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Outdoor Performance of a Thermoelectric Heat-Pumpng Solar Air Heater

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INTRODUCTION & AIM

- Solar Air Heaters (SAHs) are thermal devices which use solar radiation to heat air. Its application can be found in many processes like space heating, crop drying and dehumidification.
- The main challenge faced by traditional SAHs is poor system efficiency due to low heat transfer from the absorber plate to the air.
- The aim of this paper is to develop and present an innovative means of improving SAH efficiency using Thermoelectric Coolers (TECs).

METHOD

SYSTEM DESIGN AND SPECIFICATION

Two prototypes of SAHs were constructed: a traditional solar air heater and a thermoelectric-enhanced solar air heater (TE-SAH). The absorber plate of the TE-SAH has 11 TECs and heat sinks attached to the underside to optimize heat transfer to the air flowing under it while that of the traditional SAH has no TECs or heat sinks attached to it.

COMPONENTS OF THE SYSTEM

1. Casing 2. Glass cover 3. Absorber plate 4. Insulation 5. TEC 6. Heat sink 7. Fan

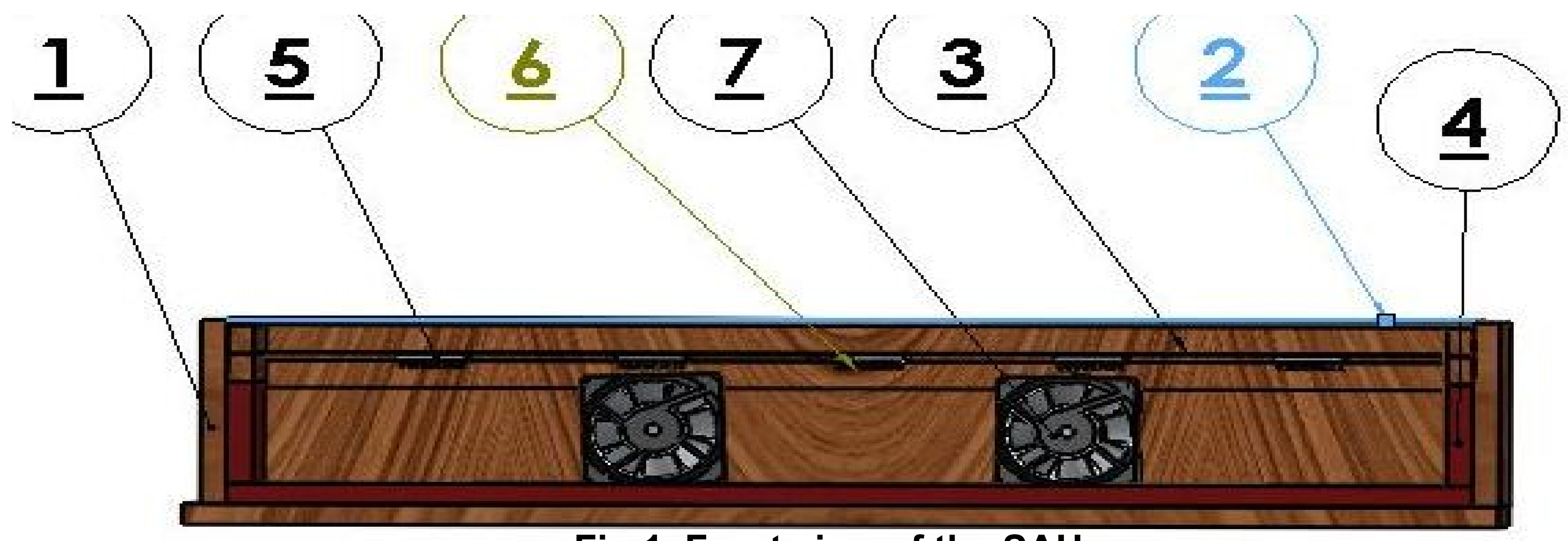

Fig 1. Front view of the SAH

Fig 2. Pictorial view of the two prototype SAHs during testing

RESULTS & DISCUSSION

- Location of testing: University of Nigeria Nsukka (6.8666°N, 7.4115°E) outdoor with exposure to natural sunlight at angle of 14° due north.
- Duration of testing: 3 days from 10:30 AM to 3:30 PM each day.
- Measurement equipment: Thermocouple, anemometer, multimeter.
- Parameters measured: Solar insolation, air flow speed, inlet and outlet air temperatures, current, & voltage across DC components.

