

Analysis (Data) of Chimney Operated Solar Power Plant

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ABSTRACT: Now a days because of high amount environmental pollution, energy production based on nonconventional energy sources is on top priority. Solar energy is the most important energy source which is available in abundant but not explored much. Among the various solar technology available, solar chimney is one of the novel technology which is simple technology with very few number of parts. This paper presents an experimental investigation of a small scale model of solar chimney power plant in central India. Solar chimney power plant consist of three parts which are chimney, collector and generator. The input parameters considered in this work are chimney height, chimney diameter, collector diameter, inlet and out air flow height from collector. The density variation, air velocity, temperature distribution and mass flow rate are considered as output parameters for the analysis of flow in solar chimney. This technology further worked upon would prove to be of great significance to the society as it would serve an alternative to the current pollution causing fuels and sources of energy.

KEYWORDS: Collector, Novel Technology Power plant, Solar energy, Turbine.

I. INTRODUCTION

A Solar chimney power plant works on the simple principle that when the air is heated it rises by creating updraft from inlet to outlet. It consists of three main components: a chimney, a collector and turbines. For maintaining this updraft a large size of collector and chimney of large height is required. To absorb more solar energy collector is made up of glass or fiber material with heat absorbent coating. Continuous generation of electricity is also possible by using packed container filled with water once and sealed kept inside the collector can absorb heat during day period and release at night maintaining the temperature inside the collector hot. This novel concept was first introduced by German author Hans Gunther. The first pilot power plant of 50 kW was set up in Manzanas Spain in early 1980s. Schiaich and Haaf et al. evaluated the performance of this pilot power plant in 1982. It runs for nearly four years but collapsed due to improper support. Various experimental investigations were carried by researchers on solar chimney by keeping a pilot plant as reference. Mehran Ghalamchi et al. designed 2m collector diameter and 3 m height power plant. They achieved a maximum velocity of 1.3m/s. A.B.Kasarian et al. constructed solar chimney of 10m collector diameter and 12m chimney height they get maximum air velocity of 2.9 m/s and inlet air velocity zero around collector. A.A. El- Haroun evaluated the performance of solar chimney in Egypt. It was found that the wind speed inside the chimney reaches more than seven times of the value of free wind speed outside chimney. The solar chimney with 500 m chimney height, 50m chimney diameter and 3000 m collector diameter is capable of producing yearly between 1.67×10^8 kW hr in some location of Egypt. A. Asnaghi et al. presented the results that the solar chimney power plants having 244 m diameter can produce electricity up to 40 MW or more in central region of Iran. Y.J.Dai performed the case study of solar chimney in China. He predicted that the chimney of 200 m high and 10m diameter and collector of 200 m diameter can be able to produce electricity nearly about 200 kW and parameter such as solar irradiance and ambient are responsible for generation of electricity along with collector diameter and chimney height. Johannes P. Pretorius et al. evaluated the performance of a large scale reference power plant. He showed that production of electricity is a function of collector roof shape and inlet height.

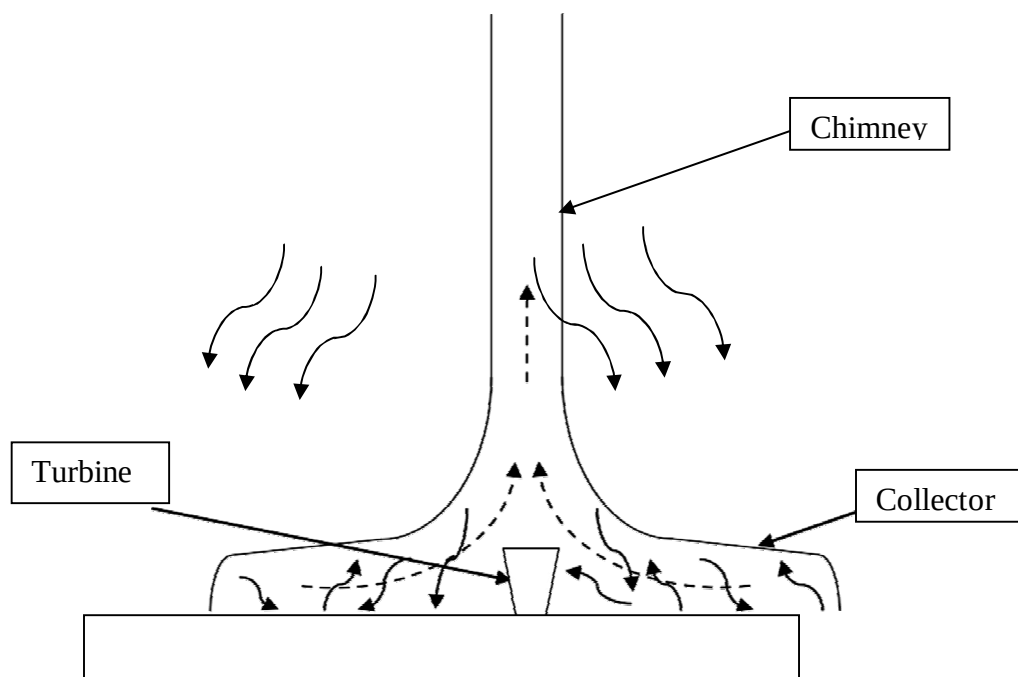
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

