Abstract

In our daily life, use of air conditioning in buildings increases greatly to satisfy human comfort level, which consumes a huge amount of electrical power, about 15% of the total power consumption. However, in the recent decades, use of the phase change material (PCM) spreads widely as a thermal energy storage towards cooling of the residential as well as commercial buildings, which is an economically beneficial technology and save use of the conventional energy. The PCM melts and stores energy during a day and releases the same in night to the ambient. Utilizing the phenomenon, maintaining human comfort is possible encapsulated or embedded PCMs on walls, or terrace of the buildings. Hence, the use of PCMs in buildings will possibly save consumption of electricity that supplied from fossil fuels based power plants. Indirectly, this method reduces the consumption of fossil fuels in power plants, hence reduces pollution in the environment-a reasonable remedy to reduce the global warming. Therefore, establishment of cooling of buildings using PCM is an important requirement and thrust area of research.

To incorporate the concept, this work considered placing of PCMs on terrace of buildings instead of tiles on walls as major portion of the heat in a sunny day enters into the room through the terrace only. Also spreading of PCMs over the terrace is difficult in handling; accordingly, preparation of a model brick filled with suitable PCM is adopted in this thesis for the cooling purpose.

In order to establish the above consideration, experimental behaviors for a model brick have been determined by carrying out mainly four successive experiments. In the experiments, two types of organic PCMs: OM-29 and OM-37 are selected because of their melting temperatures are closer to the human comfort zone, i.e., 29℃ and 37℃, respectively. All experiments are conducted at the Heat Power Laboratory of Jadavpur University. In this thesis, accordingly, the day time situation is represented by two temperatures close to the terrace temperature of a sunny day using a copper heat exchanger connected to a constant temperature bath (CTB) set at two different temperatures, i.e., 55℃ and 65℃. The night time situation is represented by a suitable ambient temperature at 20℃. Based on these conditions, four combinations of experiments are conducted: Case-I: OM-29 as PCM and 55℃ at CTB, Case-II: OM-29 as

PCM and 65℃ at CTB, Case-III: OM-37 as PCM and 55℃ at CTB, and Case-IV: OM-37 as PCM and 65℃ at CTB.

Out of the four experimental cases, it is observed that molten PCM of all cases solidifies back within end of the day, i.e., after 24 hours. Hence, recycling of the selected PCMs is possible for all cases. It is established that a minimum temperature at bottom of the model brick comes to 28.8℃ when OM-29 is used as the PCM. Finally, it is concluded that room temperature of a building can be maintained at a temperature lower than 28.8℃ in a moderate sunny day, and that may reaches to 33.3℃ in a very sunny day.

The above experimental results are then validated with numerical work. In the numerical work, all transport phenomena are modelled using a set of governing equations include mass, momentum and energy conservations along with a consideration of volume average physical properties. The control volume method (CVM) is used to discretize these governing equations appropriately, and using the TDMA, all final linear simultaneous equations are solved with proper boundary conditions and morphology of solid-liquid interface occurs during melting and solidification of the phase change materials. Thereafter, a simulation code is developed on FORTRAN platform. The numerical results are compared with experimental predictions for all four cases. It is observed that a good agreement is found for all the cases of numerical predictions with experimental ones.

In brief, in this thesis, a model brick filled with a suitable PCM is established. Such model bricks are to be placed on terrace of the buildings for cooling purpose. On using of OM-29 as a PCM in such model bricks, room temperature of a building can be maintained at a temperature below of 28.8℃, which is under human comfort zone.