International Journal For Technological Research In Engineering
Volume 7, Issue 5, January-2020 *ISSN (Online): 2347 - 4718*

SOLAR FLOATING CHIMNEY

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Abstract: Solar chimney power plant which is an application of renewable sources of energy. It operates on principle of conversion of solar energy into electrical energy. The heat radiation of sun is used to heat the air under roof and the heated air is allowed to pass through a chimney, which will rotate the turbine. The turbine is used to drive the rotor of an AC alternator which will generate the electricity. It deals with basic components of solar plant and earlier .It also gives idea of actual work is to be carried on solar chimney power plant. The solar power plant chimney is also known as updraft power plant .Solar updraft tower is one such source of renewable energy which works on the basic principle that hot air moves up. The tower acts as a giant chimney and generates necessary pressure drop to rotate a turbine at the entrance of the tower which is further converted to electrical energy. In this case we use new technology floating solar chimney. The cost of the Floating Solar Chimneys (FSC) is lower than the Concrete Solar Chimney. FSC technology is appropriate solar technology and can replace fossil fuel for large scale electricity generation. The main reasons are: It is the cost competitive, it can operate continuously thus it can replace coal fired base load power plants, demands no water for its operation, power plant of FSC technology are made of recyclable existing in the market.

Keywords: Solar Chimney, Collector, Turbines, Radiations Polyester Fabric, Dynamic Energy

I. INTRODUCTION

India is a developing country in which each sector such as automobile, process automation, real estate, agriculture growing with high speed. As each sector grow with very fast rate, they are facing major problem of power supply. Present power generation is less as compared to required demand. To balance the power distribution, they have to shut down their units for one or two days in a week in different region which will effect on Indian economy. Maximum power generation is based on conventional source of energy i.e. fossil fuels such as oil, coal, which will not last for long time. Excess use of these fuels / energy may cause shortage of energy in future. Nature also has some limitations to develop fossil fuel. The use of conventional energy also cause problem of air pollution which will affect the nature creating global warming. So that research scholars and scientists are planning for non-conventional source of energy such as wind, tidal, biogas, geothermal and solar. The geographical location and fixed seasons in India is best suitable for solar power plant which gives idea about solar chimney power plant. Solar chimney power plant is used to generate electricity by using solar energy. Solar energy radiations are used to heat the air under roof or collector. The hot air is allowed to pass through the tall chimney and it is then utilized to drive the turbine which will generate the electricity.

The Floating Solar Chimney (FSC) Technology

Power Plants, are made of three major components

A large solar collector with a transparent roof that warms the air below it, due to the solar irradiation.

A tall lighter-than-air hollow cylinder placed in the Centre of the solar collector that is up-drafting the warm air, through its open top to the upper atmosphere (the Floating Solar Chimney).

A series of air turbines, placed in the path of moving and up-drafting stream of warm air, geared to appropriate electric generators that transform part of the thermodynamic energy of the moving stream of air to electricity.

II. TECHNOLOGY

Solar chimney electricity generation power plants are referred to as solar updraft towers and the related solar chimneys are huge reinforced concrete structures. However due to the high construction cost of the concrete solar chimneys the solar up-draft tower technology is expensive demanding a high initial investment in comparison to its competitive solar technologies. Their solar up-draft towers are huge structures of high initial investment cost that cannot be split into small units. Floating solar chimney (FSC) technology is a low cost alternative of the solar updraft towers. The FSC technology is the advisable one for candidacy for large scale solar electricity generation especially in desert or semi desert areas of our planet and a major technology for the global warming elimination.

The Floating Solar Chimney (FSC). It is a tall fabric cylinder placed at the center of the solar collector through which the warm air of the greenhouse, due to its relative buoyancy to the ambient air, is up-drafting. Floating Solar Chimney is patented by the author in USA and several other countries.

The Electric Power Unit. It is a set of air turbines geared to appropriate electric generators in the path of up-drafting warm air flow that are forced to rotate generating electricity. The gear boxes are adjusting the rotation speed of the air turbines to the generator rotation speed defined by the grid frequency and their pole pairs. The energy source, for the rotation of the air turbines and the electricity generation, is the horizontal solar irradiation passing through the transparent roof of the greenhouse and heating the ground beneath it. The ground thermal energy is partly transferred to the air stream, entering the greenhouse and moving towards the FSC bottom entrance.

