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Numerical and Experimental Investigation of the Thermal Performance of a Solar Absorber and Nocturnal Radiator (SAANR) Hybrid Panel for Climatic Conditions of Gaborone, Botswana.

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ABSTRACT

Transient analysis, performance prediction and experimental investigation of a solar absorber and nocturnal radiator (SAANR) hybrid panel for water heating and cooling in summer and winter seasons of Gaborone, Botswana is presented. A transient heat transfer model was developed for the panel using heat transfer and thermodynamics principles. The mathematical model equations were then transformed into explicit finite difference forms for easy numerical analysis using MATLAB programming language. The numeric model was programmed in MATLAB software taking into consideration local climatic conditions, and then simulated to yield predicted results of panel outlet water temperature. The SAANR panel simulations raised water temperature by 19.4℃ by solar absorption and through radiation cooling decreased the water temperature by 1.2℃. The experiments showed slightly better performance for both heating and cooling than the simulation model, producing hot water over 60℃ and cold water up to 23℃. Experimental results were used to validate the simulation results to ensure that both the mathematical model and the experimental test rig can produce reliable results. From the results, it is concluded that the hybrid panel is robust enough to perform in both summer and winter seasons of Gaborone, which subsequently means it can be used simultaneously for space cooling and domestic water heating in both summer and winter. This hybrid system technology can therefore be used instead of electric water heaters and air-conditioners and thus save energy. The numerical and experimental models developed in this study should influence stakeholders in hot and dry climates to invest towards passive cooling and heating technologies which do not require expensive external electricity supply.

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