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Experimental investigation on convective heat transfer of magnetic phase change microcapsule suspension

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ABSTRACT

This paper is to conduct experimental investigation on the convective heat transfer of magnetic phase change microcapsule (MPCMC) suspension in the presence of an external non-homogenous magnetic field. The effects of the external magnetic field intensity, the volume fraction of MPCMC particles and the mass flow rate of MPCMC suspension on the convective heat transfer of MPCMC suspension are investigated. The experimental data reveal that the convective heat transfer of MPCMC suspension is significantly enhanced by the external non-homogenous magnetic field.

1. Introduction

Scientists and engineers have been searching for new types of working fluids to enhance and control energy transport processes. Microencapsulated phase change material (MEPCM) suspension is one of such novel multiphase fluids, which consists of microencapsulated phase change material particles and conventional base fluids. Within the temperature range of solid–liquid phase change, the phase change material (PCM) absorbs or releases the latent heat during its melting or crystallization process which results in the attractive ability of heat storage of MEPCM suspension [1]. Therefore, the MEPCM suspension has been investigated through the way of numerical simulation or experiment for a variety of applications [2–9]. Rhafiki presented a physical model for laminar forced convection heat transfer of microencapsulated phase change material suspension in a circular tube with the constant heat flux [2]. Diaconu developed a microencapsulated phase change material suspension with high concentrations and built an experimental setup to quantify the natural convection heat transfer occurring from a vertical helically coiled tube immersed in the MEPCM suspension [3]. Chen experimentally studied the heat transfer characteristics of a kind of MEPCM suspension formed by microencapsulating industrial-grade 1-bromohexadecane as the phase change material and put forward a new expression of Ste according to the physical definition of Stefan number [7]. Rao investigated the convective heat transfer characteristics of water-based suspension of MEPCM flowing through rectangular copper minichannels [9]. A recent review paper introduced the state-of-art development of phase change material emulsions and microencapsulated phase change material slurries, including their preparation techniques, properties, and applications [10].

So far most of MEPCM suspensions just utilized the latent heat storage ability of phase change materials and showed poor controllability of flow and heat transfer processes of the suspensions. If one can adjust the flow and heat transfer features of MEPCM suspensions by means of some external physical fields, these suspensions will find more applications for some specified purposes. The characteristics of magnetic nanofluids remind us of an approach of realizing the adjustability of MEPCM suspensions by using the external magnetic field. In fact, magnetic nanofluid of magnetic fluid is one of functional fluids and it has both the dynamic characteristic of liquid and the magnetic properties of the bulk magnetic material, which has an ability of responding to an external magnetic field. Some of its thermal parameters (such as density, viscosity, thermal conductivity, etc.) will change with the external magnetic field. Thus magnetic fluid is a controllable heat transfer fluid and its flow and energy transport process can be controlled by the external magnetic field [11]. Motozawa experimentally investigated the heat transfer characteristics of a magnetic fluid subjected to magnetic field in the rectangular duct. The heat transfer coefficient largely increases in the area where magnet field exists [12]. Yamaguchi experimentally and numerically studied the natural convections of a magnetic fluid in a cubic cavity under

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