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Performance analysis of a solar process heat system

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Abstract

This paper describes the results of a simulation study, validated by experimental results of a solar process heat system and represents the unsteady performance analysis of the system. The study focuses on the effect that the collector flow rates, temperature distribution and stratification have on the overall thermal and exergetic performance of the particular systems. The simulation is performed for the process heat system established in İzmir, Turkey. The analysis considers the unsteady-state thermal and exergetic analysis of the collector and the storage tank individually. The variation of the storage tank temperature is evaluated along the height of the storage tank at every hour during a day. The values obtained from the measurements at the İzmir Organize Sanayi Bölgesi-Industrial Process Heat System are compared with the predicted simulation results. The effects of the mass flow rates and temperature distribution of the load and collector on the performance of the system are discussed. The simulation results indicate that the exergetic efficiency is highly dependent on the ratio of mass flow rates and the use of an auxiliary heater in the system.

Keywords: Solar energy; Second-law analysis; Parabolic collector; Process heat system

1. Introduction

Solar thermal technologies are capable of providing heat across a wide range of temperatures, making them potentially attractive for meeting end use energy requirements in

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Nomenclature

A area (m^2)
c specific heat at constant pressure (J/kg °C)
D storage tank diameter (m)
d diameter (m)
$\dot{E}$ energy rate (W)
$\dot{E}x$ exergy rate (W)
F multiplier
f friction factor
g acceleration of gravity (m/s^2)
h convective heat transfer coefficient (W/m^2 °C)
I solar insolation incident on collector (W/m^2)
k thermal conductivity (W/m K)
L absorber length (m)
m mass (kg)
$\dot{m}$ mass flow rate (kg/s)
m specific flow rate (kg/s m^2)
P periphery (m)
Δp pressure drop (Pa)
S entropy (J/K)
T temperature (°C)
t time (s)
U overall heat transfer coefficient (W/m^2 °C)
V velocity (m/s)
w reflector aperture (m)
Φ mass ratio
α absorptance
γ_r interception factor
η collector efficiency
ρ density (kg/m^2)
θ temperature ratio
$\tau\alpha$ absorptance-transmittance product

Subscripts
a absorber pipe
ap absorber pipe to pyrex envelope
c collector, convective
d storage tank
e effective
i inside, inlet
gen generation