A Review: Numerical Simulation for Solar Chimney by Changing its Radius and Height

1Nilesh N. Ubhale, 2Santosh R. Mallah, 3Dr. Lavendra S. Bothra
1 D epartment of M.E., Energy System and Management, ARMIET, Sapgaon, India
2 Department of Mechanical Engineering, IIT-BOMBAY, Powai, India
,3 Department. Of Mechanical Engineering, ARMIET, Sapgaon, India

Abstract: **-** Now a days Solar chimney power plant is a very good means of solar thermal electricity generating technology. According to common trends It can divided in three major parts. A large circular greenhouse, a tall cylindrical solar chimney in middle of green house and a set of turbines, around or in the solar chimney, geared to appropriate electric generators.

CFD technology is widely used in this project to induce changes in kinetic flow energy caused by the variation of tower flow area with height. It was found that the tower area change result change in the efficiency and mass flow rate through the plant. Augmentations in kinetic energy are due to varied tower tops .the tower base significantly. Change in kinetic energy in tower is due to tower area ratio. Whereas when we conclude about related type of tower, the velocity at the tower top increases but the mass flow rate decreases. While in the case of constant area of tower the kinetic power at the top remains the same. For the divergent case, maximum kinetic energy occurs at the tower base and this suggests the potential to extract more turbine power than the constant area tower.CFX is used to solve the numerical problem. It solves the conservation equation for mass, momentums and energy using finite volume method. Adaptive unstructured tetrahedral meshes were used in given study. The plants studied were modeled as an axis-symmetric model where the centerline of the tower is the axis of symmetry. To simulate axis-symmetry, a 1 degree section of the plant is cut out from the entire periphery.

Keywords:- *CFD, solar chimney, CFX, solar chimney power plant(SCPP).*

*****

I. Introduction

Nowadays there is a rapid development in global economy and increase in population and living standards have been posing great pressure on natural resources and the environment. utilization of fossil fuels and deforestation has induced considerable climate change in warming the atmosphere by releasing greenhouse gases (GHG) .It also produce many negative effects including receding of glaciers, rise in sea level, loss of biodiversity, extinction of animals, and loss of productive forests, acidification of oceans etc. now the biggest challenge in front of us is that to find and develop the renewable sources. The drawback of most of the renewable power technologies has been their unreliability as they can't operate continuously for 24 hours or continuous operation is achieved only through hybrid systems using fossil fuels along with renewable energy sources. Solar Chimney power technology is one of them and it promises a better solution to our current energy problem.

The solar chimney power plant (SCPP) combines three familiar components: a solar collector, a Solar Chimney situated in the center of the collector, and power conversion unit (PCU) which includes one or several turbine generators. The turbines are driven by airflow produced by buoyancy resulting from greenhouse effect inside the collector. This technology has been verified by the successful construction and operation of the 50 kW Manzanares SCPP prototype. The technologies for the SCPP components are simple and reliable, accessible to the technologically less developed countries, which are sunny and often have limited raw material resources. If solar chimney power plant is built up in large area then it can be supply energy at lower LEC (levelized electricity cost) than all the other existing solar power technologies.

II. Literature Survey

Jorg Schlaich, Rudolf Bergermann, Wolfgang Schiel, Gerhardm Weinrebe 2000 [1] described he functional principle of solar updraft towers and gave some results from design, construction and operation of the first ever prototype built in Spain.

S. Beerbohm and G. Weinrebe et al. 2000 [2] conducted a techno-economic analysis on solar thermal power generation in India. In this study they analyzed the potential and the cost-effectiveness of centralized and decentralized STE-generation in India.

Y.J. Dai, H.B. Huang and R.Z. Wang et al. 2002 [3] analyzed a solar chimney power plant that was expected to provide electric power for remote villages in north western China.

M.A. dos S. Bernardes, A. Vob and G. Weinrebe et al. 2003 [4] carried out an analysis for the solar chimneys aimed particularly at a comprehensive analytical and numerical model, which describes the performance of solar chimneys

J.P. Pretorius and D.G. Kroger et al. 2005 [5] evaluated the influence of a recently developed convective heat transfer equation, more accurate turbine inlet loss coefficients, quality collector roof glass and various types of soil on the performance of a large scale solar chimney power plant.

Xinping Zhou, Jiakuan Yang, Bo Xiao &GuoxiangHouetal.2006 [6] built pilot experimental solar chimney power generating equipment in China. They carried

Out a simulation study to investigate the performance of the power generating system based on a developed mathematical model

AtitKoonsrisuk&TawitChitsomboon et al. 2007 [7] proposed dimensionless variables to guide the experimental study of flow in a small-scale solar chimney: a solar power plant for generating electricity.

T.P. Fluri, J.P. Pretorius, C. Van Dyk, T.W. Von backstrom, D.G. Kroger, G.P.A.G. Van Ziji et al. 2008 [8] compared several cost models that were available in the literature

Xinping Zhou, Jiakuan Yang, Bo Xiao, Guoxiang Hou & Fang Xing et al. 2008 [9] the maximum chimney height for convection avoiding negative buoyancy at the latter chimney and the optimal chimney height for maximum power output were presented and analyzed.

