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A Review on Utilization of Phase Change Material in Solar Water Heating System

Prof K.P. Suryawanshi[1], Prof. B.A. Burkule[2], Prof. S.R. Upasani[3], Permindur Singh[4]

[1,2,3,4] *Department Of Mechanical Engineering, Guru Gobind Singh Polytechnic , Nashik, Maharashtra, India.*

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Abstract: Renewable energy solutions are becoming increasingly popular. Solar water heating system is one example. Maximizing power output from a solar system is necessary to increase efficiency. Thermal energy storage provides a pool of energy to adjust this mismatch and to meet the energy needs at all times. It is used as a link to cross the gap between the energy source, the sun, the application and the building. So, thermal energy storage is important in the solar heating system. Therefore, in this paper, an effort has been taken to review the investigation of the solar water heating system incorporating with Phase Change Materials (PCM). Effect of three solar radiation intensity. I.e. Weak mean and strong are studied. The energy and energy efficient water heater and the time length the heater can supply not water have been compared before and after using of (PCM) in the tank.

Keywords: Phase Change Material (PCM); Thermal Energy Storage (TES).

1. INTRODUCTION

Solar water heater use two natural phenomena to work dark coloured object absorb heat and hot water rises. The effective use of solar energy is hindered by the inter mitted nature of it availability limiting it use and effectiveness in domestic applications. A solar water heater equipped with a collector to collect solar energy and an insulated storage tank to store hot water. Solar energy is free, green, and is recognized as one of the most promising alternative energy resources option. The extent and importance of solar energy are well known. Its total available value is seasonal and is dependent on the climatological conditions of the location. However, being an irregular energy source, the utilization of solar energy can be more attractive and reliable if associated with a heat storage systems. The scientists all over the world are in search of novel and renewable energy sources. One of the options is to develop energy storing devices, which are as important as developing new sources of energy. Since the solar energy supply is capricious in daytime and zero at night, considerable amount of solar energy should be stored during the daytime to meet the demands at night. Energy storage is, therefore, crucial to any system that depends largely on solar energy. It adjusts time-based mismatches between the load and the intermittent or variable energy source, thereby improving the system operability and utility. Solar radiation can't be stored as such, so first of all an energy conversion has to be brought about and, depending on this conversion, a storage device is needed. Dew to this, latent heat of fusion of Phase Change Material (PCM) is of great interest on account of high storage density and its isothermal nature of the storage process. Solar energy can be stockpiled by thermal, electrical, chemical, and mechanical methods.

2. Material

2.1 Selection of PCM:

Solid, liquid PCMs are beneficial because they store a relatively large quantity of energy over a constricted temperature range, without a corresponding large volume change and currently appear to be of greatest practical value. A decent design of latent thermal energy storage needs the acquaintance of PCM and the latent exchange process especially the melting and solidification process.

2.2 PCM used:

The temperature of water to be stored as domestic hot-water is about 55 0 c; therefore, the melting temperature of the pcm should be around 600 c, so it should maintain temperature in between 40 to 500.in the market, different PCMs with this melting temperature can be found. Experiments with paraffin's, sodium acetate trihydrate and even fatty acids have been carried out.

3. THERMAL ENERGY STORAGE

The most commonly used method of thermal energy storage is sensible and latent heat method.

3.1. Sensible Heat storage

Thermal energy is stored by rising the temperature of a solid or a liquid medium by using its heat capacity. The amount of thermal energy stored in the form of sensible heat can be calculated by Where Q is the amount of thermal energy stored or released in form of sensible heat (kJ).The amount of thermal energy stored in the form of sensible heat depends on mass, value of the specific heat of the material used to store the thermal energy and the temperature change. Water is known as one of the best materials that can be used to collect thermal energy in form of sensible heat.

Application of sensible heat:

1. In solar water system, sensible water is still used for heat storage in liquid based systems, while a rock bed is used for air based systems

2. The application of load levelling, heat is usually stored in a refractory bricks storage heater, known as a night storage heater.

3.2. Latent heat Storage

Latent heat storing uses the latent heat of the material to store thermal energy. Hidden heat is the amount of heat absorbed or released during the change of the material from one phase to another phase. There are following two type of latent heat, Latent heat of fusion and Latent heat of vaporization. Latent heat of fusion is the amount of heat engrossed or released when the material changes from the solid phase to the liquid phase or vice versa, while latent heat of vaporization is the amount of thermal energy engrossed or released when the material changes from the liquid phase to the vapor phase or vice versa. Certainly, latent heat of vaporization is neglected for latent thermal energy storage applications because of the large change in the volume accompanied by this type of phase Change.

Application of latent heat:

1. This technique of heat energy storage provides much advanced energy storage density with a smaller temperature swing when compared with the sensible heat storage method.

2. Difficulties in applying the latent heat method due to the low thermal conductivity, density change, stability of properties under extended cycling and sub cooling of the phase change materials.

4. REVIEWS OF VARIOUS WORK RELATED WITH PROJECT

4.1. Mokgaotsa Jonas Mochane(1)-In this paper they used various polystyrene capsules which used to PCM for thermal storage. Mostly used the spherical microcapsules PCM show that capsules were grouped in irregular spherical agglomerates of size 16-24 μm. However, after melt-blending with PP the much smaller, perfectly spherical microcapsules were well dispersed in the PP matrix. The results also show fairly good interaction between the microcapsules and the matrix. An increase in PS:wax content resulted in a decrease in the melting peak temperatures of PP for both the modified and the unmodified blends due to the plasticizing effect of the microcapsules.Hence we conclude in this paper the role of microcapsules is most important in pcm.

