Journal of Nuclear Energy Science & Power Generation Technology

Short Communication A SCITECHNOL JOURNAL

Novel Tube-In-Tube Integrated Solar Water Heater System Thermal Performance Analysis

Babu S[1*], Hariprakasham K[2], Subaasini M G[1] and Mathanbabu M[3]

[1]*Department of Mechanical Engineering, PSG College of Technology, Coimbatore, Tamil Nadu, India*

[2]*Department of Mechanical Engineering, Solver Minds Solutions and Technologies, Chennia, Tamil Nadu, India*

[3]*Department of Mechanical Engineering, Government College of Engineering, Bargur, Tamil Nadu, India*

***Corresponding author:** Babu S, Department of Mechanical Engineering, PSG College of Technology, Coimbatore, Tamil Nadu, India; E-mail: sjsham@gmail.com

Received date: 09 February, 2022, Manuscript No. JNPGT-22-47024;

Editor assigned date: 11 February, 2022, PreQC No. JNPGT-22-47024 (PQ);

Reviewed date: 25 February, 2022, QC No. JNPGT-22-47024;

Revised date: 13 April 2022, Manuscript No. JNPGT-22-47024 (R);

Published date: 02 May 2022, DOI: 10.4172/2325-9809.1000288

Abstract

The research work done is related to solar thermal energy storage using Integrated Tube-in-Tube Solar Water Heater (ITTSWH) encapsulated with PCM. Normally conventional solar water heater has 13 ± 3% heat loss during night time. In this connection, ITTSWH system has been designed and fabricated for conducting various experiments. Initially tube-in-tube glazing heat transfer analysis is done for different mediums like air, inert gas and vacuum condition. From this study, large quantity of solar thermal energy is absorbed during clear day time. The PCM material gets charged when there is available of solar radiation and discharges whenever the source is not there. And, the ITTSWH system thermal performance is analyzed by varying the mass flow rate of the water. This type of integrated thermal energy storage system has a good potential of acting as a thermal storage device and can be used in water heating application in absence of solar energy.

Keywords: Phase change material (paraffin); Tube-in-tube; Integrated solar water heater; Thermal performance

Introduction

Solar Water Heating (SWH) systems comprise of several innovations and many mature renewable energy technologies that have been well established for many years [1]. In SWH system, the storage tank is located horizontally where the tank surrounded by the evacuated tubes for the absorption of incoming solar thermal energy. A fluid pump moves water or Heat Transfer Fluid (HTF) and designed to deliver hot water for most of the year. Initially the tube is fabricated containing water in one tube and phase change material in another tube. Glass tank is surrounded by cast iron pipe setup. Here the whole setup is considered as the solar water tank.

The tank is again surrounded by another glass tube and properly sealed. The gap between the glass tubes is evacuated for absorbing the solar thermal energy. The phase change material absorbs considerable of energy as it has high latent heat storage capacity. Phase Change Materials are unique materials that store heat my virtue of its phase changing property. Therefore, the stored can be used when the solar energy is not available for maintaining the temperature of water in solar water heating applications [2], Here the phase change material used in paraffin wax which commonly available and can used for effective storing thermal energy.

Selection of phase change material

Phase change material selected is paraffin. The latent heat is used for the thermal storage. The melting point of the paraffin is 45°C, (Figure 1) [2].

Figure 1: Paraffin PCM.

Experimental setup

Initially the setup is made as shown in the layout. The hot water of 70°C is fed into the heat exchanger through the inner pipe using the ½ hp water pump. The inlet flow rate of the water is controlled by the control valve and the required flow rate is sent inside the tube in tube heater made of cast iron. The heat is transfer from the hot fluid to the phase change material and after the melting temperature the added heat is stored in terms of latent heat. After a certain period of time the phase change material is converted in molten state and then the heat discharging of the phase change material takes place (Figure 2) [3].

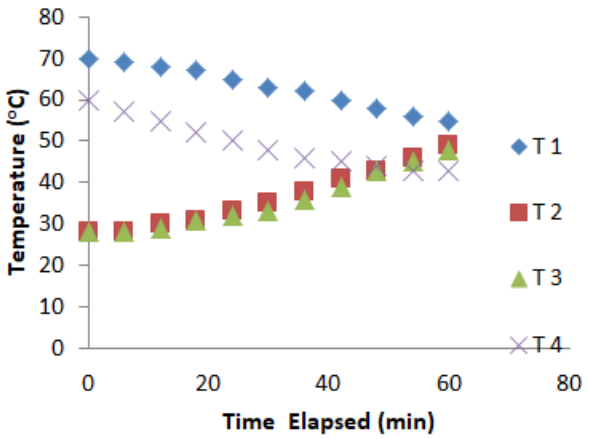

Figure 2: Experimental methodology.

The temperature measure in this is done by thermal sensors and the temperature indicator. The temperature sensors are placed in the water segment and the phase change material segment (Figure 3).

Figure 3: Flow measurement.

The flow rate of the water is controlled by the control valve and the flow of water at the inlet of the heat exchanger is displayed using the flow meter. Here different flow rates are being used such 3l pm and 5l pm. The temperature variations in water and phase change material is studied for the given flowrate (Figure 4).

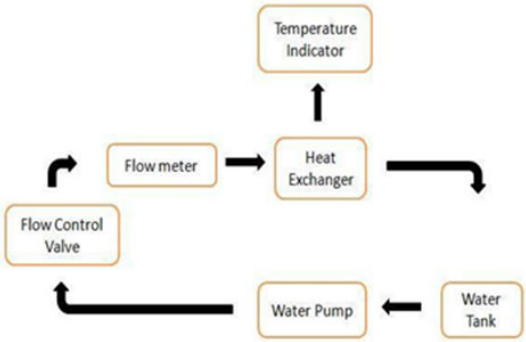

Figure 4: Temperature measurement.

