Using PCM as Energy Storage Material in Water Tanks: Theoretical and Experimental Investigation

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Abstract

In this work, the role of Phase Change Material (PCM) submerged in water tank in controlling its temperature is investigated both theoretically and experimentally. In the experimental part, an organic PCM (Tricosane) is used inside vertical tubes submerged in the water tank to absorb heat when heat is provided to the tank at constant rate and then release it to the water when the source of heat is turned off. The effect of the amount of PCM on the water temperature is studied. The amount of PCM is represented by a parameter (R) defined as (mass of PCM)/(mass of water). The effect of using PCM is demonstrated by measuring the change in the water temperature. The presence of PCM in the water resulted in the appearance of two zones in which the temperature remains constant due to melting and solidification of the PCM. In the melting zone the heat provided to the PCM is absorbed hence maintaining its temperature constant. The second zone appears after the heating is stopped where heat losses is subsidized by the heat of fusion of the PCM. The experimental results showed that as the value of R increases, both zones become longer specially the second zone. Accordingly, the time for the temperature to drop to a certain value say 45oC (a temperature that one can use the water comfortably) is longer as the value of R increases. In fact, the time it took the water to drop to 45oC is doubled when R=0.95 compared to the case when no PCM is present in the system.

The change in water temperature was theoretically calculated by performing heat balance on the system in the different zones (heating and cooling zones). It is assumed that the temperature of the components of the system (water, PCM, glass tubes, tank) is the same. The results verified those observed experimentally. The effect of the overall heat transfer coefficient (U), type of PCM expressed by its latent heat (□□□ was investigated. It was found that the time it took the temperature of the system to drop to a given temperature increases as U decreases and □ increases. Moreover, the zones at which the temperature remains constant become longer when U decreases, □ and R increase. This suggests that the system temperature can be controlled by insulating the system and using proper values of R and □. The developed model was validated using the experimental results of this work. The outcome showed an excellent agreement between the experimental results and the model.

Keywords
Energy, Phase Change Material, Energy Storage Material, Wax