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Latent heat thermal energy storage tanks for space heating of buildings: Comparison between calculations and experiments

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Abstract

Latent heat thermal energy storage tanks, where carbon fiber brushes are inserted to improve the heat transfer rates in the phase change materials, are installed in an air conditioning system of a building as a space heating resource. The measured outlet fluid temperatures are compared with the numerical ones predicted by a previously developed three dimensional heat transfer model. The preliminary numerical results had unallowable prediction errors, which probably resulted from poor contact between the brushes and the heat transfer tubes due to an installation problem of the brushes. However, the numerical results predicted by a corrected model agree well with the experimental ones under various operating conditions. The effect of the brushes on the thermal outputs of the tanks is then investigated using the corrected model. The result shows that the brushes contribute to saving space and reducing the cost of the tanks.

Keywords: Latent heat thermal energy storage; Thermal conductivity enhancement; Carbon fiber; Numerical; Experiment; Space heating

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Nomenclature

c_p	specific heat (J/kg K)
d_b	diameter of brush (m)
h	heat transfer coefficient (W/m^2 K)
k	thermal conductivity (W/m K)
$\boldsymbol{k}$	thermal conductivity tensor (W/m K)
n	coordinate normal to boundary surface (m)
q	heat transfer rate (W)
Q	thermal energy (J)
r	radial distance (m)
s	coordinate along center of tube (m)
t	time (s)
T	temperature (K)
u_h	mean fluid velocity (m/s)
V	flow rate (m^3/s)
X_{fa}	volume fraction of fibers in brush
X_f	local volume fraction of fibers

Greek symbol

ρ	density (kg/m^3)

Subscripts

0	initial
c	composite
ch	charge
dis	discharge
eff	effective
f	fiber
h	heat transfer fluid
in	inlet
out	outlet
t	tube wall
tot	total

1. Introduction

Thermal energy storage systems play an important role in solving many energy conservation programs [1–4]. Accordingly, phase change materials (PCMs) have lately attracted great interest as thermal storage materials because the thermal energy is stored with a high density. A typical phase change material is water/ice. Latent heat thermal energy storage (LHTES) systems using water/ice, i.e. an ice storage system, are commonly used for peak shifts in electrical demand.