International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 12 | Dec - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Performance Analysis of Solar Dome

Mateen Ahmed Kambar[1], *Department of Mechanical engineering, KLS VDIT Haliyal*
Nihal A Talawai[2], *Department of Mechanical engineering, KLS VDIT*
Haliyal Sammed R Munavalli[3], *Department of Mechanical engineering, KLS VDIT Haliyal*

---***---
-

Abstract - This project presents the design, fabrication, and comprehensive performance analysis of a Solar Dome Model intended for sustainable water heating applications. Utilizing the greenhouse effect within a semi-spherical glass enclosure, the system aims to maximize solar radiation absorption while minimizing convective and radiative heat losses to the environment. The experimental prototype features high-conductivity copper absorber tubes arranged in a serpentine coil on a well-insulated plywood base to facilitate efficient heat transfer to the water batch. Performance was evaluated through rigorous outdoor testing conducted over a four-day period, involving systematic hourly data acquisition of water temperatures. The results demonstrate significant thermal gain, with water temperatures rising from an initial 25 C to a peak of 52 C. A maximum hourly temperature difference 20^C was consistently observed during peak solar hours, yielding an estimated useful energy gain of approximately 837.2 kJ per peak hour for a 10 L batch. These outcomes validate the effectiveness of the solar dome geometry in heat trapping and confirm its viability as a robust, passive, and cost-effective solution for meeting domestic hot water requirements using renewable energy.

1. INTRODUCTION

The Introduction of this project establishes the critical role of solar thermal technology in addressing the global demand for sustainable and carbon-neutral energy solutions. Specifically, this study focuses on the development and evaluation of a Solar Dome Model, an innovative collector design that utilizes a transparent, semi-spherical glass enclosure to create a controlled Greenhouse Effect. Unlike conventional flat-plate collectors that often suffer from high convective heat losses, the dome geometry serves as a high-performance heat trap, capturing shortwave solar radiation and effectively insulating the internal copper absorber tubes from the ambient environment. The primary motivation behind this work is to provide an efficient, passive method for heating water—one of the most energy-intensive requirements in domestic and small-scale industrial sectors. By integrating high-conductivity copper tubing with a specialized matte black surface treatment and a thermally insulated plywood base, the model is engineered to maximize energy absorption and storage. This research contributes to the field of renewable engineering by providing a detailed performance analysis based on multi-day field testing, aiming to prove that simple, passive geometric modifications can significantly enhance the efficiency of solar-to-thermal energy conversion systems.

2. OBJECTIVES OF THE PRESENT WORK

The main objectives of the present work are:

- To design and fabricate a simple solar dome for water heating applications
- To study the working principle of the solar dome based on the greenhouse effect
- To experimentally analyze the temperature variation of water inside the solar dome
- To evaluate the temperature difference achieved during peak solar hours
- To assess the feasibility of the solar dome as a low-cost and eco-friendly thermal system

3. LITERATURE REVIEW

Numerous studies have been conducted on solar thermal collectors and greenhouse-based heating systems. Researchers have reported that transparent enclosures significantly reduce heat losses by restricting convection and radiation. Kalogirou (2020) discussed various solar thermal collector designs and highlighted the effectiveness of greenhouse-based systems for low-temperature applications.

Several authors have studied the use of copper tubes in solar collectors due to their high thermal conductivity and durability. Sharma et al. (2021) analyzed the performance of solar water heating systems and concluded that proper absorber material selection plays a crucial role in enhancing system efficiency. Recent studies by Kumar et al. (2023) emphasized advancements in passive solar technologies and their application in sustainable energy systems.Although many studies exist on flat-plate and evacuated tube collectors, limited experimental work has been

3. EXPERIMENTAL SETUP

The experimental setup consists of a hemispherical transparent solar dome mounted on a rigid plywood base. The dome material allows maximum solar radiation to enter while minimizing heat loss to the surroundings. Copper tubes are arranged uniformly inside the dome to maximize the heat absorption area. Water flows through the copper tubes and absorbs the heat accumulated inside the dome. The entire setup was fabricated and assembled by the authors and placed in an open outdoor environment to ensure unobstructed exposure to sunlight. A digital thermometer was used to measure the inlet and outlet water temperatures.
Figure 1 shows photographs of the fabricated solar dome experimental setup and the internal copper tube arrangement used during the experimentation.

