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Vishwa Deepak Kumar
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List of Symbols

Symbol	Description
A	Area (m^2)
A_{ov}	receiver area (m^2)
Bi	Biot number
C	central absorber
CR	concentration ratio
Cp	Specific heat, (J/kg-K)
C_{p_c}	the specific heat capacity of air for charging ($Jkg^{-1}K$)
C_{p_d}	the specific heat capacity of air for discharging ($Jkg^{-1}K$)
CP	coefficient of pressure
cp,sm	the specific heat capacity of storage material ($Jkg^{-1}K$)
cpm	the specific heat capacity of metal sheet ($Jkg^{-1}K$)
D	Diameter (m)
d	pebble diameter (m)
d_{ab}	Diameter of absorber (m)
D_{cas}	Diameter of the casing (m)
dh	Hydraulic diameter (m)
Dh	hydraulic diameter (m)]
d_{pr}	Diameter of pore (m)
D_R	Diameter of a ring (m)
E_{av}	Available energy (J)
E_H	Heating energy (J)
E_{HC}	energy transferred from hot air to primary storage during charging (J)
E_M	The energy stored in a metal sheet during heat treatment (J)
E_P	Pumping energy (J)
E_{PC}	the energy required for the pump workduring charging (J)
E_{PD}	the energy required for the pump work during discharging (J)
E_R	Recovered energy (J)
$E_{scf.in}$	actual heat input to SCF during heat treatment (J)
E_{RD}	energy recovered from primary storage during discharging (J)
E_S	Stored energy (J)
$E_{s,max}$	storage capacity (J)
E_{S2}	energy stored in secondary storage (J)
E_{SC}	energy stored in primary storage during charging (J)
E_u	Useful energy (J)
F	View factor
f	friction factor
G	Gap, m
G	Mass flow rate per unit cross section (kg/m^2S)
h	Convective heat transfer coefficient (W/m^2-K)
H	height (m)
I	Irradiance, (W/m^{-2})
I''	monthly-averaged DNI (W/m^{-2})
K_L	Loss coefficient (Pa/m)
k	thermal conductivity ($Wm^{-1}K^{-1)}$
L	Length (m)
M	intermediate absorber

m	*Mass (kg)*
m_m	*mass of metal sheet (kg)*
M_{sm}	*mass of storage material (kg)*
$\dot{m}$	*Mass flow rate (kg/s)*
$\dot{m}_{ac}$	*the mass flow rate of air from ambient toSCF during charging (kg/s)*
$\dot{m}_{ad}$	*the mass flow rate of air from ambient to SCF during discharging (kg/s)*
$\dot{m}_{c}$	*the mass flow rate of air for charging ofprimary storage (kg/s)*
$\dot{m}_{d}$	*the mass flow rate of air for discharging ofprimary storage (kg/s)*
$\dot{m}_{diff}$	*the mass flow rate of air fraction of $\dot{m}_{ov}$ entering SCF (kg/s)*
$\dot{m}_{f}$	*the mass flow rate of air entering SCF during charging (kg/s)*
$\dot{m}_{ov}$	*the mass flow rate of air from OVAR (kg/s)*
$\dot{m}_{scf}$	*the mass flow rate of air at the inlet of SCF (kg/s)*
N_{ab}	*Total number of absorbers*
NL	*number of rows in the heater*
np	*Number of pores*
N_R	*Number of the absorber in ring*
Nu	*Nusselt number*
$Nu_{x,Dh}$	*local Nusselt number based on hydraulic diameter*
P	*peripheral absorber*
P_f	*time-averaged power rating of the industrial ASF (W)*
Pr	*Prandtl number*
$\dot{q}$	*Power (W)*
Q	*Volume flow rate (m^3/s)*
q''_{in}	*Heat flux (W/m^2)*
$\dot{Q}_{a-p}$	*Rate of heat gain by pipe (W)*
$\dot{Q}_{p-amb}$	*Rate of heat loss to ambient (W)*
$\dot{q}_{cond}$	*Rate of heat transfer due to conduction (W)*
$\dot{q}_{conv}$	*Rate of heat transfer due to convection (W)*
$\dot{q}_{gen}$	*Volumetric heat generation (W/m^3)*
$\dot{q}_{rad}$	*Rate of heat transfer due to radiation (W)*
$\dot{Q}$	*Rate of heat transfer (W)*
Q_{in}	*The required heating rate in SCF (W)*
$\dot{Q}_{cas}$	*the rate of heat transfer to the outer casing (W)*
$\dot{Q}_{id}$	*the rate of heat transfer to the inlet dome (W)*
$\dot{Q}_{ins}$	*the rate of heat transfer to the insulation (W)*
$\dot{Q}_{m}$	*the rate of heat transfer to the metal casing (W)*
$\dot{Q}_{peb}$	*the rate of heat transfer to the pebbles (W)*
$\dot{Q}_{scf}$	*the required heating rate in SCF (W)*
$\dot{Q}_{sil}$	*rate of heat transfer to silicone rubber (W)*
r	*Radius (m)*
Ra	*Rayleigh number*
Re	*Reynolds number*
$Re_{D,max}$	*Reynolds number based on maximum velocity and rod diameter*
Re_{d_pr}	*Reynolds number based on pore diameter*
Re_{Dh}	*Reynolds number based on hydraulic diameter*
Re_{max}	*Reynolds number based on maximum velocity*
R_{th}	*Thermal resistance (K/W)*
Sl	*longitudinal pitch (m)*
S_T	*Stratification coefficient*

