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Review

Solar updraft tower power generation

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Abstract

Solar updraft tower power generation has been demonstrated to be a promising approach for future applications of solar radiation to provide energy. In this paper, the history of the solar updraft tower power plant (SUTPP, also called solar chimney power plant) technology is reviewed, its characteristics are presented, and its principle is described. The experimental studies, main important factors of theoretical modelings, and cost studies, in the past few decades, are reviewed. The characteristics of novel non-conventional SUTPP technologies are discussed as well as environmental effect and power production conditions for the SUTPP technology.

Keywords: Solar updraft tower; Solar collector; Turbine; Power generation

Contents

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Nomenclature

A	area (m^2)
b	thermal effusivity ($W\ s^{1/2}/K\ m^2$)
C	cost (€)
c_p	specific heat capacity (J/kg K)
D	diameter (m)
d_h	hydraulic diameter (m)
F	force (N/m)
f	Darcy friction factor
g	gravitational acceleration, 9.81 (m/s^2)
H	height (m)
h	heat transfer coefficient (W/m^2 K)
i	interest rate (%)
inf	inflation rate (%)
k	thermal conductivity (W/m K)
m	pressure potential exponent or collector temperature rise exponent
$\dot{m}$	mass flow rate (kg/s)
N	length of service life (year)
Nu	Nusselt number
n	pressure loss exponent
P	power (W) or electricity (kW h)
Pr	Prandtl number
p	pressure (Pa)
q	heat flux (W/m^2)
R	specific gas constant of air (J/kg K)
Re	Reynolds number
r	radius (m)
S	global solar radiation (W/m^2)
T	temperature (K)
t	time (s)
V	volume flow rate (m^3/s)
v	velocity (m/s)
x	turbine pressure drop factor
z	depth in ground or height above ground (m)

Greek symbols

α	thermal diffusivity (m^2/s)
β	volumetric thermal expansion coefficient of air (1/K)
γ	specific heat ratio
Δ	difference
η	efficiency (%)
θ	angle (radian)
μ	dynamic viscosity (kg/m s)
ρ	density (kg/m^3)
τ	shear stress (Pa)
φ	effective absorption coefficient of collector
ψ	roof heat loss coefficient (W/m^2 K)

Subscripts

a	ambient air
avg	average
b	ground at a considerable depth
coll	collector
f	air flow
force	forced convection
g	ground
h	horizontal surface
ii	initial investment
nat	natural convection
no turb	without turbine
om	operation and maintenance
p	absorber surface
pb	absorber surface into ground
pf	absorber surface to airflow
poten	potential
pr	absorber surface to roof
r	roof
ra	roof to ambient air
rf	roof to airflow
rin	compression rings
rs	roof to sky
s	sky
sup	supports
sut	solar updraft tower
tg	turbine generators
turb	turbine
turb,i	turbine inlet
w	wind
1	surroundings on ground level
2	collector inlet
3	collector outlet
4	turbine inlet
5	turbine outlet
6	SUT outlet
7	atmosphere at the height of SUT outlet