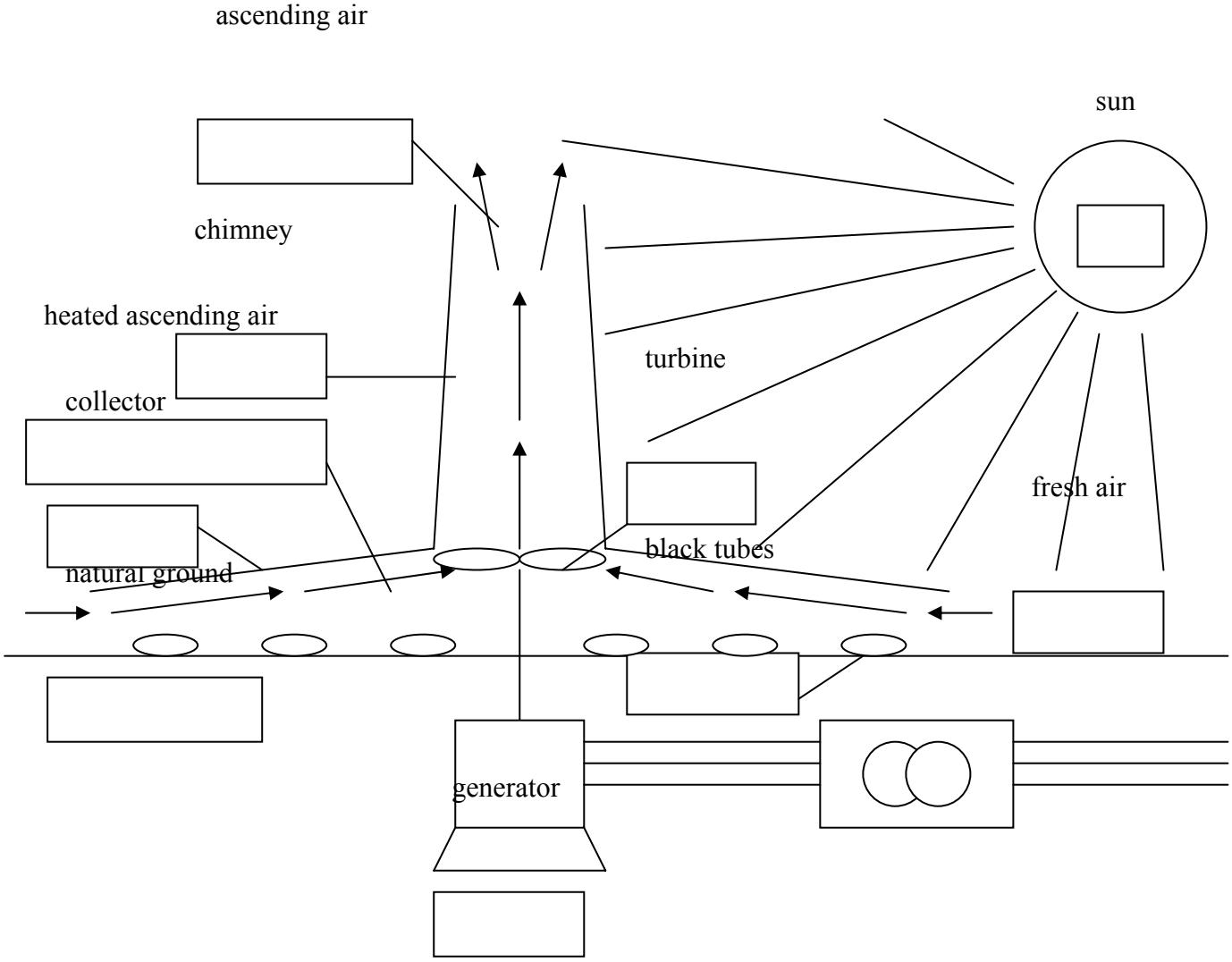
University of Applied Sciences of Bochum, Mechatronic technical English

Solar Chimney Power Plant



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Bochum, 02 July 2000

Summary

Advantages, Disadvantages and just Political Realisation Problems of the Solar Chimney Power Plant

The report ‘Solar Chimney Power Plant’ points out reasons and advantages for such a power plant. It starts with the main principle in short.

Than the text gives the main parts of the plant to show the separate advantages and the simplicity of building them. First the collector and the used hothouse effect. Belonging to that are the glass roof (absorber), natural ground (accumulator) and the operating medium (air) explaind. Also mentioned are possibilities to increase the efficiency. Further the chimney with the suction effect and the problem of its efficiency. As third part the turbine is mentioned with its principle drive and its possibilities of different positioning. In addition to the third part generator and gearing to get current power are within the report. At least the report contents a compact view to the whole plant.

The text goes on to introduce a successfull operated test plant. As well as to inform about actual plans for building solar chimney power plants. Finally it draws the readers attention to political strange activities to avoid promotions for solar chimney power plants.