The space between the glass tube and the cast iron tube in tube heat exchanger is again filled with hot water of 60°C. Another glass tube is put over the glass tube and sealed. The gap between the glass tubes is evacuated so that there is no heat loss from the inside. This heat exchanger is connected to the tubes. The heat to the water is provided by artificial heating using an electric water heater (Figure 5).

Figure 5: Tube-in-tube experimental setup.

The experiments are conducted by varying the flow rates of the water at the inlet. The different flow rates used are 3 L/min and 5 L/min (Figures 6-9) [4].

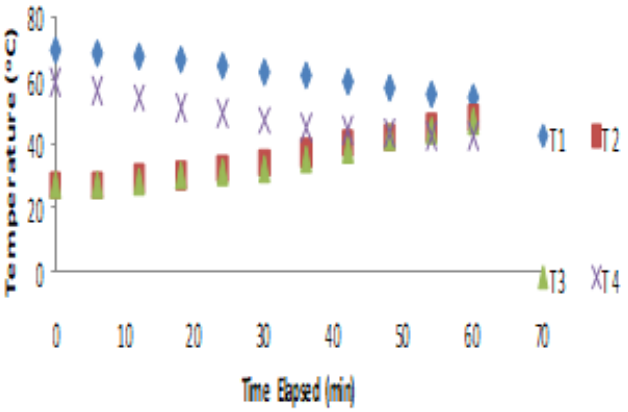

Figure 6: Temperature Plot at 3lpm (Melting Curve).

Figure 7: Temperature Plot at 3 lpm (Balancing Curve).

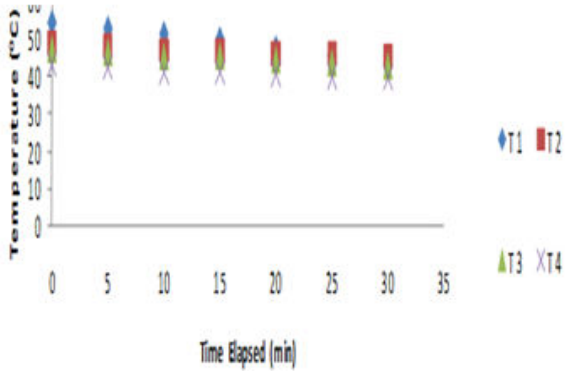

Figure 8: Temperature plot at 8 lpm (Balancing Curve).

To get the melting curve in the case of charging and balancing the temperatures, a curve was produced for fluctuation of temperature at each point in the wax versus time elapsed for each mass flow rate [5-9].

- T1- Temperature of water inside the C.I pipe
- T2-Temperature of PCM at one point
- T3-Temperature of PCM at another point
- T4-Temperature of water inside the glass

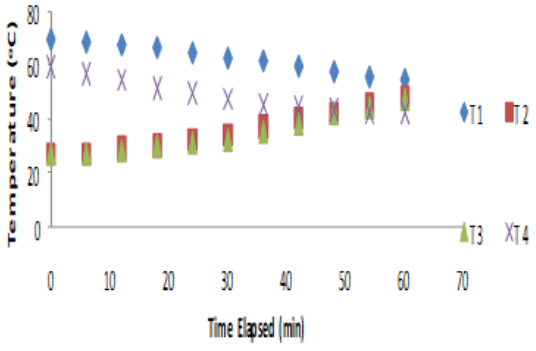

Figure 9: Temperature plot at 5 lpm (Balancing Curve).

Conclusion

In this project paraffin as phase change material is used in the solar water tank with the evacuated tube concept. This project mainly focuses on the thermal performance of the paraffin by varying the flow rate of inlet. The higher thermal efficiency is obtained when the flow rate of inter water is 4 L/min. The output hot water of temperature 44°C is achieved. Salt based phase change material can also be used for thermal storage materials.

References

1. Liu P, Shu G, Tian H, Wang X (2018) Engine load effects on the energy and exergy performance of a medium cycle/organic Rankine cycle for exhaust waste heat recovery. Entropy 20: 137.
2. Akgun M, Aydın O, Kaygusuz K (2008) Thermal energy storage performance of paraffin in a novel tube-in-shell system. App thermal eng 28:405-413.
3. Demirbas MF (2006) Thermal energy storage and phase change materials: an overview. Energ sources part B: Economics, planning, policy 1: 85-95.
4. Manjunath MS, Vasudeva Karanth K, Yagnesh Sharma N (2019) Numerical analysis of flat plate solar air heater integrated with an array of pin fins on absorber plate for enhancement in thermal performance. J Solar Energy Eng 141: 051008.
5. Babu S, Sriram R, Gopikrishnan S, Praveen A (2021) Solar Energy Simulation of Fresnel Lens Concentrated System for Thermal Electric Generator. Fluid Mechanics Fluid Power 833-839.
6. Babu S, Shyam Sashvat R R, Daniel Susai, and Ajay N (2021) FEM analysis of novel Fresnel sheet solar concentrating system for TEG. Conf Ser Mater Sci Eng 1130: 012028.
7. Akgun Mithat (2008) Thermal energy storage performance of paraffin in a novel tube in shell system. App Thermal Eng 28: 405-413.
8. Demirbas MF (2006) Thermal energy storage and phase change materials: an overview. Energy Sources, Part B: Economics, Planning, and Policy. 1: 85-95.
9. Jesumathy, SP, Udayakumar M, Suresh S (2012) Heat transfer characteristics in latent heat storage system using paraffin wax. J Mech Sci Technol 26: 959-996.