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Experimental investigation on the heat charging process by paraffin filled with high porosity copper foam

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ABSTRACT

An experimental setup was designed and built in which the paraffin was used as phase change materials and copper foam as filled materials. Experiments examining the heat charging process were carried out under two conditions: paraffin filled with and without copper foam. The time histories of the collected temperature under various conditions were plotted and the results were discussed. The results indicate that the foam material not only leads to a more uniform temperature distribution within the thermal energy storage unit, but also extensively shortens the charging time.

1. Introduction

Amongst various heat storage techniques, latent heat storage is particularly desirable mostly due to its ability to provide a high-energy storage density and its characteristics to store heat at a constant temperature [1,2]. The use of the latent heat of PCM as a thermal energy storage medium has received considerable attention recently by its applications in the areas of space craft, air conditioning systems, solar energy systems etc [3,4]. However, practical difficulties usually arise while employing the latent heat method resulting from the low thermal conductivity, density change, stability of properties under extended cycling and sometimes phase segregation and subcooling of the PCMs.

With regard to the low thermal conductivity of PCM, several ideas and systems have been proposed to enhance its heat transfer performance. These heat transfer enhancement studies can be grouped into the following categories: (1) having the PCM inserted by a metal [5]; (2) adding metallic particles with higher thermal conductivity than the PCM to the PCM [6]; (3) macro and micro encapsulating the PCM [7]; (4) using PCM-graphite composite material [8,9] or other PCM composite materials [10,11].

High porosity (usually over 85%) open-celled metallic foams are considered as one type of the most promising materials to enhance heat transfer due to their high thermal conductivities and high surface area densities. Tong and Khan [12] inserted a high porosity metal matrix into PCM to improve its heat transfer performance. Zhao et al. [13] numerically and experimentally studied the natural convection in open-celled metal foams and found the effect of natural convection was significant due to the high porosity and inter connected open-cells, Zhou and Zhao [14] experimental study on heat transfer characteristics of PCMs embeden in open-cell metal foams and expanded graphite, Chen et al. [15] found the temperature distribution in paraffin embeded with metal foam was more uniform than that of pure paraffin.

In order to examine the heat charging process of the phase change materials could be enhanced by metal foams, solid/liquid phase change heat transfer in metal foams is experimentally investigated in this paper. Specifically, an experimental system was designed and built wherein paraffin was used as the phase change materials and copper foam as filled materials. Experiments inspecting the setup's heat transfer process were conducted. The temperature field was measured using Agilent 34970A. The time histories of the collected temperature under various conditions were plotted and the results were discussed.

2. Experimental

PS58 PCM was used as phase change materials and copper metal foam with 20 ppi and 96% porosity as filled materials. The PCM was stored in a stainless steel cylindrical storage shell with inner diameter of 126 mm and height of 315 mm, covered by a horizontally-mouthed stainless steel plate on the top with a diameter of 130 mm and a thickness of 3 mm. Meanwhile, a 25 mm-diameter

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