

List of Symbols

Symbol	Description
A_b	Cross sectional area of a partly blocked pore (m^2)
A_c	Cross sectional area of a clean pore (m^2)
A_{c_c}	Cross sectional area of 1/6 th section of central absorber (m^2)
A_{cs}	Cross sectional area of an absorber (m^2)
A_{tot}	The area exposed to concentrated solar irradiance (m^2)
A_{cas_c}	Cross sectional area of 1/6 th section of casing (m^2)
A_{p_c}	Cross sectional area of peripheral absorber (m^2)
$A_{ps_{cl}}$	Wetted surface area of a clean pore (m^2)
$A_{ps_{bl}}$	Wetted surface area of a partly blocked pore (m^2)
A_{rc}	Area of influence region around central absorber (m^2)
A_{return}	Area of return air flow (m^2)
A_{rp}	Area of influence region around peripheral absorber (m^2)
A_{np}	Total flow area of absorber (m^2)
A_{pore}	Cross-section area of absorber pore (m^2)
B, B'	The coefficients in the quadratic pressure difference
B_c	Width of inlet duct of cyclone separator (m)
C_d	Drag coefficient
c	Coefficient
$C_{p_{ac}}$	Specific heat of primary air in central absorber (kJ/kgK)
$C_{p_{ap}}$	Specific heat of primary air in peripheral absorber (kJ/kgK)
C_{p_c}	Specific heat of central absorber (kJ/kgK)
$C_{p_{cas}}$	Specific heat of casing (kJ/kgK)
C_{pf}	Specific heat for fluid/air (kJ/kgK)
C_{p_p}	Specific heat of peripheral absorber (kJ/kgK)
$C_{p_{rc}}$	Specific heat of return air in central absorber (kJ/kgK)
$C_{p_{rp}}$	Specific heat of return air in peripheral absorber (kJ/kgK)
d_{cl}	Hydraulic diameter of a clean pore (m)
d_{bl}	Hydraulic diameter of a partly blocked pore (m)
d_{out}	Outer diameter of an absorber pore (m)
d_{pore}	Diameter of an absorber pore (m)
dA_{c_s}	Surface area of differential element section for central absorber (m^2)
dA_{p_s}	Surface area of differential element section for peripheral absorber (m^2)
dA_{cas_s}	Surface area of differential element section for casing (m^2)
dA_{nh_c}	Surface area of differential element section for pores in central absorber (m^2)
dA_{nh_p}	Surface area of differential element section for pores in peripheral absorber (m^2)
dA_{pl}	Surface area of lower half of peripheral absorber (m^2)
dA_{pu}	Surface area of upper half of peripheral absorber (m^2)
d_{pc}	Cut point diameter (m)
d_{pj}	Diameter of particle entering in a cyclone separator (m)
dV_{a_c}	Volume of differential element section for primary air in central absorber (m^3)
dV_{a_p}	Volume of differential element section for primary air in peripheral absorber (m^3)
dV_{ab_c}	Volume of differential element section for central absorber (m^3)
dV_{ab_p}	Volume of differential element section for peripheral absorber (m^3)
dV_{cas}	Volume of differential element section for casing (m^3)
dV_{rc}	Volume of differential element section of region r_c (m^3)
dV_{rp}	Volume of differential element section of region r_p (m^3)
dm_{cas}	Mass of differential element of casing (kg)
D_c	Diameter of a cyclone separator (m)
D_e	Outlet diameter of cyclone separator (m)
F_b	Buoyant force (N)