The up-drafting air mass through the FSC, due to its relative buoyancy to the ambient air, is offering a part of its thermodynamic energy to the air turbines rotating the geared electric generators, which generate electricity. Thus the first two components of the floating solar chimney power plants form a huge thermodynamic device, up-drafting the ground ambient air towards the upper atmosphere layers and the third component is the electricity generating device operating by the up drafting warm air mass. Due to ground thermal storage capacity the electricity generation of the FSC is continuous and uninterrupted.

III. THEORY

Solar Floating Chimney

In many parts of the world, there is a growing awareness that some alternative energy sources could have an important role to play in the production of electricity.

However, only the solar energy represents totally nonpolluting inexhaustible energy resource that can be utilized economically to supply Man's energy needs for all time.

There are lots of methods of using the solar energy, and the Solar Chimney is one of them,

The solar chimney system consists of three parts;

The collector, Turbines. The chimney

Figure 1: View of solar chimney power plant.

The Collector

Collector is the main component of solar chimney power plant. Solar energy collectors are the special kind of heat exchangers that transforms the solar radiation energy to internal energy of the transport medium. Collector is the part, which is used to absorbed or produce hot air by green-house effect. It is usually 5-6 meters high and covers a very large area about thousands of m^2. The radiations received by the collector is used to heat the air between ground surface and collector. The material used for collector construction is is plastic film or glass plastic film. The collector roof is above the ground level. The height of roof adjacent to the chimney is more to divert the air towards chimney with less friction. The amount of radiations received will be depends on material of the collector and the angle of solar radiation. Significant research has been made in the design of collector to enhance the efficiency of power plant. There are two types of collector i.e.by extended the base and introduced the intermediate medium in it which has enhance the temperature. Since glazing increases the mass of the roof, glazed collectors should have stronger rods and should be attached in figure

Figure 2: Collector

Turbines

Turbines are used to convert air current to the mechanical energy

Figure 3: Turbine

It is similar to the wind turbine and located at the base of chimney. The speed of turbine due to air flow causes to drive the generator to generate electricity and powered it to grid. Turbines are placed horizontally in chimney, vertically in the collector. In order to obtain maximum energy from the warmed air, turbines blades should cover all the cross-sectional area of the chimney.

To do this, one big turbine or a few small turbines should be used in chimney

The chimney

Chimney is another most important component of the solar chimney power plant .The efficiency of plant depends on the material, structure and height of the chimney. It also depends on the diameter of the chimney .it is mounted at the center of the roof collector. So that the chimney tower create temperature difference at the base and top of the chimney which will suck the hot air towards the top of chimney. The upward movement of the hot air is utilized to drive the turbine located at the chimney. The turbines are generally located near the base of chimney to reduce the mechanical mechanism. Efforts of different types of chimney are made to enhance the efficiency of power plant such as sloped solar chimney, floating solar chimney, geothermal solar chimney, hybrid cooling tower solar chimney

- The most important part of the plant is the chimney. It acts as a thermal engine. Since the friction loss is minimum in the chimney it likes a pressure tube.

- Longer the chimneys height, the more the energy produced from the chimney.
- The efficiency of the chimney is not depend on the amount of the temperature rising, but depends on the outside temperature.
- Thus, efficiency directly proportional to the ratio between the height of the chimney and the outside temperature
- Although, the efficiency is proportional to the height of the chimney, there is a limitation in practice.