Cristiana B. Maia, Andre G. Ferreira, Ramón M. Valle & Marcio F.B. Cortez et al. 2008 [10] arrived out an analytical and numerical study of the unsteady airflow inside a solar chimney. The conservation and transport equations that describe the flow were modeled and solved numerically using the finite volumes technique in generalized coordinates. The numerical results were physically validated through comparison with the experimental data.Tingzhen Ming, Wei Liu, Yuan Pan & GuoliangXu et al. 2008 [11] carried out numerical simulations to analyze the characteristics of heat transfer and air flow in the solar chimney power plant system with an energy storage layer

Marco Aurelio dos Santos Bernardes, T.W. Von Backstrom& D.G. Kroger et al. 2008 [12] compared the two comprehensive studies namely those of (Bernardes, M.A.d. S., Vow, A., Weinrebe, G., 2003. Thermal and technical analyses of solar chimneys. Solar Energy 75, 511–524; Pretorius,

J.P., Kroger, D.G., 2006b. S. Nizetic, N. Ninic & B. Klarin et al. 2008 [13] analyzed the feasibility of solar chimney power plants as an environmentally acceptable energy source for small settlements and islands of countries in the Mediterranean region. For the purpose of these analyses, two characteristic geographic locations (Split and Dubrovnik) in Croatia were chosen and simplified model for calculation of produced electric power output is also developed

AtitKoonsrisuk & TawitChitsomboon et al. 2009 [14] in their previous study fo und that the achievement of complete dynamic similarity between a prototype and its models imposed the use of different heat fluxes between them.

AtitKoonsrisuk&TawitChitsomboon et al. 2009 [15] used dimensional analysis together with engineering intuition to combine eight primitive variables into only one dimensionless variable that establishes a dynamic similarity between a prototype and its scaled models

III. Problem Statement

This age of globalization makes a huge demand of energy recourses and is tending even more to increase on other hand conventional sources of energy are very. The environment is affected badly and adversely. So it is necessary to develop the present renewable sources so that we can satisfy the demand. To satisfy the Solar chimney power the development of renewable sources is very important

An noteworthy example of it is plant. With the use of solar chimney we can obtain more energy compared to the traditional way of solar energy obtaining equipment

CFD technology is widely used to investigate the changes in flow kinetic energy caused by the result of variation of tower flow area with height. It was found that the tower area is affected by change of efficiency and mass flow rate through the plant. Through changing collector area, chimney tower radius and height it can possible we can obtain maximum efficiency with small change in design of SCPP. the cost of the experimental procedures can be saved by simulation of convinent performance of solar chimney.

IV. Proposed System

The solar tower's principle is shown in Fig 4.1. Air is heated by solar radiation under a low circular transparent or translucent roof open at the periphery; the roof and the natural ground below it form a solar air collector. In the middle of the roof is a vertical towering with large air inlets at its base the joint between the roof and the tower base is airtight. Hot air is lighter than cold air it raises up the tower. Suction from the tower then draws in more hot air from the collector, and cold air comes in from the outer perimeter.

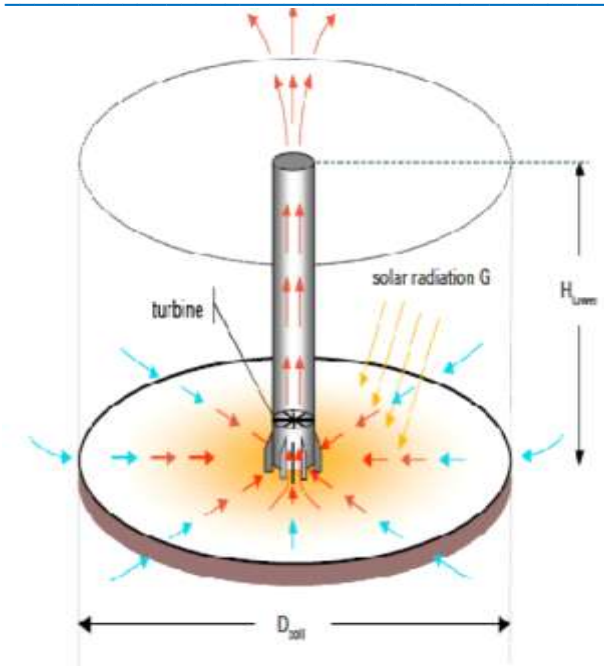

Figure 4.1 SCPP Working Principles

In this project study on solar chimney power plant is carried out with the help of CFD technology. If there is change in chimney tower radius and height and collector area then efficiency of the SCPP can increase considerably. Numerical calculation has been performed using CFX.

V. Implementation

5.1. Procedure Computational Method:-

The steps to obtain a proper solution for the flow of a fluid in FLUENT are:-

Pre Processing: Consisting in the construction of geometry, the generation of the mesh on the surfaces or volumes. This stage is done with the software AMP, linked to FLUENT. The geometry can be also imported from other CAD software's like CATIA. For creating the mesh there are different options that AMP provides. For 3D there are structured meshes of quadrilateral faces and other faces easier to develop like the triangles. Transporting the problem to 3D, hexahedral and pyramidal (tetrahedral) volumes can be carried out.

