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Performance Analysis of a Latent Heat Thermal Energy Storage System for Solar Energy Applications

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Abstract

In every solar thermal energy applications, the storage of solar energy is the most critical section of the system. To store the available solar energy at its maximum is a big challenge for the storage system. This challenge can be competed with the aid of a latent heat thermal energy storage system as it is compact and it possess high storage density. But the problem existing is cost minimization. A low cost PCM can solve this problem, from the literature survey Sodium thiosulfate pentahydrate is found to be a PCM of low cost with high latent heat of fusion and its melting point is within the desired operating environment. In order to analyze the system performance with Sodium thiosulfate pentahydrate as storage medium, the usefulness of stored energy is to be measured. But energy analysis only is inadequate to find the usefulness of stored energy. To determine this, exergy analysis based on second law of thermodynamics is required. In this work, the energy and exergy studies were experimentally done during the charging period of phase change material with a heat input of 2000W and four different mass flow rates of heat transfer fluid.

Keywords: *energy analysis; exergy analysis; phase change material; solar energy*

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Nomenclature

A	cross sectional area at outlet section of storage tank	m^2
d	inner diameter of storage tank	m
D	outer diameter of storage tank	m
g	acceleration due to gravity	m/s^2
k	thermal conductivity of HTF	W/m K
L	length of storage tank	m
$\dot{m}$	mass flow rate of HTF	kg/s
V	velocity of HTF at outlet section of the storage tank	m/s
C_{HTF}	specific heat capacity of HTF	J/kg K
C_{PCM}	specific heat capacity of PCM	J/kg K
Ex	exergy	J
Gr_D	Grashof's number based on outside diameter	
h_i	inside heat transfer coefficient	W/m^2
h_o	outside heat transfer coefficient	W/m^2
k_{PVC}	thermal conductivity of PVC	W/m K
Nu_d	Nusselt number based on inside diameter	
Nu_D	Nusselt number based on outside diameter	
Pr	Prandtl number	
Re_d	Reynolds number based on inside diameter	
r_i	inner radius of storage tank	m
r_o	outer radius of storage tank	m
T_e	environmental temperature	K
T_f	film temperature	K
$T_{HTF,in}$	inlet temperature of HTF	K
$T_{HTF,out}$	outlet temperature of HTF	K
T_m	mean temperature of HTF in storage tank	K
T_{PCM}	melting point of PCM	K
$T_{PCM,final}$	final temperature of PCM	K
$T_{PCM,in}$	initial temperature of PCM	K
Ts	outer surface temperature of storage tank	K
μ	absolute viscosity	Ns/m2
ν	kinematic viscosity	m2/s
β	volumetric thermal expansion coefficient	K-1
Ψ	exergy efficiency	
ρ	density of HTF	kg/m3

1. Introduction

In the today's world situation of growing energy crisis, renewable energy sources stands as the only possibility. Even among that, solar energy is considered to be the best because of its cheap availability and cheaper means of tapping. For the consistent utilization of this, storing is essential because its availability is intermittent. Sensible heat storage, latent heat storage and thermo-chemical storage are the various practices of storing solar energy. Latent heat storage has advantages over other methods because it is compact, economically viable and