There are two types of different chimneys using for the plant. Free standing chimneys and guyed tubes The life span of a free standing chimney is longer than that of the guyed tubes. It lasts about a hundred years, while the guyed tubes' is much shorter

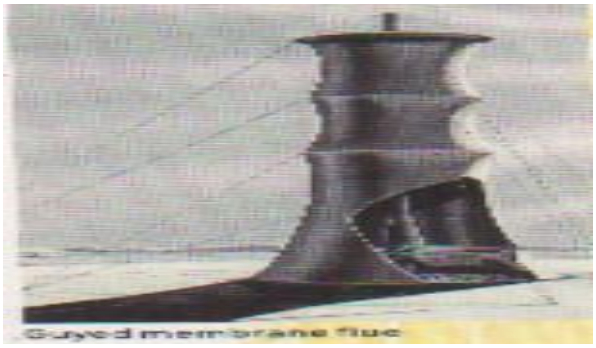

Figure 4: Guyed tube type chimney

IV. WORKING PRINCIPLE OF SOLAR CHIMNEY

- Solar chimney consists of large area of transparent covers which receive solar radiations.
- The cold air flows from the bottom of the chimney due to natural draught produced due to density difference of high density surrounding cold air & low density hot air below the transparent covers heated by the solar energy. It is called chimney draught
- Inside the chimney, turbines with electric generator produce electricity.
- The flow rate of air depends on the draught produced due to density difference of cold and hot air and the height of the chimney
- Transparent roof admits the short wave solar radiation component and retains long-wave radiation from the heated ground. Thus, when solar radiations pass through the transparent roof it is absorbed by the ground elements and it converts into heat energy.
- Since air is heated, it starts to rise up and move towards to chimney, also, it gains velocity. Heated air enters the chimney placed at the center of the roof and creates an up draught there.
- Inside the chimney, turbines with electric generator produce electricity.

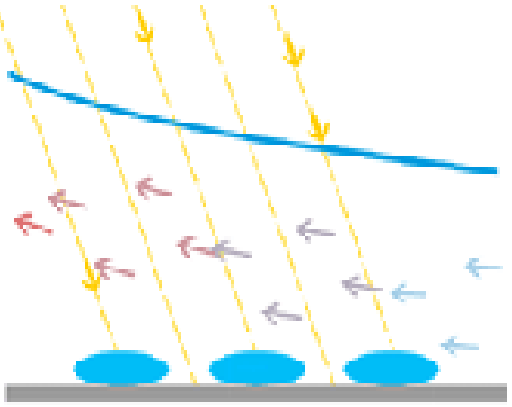

Figure 5: Schematic seen of solar chimney

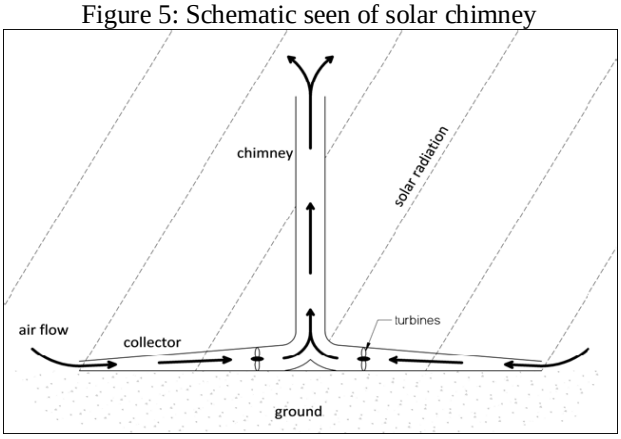

Figure 6: basic details of solar chimney power plant

Comparing with the collector and turbine, the chimney efficiency is relatively low. For example, at a height of 1000 meters, chimney efficiency is somewhat greater than 4%.

V. CONSTRUCTION OF SOLAR CHIMNEY

The FSC construction is made by a series of balloon-rings from light enduring fabric , connected successively in such a way that they form the main cylinder of the solar chimney. The internal and external ring diameters define the internal and external FSC's diameters. The ring height (h) multiplied by the number of lifting balloon rings determine approximately the height of the chimney. To encounter sub-pressure we can use, if necessary, special supporting rings place between the balloon rings. These rings have negligible thickness and diameters smaller or equal than the diameters lifting have negligible thickness and diameters smaller or equal than the diameters.