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Solar Chimney Power Plant

1. Introduction

The solar chimney power plant has been developed twenty years ago. Against the conventional alternative energy sources it has two advantages. Firstly it is not technically difficult to realise and secondly it nearly needs nothing of natural materials. Conventional solar cells have the disadvantage of an expensive current and a not environmentally friendly manufacturing and waste disposal. But the assumptions for an solar chimney power plant are a big enough amount of space and a big enough amount of insolation. Especially in countries with desert regions are these assumption in existence. Also the needed building materials as glas and concrete are no problem in those regions. So these power plants are most interresting for developing countries for which they have been developed. The energy can be produced without using fossil or radioactive combustibles and no injurious waste products emerge. And compared with other power stations the costs for operating the solar chimney power plant are on a low level.

The solar chimney power plant basically operates like a hydroelectric power plant, but instead of water it uses hot air. The principle is a relative simple one. A round ascending glass roof with a diameter of several thousand metres is used as a collector. A chimney in the middle sucks the ascending heated air and the air ascends with a velocity about fifteen metres per second. The arising air suction is driving wind turbines which are placed in the chimney. The turbines are used

together with a generator and a gearing to produce current.

The present report points out the basically parts of the solar chimney power plant. In order to make clear which well known principles are used for this power plant and that the realisation is not a matter of special materials or constructions what would be very expensive or would need further developments. Finally it gives a short overview about the facts and a view on happened enterprises as well as on future plans.

2. Glass Roof - The Collector

2.1. Absorbing Medium - Hothouse Effect

To get energy from the sun for the solar chimney power plant is the same effect used like it is used for hothouses. All bodies absorbs the insolation at least partly. The absorbed insolation of short wave length is going to be changed from the bodies into radiations of long wave length, so to be changed into warmth. And in general transparent material like glas or foil, the typical material for hothouses, has also the ability of reflecting the radiations of long wave length. So such material is impervious for long wave radiations (‘elamination of radiation casualties’), which gives the material a good efficiency. Beside that there is the advantage of the mentioned kind of material that it also absorbs diffuse light. That means that the solar chimney power plant also operates with overcast sky, what is importand to tropical regions in addition to the regions mentioned in the introduction.

2.2. Warm Air Collector (a kind of a flat collector)

The absorber is the mean part of the collector. In the case of the solar chimney power plant large glass roofs are needed. These power plants have an output of 50 to 400 MW each. A 200 MW plant will produce about 1.500 GWh/year at 2.300 kWh/square(m) radiation. For such measurements is it now important to have proceedings against casualties because of convection (due to wind outside the

absorber) and transmission (due to the contact with colder materials like steel wich supports the glass roof). But just in the closer area of the roof to the chimney is to adjust thermal covering and translucer for the air temperature which is high at the biggest diameter and decreases with decreasing diameter. The costs for a panelling at the sides and the support places with material that thermal covers or a vaccum insulation of the complete absorber (glass or foil) would not been useful with a view to the efficiency.

Than there is natural ground as an accumulator for warmth. Over the day the ground gets heated and over the night it gives its warmth to the ascending collector air. This effect can be supported with black tubes placed on the ground under the glass roof. The tubes are filled with water only once (no further water is needed) to increase the effect. Black coloured bodies have best abilities to absorb radiations of long wave length at day to heat the water and at night to heat the air.

All in all the warm air collector. A collector which is robust , not difficult to realise and to operate 24 hours a day. Its glass roof ascends to the middle (in two to six metres over the ground and with up to 10m x 10m big glass segments) , so that the heated air can accelerate on the way up to the middle where the chimney is.

3. Chimney

3.1. Cold and Warm Air - Ascending Force

The ascending force emerges due to the fact that hot air is not as heavy as cold air. The only way for the hot air from the collector is along the glass roof up to the middle through the chimney. In the chemney exists a suction in cause of the small and cold (compared to the heated air) surface of the chimney. The hot air likes to get upper the cold air and if the space for the air gets smaller the air accelerates. Further the air accelerating depends to the temperature difference between inside the plant (mainly inside the chimney) and outside the plant. In case of the mentioned plant approximately 35 degrees. As higher the chimney is as higher is the suction effect.

At this point it is to recognize that the effect of the ascending glass roof and the suction effect are superimposed.

3.2. Measurements and Efficiency

The chimney is basically the thermal engine of the solar chimney power plant. Due to the optimized proportion of surface and volume the chimney is a low loss and low friction pressure pipe. Compareable with the pressure pipe of a water power plant.

Compared with the efficiency of collectors or of turbines the efficiency of the chimney is relative small. So the efficiency of the chimney is the determining efficiency.

- flat collector depending to the air throughput: up to 70% and approximately 50% over a year
- a chimney like the one mentioned (height about 1000m): just roughly 3%
- efficiencies of turbines and generators are surely higher than 70%

At least that is the reason for the height.

For a 200 MW plant (as mentioned in 2.2) a suitable height would be 1000m with a diameter of 170m. The thickness decreases from about 100cm to about 25cm. Today it is no problem to build chimneys of such heights (in Japan are plans to build skyscrapers with a height of 2000m). Therefore there are a lot of possibilities to build the chimneys. Probably the best is to build them self supporting with ferroconcrete. Also possible are pipes of steel, rope networks and membranes. To give the structure more stability on the inside ground stiffening spoked wheels should be placed. But all kinds are well known from the cooling tower building. They do not have to be developed.