F_c	Centrifugal force (N)
F_{c_pl}	View factor of central absorber to peripheral absorber
F_{cas_pu}	View factor of casing to peripheral absorber
F_d	Drag force (N)
F_{pl_c}	View factor of peripheral absorber to central absorber
F_{pu_cas}	View factor of peripheral absorber to casing
g	Gravitational acceleration (m/s^2)
G	Half of the gap between central and peripheral absorber ($G = S/2$) (m)
h_{a_c}	Heat transfer coefficient in pores of central absorber (W/m^2K)
h_{a_p}	Heat transfer coefficient in pores of peripheral absorber (W/m^2K)
h_{cl}	Heat transfer coefficient in a clean pore (W/m^2K)
h_{bl}	Heat transfer coefficient in a partly blocked pore (W/m^2K)
h_{rc_c}	Heat transfer coefficient in region r_c (W/m^2K)
h_{rp_cas}	Heat transfer coefficient in region r_p for casing (W/m^2K)
h_{rp_p}	Heat transfer coefficient in region r_p for peripheral absorber (W/m^2K)
H_c	Height of inlet duct of cyclone separator (m)
H_f	Total enthalpy of fluid/ air (kJ/kg)
H_v	Number of inlet velocity heads
I	Intensity of irradiance at a given location in Bouguer's law (W/m^2)
I_o	Intensity of incident irradiance in a pore (W/m^2)
k_c	Thermal conductivity of central absorber (W/mK)
k_d	Thermal conductivity of dust (W/mK)
k_{ca}	Thermal conductivity of primary air in central absorber (W/mK)
k_{cas}	Thermal conductivity of casing (W/mK)
k_{cr}	Thermal conductivity of return air in region r_c (W/mK)
k_p	Thermal conductivity of peripheral absorber (W/mK)
k_{pa}	Thermal conductivity of primary air in peripheral absorber (W/mK)
k_{pr}	Thermal conductivity of return air in region r_p (W/mK)
k_s	Thermal conductivity of solid (W/mK)
K	Pressure drop coefficient
K_p	The coefficient of pressure drop
K_∞	Pressure drop coefficient at a reference temperature
L	Length of absorbers (m)
L_c	Perimeter of $1/6^{th}$ section of central absorber (m)
L_{cs}	Barrel length of cyclone separator (m)
L_{cs}	Length of region 3 on casing (m)
L_{pl}	Perimeter of lower half of peripheral absorber (m)
L_{pu}	Length of region 1 on peripheral absorber (m)
\dot{m}_a	Mass flow rate of air (kg/s)
\dot{m}_{bl}	Mass flow rate of air in a partly blocked pore (kg/s)
\dot{m}_{cl}	Mass flow rate of air in a clean pore (kg/s)
\dot{m}_r	Mass flow rate of return air entering in the primary side of the absorber (kg/s)
\dot{m}_{rc}	Mass flow rate in region r_c (kg/s)
\dot{m}_{return}	Mass flow rate of return air (kg/s)
\dot{m}_{rp}	Mass flow rate in region r_p (kg/s)
m''	Mass flux of air (kg/m^2s)
n	Number of pores in absorber
n_b	Number of partly blocked absorber pores
n_c	Number of clean absorber pores
N_e	Number of helical turns
Nu	Nusselt number
p	Static pressure (Pa)
p_{inlet}	Absolute static pressure at the absorber inlet (Pa)
p_{outlet}	Absolute static pressure at the absorber outlet (Pa)