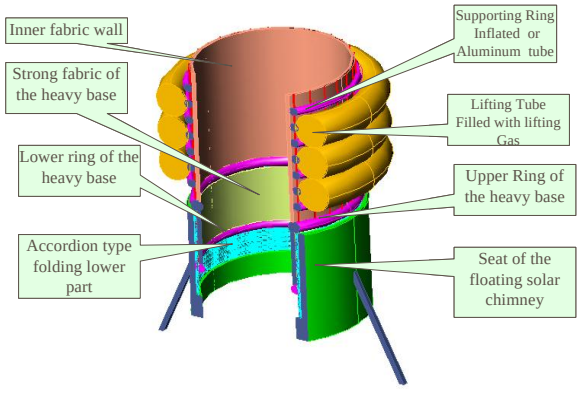

Figure 8: Part of the fabric cylinder of the FSC.

The polyester fabric of the tubular rings and the rest parts of the FSC is similar to the polyester fabric already used for the construction of air balloons or airships. An extensive presentation of "light" structures is given by Prof Beukers. These tubular balloon rings can become lighter than air containing special balloons filled with lighter than air gas (He or NH3). In order to keep the rigidity of the structure the balloon tubular rings should be over pressed with ambient air. Thus the whole fabric cylinder cannot be deformed by external winds or by the operational sub pressure and can be a free standing lighter than air structure. Through this free standing cylinder the warm air of the greenhouse is up drafting. When external winds appear the structure is bending due to its inclining special patented heavy base. of course its up drafting operation is not interrupted by the inclining position of the structure, however the operating height of the solar chimney it becomes smaller. The external winds, for a properly dimensioned FSC, have a marginal effect on its average annual operating height.

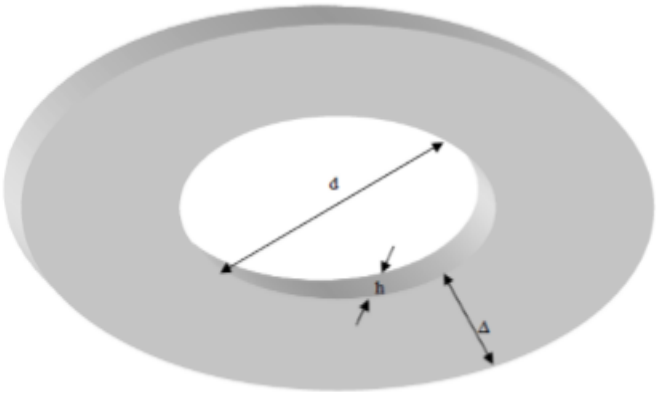

Figure 9: Balloon ring

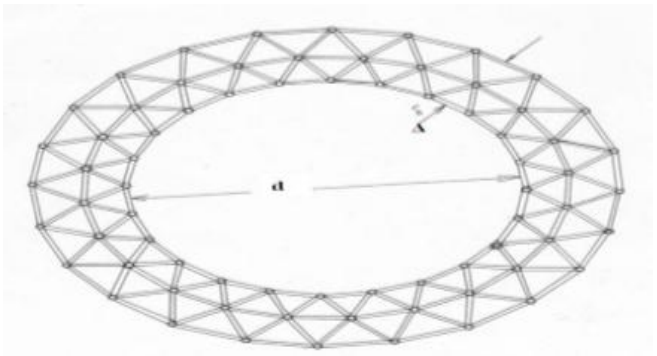

Figure 10: Internal structure of ring

To encounter external wind's forces is a rather more complicated issue. To do so the supporting rings are not sufficient, although they do help in this respect. The external winds' problem is encountered by the FSC's deflecting ability. Thus when external winds appear the FSC is deflecting, reaching its angle of balance. In this way, in its balance position, the FSC encounters vertically only the drag forces from the velocity's normal components, which are counter-balanced from the opposite FSC's buoyancy components. These normal forces to the FSC's cylinder are encountered locally with the assistance of the supporting rings. Wind velocity's tangent component creates a friction force parallel to the FSC's cylinder without deforming its shape. As already stated in order to encounter the winds' action on the FSC, it should have a deflecting ability.For this purpose two more elements are necessary:

A system that will keep the FSC at its position and which will receive the parallel and tangent forces from the external winds. This system is a two-part heavy base, which can incline on the FSC's seat without parting from it.