Fig 1
The copper tubes were painted matte black to enhance solar absorptivity.

5. WORKING PRINCIPLE

The working principle of the solar dome is based on the greenhouse effect. When solar radiation falls on the transparent dome surface, short-wave radiation passes through and enters the enclosure. This radiation As the temperature inside the dome increases, long-wave

reported on compact solar dome systems designed specifically for water heating. This research attempts to address this gap by developing and experimentally evaluating a simple solar dome configuration . This radiation is absorbed by the internal surfaces. As the temperature inside the dome increases.

Copper tubes, owing to their high thermal conductivity,efficiently transfer the absorbed heat to the water flowing through them. The dome geometry further reduces convective heat losses and maintains a relatively uniform temperature distribution. The combined effect of heat trapping and efficient conduction results in improved water heating performance.

4. METHODOLOGY

The experimental analysis was conducted under natural climatic conditions. The solar dome system was installed in an open area to ensure unobstructed exposure to sunlight. Initial water temperature was recorded before exposure to solar radiation.
Temperature readings were recorded at regular intervals between 9:00 AM and 4:00 PM using a digital thermometer. Experiments were repeated over multiple days to ensure repeatability and consistency of results. The temperature difference was calculated to evaluate the thermal performance of the solar dome.

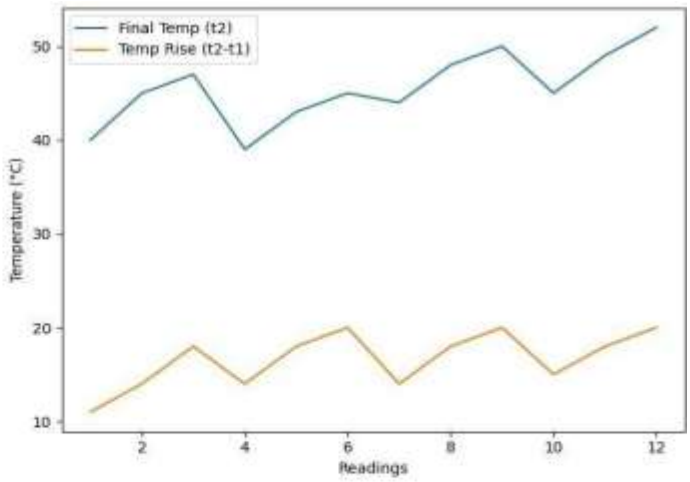
6. RESULTS AND DISCUSSION

The experimental results indicate a steady increase in water temperature during peak solar radiation hours. The maximum outlet water temperature recorded was 52°C, while the temperature difference ranged from 11°C to 20°C.
The temperature difference graph shows a gradual rise during morning hours, reaching a peak around noon, followed by a slight decline in the afternoon due to reduced solar intensity. Minor fluctuations are attributed to variations in ambient conditions.

Experimental Temperature Readings

S.No	Final Temp (°C)	Temp Rise (°C)
1	40	11
2	45	14
3	47	18
4	39	14
5	43	18
6	45	20
7	44	14
8	48	18
9	50	20
10	45	15
11	49	18
12	52	20

Temperature variation of final temperature and temperature rise



The results confirm effective heat trapping due to the greenhouse effect and enhanced heat transfer through copper tubes.

7. CONCLUSION

The experimental performance analysis of the solar dome confirms its effectiveness as a solar thermal water heating system. The dome structure successfully traps solar heat, while copper tubes enhance heat transfer efficiency. The system is simple in construction, cost-effective, and environmentally friendly, making it suitable for domestic and small-scale applications.

