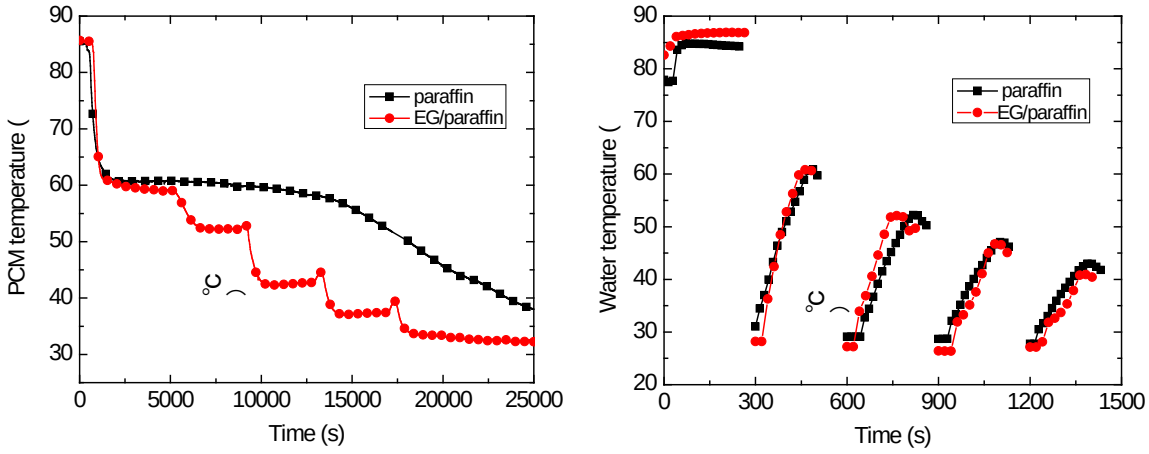

(a) (b)

Fig. 7. Temperature evolutions of PCM (a) and the outlet HTF (b) during step-by-step heat retrieval

4. Conclusions

Paraffin/EG composite PCM with 7% mass fraction of EG was prepared for enhancing the heat transfer of paraffin. The paraffin/EG composite PCM and the paraffin were used in a shell and tube heat storage system and the performance of the LTES system was experimentally investigated. The following conclusions were drawn:

1. The utilization of paraffin/EG composite PCM greatly enhanced the heat storage/retrieval rates of the LTES system. The LTES system with paraffin/EG composite PCM, under the operation condition (flow rates: 150 L/h during both heat storage and heat retrieval; the inlet temperature of HTF: 28 ^{o}C during heat retrieval and 85 ^{o}C during heat storage), showed a 44% reduction in heat storage duration and a nearly 69% reduction in the retrieval duration, respectively, compared to those for pure paraffin.

2. The most outstanding advantage, for the LTES system filled with paraffin/EG composite, was that the outlet temperature of HTF can be maintained at a higher level in a longer term than that with paraffin, which was significant for the utilization of the LTES system.

3. A higher flow rate of the HTF led to a better heat transfer performance and consequently more rapid heat storage and retrieval. It is positive for heat storage, whereas higher flow rate of the HTF may cause lower outlet temperature of the HTF during heat retrieval though it can enhance the heat retrieval power.

4. There was a large difference between the temperature evolutions of the pure paraffin and paraffin/EG composite PCM in the step-by-step heat retrieval mode, whereas the temperature evolutions of the outlet HTF in the two LTES systems were almost the same with each other.

References

[1] G.A. Lane, Solar heat storage: latent heat materials, background and scientific principles vol. I. Florida: CRC Press Inc, 1983.

[2] A. Felix Regin, S.C. Solanki, J.S. Saini, Heat transfer characteristics of thermal energy storage system using PCM capsules: A review, Renewable and Sustainable Energy Reviews12, 2008, pp. 2438–2458.

[3] C. Arkar, B. Vidrihb, S. Medveda, Efficiency of free cooling using latent heat storage integrated into the ventilation system of a low energy building, International Journal of Refrigeration 30, 2007, pp. 134–143.

[4] A. Benmansour, M.A. Hamdan, A. Bengeuddach, Experimental and numerical investigation of solid particles thermal energy storage unit, Applied Thermal Energy 26, 2006, pp. 513–518.

[5] F. Agyenim, N. Hewitt, P. Eames, M. Smyth, A review of materials, heat transfer and phase change problem formulation for latent heat thermal energy storage systems (LHTESS), Renewable and Sustainable Energy Reviews 14, 2010, pp. 615–628.

[6] A. Trp, An experimental and numerical investigation of heat transfer during technical grade paraffin melting and solidification in a shell-and-tube latent thermal energy storage unit, Solar Energy 79, 2005, pp. 648–660.

[7] H.A. Adine, H.E. Qarnia, Numerical analysis of the thermal behaviour of a shell-and-tube heat storage unit using phase change materials, Applied Mathematical Modelling 33, 2009, pp. 2132–2144

[8] F. Agyenim, P. Eames, M. Smyth, A comparison of heat transfer enhancement in a medium temperature thermal energy storage heat exchanger using fins, Solar Energy 83, 2009, pp. 1509–1520.

[9] M. Esen, A. Durmus, Geometric design of solar-aided latent heat store depending on various parameters and phase change materials. Solar Energy 62, 1998, pp. 19–28.

[10] F. Agyenim, P. Eames, M. Smyth, Heat transfer enhancement in medium temperature thermal energy storage system using a multitube heat transfer array. Renewable Energy 35, 2010, pp. 198–207.

[11] A.A. Ghoneim, Comparison of theoretical models of phase-change and sensible heat storage for air and water-based solar heating systems, Solar Energy 42, 1989, pp. 209–220.

[12] L. Xia, P. Zhang, R.Z. Wang, Preparation and thermal characterization of expanded graphite/paraffin composite phase change material, Carbon 48, 2010, pp. 2538-2548