DESIGN, OPTIMIZATION AND PERFORMANCE ANALYSIS OF SOLAR CHIMNEY USING CFD TECHNIQUE

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Abstract- Solar chimney power plants use the buoyancy-nature of heated air to harness the Sun's energy without using solar panels. The flow is driven by a pressure difference in the chimney system, so traditional chimneys are extremely tall to increase the pressure differential and the air's velocity. Computational fluid dynamics (CFD) was used to model the airflow through a solar chimney. Different boundary conditions were tested to find the best model that simulated the nighttime operation of a solar chimney assumed to be in Jaipur location. At night, the air is heated by the energy that was stored in the ground during the day dispersing into the cooler air. It is necessary to model a solar chimney with layer of thermal storage as a porous material for FLUENT to correctly calculate the heat transfer between the ground and the air. The solar collector needs to have radiative and convective boundary conditions to accurately simulate the night-time heat transfer on the collector. To correctly calculate the heat transfer in the system, it is necessary to employ the Roseland radiation model. Different chimney configurations were studied with the hopes of designing a shorter solar chimney without decreases the amount of airflow through the system. Clusters of four and five shorter chimneys decreased the air's maximum velocity through the system, but increased the total flow rate. Passive advections wells were added to the thermal storage and were analyses as a way to increase the heat transfer from the ground to the air.

Keywords- CFD, SCPP, Solar chimney, inclined collector, collector roof.

I INTRODUCTION

Current power generation from non-renewable energy sources like petroleum gas, oil or coal is harming to the earth and stresses the confinement that it depends upon non renewable energy sources. Many creating nations can't manage the cost of these customary energy sources, and in some of these areas atomic power is considered an unacceptable hazard. It has been demonstrated that an absence of energy might be associated with poverty and power to population explosion. The requirement for an ecologically benevolent and practical power creating plan is in this way obviously demonstrated and will turn out to be more articulated later on.

A conceivable answer for this consistently expanding issue is solar energy. It is a rich, inexhaustible wellspring of energy that exclusive should be tackled to be useful. Solar power plants being used on the planet are prepared to change solar oriented radiation into electrical energy by means of any of various cycles or common wonders. Maybe a couple, nonetheless, can store adequate energy during the day so a supply can be kept up during the night too; when the solar radiation is insignificant. The important limit of this stockpiling is typically too high to be in any way reasonable.

II SPECIFICATIONS OF DRIVE SHAFT

The collector is additionally named as the greenhouse; it is a unique sort of heat exchanger that changes solar radiation into thermal energy. The gatherer gives the primary normal wellspring of thermal to the plant. Dissimilar to CSP gatherers, which ingest just the immediate ordinary solar light (DNI), the gatherer for the solar chimney plant makes utilization of both the guide and the diffuse solar powered radiations to produce heat energy.

The material utilized for the gatherer rooftop is either plastic or glass. The covering or what is named as the coating concedes the short wave solar radiation part and holds long wave radiation from the heated ground, in that way the air underneath gets heated. The gatherer comes in different design in view of the materials utilized for its rooftop. It could be roundabout, or rectangular fit as a fiddle.

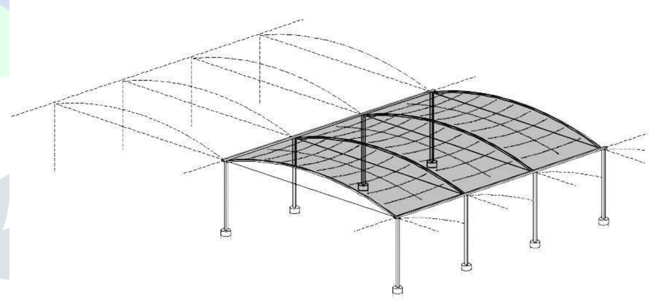


Fig.1

A. Modeling of Chimney

Pro-E used as Solid Modeler to Model Chimney, which works on Parametric Feature based module to create Solid Models and Assemblies. Parameters are design Constraints to determine roof collector angle of the SCPP Model & its Assembly. Parameters of Chimney are numeric values such as Length of Line, Diameter of Circle. Geometric Parameters of Chimney are such as Roof collector angle, β Angle etc. Numeric Parameters are associated with other parameters.

