

Effect of loading temperature on thermophysical properties of paraffin wax as PCM for thermal energy storage

Tai K. Siang¹, Anusuiah Vasu¹, Ftwi Y. Hagos^{1,2}, M.M. Noor^{3,4}, Rizalman Mamat¹, Kumaran Kadirgama, Wan Azmi Wan Hamzah^{1,3}, Mahendran Samyako¹, Ravi Kumar Sharma⁵

¹Advanced Fluids Focus Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, Pekan 26600, Pahang, Malaysia

²Center of Excellence for Advanced Research in Fluid Flow, Universiti Malaysia Pahang, Pekan 26600, Pahang, Malaysia

³Automotive Engineering Center, Universiti Malaysia Pahang, Pekan 26600, Pahang, Malaysia

⁴Automotive Engineering Research Group, Faculty of Mechanical Engineering, Universiti Malaysia Pahang, Pekan 26600, Pahang, Malaysia

⁵Department of Mechanical Engineering, Manipal University Jaipur, Jaipur, India

Corresponding author: ftwi@ump.edu.my

Abstract

Phase change materials (PCMs) have been widely used in Thermal Energy Storage (TES) system as a storage medium. The thermal and physical properties of PCMs can be affected by heat loading temperature. In this study, four samples were exposed to four different heating temperatures at 65°C, 75°C, 85°C, and 100°C for ten number of thermal cycles. Heating is done by using an oven at the same time the samples are allowed to cool freely at room temperature. Melting temperature, latent heat capacity, void ratio, thermal stability, thermal conductivity and density were measured using Differential scanning calorimetry (DSC), Scanning electron microscope (SEM), Thermogravimetric analysis (TGA), KD2 Pro and water displacement method, respectively. Results obtained from the DSC test has shown that the sample with 100°C loading temperature has the lowest phase change enthalpy among the other samples. The effect of high-temperature loading reduces the overall latent heat capacity of PCM more than 50% compared to that of 65°C sample. This reduction significantly affects the overall performance of the thermal energy storage system. The sample of 100°C loading temperature showed the highest thermal conductivity among the other samples which is 0.26667 W/mK. This result reveals that the increase in temperature of heat loading will increase the thermal conductivity of PCMs. Closer the temperature of heat loading towards the transition temperature, higher the thermal stability. Thus, the sample of 65°C loading temperature has higher stability compared to the sample of 100°C loading temperature. Density and void ratio shows the same trend as the heat loading temperature increases. However, based on the results from SEM, the void ratio does not show any significant effect on thermal and physical properties. The sample of 100°C heat loading temperature has high thermal conductivity but has a high melting temperature, low density, low latent heat capacity and low stability. Paraffin wax of 65°C heat loading temperature has all the superior characteristics as a thermal energy storage material.

Keywords: Energy Storage; Phase change material; paraffin wax; loading temperature; thermophysical property