St	*transverse pitch (m)*
T	*Temperature (K)*
t	*Time, s*
tc	*charging time (s)*
td	*discharging time (s)*
TF	*air temperature at point F (K)*
T_{ac}	*ambient air temperature at SCF inlet (K)*
T_{fi}	*air temperature at SCF inlet (K)*
T_{fo}	*air temperature at SCF outlet (K)*
T_{ov}	*air temperature at OVAR Outlet (K)*
$T_{S1i,C}$	*air temperature at TES1 inlet (K)*
$T_{S1o,C}$	*air temperature at TES1 outlet (K)*
T_{Scf}	*air temperature at SCF inlet (K)*
T_G	*air temperature at point G (K)*
th	*heating time (s)*
Th,in	*air temperature at hearth inlet (K)*
Ti	*air temperature before metal sheet (K)*
Tm	*metal temperature (K)*
To	*air temperature after metal sheet (K)*
T_{out}	*Average primary air outlet temperature (K)*
$Tpsi$	*air temperature at the inlet of primary storage (K)*
$Tpso$	*air temperature at outlet of primary storage (K)*
$Ts2i$	*air temperature at the inlet of secondary storage (K)*
$Ts2o$	*air temperature at the outlet of secondary storage (K)*
v	*velocity (m/s)*
v_∞	*air velocity at the inlet of main heater (m/s)*
$\dot{V}$	*the volume flow rate of air (m^3/s)*
V_{TES}	*the volume of TES (m^3)*
$\dot{\chi}$	*Rate of exergy (W)*
$\forall$	*Volume (m^3)*
x	*axial length (m)*
z	*Axial length (m)*
η	*Thermal efficiency*
ψ	*Exergy efficiency*
ε	Porosity
ϵ	emissivity
β	extinction coefficient
σ	Variance
ρ	Density
θ	azimuthal angle
μ	dynamic viscosity (Pa-s)

List of Abbreviations

Abbreviation	*Full form*
AA	*Ambient Air*
ARR	*Air Return Ratio*
ASF	*Aluminum Soaking Furnace*
CP	*Coefficient-of-Pressure*
CST	*Concentrated Solar Thermal*
DNI	*Direct Normal Irradiance*
EHU	*External Heating Unit*
FoM	*Figure of Merit*
HTF	*Heat Transfer Fluid*
LHS	*Latent Heat Storage*
mfr	*Mass Flow Rate*
OVAR	*Open Volumetric Air Receiver*
POA	*Power On Aperture*
QSST	*Quasi Steady State Time*
RAFC	*Return Air Flow Chamber*
SATS	*Solar Air Tower Simulator*
SCF	*Solar Convective Furnace*
SHS	*Sensible Heat Storage*
TES	*Thermal Energy Storage*