Definition of boundary conditions and other parameters, initial conditions, before starting a simulation in FLUENT, the mesh has to be checked and scaled and modified if necessary. The physical models have to be tackled. This includes the choice of compressibility, viscosity, heat transfer considerations, laminar or turbulent flow, steady or time dependant flow. The boundary conditions have to be clear because they specify the information of the state of the flow in the determined zones: walls, symmetries, inlet air, outlet air, etc.

Resolution of the problem, which is done through iteration until the convergence of the variables is obtained. First of all, the variables of the flow have to be initialized and set to be computed from a certain part specified by the user. In this stage the equations of the flow are solved. The values of the pressures are constantly updated and corrected through iterations. The convergence is checked until it reaches the criterion value set by the user.

Post Processing or analysis of the results computed. There are lots of choices: Contours, X-Y plots, velocity vectors, path lines. In them, several variables can be analyzed: velocity, pressure, turbulence, forces, density and others.

VI. Software requirement for the system

Hardware Requirements:
System : Pentium IV 2.4 GHZ
Hard Disk: 500 GB
Monitor : 15 VGA Color
Ram : 8GB
Software Requirements:
Operating System: WINDOWS 7
Graphics card: 1GB
CFD SOFTWARE

VII. Conclusion

With the help of results we can find that chimney height and Tower outlet radius and base area are very important parameters for improving the gained power,another important thing in it is to choose the region with suitable mean ambient temperature. We also find limitations to this like to collector and chimney sizes to get suitable profit output power and any increment in system size becomes a small percentage increment in profit output power. WE compared the results from some other researcher and agreed to this that there is good stimulated and calculated result ..

References

[1] Schlaich J, Bergermann R, Schiel W, Weinrebe G. "Design of commercial solar updraft tower systems—utilization of solar induced convective flows for power generation". J Solar Energy Eng 2005; 127:117–24.

[2] S.Beerbaum, G.Weinrebe, Solar thermal power generation in India- a techno-economic analysis. J Renewable Energy 21(2000) 153-174.

[3] Y.J. Dai, H.B. Huang and R.Z. Wang, Case study of solar chimney power plants in northwestern regions of China, J Renewable energy 28(2003) 1295-1304.

[4] M.A. dos S. Bernardes, A. Vow and G. Weinrebe, Thermal and technical analysis of solar chimneys, J Solar Energy 75(2003) 511-524.

[5] J.P.Pretorius and D.G. Kroger, Critical evaluation of solar chimney power plant performance, J Solar Energy 80(2006) 535-544.

[6] Xinping Zhou, Jiakuan Yang, Bo Xiao & GuoxiangHou, Simulation of a pilot solar chimney thermal power generating equipment, J Renewable Energy 32(2007) 1637-1644.

[7] AtitKoonsrisuk&TawitChitsomboon, Dynamic similarity in solar chimney modeling, J Solar Energy 81(2007) 1439-1446.

[8] T.P. Fluri, J.P. Pretorius, C. Van Dyk, T.W. Von backstrom, D.G. Kroger, G.P.A.G. Van Ziji, Cost analysis of solar chimney power plants, J Solar Energy 83(2009) 246-256.

[9] Xinping Zhou, Jiakuan Yang, Bo Xiao, GuoxiangHou& Fang Xing, Analysis of chimney height for solar chimney power plant, J Applied Thermal Engineering 29(2009) 178-185.

[10] Cristiana B. Maia, André G. Ferreira, Ramón M. Valle &Marico F.B. Cortez, Theoretical evaluation of the influence of geometric parameters and materials on the behavior of the airflow in a solar chimney, J Computers & Fluids 38(2009) 625-636.

[11] Tingzhen Ming, Wei Liu, Yuan Pan &GuoliangXu, Numerical analysis of flow and heat transfer characteristics in solar chimney power plants with energy storage layer, J Energy conservation and management 49(2008) 2872-2879.

[12] Marco Aurelio dos Santos Bernardes, T.W. Von Backstrom & D.G. Kroger, Analysis of Some available heat transfer coefficients applicable to solar chimney power plant collector, J Solar Energy 83(2009) 264-275.

[13] S. Nizetic, N. Ninic & B. Klarin, Analysis and feasibility of implementing solar chimney power plants in the Mediterranean region, J Energy 33(2008) 1680-1690.

[14] Atit Koonsrisuk & Tawit Chitsomboon, Partial geometric similarity for solar chimney power plant modeling, J Solar Energy 83(2009) 1611-1618.

[15] Atit Koonsrisuk & Tawit Chitsomboon, A single dimensionless variable for solar chimney power plant modeling, J Solar Energy 83(2009) 2136-2143.

Nilesh Namdeo Ubhale received his B.E. degree in Mechanical Engineering from Yadavrao Tasgaonkar Institute of Engineering and Technology, Mumbai, India, in 2013, He is persuing M.E. in Energy System and Management from Alamuri Ratnamala Institute of Engineering and Technology, Sapgoan, India. His research interests include Numerical Simulation for Solar Chimney by Changing its Radius and Height.