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PERFORMANCE ANALYSIS OF PHASE CHANGE MATERIAL IN SOLAR ENERGY STORAGE AND TRANSPORT

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Abstract – *Energy is the basic necessity for the economic development of a country. Effective energy has the ability to meet many challenges. The energy source classification is categorized as, renewable and non-renewable energy. Non-renewable energy is a finite energy, which does not renew itself. Non-renewable sources such as coal, petroleum, natural gas etc.., are depleting at a faster rate and an unregulated industry practice will lead to complete sources depletion in a century or so. The non-renewable energy sources cause extreme pollution to this planet. In order to overcome the pollution & sustainability of finite resources, renewable resources are coming into practice, such as solar, geothermal, bio mass, wind energy, tidal etc…*

Renewable energy is the future source of energy for almost all applications. In this project we have utilized solar energy for energy storage and utilization at different times and places. For this purpose energy transfer using hot water collector have been used. With appropriate selection of hot water collector and heat exchanger using phase change material (PCM), latent heat storage is attained. The heat exchanger is provided with inlet and outlet tube for transfer of heat from the phase change material. After careful study of different types of wax materials available in market, paraffin wax (with properties specified in Table 4.1) was chosen as PCM. In order to further improve the characteristics, the shell and tube type heat exchanger was selected. The charging and discharging cycles of the thermal energy storage system has been found and reported.

Key Words: Solar energy, Energy storage, Phase change material, solar water heater, flat plate collector, latent heat storage.

1. INTRODUCTION

Energy is the inevitable one in the world for all kinds of activities. The consumption of energy in various fields increased dramatically. To fulfil this demand the present system must be greatly expanded. Generally, we use fossil fuels as the main resource, but this will cause damages to the environment and lead to global warming. The fossil fuels are depleting at a faster rate and the cost of that is increasing rapidly in the upcoming years. Therefore, fulfil the energy demand requires sustained energy resources called renewable sources which renew itself within a stipulated time. Renewable energies will play a vital role in the upcoming energy demands. Inexhaustible sources can recharge itself and feasible and don't make any contamination for nature while petroleum derivatives are not practical and cause broad contamination that harms the earth. Sustainable power sources are sun-powered energy, wind energy, bioenergy, geothermal energy, flowing energy, and hydropower. Roughly every one of these types of energy is hampered by their significant expenses. Besides, sun based energy, wind energy and flowing energy are portrayed by their irregular nature, as they are not accessible constantly. This discontinuous issue can be explained by energy stockpiling.

Sustainable power source assumes a significant job from the political perspective. Nations with helpless minor energy assets from petroleum products found the sustainable power source as an esteemed open door for another period of reliance on their inexhaustible assets for energy as opposed to bringing in their energy needs from different nations

1.1 Thermal Energy Storage

Thermal energy storage can be achieved in three ways. That is namely sensible, latent, and thermochemical heat storage. The need for thermal energy storage in solar is mainly due to the intermittent nature. The thermal energy storage system can store the energy when it is abundant and that can be utilized when it is insufficient. Then only the solar energy system could benefit the industry in a major way. That is the vital role of the thermal energy storage system in the new era of evolution without the storage system, it is incomplete.

1.2 Phase Change Material

The PCM changes its phase from solid to liquid, solid to gas, liquid to gases and vice versa respectively. During the phase changes, it has a huge amount of energy that can be stored from one state to another state and that can be released while reversing the state of the material.

2. Material Selection

After a careful study from the literature, it has been chosen the phase change material as paraffin. The paraffin is easily and commercially available in the market also called paraffin wax. The melting point of selected PCM and our system is close to the domestic as well as industrial water heating application. The properties of the PCM is listed below.

Sl.no	Properties	Paraffin
1.	Melting Point	60 °C
2.	Chemical Formula	C_nH_2N+2
3.	Latent Heat	220 Kj/Kg
4.	Density	900 Kg/m^3
5.	Thermal Conductivity	3-5 W/m-k

Table -1: Properties Of PCM

3. Experimental Work

For our work, we have focused on the flat plate collector to utilize the phase change material in the solar thermal energy storage.

Fig -1: Energy Storage Unit

The energy storage unit is fabricated to store and recover the solar thermal energy. The ESU is having shell and tube which is used to place the PCM and transfer of heat through fluid respectively.

Fig -2: Radiation & Temperature Indicator

4. Result & Discussion

4.1Differential Thermal Analysis

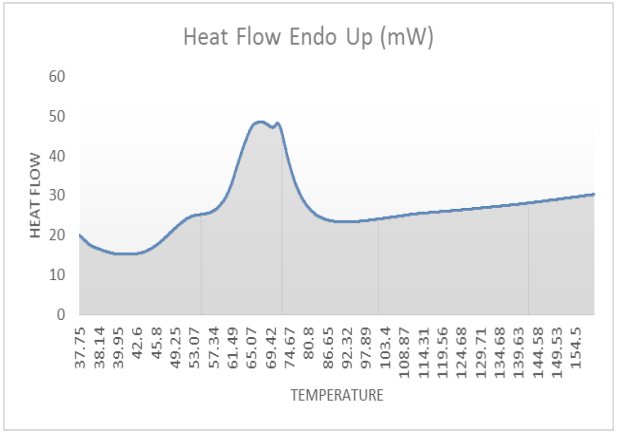

Chart -2: DTA analysis curve

It is identified that the PCM melting point at 60 degree Celsius and the curve belong to endothermic peak.

The experimental work was carried out in two processes, which is mentioned below.

