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Performance analysis of a direct-contact thermal energy storage-solidification

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Abstract

Performance of a direct-contact latent heat energy storage during discharging process has been investigated. The storage medium used is sodium thiosulphate pentahydrate of which the melting temperature is 48°C and the heat exchanging fluid is heat transfer oil. An empirical expression to evaluate the volumetric heat transfer coefficient has been carried out. A lumped analysis is also found to be quite suitable to analyze the temperature of the storage medium and its solid fraction including the temperature of the oil leaving the storage. The results agree well with those of the experiments.

Keywords: Latent heat storage; Direct-contact heat transfer; Solidification

1. Introduction

Energy storage is essential whenever the supply of energy cannot meet the demands. In latent heat storage, thermal energy is stored in materials which undergo change of phase in a suitable temperature range. Solid–liquid transformation is most commonly utilized and the energy stored could be

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Nomenclature

C_p	specific heat, J/kgK
h	specific enthalpy, J/kg
k	thermal conductivity, W/mK
λ	latent heat, J/kg
M	mass of storage medium, kg
$\dot{m}$	mass flow rate of fluid injected, kg/s
Pr	Prandtl number
$\dot{Q}$	heat transfer rate, W
St	Stanton number
Ste	Stefan number
T_{oil}	oil temperature, °C
T_s	storage temperature, °C
$(\Delta T)_{lm}$	log mean temperature difference, °C
Δt	time lapse, s
U_v	volumetric overall heat transfer coefficient, W/m^3K
V	volume of the storage medium, m^3
x	solid fraction

Greek symbols

μ absolute viscosity, Ns/m^2

Subscripts

l liquid (fluid injected)

s storage

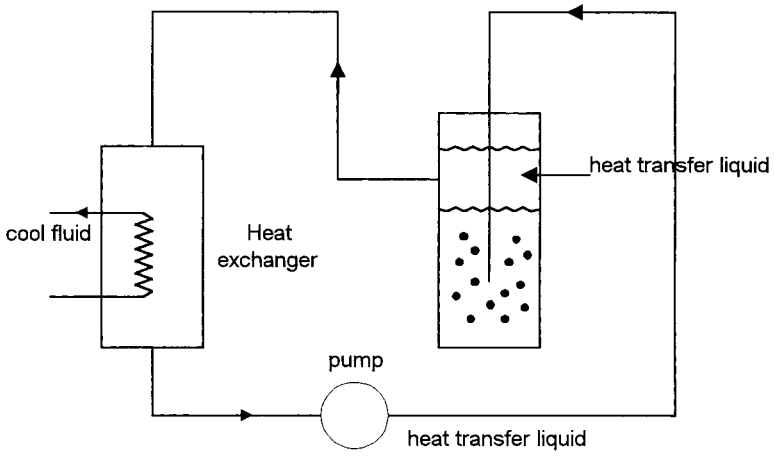

Fig. 1. Schematic of the direct-contact thermal energy storage.