Study of Designing a Solar Concentrator for Crematorium using Solar Energy

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Abstract

While cremation is an established Hindu ritual practice since ancient times and the Hindu religion permits the cremation of dead body in day-time only, there is much more scope of solar crematorium in this ritual; as solar power is also available in day-time only. Between 500 and 600 kg of wood are used to cremate a dead body. Many trees are felled to meet this requirement. As a result we are significantly contributing in global warming and polluting the atmospheric air much more. Therefore today, world is moving towards the sustainable energy sources which are renewable and biodegradable in nature. One of most sustainable energy source is sunlight that too is inexhaustible and available free of cost. The heat (energy) produced is very clean with no pollutants. So above environmental problems can be the addressed very well by using solar crematorium. Therefore anyone can be a firm believer of world powered by solar energy. In this paper, a special concentrator has been designed to supply required sufficient heat energy to the crematorium by concentrating solar energy. Its speciality is a flexible surface curvature and simultaneously with a non-moving focal area.

1. Introduction

India is facing the twin problems of fast depletion of conventional fuels and environmental degradation. There is an urgent need to reduce dependence on petroleum and other conventional fuels for better economy and environment. Utilization of solar energy can address both these issues. Nearly the sun is the source of all the energies on earth.

When one thinks of the word “solar”, photovoltaic modules and panels automatically come to mind, which converts the sunlight into electricity but that is not the case here. Since the sunlight has very little part, only 10% of its energy as lighting effect and large portion, 90% as thermal effect. So energy of solar radiation can be utilized more in solar thermal power generation than in solar photo-voltaic (which utilizes only lighting effect of sunlight) for power generation. A crematorium too requires very large amount of heat energy which can be harnessed by directly by solar concentrator. On the other hand, I will never suggest using of solar photo-voltaic panels to obtain such a large amount of heat indirectly for cremating a corpse. As firstly, PV panels convert only 10% (lighting effect) of solar energy into electricity, and then this electricity is converted into heat by allowing passing through very high amount of resistance. This conversion of electricity into the heat is too associated with several losses. So employing solar PV panels will not be feasible for cremating a corpse. Although these PV panels can be used to get electricity for running the accessories like tubes, fans in office/cabins and necessary motors installed in tracking system.

Since combustion chamber of crematorium is stationary and not movable but solar concentrators require tracking the Sun, as a result a movable focus is obtained. This is major problem in designing a solar concentrator for the crematorium. This problem was shorted out by Wolfgang Scheffler who invented a new concentrator (scheffler reflector) tracking the Sun without changing it focus. In this paper, scheffler reflector is redesigned to determine required size (Aperture Area) of the concentrator to obtain sufficient heat energy for cremating a corpse.

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2. Literature Review

Not much extensive and dedicated work is seen after studying a lot of different popular journals available. Few works has been reported and added in this paper for solar furnaces and cost estimation of solar equipments.

The largest solar furnace is located in Font-Romeu-Odeillo-Via, high in the Pyrenees Mountains in the Basque region of the French/Spanish border. It has been operational since 1970. This is the same area in which the world’s first solar furnace was built; this solar furnace was put in place at Mont-Louis in 1949 by Professor Felix Trombe. Odeillo and Mont-Louis are within 15km of each other. The furnace makes use of an array of 10000 mirrors to reflect sunlight into a gigantic concave hemisphere which then focuses the energy onto an area roughly the size of a cooking pot. The flat mirrors track the sun in unison and redirect the solar thermal energy towards the crucible which is being used for melting steel.

World’s first solar crematorium is being developed in our country of Goraj village (30 km East of Baroda) in Gujarat state by Muni Seva Ashram with the help of Ronnie Sabawalla of Rashron Energy and Auto limited. In 1998 they started with a specially designed Scheffler reflector with 50m² mirror surfaces. But its initial concentration-factor of about

C = 100 turned out to be by no means enough to allow proper cremation.