A flexible (accordion type) folding part of its base which will be unfolded partly as a result of the deflection, preventing the warm air to escape by the bottom of the structure . The above-mentioned system is sufficient with regard to constant speed winds, independently of the chimney's altitude. However, additional measures should be taken to encounter the differential forces on the chimney due to any possible variation of the wind's velocity with altitude. This wind's velocity variation creates differential forces along the chimney's cylinder. To encounter these differential forces the chimney's cylinder is separated in parts. These parts are constructed by a fixed number of tube balloon-rings. The parts are separated by isolation tubes filled with environment's air, which can easily get in and out of them. These relief tube isolate dynamically the consecutive parts of FSC from each other, allowing each part to reach its own deflecting angle, depending on the average wind velocity on the altitude where it is located. Since the external wind forces are increasing with the square of their velocity, it is recommended that in the places of installation of the FSC, the annual average of wind velocity not to exceed a certain limit, (for example 3 m/sec). The seismic activity of the place of installation does not affect the FSCs, although it does so in the case of reinforced solar concrete chimney.

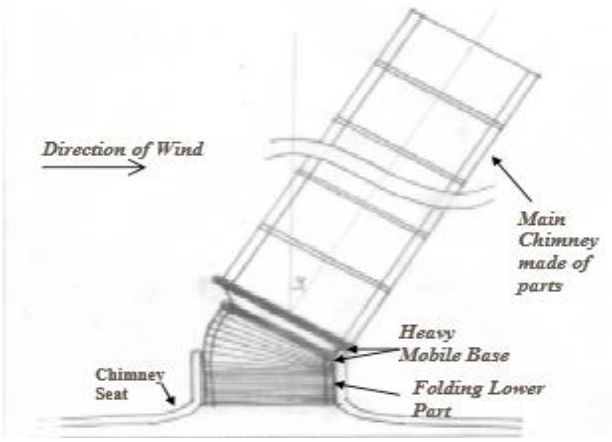

Figure 11: FSC under external winds

VI. THE WIND EFFECT ON THE OPERATIONAL HEIGHT

Due to the titling property of the FSC, its operational height is decreasing under external winds

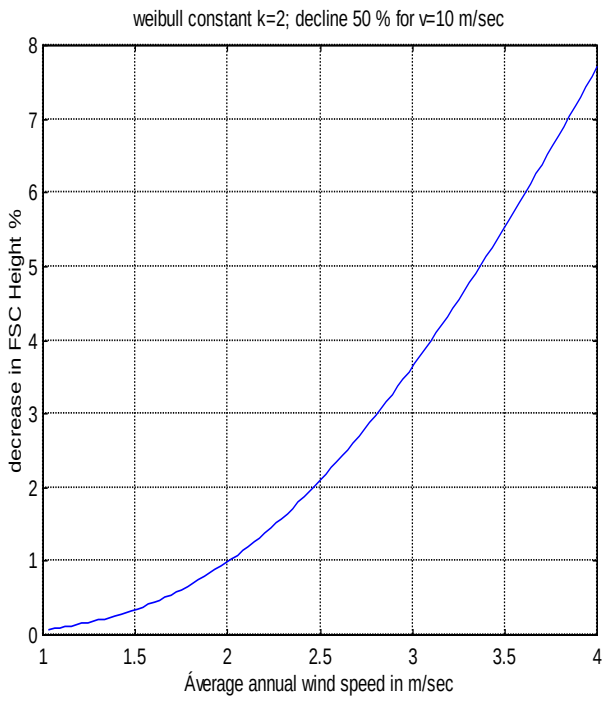

Figure 12: Wind Speed

VI. CHARACTERISTICS

The FSC power plants named by the author as Solar Aero Electric power plants (SAEPPs) are similar to hydroelectric power plants. In hydroelectric power plants the dynamic energy of the falling water, due to gravity, is partly transformed to electricity through water turbines geared to appropriate electric generators. In the SAEPPs the dynamic energy of the warm air, due to buoyancy, is partly transformed to electricity through their air turbines geared to their appropriate electric generators. Furthermore both power plants efficiencies are proportional to their heights (falling water height or up drafting air height)