II. METHODOLOGY

Solar chimney power plant is thermal energy conversion device which uses the combination of three main parts that are collector, chimney and Turbine. Collector is work on the principle of green house in which the Sun rays incidence on the surface get absorbed in the collector. The temperature inside the collector increases than the surrounding and creates hot air draft in upward direction. The chimney made up of metal or concrete material acts as a penstock similar to hydro electric power plant, take these hot air in and direct it to atmosphere. The updraft created by the hot air is utilized for running the turbine. The turbine is coupled with generator to convert heat energy into electrical energy The axis turbine can be located horizontally or vertically as per requirement .



III. EXPERIMENTAL SETUP OF SOLAR CHIMNEY

In order to evaluate the performance of solar chimney a working model has been fabricated and assembled using various components. For supporting collector 12mm thick plywood sheet was used. A crystal clear glass made up of soda- lime glass sheets of saint Gobain make was used as collector material of 1.8m diameter . A PVC pipe of height from 0.5 m to 2.0 m was used as chimney had a diameter of .040m. The collector had inlet height of 0.003m and outlet height of 0.007m. A quadrilateral shape galvanized sheet metal dome was mounted on blanked plywood sheet for the central support. At bottom of chimney at some distance above the ground a turbine with aluminum foil blade with 3 Volt D.C generator was mounted. To obtain variation in height of chimney made of P.V.C pipe was cut into four parts of length 0.5 m each. The first part was fixed to the square dome then to increase height a coupling of suitable size was provided. The complete system is made air tight by using suitable material like M-seal and Teflon tape . Area under canopy was coated with black paints for absorbing maximum radiations from Sun. For the measurement of temperature thermocouples made up of PT-100 material were used. Sensors were used to measure the temperature variation from inlet to outlet. In order to measure air flow velocity inside the chimney A pyrometer of Lutron make Am-4201 was used which has maximum capacity of 25m/s. Fig.1 indicates the schematic and fig. 2 & 3 shows photographs of experimental setup of solar chimney.