8. FUTURE SCOPE

The performance of the solar dome can be further improved by incorporating selective absorber coatings on copper tubes. Integration of thermal energy storage materials such as phase change materials can help retain heat during non-sunshine hours. The solar dome concept can also be extended to applications such as solar drying and space heating.

ACKNOWLEDGEMENT

The satisfaction and euphoria accompanying the successful completion of the task would be incomplete without mentioning the people responsible for the project's completion. We wish to express our gratitude to those whose guidance has enabled us to accomplish this project. We feel fortunate to have worked with a wonderful group of people whose experience, timely help, and advice have been invaluable in the success of our work.

We would like to express our gratitude to ***Prof Gururaj H Joshi,*** *our project guide, Department of Mechanical Engineering for his guidance and wholehearted support and very valued constructive criticism that has driven to complete the project work successfully.*

We also thankfully acknowledge the help received from ***Dr Gururaj Hatti,*** *project work Coordinator, Department of Mechanical Engineering for guiding us in right way to complete the work according to the university requirements.*

We would like to thank ***Dr. K. S. Pujar,*** *our HOD Department of Mechanical Engineering, for his faith in us and needful support and encouragement throughout the course of our project work.*

It gives us pleasure to express our sincere gratitude to ***Dr. V A Kulkarni,*** *our beloved Principal KLS Vishwanathrao Deshpande Institute of Technology, Haliyal for his inspiring advice, motivation, constant support, guidance and help during our course of study and project work.*

We extend our heartfelt gratitude to all faculty members and supporting staff of Department of Mechanical Engineering at KLS VDIT Haliyal for their invaluable suggestions and unwavering support throughout this project. Words seem inadequate to convey our appreciation to our teachers, friends, and family members. Finally, we express our thanks to all those who, directly or indirectly, contributed to the successful completion of this project.

REFERENCE

- Saravanan, A., Sree, S. R., Reddy, M. S., *et al.*, "Thermal performance prediction of a V-trough solar water heater with a modified twisted tape using ANFIS, GLR, RT, and SVM models," *Scientific Reports*, vol. 14, p. 27206, 2024.
- Remlaoui, A., Nehari, D., Kada, B., *et al.*, "Numerical simulation of a forced circulation solar water heating system," *Scientific Reports*, vol. 14, p. 28999, 2024.
- Mehta, P., Patel, V., Kumar, S., *et al.*, "Performance assessment of thermal energy storage system for solar thermal applications," *Scientific Reports*, vol. 15, p. 13876, 2025.
- Zhang, Y. & Zhang, W., "Research and optimization of focused solar heating system with phase change thermal storage," *Frontiers in Energy Research*, vol. 12, 1279491, 2024.
- Fabian Eze, M., Egbo, M., Anuta, U. J., *et al.*, "A review on solar water heating technology: Impacts of parameters and techno-economic studies," *Bulletin of the National Research Centre*, vol. 48, article 29, 2024.
- Alkhafaji, M. A. F. & Koç, İ., "Improving thermal efficiency of photovoltaic thermal systems," *AURUM Journal of Engineering Systems and Architecture*, vol. 8, no. 1, 2024.
- "Analysis of the thermal performance of a novel dome-shaped solar collector," *Applied Thermal Engineering*, vol. 282, 128876, 2026.
- Kumar, A., et al., "Advancements in passive solar thermal technologies," *Energy Reports*, 2023.
- Sharma, A., et al., "Performance analysis of solar thermal water heating systems," *Renewable Energy*, 2021.
- Kalogirou, S. A., "Solar thermal collectors and applications," *Progress in Energy and Combustion Science*, 2020.
- Tiwari, G. N., *Solar Energy: Fundamentals, Design and Applications*, Narosa Publishing.