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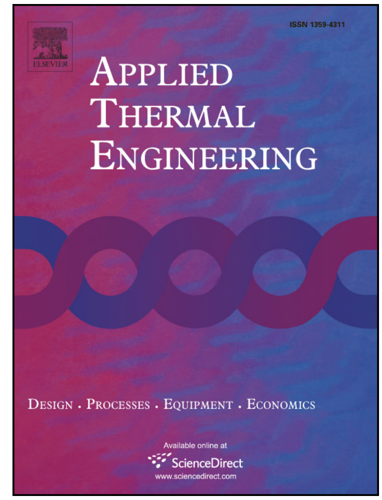

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Feng Zhu, Chuan Zhang, Xiaolu Gong

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Numerical analysis on the energy storage efficiency of phase change material embedded in finned metal foam with graded porosity

Feng ZHU, Chuan ZHANG, Xiaolu GONG*
Charles Delaunay Institute, Laboratory of Mechanical System and Simultaneous Engineering, University of Technology of Troyes, UMR CNRS 6281, 12 Rue Marie Curie, 10004 Troyes, France
(*) Correspondent author, Tel: 33 3 25 71 56 70 Fax: 33 3 25 71 56 75
e-mail：gong@utt.fr

Abstract

The metal foam/phase change material (PCM) composite is a promising material in the thermal energy storage system. In the present study, a modified structure of metal foam, finned metal foam with graded porosity (FFGP), is proposed to further accelerate the melting process of the composite. The finite volume method and two equations model are applied in the modeling of FFGP. The average power of energy storage is defined to evaluate the energy storage efficiency of the composite. The effects of the structural parameters of FFGP on the average power of energy storage are investigated, including thickness of metal fin, porosity gradient of metal foam and pore per inch (PPI). The results indicate that FFGP structure could reduce the total melting time and enhance greatly the energy storage performance. This is because the metal fin changes the melting sequence of PCM and the gradient metal foam contributes to the heat transfer between the heat source and the composite. Besides, the value of PPI has a great impact on natural convection in the composite. Through combining the proper metal fin, gradient metal foam and PPI, the FFGP structure with the good performance could be obtained.

Keywords: metal foam; graded porosity; metal fin; phase change material; heat transfer enhancement

Nomenclature

Symbols			
A	interfacial area density (m^{-1})	T_{m2}	upper melting temperature, K
C	consecutive number	**U**	velocity filed, ($m\ s^{-1}$)
C_l	specific heat of liquid phase ($J\ kg^{-1}\ K^{-1}$)	x,y	Cartesian coordinates
C_s	specific heat of solid phase ($J\ kg^{-1}\ K^{-1}$)		
d_f	cell ligament diameter (m)	*Greek symbols*	
d_p	cell pore average diameter (m)	α	constant number
e	energy saturation (%)	β	volume fraction of the liquid
E	energy (J)	λ	thermal conductivity ($W\ m^{-1}\ K^{-1}$)
F	term source	∆	porosity gradient (%)
g	gravity ($m\ s^{-2}$)	ρ	density ($kg\ m^{-3}$)
Gr	Grashof number	ε	porosity (%)
h	heat transfer coefficient ($W\ m^{-2}\ K^{-1}$)	μ	dynamic viscosity ($kg\ m^{-1}\ s^{-1}$)
H	thickness of fin (mm)	γ	thermal expansion coefficient (K^{-1})
K	permeability (m^2)		