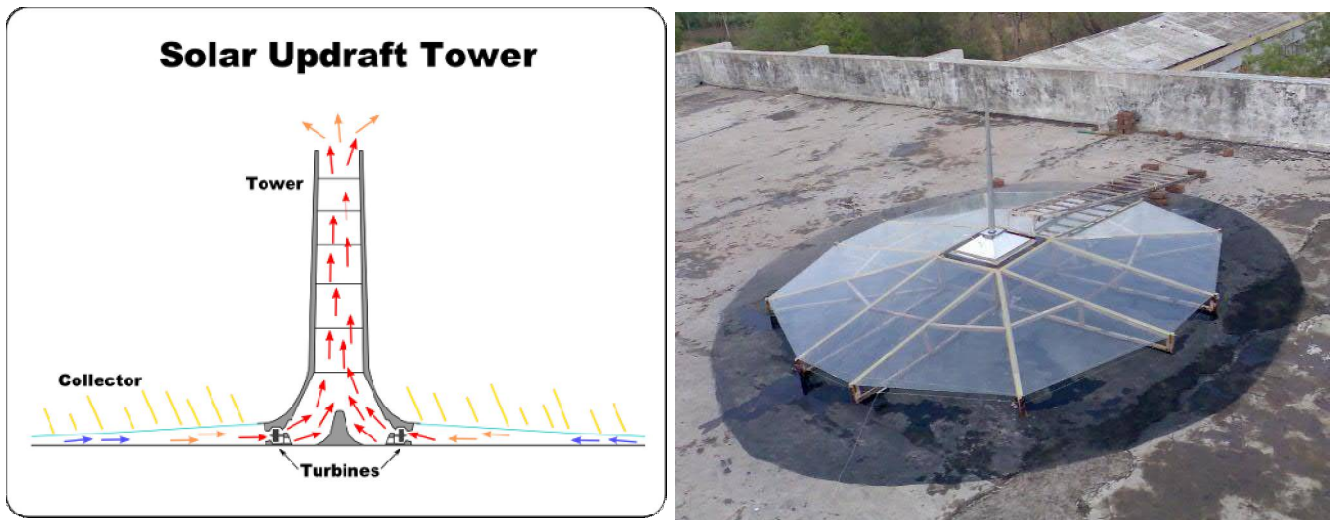


Figure 2 Block Diagram & Front view of solar chimney Experimental setup

IV. RESULT AND DISCUSSION

The readings are recorded from the experimental setup in the month of May which is the hottest month of the year to evaluate the performance of the chimney and the maximum out put the plant can deliver. Readings are taken with variation in height of cylindrical (PVC) chimney for a day from 10.00 a.m to 5.00 p.m. Figure 3. Indicates the variation of mass flow rate with collector out let temperature for the various heights of solar chimney.

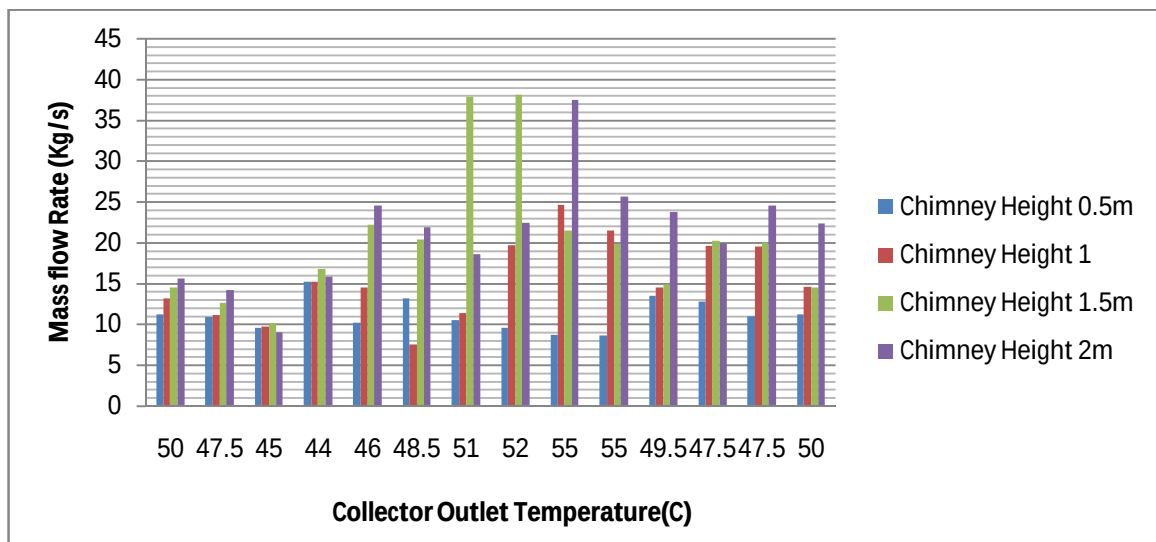


Figure 3 Variation of mass flow rate with collector outlet temperature.