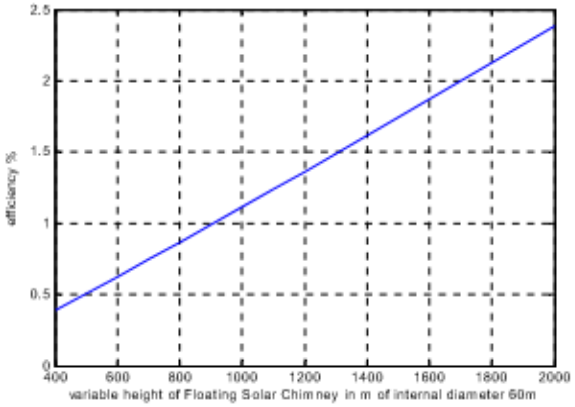

Figure 13: Annual efficiency of a typical SAEPP as function of its FSC height

The annual efficiency is defined as the ratio of the produced electricity in KWh to the annual solar irradiation arriving on the greenhouse roof. For example if in the place of a installation of a SAEPP the annual horizontal irradiation is 2000 KWh/m2 and the greenhouse of the SAEPP has a roof of 4 Km2 (4 million m2), 8000 GWh/year irradiation solar energy is arriving on its roof. If its FSC height is 900m than approximately by the diagram its efficiency is 1.0 % thus the annual electricity production is 80 GWh/year.

The annual efficiency can be estimating, as a product of three efficiencies, the efficiency of the greenhouse estimated to 55%, the efficiency of the Turbo generators estimated to 80% and the efficiency of the FSC estimated to 2.6% per Km height of the FSC. That is why the overall SAEPP efficiency for a Km FSC is about 1.15 %. However by theoretical analysis, not yet published by the author, the greenhouse efficiency is achieved only if there is a double glazing roof. The inner glazing could be made of a thin crystal clear plastic sheet, hanged below the outer strong glazing of the roof. For single glazing roof, as calculated by the analysis of the greenhouse efficiency is not more than 40%.

Efficiency of Tower And Overall Plant Output

Net efficiency of tower is given by the Back Storm's work as:

Tower = gxH/ (c_px T)

Where g = gravitational acceleration

H = height and cp is specific heat at Constant pressure.

Net power output from the system:

P= Q × ɳ Tower × ɳ Turbine × ɳ Collector……..

Q is the rate of heat input to the system

Q= M× cp ×T

Where, M = mass flow rate of air into the system

T =temperature rise between ambient and collector outlet (= tower inflow)

VII. ADVANTAGES AND DISADVANTAGES

Advantages

- Solar chimney power stations are particularly suitable for generating electricity in deserts and sun-rich wasteland.
- No ecological harm and no consumption of resources.
- It provides electricity 24 hour a day from solar energy alone.
- No fuel is needed. It needs no cooling water and is suitable in extreme drying regions
- It is particularly reliable and a little trouble-prone compared with other power plants
- The materials concrete, glass and steel necessary for the building of solar chimney power stations are everywhere in sufficient quantities.
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- The materials concrete, glass and steel necessary for the building of solar chimney power stations are

everywhere in sufficient quantities.

Disadvantages

- The structure itself is massive and requires a lot of engineering expertise and materials to construct
- Some estimates say that the cost of generating electricity from a solar chimney is 5x more than from a gas turbine. Although fuel is not required, solar chimneys have a very high capital cost
- Solar chimney power stations could make important contributions to the energy supplies in Africa, Asia and Australia, because there is plenty of space and sunlight available there
- It is very important for the future, because our resources are limited, except our sun.
- 16. Conclusion
- Solar chimney power stations could make important contributions to the energy supplies in Africa, Asia and Australia, because there is plenty of space and sunlight available there.
- It is very important for the future, because our resources are limited, except our sun.

VIII. CONCLUSION

- Solar chimney power stations could make important contributions to the energy supplies in Africa, Asia and Australia, because there is plenty of space and sunlight available there.
- It is very important for the future, because our resources are limited, except our sun.
- Future electricity demand could reach the 45000 T Wh. The necessary land for the 30 years FSC power plants is 1.000.000 Km2 (1000 Km X 1000 Km)

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