4. Turbines, Generator and Gearing

4.1. Wind Turbines in Solar Chimney Power Plants and Adjustable Airscrews

With turbines it is now possible to get power in form of rotational energy out of the vertical air current in the chimney. The turbines are basically more closely related to the pressure staged hydroelctric turbines than to the speed stepped open air turbines. Similar to the water power plant the static pressure is reduced in a pipe. The efficiency is approximately eight times higher than the efficiency of speed stepped open air turbines. The velocity of the air is in front of and behind the turbine the same. Arround fifteen metres per second. This amount of speed allows maintenance and repair while the plant is operating.

The airscrews have to be adjustable. Because the angle of maximum efficiency is different like the pressure difference changes. With that the adjustable airscrews are controlling the turbine, the air velocity and the air current in the plant. In vertical and horizontal position the airscrews would stand still in spite of the ascending air.

4.2. Position and Alternatives for Wind Turbines

Fundamentally the turbines are psitioned at the chimney foot. It is possible and for the bigger plants more economical to use a lot of smaller turbines with a horizontal axis (like it is usual for cooling tower fans). They are to place at the

circumference of the change over area between the glass roof and the chimney.

The second possibility is just one or also several turbines with a vertical axis. The airscrew for just one turbine is in length as big as the radius of the change over area. The airscrew length of several turbines depends on the number of turbines and the change over area diameter, as in the first possibility. Turbines with a vertical axis have an especial quiet running and they are more robust.

An reversing system is placed under the chimney in the middle of the glass roof corresponding to the used number and kind of turbines. It gives the air current a more direct and efficient way to drive the turbines.

4.3. Generator And Gearing

Generator and gearing are just conventional. They correspond to them which are in use in similar fields of application. Very well known technology. At least a network is to add to consume the current. But further explaining would be to much for this report.

5. Conclusion and Outlook

5.1. The Plant Itself with View to the Life Span

Firstly emerges a self controlling for the air mass throughput due to the combining of collector and chimney. The collector efficiency increases with decreasing insolation or temperature increasing.This causes a very well balanced operating over the day. It is also good for the turbines because of the constant charge. The roof is good for the turbines because it permits just slight and slow changes of pressure and velocity. So the turbines have a very high life span and beside that they are not to expensive and their construction is not to complexe.

The life span of ferroconcrete towers is in dry regions at least 100 years. Water is needed to destroy the protection effect of the concrete to the concrete steel.

The collector can reach a life span about 60 years. Provided that there is a continouing maintenance.

All in all a plant which is simple to realise and which makes maintenance and repair easy. Exactly what developing countries need with not enough money and personnel with a high enough amount of technical knowledge.

Also the environmental pollution is for the solar chimney power plant no matter. Because the main burding material is just concrete, steel and glass. All materials are involved in common recycling processes. Than the operating medium was just air !

5.2. A Successful Test and Big Plans

The solar chimney power plant was mentioned and prospected in the beginning of the last century. 1982 in Spain was build the first plant of that kind with a maximum output of 50 kW. As a test plant it sserved to figure out what is the efficiency about one year in reality. It was in operating for 7 years. It operated with a chimney of 150m in height and a collector surface of arround 2000m². The collector is made of glass because foil is overtaxed with the wind conditions in dry and sandy regions. For glass are also hard sand storms no matter. So the collector got over the seven years without damage. At the turbines could after seven years no attritions be determined. The chimney determined the end of that plant. In addition to a test plant it was just a light construction tin chimney, which was rusted through after seven years. A storm got the chimney to fall. That test plant was a successfully project which showed the principle possibilty to produce enregy with a solar chimney power plant.

Further other advantages could be determined. The construction of chimney and ascending glass roof is self cleaning. For the sand and dust is from time to time just a little bit rain necessary. Secondly plants can be placed in the area of bigger diametres under the glass roof for growing like in a hothouse.

But today plans existing for plants with much more power. Plans for several 100 MW plants in Ghana and in Rajasthan, India. Plants with chimneys of 950m in

height and 115m in diameter and a glass roofs with a radius of 1800m. Surely the main engineering problem will be to build the chimneys.

5.3. The EXPO 2000 and the Solar Chimney Power Plant

Finishing the report it is to mention that a model, 180m in height, of the solar chimney power plant was in discussion to beccome the emblem of the EXPO 2000. With that height the model should have loomed over all other buildings of that event. It has not been realized. No sponsors have been found. And also the Federal Ministry of Science (sponsored the successful operated test plant in Spain) did not want to support the project for the EXPO 2000. That with the mere reason that the test plant in Spain was not economic enough. Probably another time the possibility to be trendsetter of a new technology is passing by Germany.

Hopefully the mentioned plans for Ghana and India will be carried out. But the lobby of the atom power is hard fighting against such plans. They won in Hannover but they should not win the next time.

So far to take position for technologies which are just good, environmentally friendly and supporting the balance between the different classes of human beings. In order to support the global village and the developing of team works between nations or even continents.

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