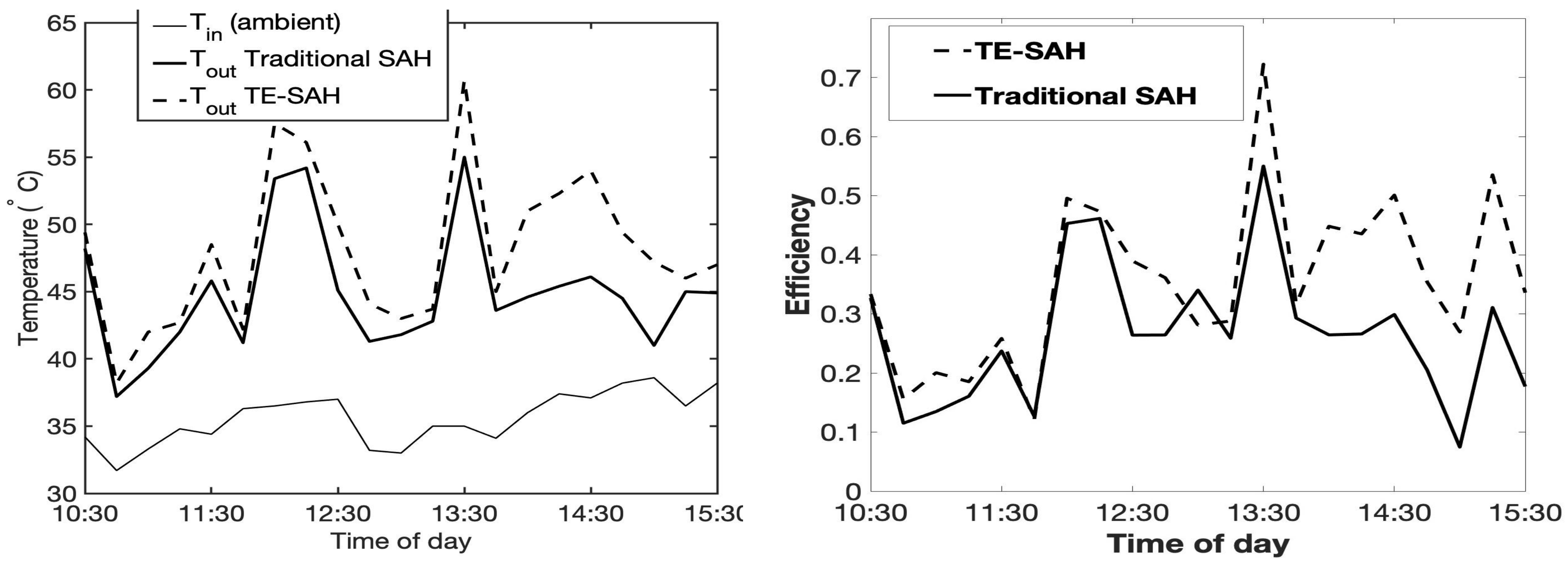

Fig 3. Temperature and efficiency graphs for day 2

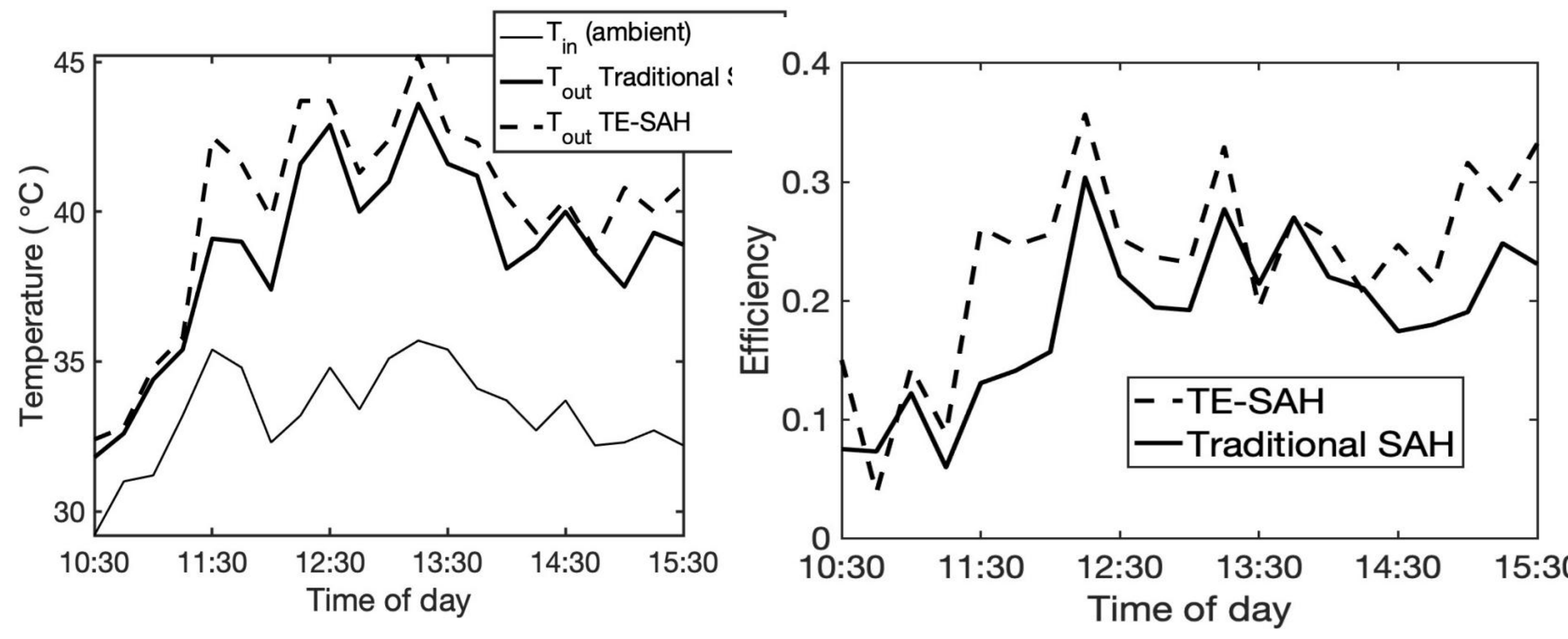

Fig 4. Temperature and efficiency graphs for day 3

- Efficiency gain: The TE-SAH offers improved efficiency and heat gain compared to traditional SAH.
- Air heating capacity: The TE-SAH provides higher air temperatures.

CONCLUSION

Integrating TECs into a SAH improved its thermal efficiency by 31.5%, achieving an average of 23% compared to 18% for the traditional SAH. The TE-SAH reached a maximum efficiency of 74% at a 0.013 kg/s mass flow rate, outperforming the traditional SAH's 57%. This highlights the potential of TEC technology in enhancing solar thermal systems for efficient heat transfer applications.

FUTURE WORK

- Long-term testing: Further testing across seasons and climates.
- Integration with storage systems: Exploring combined thermal or electrical storage.