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Performance Analysis of SCPP

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Abstract: **The solar lift tower, also known as solar chimney, is a system that allows zero emission of greenhouse gases and promotes green energy technology. It is one of the technologies for renewable energy. The objective of this project is to use the convective flow induced by the solar radiation generated by the ascending pipe. Solar chimneys are ideal for remote communities where solar energy is used as an energy source for residential and industrial purposes, depending on reliability, price and operational factors. This aims to evaluate the overall performance of the solar cell plant (SCPP) in India. The simulated model is analyzed with different parameters to optimize the overall efficiency. The height and diameter of the solar chimney are respectively 792 m and 44 m, and the diameter of the solar collector is 1289 m. This is considered an optimized value because the goal is to increase the power. Due to the high direct solar radiation and the desert lands available in India, are factors that favor the full development of solar power plants, such as solar power plants for the production of thermal and electrical energy for various uses. The different regions are India such as Bihar, Pradesh, Rajasthan, Madhya Pradesh, Tamil Naidu, Maharashtra, etc. India, where solar radiation and global insulation are much better than in other regions. However, to assess the performance of SCPP and energy production throughout India.**

Keywords*:* Solar Chimney; Geometric parameters; Solar Collector; Chimney; Turbine;

1. INTRODUCTION

The continued increase in energy demand, due to world population growth and the depletion of fossil fuels, has revealed more than ever the importance of renewable energy sources. The solar tower (chimney) is one of the technologies that use the energy of the sun to produce energy. The idea of producing electricity from a solar tower has been suggested by Haaf et al. (1983). In addition, they presented the first experimental results of a small-scale prototype (50 kW) in Manzanares, Spain [1]. Solar energy as a clean and renewable source of energy can play an important role in meeting these challenges. Intensive research efforts to improve the reliability and sustainability of renewable energy systems can support the deployment of these technologies [2]. The current production of energy from coal and oil is harmful to the environment and is not renewable. Therefore, there is an urgent need to develop technologies that use clean and renewable sources of energy to solve these problems. A solar chimney plant offers interesting possibilities for using non-polluting energy resources. Solar fireplace

Energy technology, designed to produce electricity on a large scale, uses solar energy to produce ventilation that drives the axial turbine to produce electricity [3]. The increase in greenhouse gases can have several negative effects, including glacier retreat, loss of biodiversity, animal extinction and loss of productive forests, ocean acidification, decreasing heat waves and the collection of butterflies in the mountains around the world. Renewable energy sources can play an important role in solving past problems in the future. A stack plant that absorbs direct and diffuse solar radiation and converts parts of solar energy into electricity offers interesting opportunities to use non-polluting energy resources. The solar chimney power plant can make a significant contribution to the energy supply of countries where solar radiation is highly available and many desert lands are not used. Currently, solar energy is still not used and, unfortunately, it occupies a smaller part of the total energy demand. Due to the decrease in the amount of

With conventional fuels available (fossils), renewable solar energy has become extremely important and commercially more accessible [4]. The solar chimney power plant functions as a natural energy generator that uses the energy of solar radiation to increase the internal energy of the circulating air. In this system, solar radiation heats the air under the roof of the collector, creating a temperature

gradient because the density of air is inversely proportional to its temperature, the temperature gradient will create the density gradient. As a result, floating effects cause air to flow from the manifold inlet to the chimney inlet, where the flowing air will move a turbine to produce energy [5, 6]. A solar chimney is a solar power plant that uses solar radiation to increase the internal energy of the air flowing through the system, converting solar energy into kinetic energy. The kinetic energy of the air is then converted into electricity by the use of a suitable turbine. The collector, supported a few meters above the ground, is covered with a transparent window. Its main purpose is the collection of solar radiation to heat the air mass inside. Buoyancy pushes the hottest air towards the chimney, which is located in the center of the collector. A turbine is located in the air flow path to convert the kinetic energy of the air flowing into electricity. The collector can be equipped with a water storage system. Increases energy production during the night [7]. Since warm air is lighter than cold air, it rises above the chimney. The intake of the chimney extracts more hot air from the collector and the cold air enters from the outer perimeter. In this way, solar radiation causes a constant upward flow in the chimney. The energy contained in the hot air is converted into mechanical energy by wind turbines placed at the base of the chimney and in conventional electric generators. This is the new generation of technological energy [8].