TABLE1 Details specifications of Geometry SCPP

Object Name	*Geometry*
State	Fully Defined
Source	C:\Users\Engineers Boy\Downloads\solar chimney files\dp0\FFF\DM\FFF. agdb
Type	Design Modeler

Length Unit	Meters
Length X	2750. mm
Length Y	3072.6 mm
Length Z	2750. mm
Volume	4.0481e+008 mm³
Scale Factor Value	1.
Bodies	1
Active Bodies	1
Nodes	130964
Elements	117970

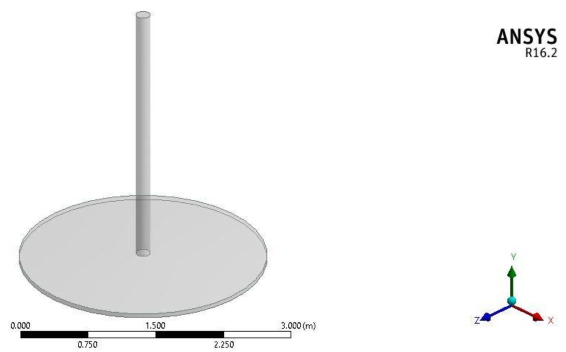


Fig.2

Existing Roof collector angle
$\beta = 1^\circ$, $\beta = 0^\circ$, $\beta = -1^\circ$, $P = -1.5^\circ$

Proposed roof collector angle of $\beta = 1^\circ$, $\beta = 0^\circ$, $\beta = 1.5^\circ$, $\beta = 2^\circ$ $\beta = -1^\circ$, $\beta = -1.5$

B. Drive Shaft Material

Table2 Fluid materials properties of Air as per ASHRAE use in ANSYS Fluent

Air (Fluid Materials)				
Name	Formula	Unit	Function	Property
Density	d	Kg/m^3	constant	1.225
Specific Heat	C_P	j/kg-k	constant	1006.43
Thermal Conductivity	k	w/m-k	constant	0.242
Viscosity		Kg/m-s	constant	1.7894e-05
Absorption Coefficient		1/m	constant	0
Surface coefficient		1/m	constant	0
Scattering Phase Function			Isotropic	
Refractive index			constant	1

Table3 Solid materials properties of solar glass (semi-transparent) as per ASHRAE

Solar Glass (Solid Materials)				
Name	Formula	Unit	Function	Property
Density	d	Kg/m^3	constant	2500
Specific Heat	C_P	j/kg-k	constant	750
Thermal Conductivity	k	w/m-k	constant	1.15
Viscosity		Kg/m-s	constant	0
Absorption Coefficient		1/m	constant	0
Surface coefficient		1/m	constant	0
Refractive index			constant	1

Table4 Solid materials properties of Aluminium used in Ansys Fluent

Aluminium (Solid Materials)				
Name	Formula	Unit	Function	Property
Density	d	Kg/m^3	constant	2719
Specific Heat	C_P	j/kg-k	constant	871
Thermal Conductivity	k	w/m-k	constant	202.4
Viscosity		Kg/m-s	constant	0
Absorption Coefficient		1/m	constant	0
Surface coefficient		1/m	constant	0
Scattering Phase Function			Isotropic	
Refractive index			constant	1

Table5 Descriptions of Boundary conditions

Surface	Type	Value
Collector Inlet	Pressure Inlet	P=101325 Pa
Chimney	Pressure outlet	P=101325 Pa
Chimney Wall	Opaque wall	$Q = 0\ W/m^2$
Collector	Semi-Transparent	$Q = 800\ W/m^2$

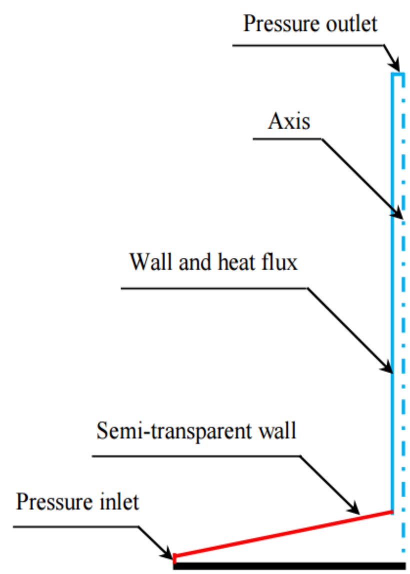
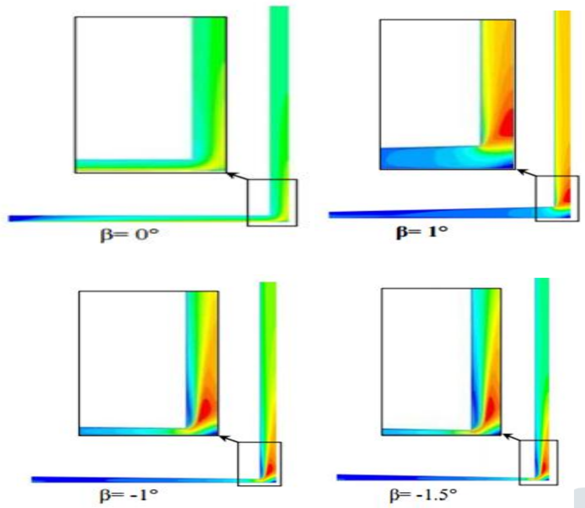


