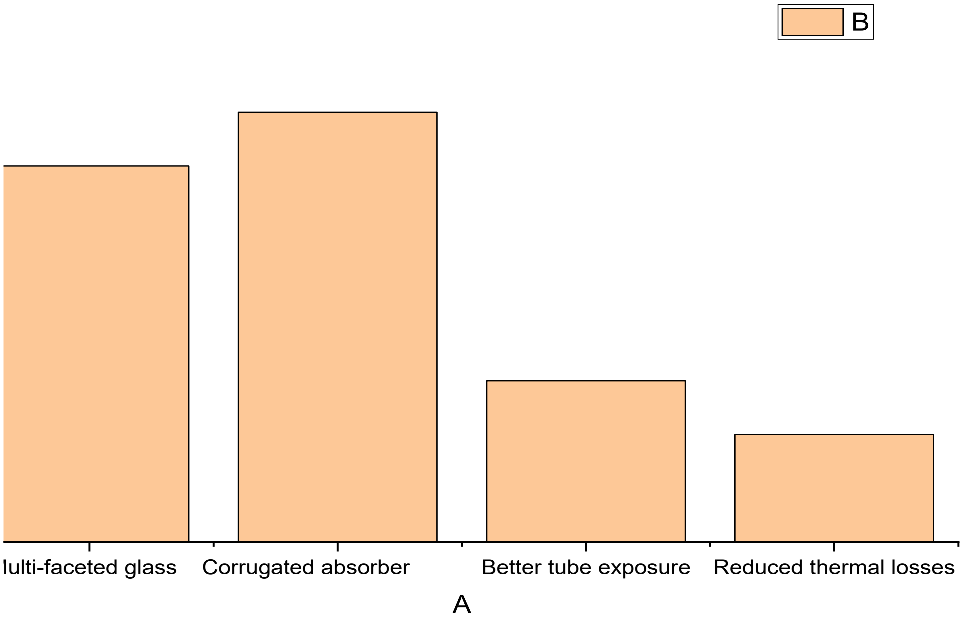

Figure 4. Qualitative representation of the main factors contributing to the improved thermal performance of the proposed solar water heater.

The ripple allows more solar radiation to reach almost all sides of the tube, meaning the copper tubes concentrate solar radiation across most of their circumference, resulting in a greater amount of heat energy being transferred to the hot water. The ripple also helps capture more solar radiation in the same time period because it captures radiation from multiple directions simultaneously. For these reasons, this solar heater model performed better than the first.

Conclusion

In this study, two solar water heater designs were fabricated and experimentally evaluated under the climatic conditions of Al-Shatra, southern Iraq. The first model (hN1) represented a conventional flat-plate solar water heater, while the second model (hN2) incorporated a novel design consisting of a multi-faceted glass enclosure and a corrugated absorber surface.The experimental results demonstrated that the proposed heater (hN2) achieved superior thermal performance compared with the conventional heater (hN1) under both clear and partially cloudy weather conditions. The enhanced performance can be attributed to two key design modifications. First, the polygonal glass structure enabled solar radiation to be received from multiple directions throughout the day, reducing the dependence on continuous solar tracking. Second, the corrugated absorber surface increased the effective absorption area and improved the exposure of the copper tubes to incident solar radiation. The combined effect of these modifications increased the amount of absorbed solar energy and enhanced heat transfer to the stored water. Furthermore, integrating the storage tank within the collector enclosure reduced thermal losses and simplified the overall system configuration. The findings confirm that the proposed multi-faceted solar water heater is a practical and low-cost solution for improving solar thermal energy utilization in regions with high solar irradiance. Future work should include long-term seasonal testing, detailed efficiency calculations, and optimization of the absorber geometry and enclosure angles to further improve thermal performance.

REFERENCES

[1] REN21, Renewables 2011: Global Status Report. Paris, France: REN21 Secretariat, 2011, pp. 17–18.

[2] International Energy Agency (IEA), Energy Technology Perspectives 2012. Paris, France: OECD/IEA, 2012.

[3] J. Fan, L. Shah, and S. Furbo, "Flow distribution in a solar collector panel with horizontally inclined absorber strips," Solar Energy, vol. 81, no. 12, pp. 1501–1511, 2007.

[4] M. Yoseph, "Numerical and experimental investigation of new design at primate solar collector."

[5] C. Marken, "Solar collectors – behind the glass," Home Power Magazine, no. 133, pp. 70–76, 2009.

[6] J. Gulland, "Heating water with a wood stove," Wood Heat Organization Inc. [Online]. Available: https://www.woodheat.org. Accessed: Mar. 29, 2012.

[7] C. Ho and T. Chen, "Collector efficiency improvement of recycle double-pass sheet-and-tube solar water heaters with internal fins attached," Renewable Energy, vol. 33, no. 4, pp. 655–664, 2008.

[8] T. Anderson, M. Duke, and J. Carson, "The effect of color on the thermal performance of building integrated solar collectors," Solar Energy Materials and Solar Cells, vol. 94, no. 2, pp. 350–354, 2010.

[9] P. Singh, R. Sarviya, and J. Bhagoria, "Heat loss study of trapezoidal cavity absorbers for linear solar concentrating collector," Energy Conversion and Management, vol. 51, no. 2, pp. 329–337, 2010.

[10] K. Mankhi, N. H. N. Al-Hashimi, and J. M. Al-Asadi, "New laboratories design of solar collectors suitable for Basrah City 30.50°N," IOSR Journal of Engineering (IOSRJEN), vol. 4, no. 12, pp. 15–19, 2014.

[11] J. Cadafalch, "A detailed numerical model for flat-plate solar thermal devices," Solar Energy, vol. 83, no. 12, pp. 2157–2164, 2009.

[12] G. Martinopoulos, "CFD modeling of a polymer solar collector," Renewable Energy, vol. 35, no. 7, pp. 1499–1508, 2010.

[13] I. Michaelides, P. Efthimiou, G. A. Florides, G. Roditis, and P. Christodoulides, "Experimental investigation of the night heat losses of hot water storage tanks in thermosyphon solar water heaters," Journal of Renewable and Sustainable Energy, vol. 3, no. 3, Art. no. 033103, 2011, doi: 10.1063/1.3595742.

[14] J. Cadafalch, "A detailed numerical model for flat-plate solar thermal devices," Solar Energy, vol. 83, no. 12, pp. 2157–2164, 2009.

[15] G. Martinopoulos, "CFD modeling of a polymer solar collector," Renewable Energy, vol. 35, no. 7, pp. 1499–1508, 2010.

[16] I. Michaelides, P. Efthimiou, G. A. Florides, G. Roditis, and P. Christodoulides, "Experimental investigation of the night heat losses of hot water storage tanks in thermosyphon solar water heaters," Journal of Renewable and Sustainable Energy, vol. 3, no. 3, Art. no. 033103, 2011, doi: 10.1063/1.3595742.