PERFORMANCE INVESTIGATION OF EVACUATED TUBE SOLAR COLLECTOR USING NANO FLUIDS FOR HEATING APPLICATIONS

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Solar Energy, Heat transfer oil and thermal efficiency

Introduction:

The global energy landscape is witnessing a significant shift towards renewable energy sources, spurred by the urgent need to address environmental concerns and to reduce dependence on fossil fuels. Solar energy, with its vast potential and sustainability, plays a pivotal role in this transition. Among the various technologies developed to harness solar power, evacuated tube solar collectors (ETSCs) have emerged as highly efficient systems for solar thermal applications. These systems are particularly effective due to their ability to minimize heat loss, thereby optimizing the heat collection even under less favorable environmental conditions. As the demand for more efficient renewable energy systems grows, the exploration of innovative methods to enhance the performance of ETSCs becomes increasingly crucial.Recent advancements in nanotechnology offer promising opportunities to improve the thermal performance of solar collectors. Nanofluids, which consist of a base fluid infused with nanoparticles, have shown potential in enhancing thermal conductivity and heat transfer properties. This enhancement can be attributed to the unique characteristics of nanoparticles, which when dispersed in a fluid, significantly increase its ability to conduct and store heat. This integration not only aims to elevate the heat transfer rates but also to maintain lower temperature gradients, thus potentially leading to higher operational efficiencies and effectiveness in energy conversion.

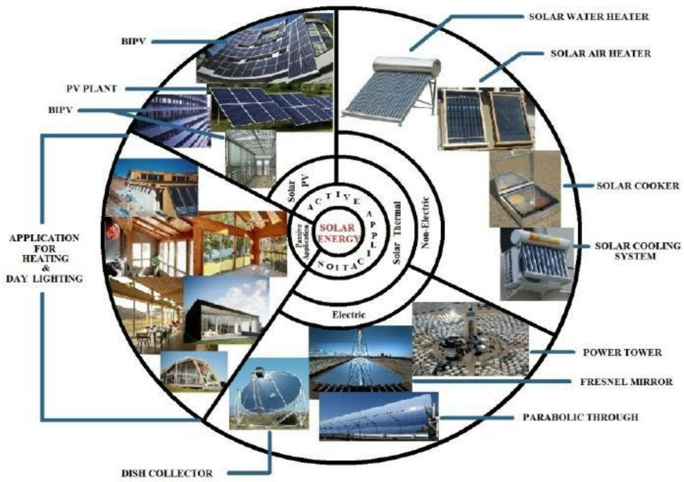


Fig 1 Represents applications of solar energy

This study focuses on the experimental investigation of the thermal performance of an ETSC when operated with water-based nanofluids containing copper oxide (Al_2O_3) nanoparticles. The research assesses the efficiency improvements brought about by varying concentrations of Al_2O_3 nanoparticles, under different operational conditions such as flow rates and solar irradiance levels. Through comprehensive energy and exergy analyses, the study seeks to provide a detailed understanding of how nanofluids could play a transformative role in enhancing the efficiency of solar thermal collectors, thereby contributing to the broader adoption of solar energy technologies in sustainable heating solutions.

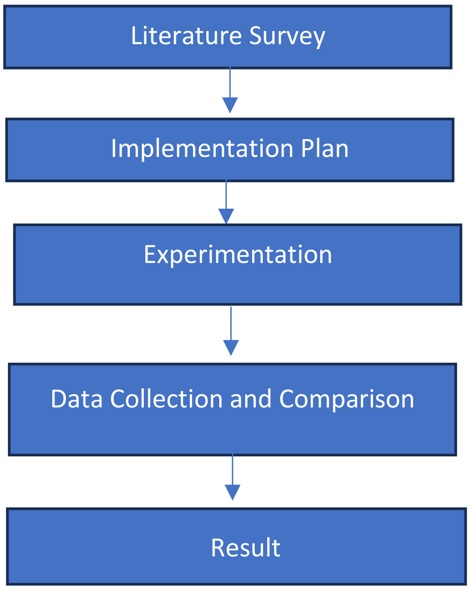
Objectives

The main objectives of the project include as following:

- **Assess Thermal Performance:** To evaluate the impact of using nanofluids on the thermal performance of evacuated tube solar collectors compared to traditional water-based systems.
- **Optimize Nanofluid Concentration:** To determine the optimal concentration of nanoparticles (such as copper oxide) that maximizes the heat transfer efficiency without compromising the fluid dynamics within the collector system.
- **Investigate Environmental and Economic Impact:** To examine the potential environmental benefits, such as reductions in CO_2 emissions due to increased efficiency, and to assess the economic implications of integrating nanofluids into existing solar collector systems.

- **Explore Practical Implementations:** To consider the practical aspects of deploying nanofluid-based ETSCs in real-world applications, including system stability, maintenance needs, and long-term operational considerations, thereby establishing guidelines for future implementations and scalability.

