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Experimental and Numerical Investigation of the Solid-Liquid Phase Change of a Low Temperature Paraffin for Refrigerated Transport Applications

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Extended Abstract

It is known that only keeping specific operating conditions (air and products temperatures, humidity inside the refrigerated cell, …) along the cold chain can let the perishable goods to be delivered in the safer way to the customer in order to reach its satisfaction. This latter occurs when the quality, the freshness and the safety of the final products are fully ensured.

In the last years, researchers have been putting their efforts in developing innovative solutions which can maintain an adequate temperature of the products along the cold chain with contemporary lower environmental impacts. Latent Thermal Energy Storage systems (LTESs) based on Phase Change Materials (PCMs) seem to be a promising technology to be implemented in the cold chain applications.

In this context, aiming at designing a proper LTES system, the right selection of the needed PCM is crucial. When screening the different options, among the PCM features two important parameters have to be considered: the ideal melting (solidification) temperature and the latent heat of fusion of the PCM. Unfortunately, it may happen that a discrepancy occurs between the PCM characteristics declared in catalogues or measured at laboratory scale and the PCM behavior in the real application. It is clear that a PCM melting temperature different from what expected can affect product quality and, similarly, diverse latent heat of fusion values can limit the effectiveness of the LTES system.

In this work, the melting characteristics of the commercial RT2HC paraffin are investigated. An experimental setup is built which consists of an airtight box. The walls are made of 6 cm thick expanded polystyrene (XPS) insulation material. The box presents an air 15 cm cubic space. Inside the air volume, an aluminum box (42 x 42 x 40 mm), open at the top, is filled with PCM. The ratio between PCM and air volumes is around 2%. By means of T-type thermocouples, the temperatures of the air and of the RT2HC are monitored and recorded by an acquisition system. The box is previously cooled down up to 3 °C and the PCM down to -10 °C in order to ensure its complete solidification before running the experimental test. Subsequently, the box is put inside a climate chamber maintained at a constant temperature of 30 °C. The experimental measurements of temperatures as function of time are compared with results coming from numerical simulations. In fact, the same system is numerically investigated in Ansys Fluent environment by adopting the well validated solidification and melting model. It is obtained that the melting process starts at a similar moment but the melting time of the numerical model is noticeably higher. It can be inferred that the paraffin, when in operation, presents a latent heat value which is lower than what declared. Therefore, at the designing stage of an LTES system, it is essential to take into consideration the potential occurrence of a lower PCM latent heat value. The results also suggest that additional studies on PCM characteristics are needed.