Design and Development of Solar Water Heater Using Phase Change Material (PCM)

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Abstract- *A Solar space heating system using Phase Change Material (PCM) is described in this paper. In this research, the effect of Phase Change Material (PCM) as storage medium on the performance of a solar water heater have been experimentally investigated. A type of Barium Hydroxide Octahydrate {$(OH)_2.8H_2O$} is used as PCM in spherical capsule as a storage material in the tank of solar water heater.*

Keywords- Integrated design,Solar Collector, Solar Energy, PCM, Solar heating System.

I. INTRODUCTION

Energy has already become a crucial issue for mankind. We are still heavily relying on traditional fossil energy such as coal, natural gas and oil, which accounts for 78.3% of global energy consumption in 2018. However, fossil energy is not unlimited and we are going to run out of it if the trend continues. Meanwhile, fossil is mainly utilized in the form of direct combustion to produce electricity as well as thermal energy. This method causes several environmental problems such as air pollution and intensive CO_2 emission.
To overcome these major problems, a new design has been devised to heat efficiently using the sunny days and as well as the other dusky situations. This device not only transfer energy efficiently and store it for continuous usage. The PCM material layered inside the tubes stores heat effectively and heats up the blowing air. This helps in reducing the fuel consumptions to a greater extent during non-sunny days.
During winter season in hilly areas as well as in European countries people usages room heaters to protect from excess drop in temperature which is about -15 to -10°C. The conventional room heaters give effective heating but is use motor to drive the heater and to generate heat also.

The motor consumes 70 to 80% of energy to drive the room heating system which tends to increase the maintenance and capital cost of the system due to limitations of the conventional energy we are using solar energy which is renewable and readily available so, “Design and development of solar water heater using Phase Change Material (PCM)”.

Methodology: The experimentation to be carried out in two phases:

Hot water storage tank heat capacity without PCM and hot water storage tank heat capacity with PCM. The experiment will be carried out for forced convection. The energy from hot water will be extracted for heating air from ambient temperature to 26^0c. The two phases of experimentation are:

Phase 1: In first phase the combination of coil and hot water storage tank will be incorporated and air will be passed through the coil which is submerged in hot water. The temperature of air at coil exit will be measured also the drop of water temperature at the end of heating hours will be observed.

Phase 2: In this phase, phase change material (PCM) will be introduced in the above combination of heating coil and hot water tank. Again, the air will be passed through the coil and the coil exit temperature of air along with drop in temperature of water will be measured. The change in drop of water temperature with PCM will be evaluated. The changes in energy storage capacity (Energy density) of hot water tank will evaluated for the hot water storage tank with and without PCM.

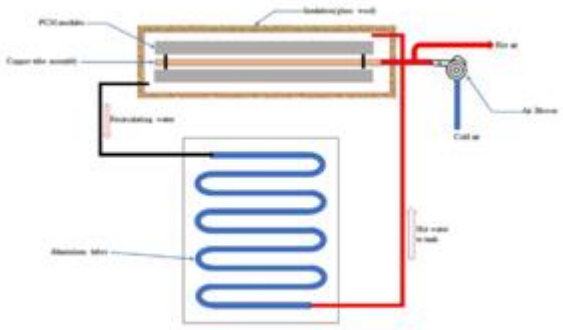

Fig no. 1 solar heating system

Selection of Phase of Change Material(PCM)

The selection of phases of change material PCM depends on the thermo physical properties mainly, melting point temperature latent heat of fusion, specific heat and thermal conductivity along with this, the other factors such as, toxicity level, corrosion, stability, cost and availability also influence the selection of PCM. Considering all above parameters, we have selected:

Barium Hydroxide Octahydrate $\{(OH)_2.8H_2O\}$

- Melting Point -48^{0}C
- Thermal Conductivity – 0.653(W/mK)
- Specific Heat – 265.7 KJ/KgK

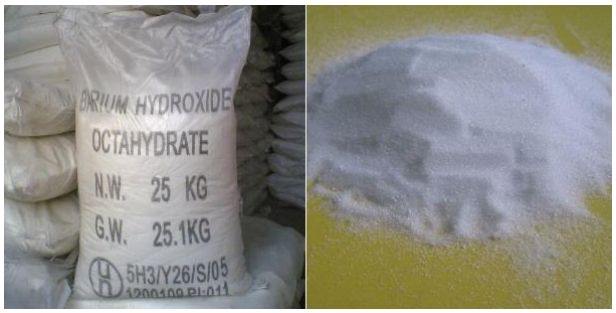

fig.no.2 Actual $\{(OH)_2.8H_2O\}$

Selection of Pipe:

As in our experiment, highest temperature up to 60^{0}C.CPVC is thermoplastic material used for thermal resistance, to avoid heat loss from to the surrounding. So CPVC is more suitable for hot water applications up to 93^{0}C (200F). The ability to band, shape and weld CPVC enables its use in a wide variety of processes and applications it exhibits fire-retardant properties.

Selection of encapsulation material and copper tube

Aluminium is a good conductor of heat. This means that if we heat one end of the piece of aluminium, other end will quickly reach the same temperature. The thermal conductivity of silver is highest but it has higher cost. So, it is preferable to use aluminium which has less cost than silver, copper and has good thermal conductivity then other material. Aluminium is a low in reactivity series this means that it does not tends to corrode. Due to its lots of advantages we have selected aluminium metal for encapsulation.

For high heat transfer copper is used as material for heat transfer tubes i.e. copper tube assembly. Fins on the tube enhance the heat transfer to the tubes.

Fig no. 3Solar heating system

II. LITERATURE REVIEW

Present theories and practices

H.M. Teanah, M.F. Lightstone and J.S. Cotton [5] An alternative approach for assessing the benefit of phase change materials in solar domestic hot water systems. (2017)

Atul sharma, C. R. Chan [2] Solar water heating system with Phase Change Materials. (July 2009)

Shrinivasan. S, Tinnokesh, Siddhardh [3] Residential solar cooker with Enhanced heat supply. (10 October 2013)

III. CONCLUSION

Room heating can also be done by air conditioning system but it has been found that during a particular year 40% of total electricity is consumed for air conditioning. Hence, again depending on the conventional energy sources. A lot of research and experimentation is carried on the use of phase change materials in the performance of the upgrading of the conventional solar water heating systems.

Phase change material (PCMs) have been used as a cheap alternative for space heating by utilizing a solar heat energy.Also, the use of PCM for storing access heat energy during day time hours and then using this energy at night for domestic use as PCMs have capability of keeping the water temperature constant.

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