1. Charging Cycle
2. Discharging Cycle

4.2Charging Cycle:

In charging cycle, the PCM is melting from solid to liquid

The paraffin PCM was charged in the energy storage unit with a 0.18 kg/min flow rate using HTF. It took about 20 min to reach the required temperature of the HTF. Input temperature of the HTF was varied between 75 °C to 83 °C. The PCM started to melt at the melting point and after 140 min it completely melted.

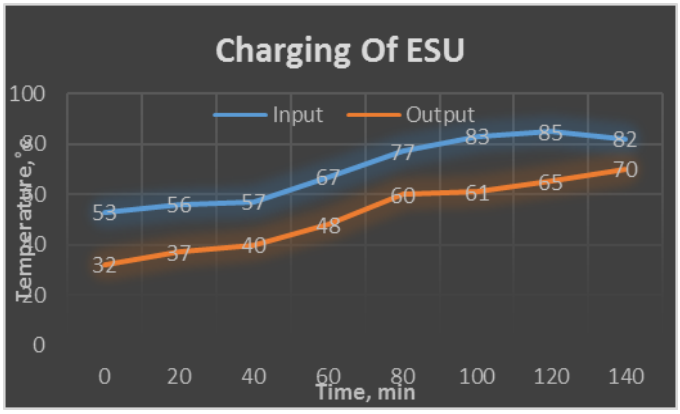

Chart -2: Charging of ESU

In the charging cycle, the energy utilized to melt the PCM is 0.45 KW. The energy harnessed from the solar water collector to be utilized to charge the PCM is around 14 kilojoules.

4.3 Discharging Cycle:

The discharging cycle varied between 110 min to 236 min for the different flow rates of HTF. This discharging of stored energy from the ESU to HTF has ended when the outlet temperature became the same as the environment temperature.

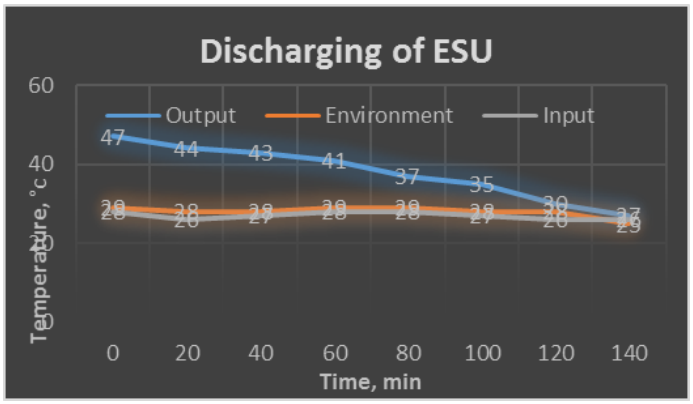

Chart -3: Discharging of ESU

The stored energy recovered from the experimental setup using the heat transfer fluid as the water was 8 kilojoules for the flow rate of 0.167 kg/min.

5. CONCLUSIONS

The experimental setup of shell & tube energy storage device is fabricated, to utilize the phase change material for solar energy storage and recovery.

The solar energy used to charge the PCM is at 14 kilojoules and the energy recovered from the PCM using the different flow rates and the maximum energy gained is 8 kilojoules in the energy storage unit

The trial work was structured and completed to decide the heat stockpiling limit. The outcomes demonstrated the specialized capability of PCM expands heat stockpiling frameworks utilizing PCM. This work steps forward procedures utilized in the warm capacity framework.

REFERENCES

[1] A.K.Pandey, Novel approaches and recent developments on potential applications of phase change materials in solar energy (2018)

[2] B.Kanimozhi, Experimental Study of Thermal Energy Storage in Solar System Using PCM (2012)

[3] Solar energy utilization authored by G.D.RAI, Khanna publishers.

[4] Samer Kahwaji, A comprehensive study of properties of paraffin phase change materials for solar thermal energy storage and thermal management applications (2018)

[5] Principles of energy conversion by Culp, Archie W

[6] Zubair Ahmad Qureshi, Recent advances on thermal conductivity enhancement of phase change materials for energy storage system: A review (2018)

[7] Yaxue Lin, Review on thermal conductivity enhancement, thermal properties and

[8] Applications of phase change materials in thermal energy storage (2018)

[9] Energy around the world by J C McVeigh, Brighton polytechnic, UK

[10] M.H.Mahfuz, Performance investigation of thermal energy storage system with Phase Change Material (PCM) for solar water heating application (2014)

[11] Swaroop Kumar Mandal, Performance investigation of CuO-Paraffin Wax nanocomposite in solar water heater during Night (2018)

[12] .Renewable energy sources and conversion technology authored by N K BANSAL, Tata McGraw-Hill publishing company limited,newdelhi

[13] Ahmet sari, Thermal conductivity and latent heat thermal energy storage characteristics of paraffin/expanded graphite composite as phase change material (2007)

[14] Solar energy principles of thermal collection and storage authored by S.P.SUKHATME, Tata McGraw-Hill publishing company limited, New Delhi.

[15] Khyad, Energy storage with PCMs: Experimental analysis of paraffin's phase change phenomenon & improvement of its properties

[16] Ojike, Study of a passive solar air heater using palm oil and paraffin as storage media (2019)

[17] Solar energy and conservation, edited by Nejat Veziroglu, Pergamon Press.

[18] Dobrescu Paul, Study of thermal energy storage using phase change materials (2017)

[19] Charalambos N.Elias, A comprehensive review of recent advances in materials aspects of phase change materials in thermal energy storage.