4.2.R. Meenakshi Reddy, N. Nallusamy, and K. Hemachandra Reddy(2)- In the charging process using a varying heat source (solar) the results show that the different flow rates of HTF does not have a much significant influence on the charging time. Because the duration for charging is around 4 h (i.e. 10:00 a.m. to 2:00p.m.), which is a long duration, the heat transfer rate from HTF to PCM has a very low influence (5–10%). For the discharging process there is no much difference in the quantity of thermal energy recovered in the batch wise discharge process for different flow rates (2, 4, and 6 lit/min) even though the quantities of hot water discharged are different. This is because in the 6 lit/min discharge flow rate the average temperature is high and the quantity is low, and in the case of 2 lit/min discharge flow rate the average temperature is low and the quantity is more correspondingly. The variation in spherical capsule diameters between 68 and 38mm does not have much effect on charging time because the heat source (solar flat plate collector) energy supply rate is very low (the heat absorption of HTF from the solar flat plate collector is low) even though the heat transfer rate (heat discharge of HTF to PCM) is more in the TES system.

4.3. Lavinia Gabriela(3)- In this paper incorporation of PCMs into building elements takes the advantage of latent TES for additional energy savings. The development of energy-storing building is a solution to the on-going quest for energy conservation, and also to improving the indoor environment in which people work and live. In terms of thermal comfort, it is predicted that the indoor environment of a building which uses PCM construction materials will have significantly lower mean radiant temperatures and more thermal stability, having less likelihood of overheating and fewer temperature fluctuations. Thermal improvements in a building due to the inclusion on the type of PCM, the melting temperature, the percentage of PCM mixed with conventional material, the climate, design and orientation of the construction of the building.

4.4. Mohammed M. Farid, Amar M. Khudhair, Siddique Ali K. Razack,(4)-In this paper used the two most common groups of PCMs that is organic and inorganic compound. Most of the organic Phase change materials are non-corrosive and chemically stable, exhibit little or no subcooling, are compatible with most building materials and have a high latent heat per unit weight and low vapor pressure. Their drawbacks are low thermal conductivity, high changes in volume on phase change and flammability. The Inorganic compounds have a high latent heat per unit volume and high thermal conductivity and are non-flammable and low in cost in comparison to organic compounds.In this way, they are corrosive to most metals and agonize from decomposition and subcooling, which can affect their phase change properties. The applications of inorganic PCMs require the use of nucleating and thickening agents to minimize sub cooling and phase segregation. The applications in which PCMs can be applied are vast, ranging from heat and coolness storage in buildings to thermal storage in satellites and protective clothing. A PCM with an easily compliant melting point would be a necessity as the melting point is the most important criterion for selecting a PCM for passive solar applications. Many more applications are yet to be discovered.

5. Applications

5.1 Application area for PCM in building:

Thermal energy storage in the walls, ceiling and floor of the buildings may be improved by encapsulating or embedding suitable pcms within these surfaces. pcms can either capture solar energy directly or thermal energy through natural convection. Rising the thermal storage capacity of building can rise human comfort by decreasing the frequency of internal air temperature swipes so that indoor air temperature is closer to the desired temperature for a longer period of time

5.2 PCM Solar Wall:

A PCM wall is capable of capturing a high proportion of the solar radiation incident on the walls or roof of a building. As PCM wall has high thermal mass, they are capable of reducing the effect of large fluctuations in the ambient temperature on the inside temperature of the building. They can be very operative in shifting the cooling load to off-peak electricity period.

5.3 PCM Integrated Roof:

A roof-integrated solar air heating/storage system uses existing ridged iron roof. Sheets as a solar collector for heating air. A PCM thermal storage unit stores heat during the day so that heat can be supplied at night or when there is no sunshine.

5.4 PCM Filled Glass Windows

The main focus is on the “opaque” part of building envelopes, such as walls, ceilings, and floors. However, we should note one fact: generally speaking, “transparent” part of the building envelopes, i.e. window, has lower thermal resistance than other parts of the envelopes.

6.5 PCM Assisted Sun-Shading

The PCM use in PCM assisted sun-shading system is hydrated salt $CaCl_2$�H_2O. This system is very suitable to be utilized under the hot summer climate, especially for those areas with significant daytime and night time temperature fluctuations.

6. CONCLUSION

From the present study it is concluded that with this Solar heater with PCM there is availability of thermal energy for getting hot water at night time which is not possible with conventional solar water heater.

7. REFERENCES:

1. M. Akg¨un , O. Aydın, and K. Kaygu, Experimental study on melting/solidification characteristics of a paraffin as PCM, Energy Conversion and Management.

2. S. S. Al-Sandal and A. A. M. Sayigh, Thermal performance characteristics of STC system with phase change storage.

3. Abedin A.H., Marc A. Rosen, A Critical Review of Thermo chemical Energy Storage Systems, The Open Renewable Energy Journal, 2011, 4, p. 42-46.

4. Pavlov G., Olesen B.W., Building thermal energy storage-concepts and applications, Available content, (accessed 10/05/2012).

5. Dincer I., Rosen M., Thermal energy storage. Systems and applications, Ed. Wiley, second edition, 2011.

6. Demirbas M.F., Thermal Energy Storage and Phase Change Materials: An Overview, Energy Sources, Part B, 2006.