From the fig.3 it is observed that the maximum mass flow rate is obtained at higher collector outlet temperature and with chimney height of 1.5 m and 2 m. At 55 °C the maximum mass flow rate is observed with chimney height of 2 m but the difference is very small as compared to chimney height is 1.5 m.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

Fig. 4 shows variation of air temperature with temperature difference ΔT for the different height of solar chimney from 0.5 m to 2m

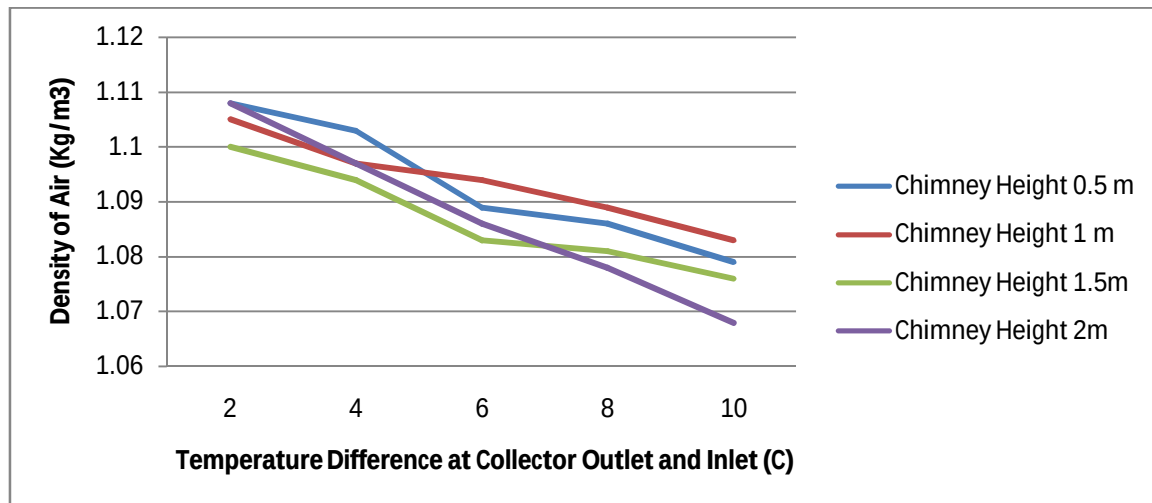


Figure 4 Variation in density of air with temperature difference ΔT

It is evident from the figure that as the temperature difference between the collector outlet and inlet goes on increasing, the density of air flowing through the collector towards the chimney decreases, which on other hand increases the mass flow rate. It can be seen from the figure that lowest value of density is observed for chimney height of 2 m.

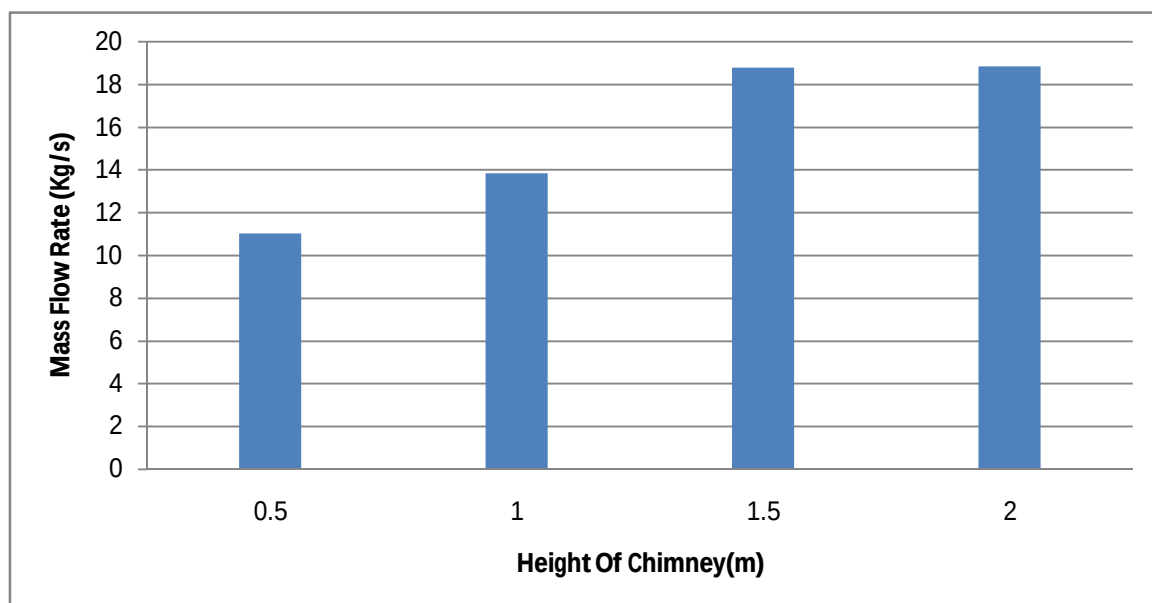


Figure 5 Variation in Average mass flow rate for different height of cylindrical (PVC) chimney.