3. Cremation Process

A crematorium is a furnace that is able to generate temperatures of 760–1150°C to ensure disintegration of the corpse. Cremation is the process of burning a dead body at very high temperatures until there are only brittle, calcified bones left, which are then pulverized into "ashes." These ashes can be kept in an urn, buried, scattered or even incorporated into objects as part of the last rites of death.

As per Hindu ritual practice, there is an established sentimental fact of cremating the dead body completely at one goes. And there must not be left any un-burnt portion of the body. Otherwise the soul of that person will remain unsatisfied, and it will be converted into the devil or imp which will victimize or terrorize the concerned relatives for his/her satisfaction.

4. The Concept of Solar Crematorium

The basic concept of solar crematorium is to ignite the dead body locally anywhere and anyhow with the help of a huge concentrating reflector having very high CR and to maintain the combustion of dead body by supplying the fresh atmospheric air with the help of blower. Once combustion of dead body starts within the cremation chamber, it also releases heat which automatically in combination with solar energy obtained from concentrating reflector maintains continuous burning of dead body until complete dead body gets converted into ash. See figure:1. A system of solar crematorium can be divided into following components:

- Solar Concentrator
- Tracking System
- Cremation Chamber

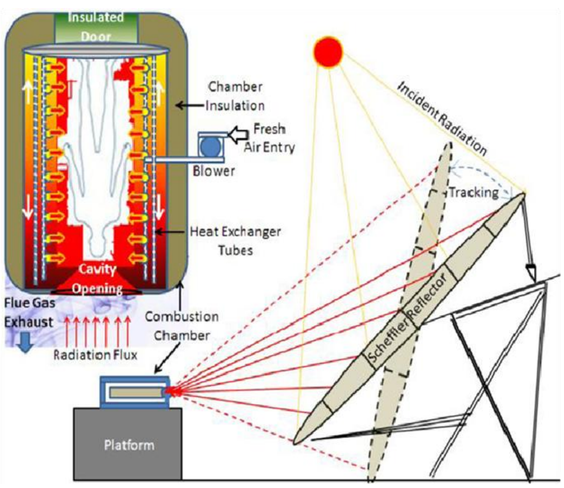


Fig: 1. Block Diagram of Solar Crematorium

5. Solar Concentrator

Parabolic Scheffler Reflectors can provide (you with) high temperature heat. Their speciality is a flexible surface curvature and a nonmoving focal area. Therefore their use is now becoming increasingly popular in many parts of the world, especially in India.

5.1. Designing the Solar Concentrator

The size (Aperture Area) of concentrator (Scheffler reflector) is determined by reverse design procedure. Which is described step by step as following:

First of all "**E**" (total energy) required to burn completely a single dead body is calculated. Since a traditional Hindu funeral pyre takes 2-3 hours and consumes 500–600kg of open wood pile to burn completely a corpse. But considering 100% efficiency of combustion chamber, if all the energy released from wood is utilized, only 22 kg of wood will be sufficient to completely burn down a body. Considering 80% efficient cremation chamber, 100kg of wood will be sufficient for cremating a single corpse in 1 to 2Hrs if heat loss is optimized to minimum value by effective insulation of combustion chamber. Since calorific value of wood is 19700kJ/kg. Therefore

$$E = 100kg \times \frac{19700kJ}{kg} = 1970000kJ = 1970MJ$$

Now "**P**" power (in MJ/hr) required to burn completely the body in combustion chamber is determined. If we design a reflector to cremate a dead body in 2hrs then this (total energy) "**E**" required to burn completely the dead body must be obtained/captured by the reflector within 2hrs. Therefore

$$P = \frac{1970MJ}{2Hrs} = 985MJ/Hrs$$

Finally "**A**", **size** (Aperture Area) of Scheffler reflector is determined. Since DNI (Direct Normal Irradiance) is 5MJ/m^2hr (≈ 4.9212 MJ/m^2hr = 1367W/m^2 X 3600sec). So Aperture Area "**A**" is obtained by dividing "**P**" (power) with DNI. i.e.