Methodology



shows the methodology of the project

The fig presented above illustrates the comprehensive methodology used for the project. It starts with an extensive literature survey followed by an implementation plan. This plan involves designing the experimental setup and selecting appropriate nanoparticles and oil for the experiments. The methodology ensures a structured approach to the project, facilitating systematic investigation and reliable results. This structured approach is essential for addressing the research questions effectively and achieving the project objectives.

Results And Conclusions

The following observations were made:

- As per the results obtained from the experiments from the Polyethylene Glycol with different combinations of Aluminum Oxide (Al_2O_3), the highest temperature noted for

0% of Al2O3 is 64 degree Celsius, the highest temperature noted for 2% of Al2O3 is 69 degree Celsius, the highest temperature noted for 4% of Al2O3 is 71 degree Celsius, the highest temperature noted for 4% of Al2O3 is 78 degree Celsius. The above readings were the outlet temperatures of the outlet of the setup during the peak hours during the day light.

- It was also found that the heat retention of the Polyethylene Glycol also played an important role in providing higher temperatures during off-peak time that was in the evening from 6pm to 8pm. The highest temperature that was obtained at 8pm was 42 degree Celsius for the combination of 4% of Al2O3 in Polyethylene Glycol.

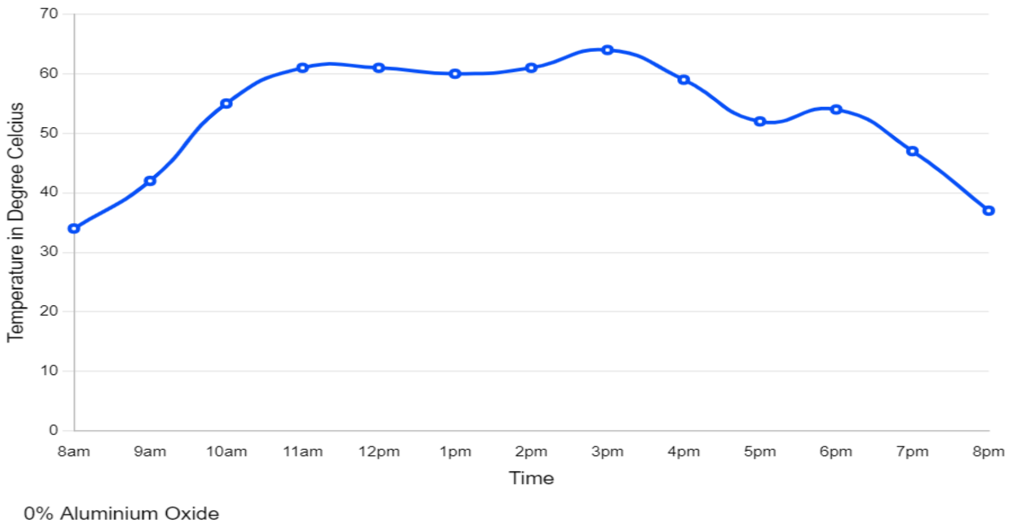


Fig 5.1 shows the highest temperature of 64 degree Celsius for the PEG with combination of 0% Al_2O_3

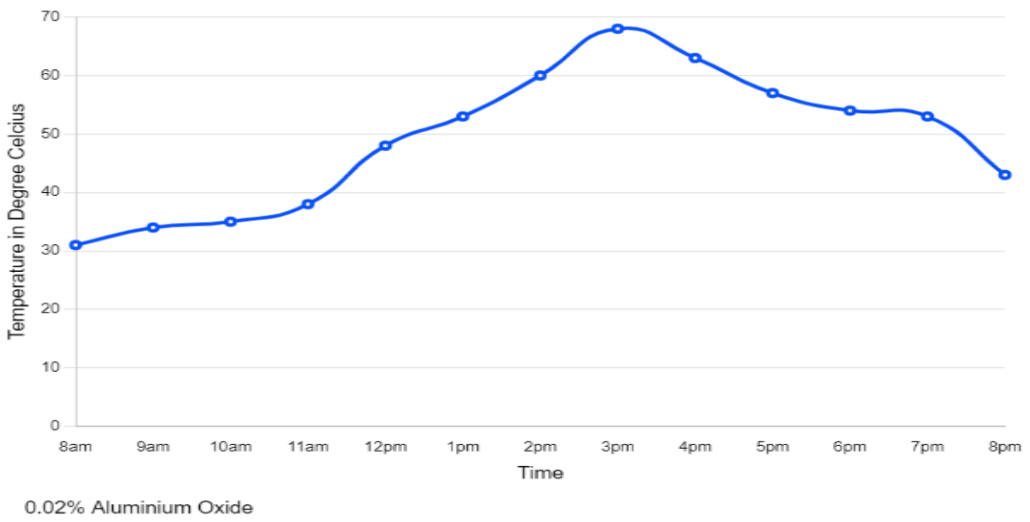


Fig 5.2 shows the highest temperature of 69 degree Celsius for the PEG with combination of 2% Al_2O_3