Fig.3

III RESULT AND ANALYSIS

Existing Roof Collector Angle Result



Proposed Roof Collector Result

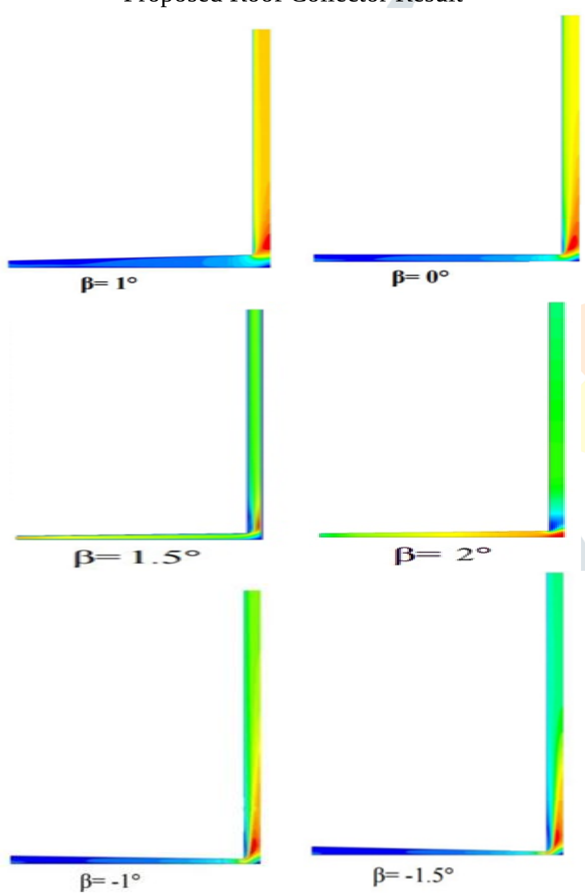


Fig.4 (Existing and Propose)

Table 6 Existing Roof collector angle Analysis Result

β angle in Degree / Properties	1	0	-1	-1.5
Magnitute Velocity	1.89	2.13	2.31	2.36
Static Pressure	3.3	3.31	3.31	3.26
Total Pressure	101326.3	101326.2	101325.9	101325.5
Incident Rediation	3.25E+03	3.26E+03	3.26E+03	3.27E+03
Turbulent Kinetic Energy	4.22E-01	3.88E-01	3.72E-01	3.89E-01
Turbulent Viscosity	7.31E-03	2.87E-03	2.73E-03	3.29E-03

Table7 Propose Roof collector angle Analysis Result

β angle in Degree / Properties	1	0	1.5	2	-1	-1.5
Magnitute Velocity	2.82	2.32	1.91	1.2	2.38	2.91
Static Pressure	3.32	3.3	2.76	3.31	3.31	3.26
Total Pressure	101326.9	101326.2	101326.7	101326.2	101325.9	101325.5
Incident Rediation	3.29E+03	3.26E+03	3.26E+03	3.27E+03	3.26E+03	3.27E+03
Turbulent Kinetic Energy	4.33E-01	3.89E-01	4.28E-01	3.99E-01	3.75E-01	3.66E-01
Turbulent Viscosity	7.33E-03	2.87E-03	7.45E-03	7.45E-03	2.70E-03	2.27E-03

IV CONCLUSION

The considered prototype is characterized by the collector diameter equal to D=2750 mm, the collector height equal to h=50 mm, the chimney diameter equal to d=160 mm, the chimney height equal to H=3000 mm and the collector roof angle equal to β=2°, β=1.5°, β=1°, β=0°,β=-1.5°, β=-1° the value of the magnitude velocity can be raised by 142% inside the SCPP.

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