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Enhancing a Trombe wall charging and discharging processes by adding nano-Al_2O_3 to phase change materials

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Abstract— In this study, two Trombe walls were designed and fabricated to evaluate the effect of enhancing the paraffin wax thermal conductivity on the charging and discharging period of the wall. The nano Al2O3 was added to the paraffin wax of one wall. The study results revealed a faster charging and discharging times due to the improvement in the thermal conductivity of the wall with wax mixed with nano-material. The wall, which uses wax with nano, had higher temperatures and faster charging period than the wall with wax only. The exit air of this wall is hotter that of the other case. Given high thermal conductivity of the wax with nano-material (case 2), the loss of storage energy was faster, depending on the entering outside air temperature and its mass flow rate. The Trombe wall with nano-materials and wax had overall higher temperatures up to 29.08% compared to wax alone. At discharge period, the paraffin wax with nano-material temperatures was higher than that for the wax alone case up to 42.68%. The exit air temperatures from a Trombe wall with the nano-wax compound was higher by about 43.24% compared to the air exited from the other wall with wax only.

Keywords- Trombe wall, thermal conductivity, charging period, discharging time, nano-Al_2O_3.

1 Introduction

The greenhouse gas emission levels are increasing continuously, and the fuel prices are jumping highly; these are the two most significant dilemmas which serve as the catalyst behind the efforts to expand the use of effective alternative energies from various renewable energy sources [1]. Direct solar radiation is considered one of the most important future sources of renewable energy, in many parts of the world [2]. The development of energy storage devices is just as important as the development of new energy sources [3]. The suitable energy storage is that system which makes the energy restored and converted properly to the desired form of energy. This system is the best way to expand the use of renewable energies such as solar power [4].

The use of storage system depends on using the latent heat storage material (PCMs) is an efficient way to store thermal energy storage with high energy density [5]. The stored energy potential concept is from the best thermal energy storage technologies, with an energy storage density as high as possible. This type of storage is characteristic by its ability to store heat at constant temperature (which represents the temperature of the phase change either at fusion or freezing) [6].

The employments of phase change materials (PCMs) for thermal storage purpose are widely used in the heat pumps systems, solar energy engineering, and spacecraft technologies [7]. The PCMS uses for heating and cooling buildings have been investigated in many articles. Phase-changing material is a collection of large numbers of materials organic and inorganic. The degrees of melting and freezing for these materials is spreading over a wide range of temperatures, making the possibility of using it in various applications in diverse storage temperature degrees very attractive [8].

Tromp wall provides when used PCMs, better performance than if it used sensible heat storing materials like concrete. The amount of latent heat stored during the stage of transition or the phase change is colossal compared to sensible heat storing materials [9]. So, the choice of PCM material for a particular application must be taught accurately to specify the temperature change of the PCM material which is suitable for the application degree heat, whether it is for heating or cooling application [10]. The substance must be selected to give the highest latent heat possible by volume, to reduce the physical size of the treasurer of the heat storage. Also, high thermal conductivity of the material PCM facilitates and speeds up the processes of charging and discharging the thermal energy stored [11].

Many researchers studied the use Trombe wall in Iraq, and everyone praised the results with confirming on some of the restrictions due to the low thermal conductivity of the used PCMs [12]. The thermal conductivity means the possibility of charging and discharging the thermal reservoir (here PCM) quickly commensurate with the exposed load to give temperatures appropriate to the comfort conditions. Enhancing the thermal conductivity of the PCM is, in fact, the way to improve the effectiveness of thermal energy storage (TES) depends fundamentally on the PCM systems [13].

Several methods have been examined to improve the thermal conductivity of PCM such as adding metal fins of high thermal conductivity material inside the PCM store [14], or using fibers made in various forms to act like flippers [15]. Also, adding honey, wool, and brush was used to enhance the thermal conductivity of PCM [16]. Research results show that these methods cause an increase in the weight and the costs of

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