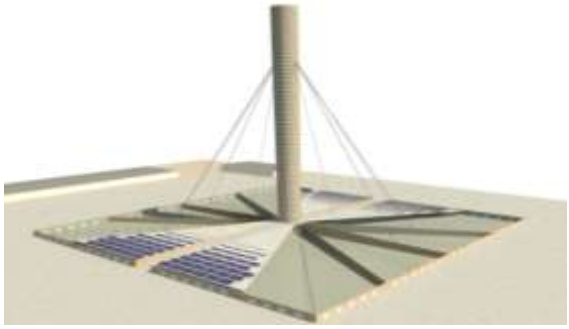


Fig 1: Proto-type Solar Tower in Manzanares.

A solar chimney power plant consists of three main parts, the collector, the chimney and the power conversion unit which includes one or several turbine generators. SCPP works like a natural power generator that uses solar radiation energy to increase the internal energy of the flowing air. In this system, the solar radiation heats the air below the transparent collector roof, creating temperature difference. Because the density of air is proportional to its temperature, the temperature difference will create the density difference.

Mathematical modeling

SCPP consists of three main parts (Fig. 1): a solar collector, a chimney (tube) located in the center of system and a power conversion unit (PCU) installed inside the solar chimney.

Assumptions

1. Heat storage in the ground and heat transfer between the ground and air in the collector are ignored and only heat transfer from the surroundings to the collector is considered.
2. A steady state condition is assumed, which is an approximation because solar radiation is transient in real conditions.
3. The incompressible flow across the chimney is Assumed because Mach number is below 0.3. Also, the experimental results support use of the incompressible flow assumption since it has been displayed that air flow velocity is much lower than the sound speed.
4. Costs of buying land of plants and construction labors are not included in the economic model.

Collector

This unique combination accomplishes the task of converting solar energy into electrical energy. This solar to electric conversion involves two intermediate stages. In the first stage, conversionof solar energy into thermal energy is accomplis- lished in the greenhouse (also known as the collector) by means of the greenhouse effect. In the second stage, the chimney converts the generated thermal energy into kinetic energy and ultimately into electric energy by using a combination of a wind turbine and a generator. provides an overall view of a solar chimney power plant. In its simplest form, the collector is a glass or plastic film cover stretched horizontally and raised above the ground. This covering serves as a trap for re-radiation from the ground. It transmits the shorter wavelength solar radiation but blocks the long wavelength radiation emitted by the ground. As a result, the ground under the cover heats up, which, in turn, heats the air flowing radially above it. A flat collector of this kind can convert a significant

Chimney

The air heated from collector outlet is passing by solar turbine blade and after that air enter into chimney. Hot air which is obtain from collector is convert into kinetic energy as wel as potential energy, due to convection phenomenon

in chimney pressure drop in the turbine. This cause the needed driving force is supplied by the difference of density of heated air in the collector. Hot air have low density as compare to ambient air due to gravitational forces hot air start rising from the chimney

2. EXPERIMENTATION ALGORITHM

Software used for the Study ANSYS 16.0

For the present work ANSYS 16.0 Simulation Software is used. ANSYS Fluent Software is the most compatible software for solving fluid based problems. Fluent is a multi physics software which works on various governing equations and finite volume methods. Fluent incorporates very much approved physical demonstrating capacities, precise outcomes over the amplest scope of CFD and Multi physics applications.

FLUENT/CFD

Computational fluid dynamics (CFD) is a branch of liquid mechanics that utilizations numerical examination and information structures to take care of and investigate issues that include liquid streams. To reproduce the cooperation of fluids and gasses with surfaces characterized by limit conditions Computers are utilized to play out the required counts. With fast supercomputers, better arrangements can be accomplished.

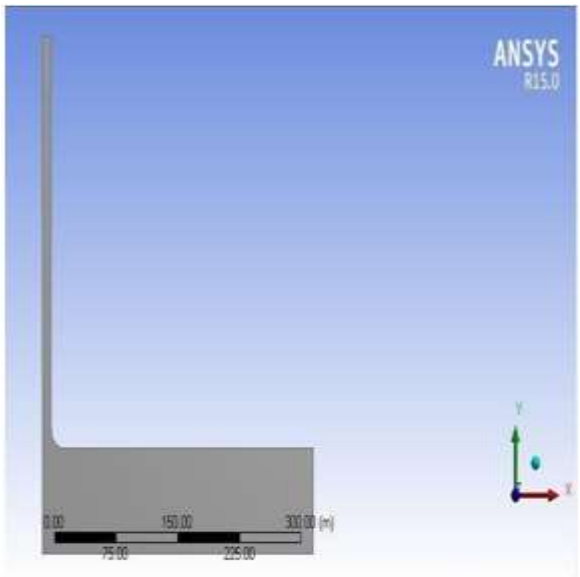


Fig.2: Solar chimney

Meshing

Air Properties

Properties of the air inside of the flow area .