Pr	Prandtl Number
\dot{q}_a	Incident power on the absorber material of the pore (W)
\dot{q}_{CI}	Incident power in casing (W)
\dot{q}_{gen_c}	Volumetric heat generation in central absorber (W/m ³)
\dot{q}_{gen_p}	Volumetric heat generation in peripheral absorber (W/m ³)
\dot{q}_s	Incident power on a pore with absorber material (W)
\dot{q}_t	applied power on the circumference of absorber (W)
\dot{q}_p	Incident power on the inner surface of the absorber pore through the opening (W)
\dot{q}_{pr}	Power transferred to the primary air (W)
\dot{q}_{s_c}	Heat source term in central absorber (W)
\dot{q}_{s_p}	Heat source term in peripheral absorber (W)
q''_{in_c}	Incident concentrated heat flux on front wall of central absorber (W/m ²)
q''_{in_cas}	Incident concentrated heat flux on front surface of casing (W/m ²)
q''_{in_p}	Incident concentrated heat flux on front wall of peripheral absorber (W/m ²)
q''_{nu_c}	Non-uniform heat flux entering in pores of central absorber (W/m ²)
q''_{nu_p}	Non-uniform heat flux entering in pores of peripheral absorber (W/m ²)
\dot{q}_r	Power transferred to the return air (W)
q''_s	The concentrated solar irradiance on the receiver aperture (W/m ²)
\dot{Q}	Volume flow rate of air (m ³ /s)
r_{ab}	Radius of absorbers (m)
r_{cas_i}	Internal radius of casing (m)
r_{cas_o}	Outer radius of casing (m)
r_h	Radius of an absorber pore (m)
r_p	Radius of particle (m)
r_{pd}	Radius of particle (using drag coefficient) (m)
r_{ps}	Radius of particle (using Stokes Law) (m)
R	Gas constant of air (J/kgK)
R_{th_cl}	Thermal resistance offered by a clean absorber pore (K/W)
R_{th_bl}	Thermal resistance offered by a partly blocked absorber pore (K/W)
Re	Reynolds number
Re_{dh}	Reynolds number at cyclone separator inlet
Re_p	Reynolds number in an absorber pore
S	Shortest gap between absorbers (m)
t	Time (s)
t_d	Thickness of dust layer in an absorber pore (m)
T	Temperature (K)
T_{a_c}	Temperature of primary air in central absorber (K)
T_{a_p}	Temperature of primary air in peripheral absorber (K)
T_{atm}	Temperature of surroundings (K)
T_c	Temperature of central absorber (K)
T_{cas}	Temperature of casing (K)
T_o	Temperature of air at inlet of the absorber pore (K)
T_{out}	Temperature of air at the absorber pore outlet (K)
T_p	Temperature of peripheral absorber (K)
T_{rc}	Temperature of return air in central absorber (K)
T_{rp}	Temperature of return air in peripheral absorber (K)
v_p	Average speed of air in an absorber pore (m/s)
V_{in}	Inlet speed of air in cyclone separator (m/s)
V_r	Radial velocity (m/s)
V_t	Tangential velocity (m/s)
Z_c	Cone length of cyclone separator (m)
Δp	Pressure drop (Pa)
Δp_o	Total pressure drop in an open volumetric air receiver (Pa)

Δp_{∞}	Pressure drop at a reference temperature (Pa)
ε	Porosity of absorbers
ξ	Extinction coefficient (m^{-1})
ε_{ab}	Emissivity of absorber material
ε_{cas}	Emissivity of casing material
ρ	Reflectivity of absorber material
ρ_f	Density of fluid/air (kg/m^3)
ρ_{f_bl}	Density of air in a partly blocked pore (kg/m^3)
ρ_{f_cl}	Density of air in a clean pore (kg/m^3)
ρ_g	Density of gas (kg/m^3)
ρ_p	Density of particle (kg/m^3)
ρ_{a_c}	Density of primary air in central absorber (kg/m^3)
ρ_{a_p}	Density of air in peripheral absorber (kg/m^3)
ρ_{ab}	Density of absorbers (kg/m^3)
ρ_{rc}	Density of return air in region r_c (kg/m^3)
ρ_{rp}	Density of return air region r_p (kg/m^3)
ρ_{∞}	Density of air at a reference temperature (kg/m^3)
η_j	Collection efficiency of a cyclone separator
η_{th}	Thermal efficiency of an open volumetric air receiver
η_{ov}	Overall efficiency of an open volumetric air receiver
η_r	Efficiency ratio (η_{th}/η_{ov})
ζ_c	Pressure drop coefficient in Casal and Martinez model
μ	Dynamic viscosity of air (kg/ms)
ν	Kinematic viscosity (m/s^2)
ν_f	Kinematic viscosity of fluid/air (m/s^2)
ν_{f_bl}	Kinematic viscosity of air in a partly blocked pore (m/s^2)
ν_{f_cl}	Kinematic viscosity of air in a clean pore (m/s^2)
ν_{∞}	Kinematic viscosity of fluid/air at a reference temperature (m/s^2)
σ	Stephen-Boltzmann constant (W/m^2K^4)
Σ	Emissivity of solid