$$A = \frac{P}{DNI} = \frac{985MJ/Hr}{5MJ/m^2\,Hr} = 197\,m^2$$

5.2. Material of the Concentrator

The concentrators (Scheffler reflector) are made up of several small double sided (two plane mirrors are joined on their each other silver coating sides) plane mirrors. Theoretically single sided mirror is sufficient for the Scheffler reflector, but double sided mirror is used to protect the silver material which is coated on the almost completely transparent glass. Because of intense heat and temperature of solar energy there is possibility of silver coatings to melt away from the rear surface of the glass. Therefore the rear side mirror protects the silver coating to melt away by reflecting back the sunlight if any from rear side, and simultaneously by avoiding the erosion and corrosion. This rear side mirror also provides the additional strength to the front mirror.

The efficiency/reflectivity of several plane mirrors in the Scheffler reflector ranges 90-95% when new. Though it is not important much more, because efficiency is greatly considered where we pay money for energy/fuels which (solar energy) is free here. Here efficiency/reflectivity of mirror is only considered to determine size (aperture area) of the Scheffler reflector.

6. Tracking System

Since the speciality of Scheffler reflector is flexible surface curvature and a nonmoving focal area. Their use is now becoming increasingly popular in many parts of the world, especially in India. Almost all concentrators have a rigid structure and the focus, the hot area where all light is concentrated, moves along with the direction of the sun. This makes its use a little bit impractical.

This is a paraboloidal mirror which is rotated about axes that pass through its centre of mass, but this does not coincide with the focus, which is outside the dish. If the reflector were a rigid paraboloid, the focus would move as the dish turns. To avoid this, the reflector is made flexible, so it is bents as it rotates so as to keep the focus stationary. Ideally, the reflector would be exactly paraboloidal at all times. In practice, this cannot be achieved exactly, so the Scheffler reflector is not suitable for purposes that require high accuracy.

6.1. Stopping the Sun

The sun gives us the impression of movement basically because the earth is revolving under our feet. One way to stop moving while rotating is to locate yourself in the center or axis of the rotation. Imagine a carousel. When you go to its center, you will still rotate, but will not move sideways any longer. The same way, the hot focus of the Scheffler Reflector is placed in the axis of rotation of the reflector. Thus it remains in a fixed place, giving maximum convenience.

6.2. Moving with the Sun

Just as the earth spins around an axis through the North Pole and the South Pole, the Scheffler Reflector spins around an axis parallel to that, just in the opposite direction. (It counteracts the earth's rotation, cancel it out.)

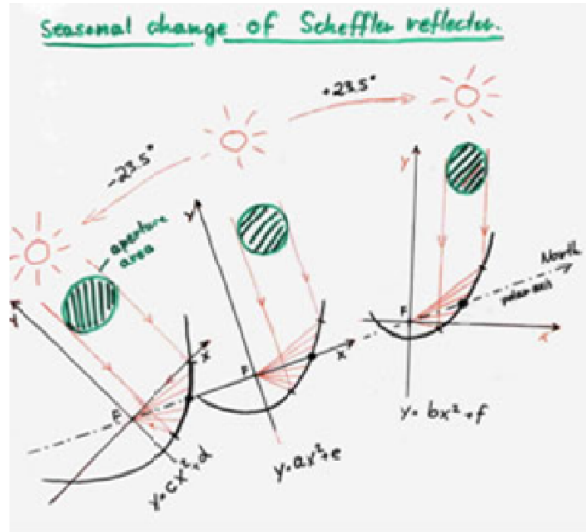
This is called polar mounting or mounting on a polar axis. The speed is one revolution per day, or, better, half a revolution in half a day, since we do not use at night. This way the reflector keeps facing the sun in a constant manner. The constant speed is controlled with mechanical clockwork. For practical reasons, the shape of the reflector is such that the hot focus is outside of the reflector, either on the north side or the south side. This way the hot focus can be even inside a building while the reflector remains outside.