Properties of air

Medium: air

Air Density: 1.22 Kg m^{-3} Specific

heat: 1006.43 J $Kg^{-1}K^{-1}$

Thermal Conductivity: 0.24$Wm^{-2}K^{-1}$ Viscosity:

$1.68\times10^{-5}Kgm^{-1}s^{-1}$

Working with ANSYS

The different analysis steps involved in ANSYS are mentioned below:

Preprocessor: The model setup is basically done in preprocessor. The different steps in pre- processing are

Building the Model

The ANSYS Design Modeler provides the following approaches for model generation: Creating a solid model within ANSYS Design Modeler. The solar chimney power plant, in which the chimney height and diameter are 726m and 22 m, respectively, and the diameter of the solar collector diameter, is 1289m.

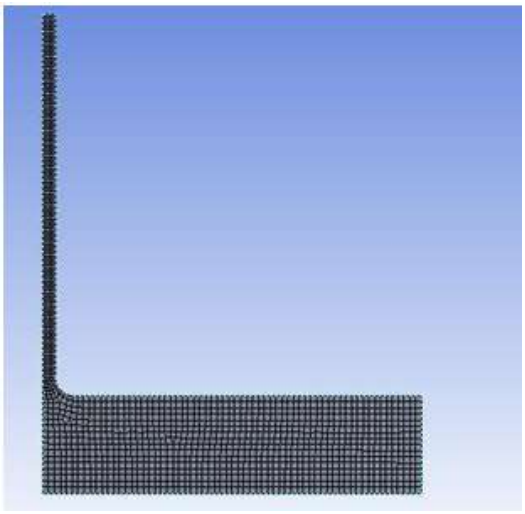


Fig.3: Meshing: Total No. of Nodes: 1735 & Total No. elements: 1531

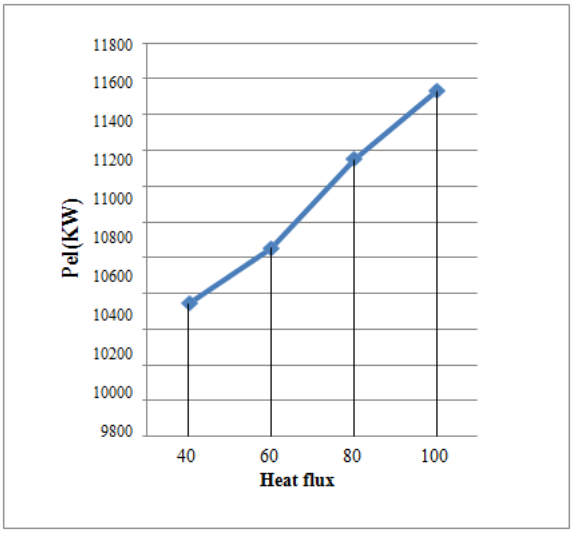
The mesh created in this work is shown in figure No.4.3. The total Node is generated 1735 & Total No. of Elements is 1531 for Solar chimney without draft.

3. RESULT ANALYSIS

The numerical simulation was performed on ANSYS FLUENT 16 CFD software that can be simulate two dimensional axis symmetry model of solar updraft tower with standard k-epsilon turbulence model and Boussiesq approximation was also taken for considering buoyancy driven flow also known as natural convection. This simulation was also taken heat flux from bottom of collector during night time as heat flux transfer from thermal storage system.

Table I: Maximum and Minimum Temperature Obtained From Analysis

Heat flux (W/m^2)	Electric Power(Kw)
400	**10343.095**
600	**10652.09**
800	**11148.67**
1000	**11531.26**



Graph 1: Effect of solar radiation on power output

4. CONCLUSION

- This study is directed to evaluate the performance of SCPP. Mathematical and analytical studies were performed in order to optimize geometrical parameters.
- The numerical analysis of the fluid flow of the air is the focusing point in this study. The main objective is to analyze the thermal comportment and velocity distribution engendered by the temperature gradient, and to compare the thermal behavior of the solar chimney. The velocity of the system increases due to change of solar radiation. The velocity of the system directly related to height and diameter of the chimney.
- The heat flux is directly related to solar radiation and solar radiation directly related to earth rotation.
- Temperature of the bottom air increase due to higher heat flux and pressure of the air increases inside the collector. Due pressure difference the air moves upward direction in higher velocity and the velocity of the air inside the chimney increases.
- The velocity of air increase the electric power output also increases due to higher velocity at the turbine.
- The large amount of electric power is produce by using this type model.

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