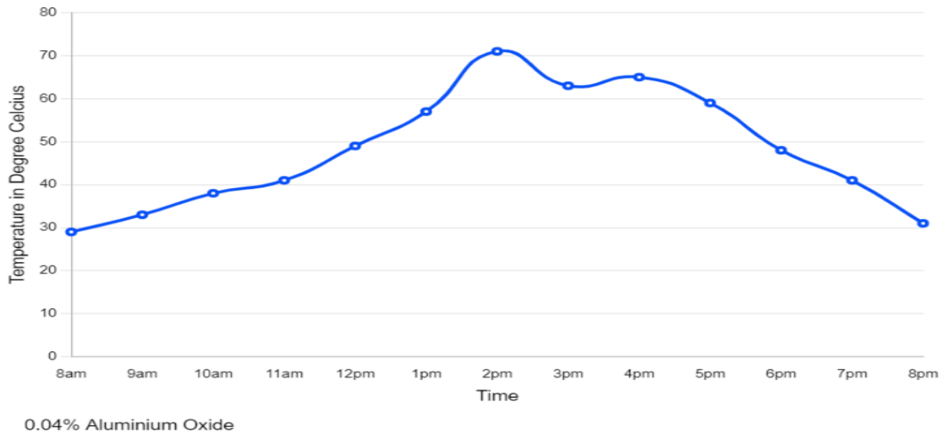


Fig 5.3 shows the highest temperature of 71 degree Celsius for the PEG with combination of 4% Al_2O

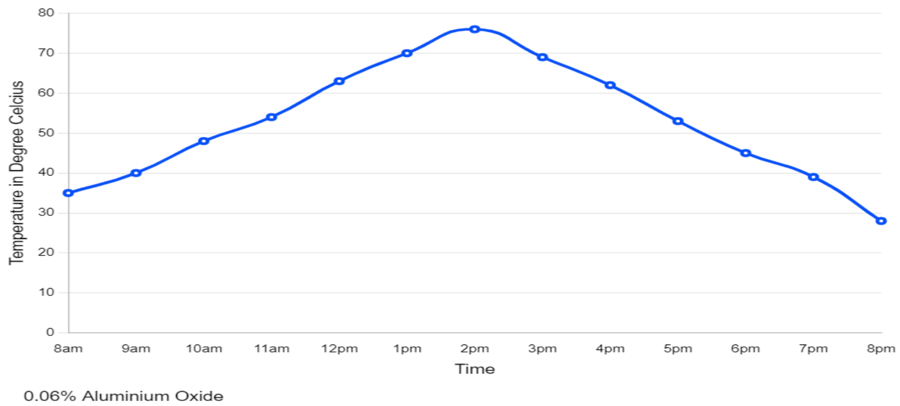


Fig 5.4 shows the highest temperature of 78 degree Celsius for the PEG with combination of 6% Al_2O_3

Conclusions

In summary, the exploration and analysis of the Evacuated Tube Collector utilizing Oils and Nanoparticles offer a promising pathway for the advancement of solar thermal technology. The favourable results observed in thermal efficiency, optimized heat transfer, versatile applications, economic feasibility, and environmental friendliness highlight the importance of this research. Looking ahead, further exploration and enhancement of this advanced collector have the capacity to transform solar energy utilization, fostering a more sustainable and effective energy environment.

- **Improved Thermal Efficiency:** By integrating specific nanoparticles and oils, significant enhancements in the thermal performance of the Evacuated Tube Collector have been achieved. This advancement is evident in superior heat absorption, conductivity, and overall operational efficiency compared to traditional collectors.
- **Enhanced Heat Transfer Mechanisms:** Through a meticulous formulation process, nanoparticles have been uniformly dispersed within the selected oils, ensuring consistency and stability. This optimization has positively impacted heat transfer processes, resulting in heightened energy absorption and utilization capabilities.
- **Financial Feasibility:** Although further economic evaluation is advised, initial findings suggest that the upgraded collector, despite incorporating advanced materials, demonstrates economic viability. The long-term advantages of increased efficiency and reduced dependence on conventional energy sources contribute to its potential economic attractiveness.
- **Future Research Directions:** The study emphasizes the necessity for ongoing research to refine nanoparticle-oil combinations, explore various collector configurations, and assess the scalability of the enhanced system. Additionally, future investigations should prioritize real-world applications and conduct comprehensive, long-term performance evaluations.

Novelty

The novelty of the project includes

- Conventional energy consumption will reduce for the various heating applications.
- It reduces the impact of Ozone and Global warming potential.
- The project will able to deliver a cost-effective heating system (Solar dryer) for particular applications.

Scope Of Future Work

The some of the future plans are listed below to utilize the heat transferred by Evacuated Tube Collector:

- Heat transfer by ETC can be drawn using air blower at the input.
- By constructing the drying unit at the output, the heat can be used for drying applications.
- The ETC can be adopted in Parabolic Trough Collector to improve the thermal performance of the working fluid.