6.3. Bending and Flexing, the Most Unique Feature of the Scheffler Reflectors

This is the most important point of the design of the Scheffler reflector, and is normally completely overlooked by people who see the reflector. In winter, the sun is low above the horizon, while in summer it moves high up into the sky. Under these changing conditions, having a different angle of the sunlight every day, it is difficult to maintain a small and hot focus in a fixed place during all the four seasons. The design of the Scheffler Reflectors provides the only widespread solution to this demanding situation. First it sounds almost unbelievable, but the reflector is made to change the shape of its entire surface to adapt itself to the different angles of the sunlight.

This way, a small and hot focus is achieved during all seasons. This sounds very complicated to make and to handle, but it turns out not to be so.

If you take a round or elliptical piece of orange peel and slightly squeeze it in your hand, you get a similar change of shape as it is required for the reflector. When you squeeze it, in one direction it will become more curved, while in the other direction it flattens out a bit. When you pull it apart instead, it will flatten out in this direction and curve in the other one. This gives you the basic idea on what type of shape change is required for the reflector to achieve a small focus at all seasons. For the real reflector all these shapes are of course calculated first. A scientific pocket calculator and your school math are sufficient to do this job. It's all based on the equations of a parabola and straight lines and calculating their intersection points.



Different parabolas focus the sunlight at different seasons. The incident light has to be parallel to their y-axis. Note the seasonal change in the aperture area, focus "F" and the center of the Scheffler reflector (black dot) remain stationary

It also uses the fact that whenever you cut a paraboloid with a plane, you get an ellipse; in school we used to learn this only for a cone. That is why the Scheffler reflectors have this typical elliptical shape.

The small straight section of the frame near the focus improves the flexing behavior in that section. This is found by trial and error method. Reflectors like the SK-14 (used for cooking or, steam generation) are circular. This is because their plane of cutting is perpendicular to the paraboloid. In that special case the short and the long diameters of the ellipse become of the same length and we get a circle. After a lot of observation done on Scheffler reflector it is found that five points are sufficient to support the reflector frame. And, very important, only two of them needed to be adjusted in order to create all different shapes required during the whole year. These two are adjusted manually after every few days, just pushing or pulling them until all light enters the hot focus again properly.

It is very important to keep the number of adjustments to this minimum; otherwise it is felt that handling would be too cumbersome for the user. Actually a third adjustment in the center of the dish would have been necessary, but after studying the geometry for some time, it is found that it could be designed this adjustment as an automatic lever. The lever pushes the center of the reflector forward or retracts it automatically when the reflector is set for the seasonally lower or higher sun. At that time, the angle of the reflector towards its mounting along the polar axis changes, and the lever is activated. The whole structure is well balanced and easy to turn. It is made from light iron tubes and bars, which are softer in the places which require more bending (like near the focus) and stiffer where less bending is appropriate (the areas far from the focus).

Fig: 3. Automatic tracking Stand for small Scheffler reflector

Fig: 4. Crematorium tracking stand aligned with back crane and reflector frame

The power output varies with the season (Fig: 2). The Sun which shines more from the front into the reflector sees a larger reflector (large aperture), and thus more power is collected. In the same way, a sun shining more from behind sees a smaller reflector and less power is collected. A 2.7 m² reflector can typically bring 1.2 lts of water to boiling point within 10 minutes. The circle (see figure 5) at the center highlights the position of the lever for the seasonal shape change.

Manual changing of length of the reflector's rear support for seasonal adjustment

7. Application

Parabolic Scheffler Reflectors can provide (you with) high temperature heat. So it can be used besides solar crematorium, for all types of cooking, steam generation and many other applications.

8. Conclusion

In conclusion, it is established that a well-designed and maintained system is capable of solar cremation. Utmost care should be taken in maintaining such a system and operating at appropriate weather conditions. It is finally recommended that such systems should be highly promoted to conserve energy and foster a cleaner environment.

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