Variation in Average mass flow rate for different height of cylindrical (PVC) chimney is depicted in Figure 5. Figure clearly indicates that the average value of mass flow rate through 1.5 m and 2.0 m high chimney is nearly equal. The values of 0.5 m and 1.0 m high chimney are far below than other two as mentioned above.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 3, March 2016

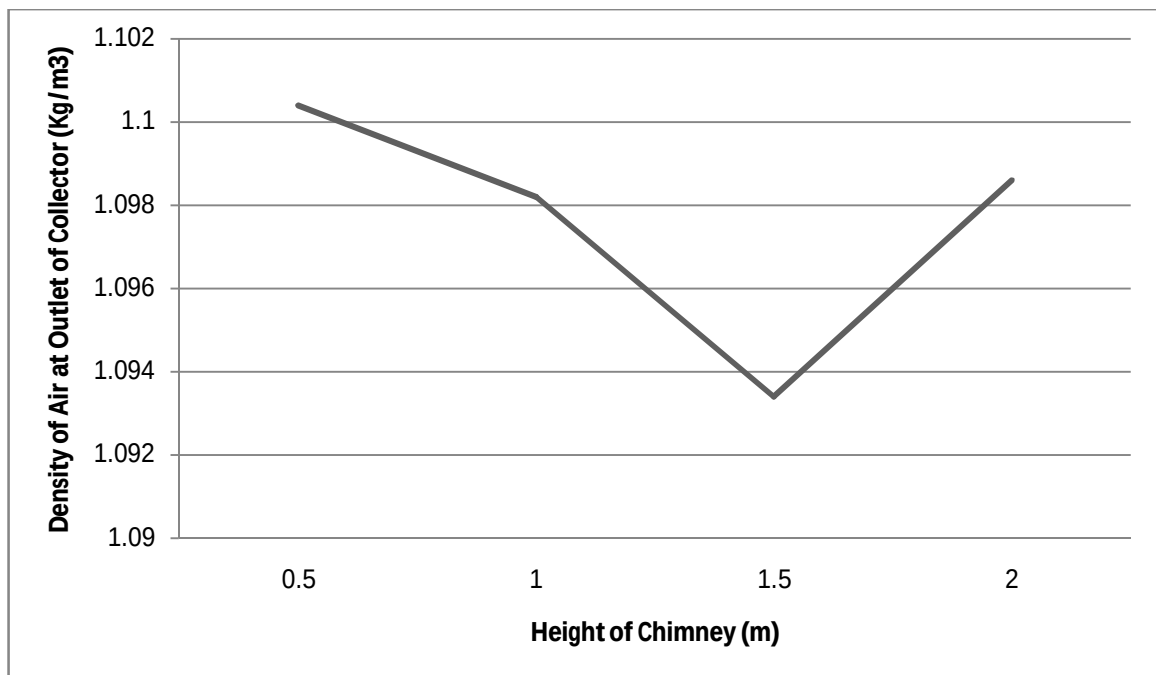


Figure 6 Variation in density of air (Average) at collector outlet against chimney height.

Fig. 6 shows the plot between chimney height and the density of air at the collector outlet. It is evident from the figure that the lowest value of average density is obtained with 1.5 m chimney.

V. CONCLUSION

The Experimental setup of small scale solar chimney power plant constructed in central India to the study the effect of various geometrical parameters on the process parameters used to evaluate the performance of solar chimney. Following conclusions are drawn from the experimental investigation.

1. The higher temperature is responsible for maximum mass flow rate inside the chimney at large chimney height.
2. The value of Density decreases from inlet to out let of chimney. Lowest value of density was observed at maximum height of chimney.
3. Mass flow rate remains nearly constant at higher heights of solar chimney power plant.

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Vol. 5, Issue 3, March 2016

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