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The effects of thermistor linearization techniques on the T-history characterization of phase change materials

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A B S T R A C T

Phase Change Materials (PCMs) are increasingly being used in the area of energy sustainability. Thermal characterization is a prerequisite for any reliable utilization of these materials. Current characterization methods including the well-known T-history method depend on accurate temperature measurements. This paper investigates the impact of different thermistor linearization techniques on the temperature uncertainty in the T-history characterization of PCMs. Thermistor sensors and two linearization techniques were evaluated in terms of achievable temperature accuracy through consideration of both, nonlinearity and self-heating errors. T-history measurements of RT21 (RUBITHERM® GmbH) PCM were performed. Temperature measurement results on the RT21 sample suggest that the Serial–Parallel Resistor (SPR)[1] linearization technique gives better uncertainty (less than ±0.1 °C) in comparison with the Wheatstone Bridge (WB)[1] technique (up to ±1.5 °C). These results may considerably influence the usability of latent heat storage density of PCMs in the certain temperature range. They could also provide a solid base for the development of a T-history measuring device.

1. Introduction

In the past few years the utilization of Phase Change Materials (PCMs) in applications for reduction of energy consumption and CO_2 emission has grown significantly [1]. Thermal characterization of these materials is essential prior to any application. Namely, according to Mehling and Cabeza [1] the commercial TES systems using PCMs as well as the heat transfer models involving phase change lack the experimentally determined material data, especially in terms of the heat release/storage density variation with temperature. Additionally, the accuracy of the reported results is questionable due to variant reports by different researchers as also indicated by Mehling and Cabeza [1]. This is one of the main limiting factors for the effective applications of PCMs.

Differential Scanning Calorimeter (DSC) and T-history are the two most commonly used methods for the investigation of thermophysical properties of PCMs, as indicated in the comprehensive reviews written by Zalba et al. [2] and Zhou et al. [3] as well as in the research conducted by Castellon et al. [4], Zuo et al. [5], Cheng et al. [6] and Yinping et al. [7]. The DSC method has significant drawbacks mainly in terms of the limited sample size [7], possible temperature gradient that can be created inside the sample [4], and relatively low signal to noise ratios [1]. The small sample size in DSC tests which results in higher degree of subcooling and lower degree of phase segregation [7] is the reason T-history was used in this study.

PCMs are able to store/release large amounts of heat in a narrow temperature range of few degrees. Günther et al. [8] reported that the typical temperature ranges of PCM applications are in the order of ±10 °C around the phase change temperature of the material. Nevertheless, this range in practice is sometimes reduced to ±5 °C or less (e.g. in free cooling applications) implying that the maximum decrease in the temperature uncertainty associated with the measurements on the PCMs is very important since it could provide a more optimal usage of these materials. The decrease in uncertainty can be achieved through the application of accurate temperature sensors during T-history measurements. In addition to temperature accuracy, the size of the sensor should be kept small enough in order to reduce any interference during the phase change process. The cause of such interference is due to the physical presence of the temperature sensor inside the PCM sample which can act as a nucleating agent and thereby change the natural course of the phase change process resulting in incorrect determination of PCM properties (e.g. the degree of subcooling) [1].

The majority of the T-history studies reported in the literature has not emphasized either the accuracy of the applied sensors or any other relevant sensor selection criteria as reported in the

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[1] Serial–Parallel Resistor (SPR), Wheatstone Bridge (WB).

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