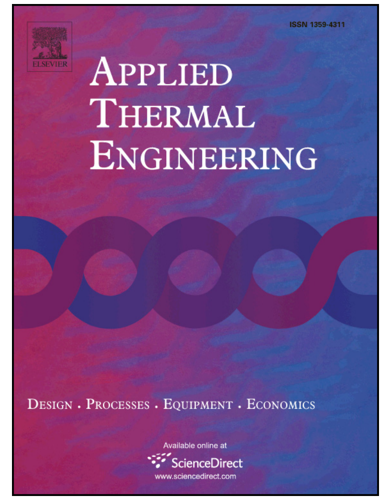

Numerical and Statistical Study on Melting of Nanoparticle Enhanced Phase Change Material in a Shell-and-Tube Thermal Energy Storage System

Mohammad Parsazadeh, Xili Duan

PII: S1359-4311(16)31883-X
DOI: http://dx.doi.org/10.1016/j.applthermaleng.2016.09.133
Reference: ATE 9158

To appear in: *Applied Thermal Engineering*

Received Date: 10 April 2016
Revised Date: 21 September 2016
Accepted Date: 23 September 2016

Numerical and Statistical Study on Melting of Nanoparticle Enhanced Phase Change Material in a Shell-and-Tube Thermal Energy Storage System

Mohammad Parsazadeh, Xili Duan[1]

Faculty of Engineering and Applied Science, Memorial University of Newfoundland

St. John's, Newfoundland, Canada A1B 3X5

Abstract

This paper presents a numerical and statistical study on heat transfer and energy storage performance of a vertical shell and tube thermal energy storage unit, where CuO – water nanofluid is used as heat transfer fluid (HTF) in the tube and CuO – paraffin nanoparticle enhanced phase change material (NePCM) is used on the shell side for latent thermal energy storage. A computational fluid dynamics (CFD) model is developed to simulate the laminar nanofluid flow, melting of NePCM and the overall heat transfer between the HTF and NePCM, where an enthalpy porosity technique is used in modeling the melting process. With this numerical model, the response surface methodology (RSM) is applied to statistically investigate the effects of three main operational parameters on the NePCM melting process: (1) concentration of CuO nanoparticles in the HTF, with a range of 0 - 4 vol. %; (2) concentration of CuO nanoparticles in the NePCM, with a range of 0 - 7 vol. %; and (3) inlet temperature of the HTF. Thermophysical properties of the NePCM are considered to be temperature dependent in the analysis. Face-centered central composite design (CCF) is employed to find the significant factors and their interactions in affecting liquid fraction rate in the melting process. It is found that changes in all these three factors are responsible for 99.8% liquid fraction variation, with HTF inlet temperature as the most significant parameter. Moreover, all three factors show a parabolic behavior on the liquid fraction variation. Finally, a regression model is developed for prediction of liquid fraction in the NePCM.

[1] Corresponding author: Tel: + 1 709 864 7108, Email address: xduan@mun.ca