Scheffler Dish and its Applications

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Abstract-The Scheffler reflector is a new solar concentrator design which maintains a fixed focus while only having a single axis tracking mechanism. This design makes the construction and operation of high temperature solar concentrators accessible to developing nations. The document maintains a focus on the practical day-to-day tasks of operating a parabolic trough system. The special feature of the reflector is that concentration point of the sunshine is at the same place throughout the day even though reflector dish is moving along with the sun from morning to evening. So it is possible to cook the food or use the concentrated heat at the concentration point which is somewhat away from the reflector. The report also gives the design and specification of Scheffler Reflector. The report also deals with methodology, working and various components of Scheffler Reflector. There is a detail description of existing system and Scheffler Reflector. The various industrial applications of Scheffler Reflector are mentioned in the report.

Keywords- *Scheffler reflector, axis tracking mechanism.*

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I. INTRODUCTION

A parabolic (or paraboloid or paraboloid) reflector (or dish or mirror) is a reflective surface used to collect or project energy such as light waves. Its shape is part of a circular paraboloid, that is, the surface generated by a parabola revolving around its axis. The parabolic reflector transforms an incoming plane wave traveling along the axis into a spherical wave converging toward the focus Parabolic reflectors are used to collect energy from a distant source (for example sound waves or incoming star light) and bring it to a common focal point, thus correcting spherical aberration found in simpler spherical reflectors. Since the principles of reflection are reversible, parabolic reflectors can also be used to project energy of a source at its focus outward in a parallel beam, used in devices such as spotlights and car headlights

The Scheffler Reflector, named after its inventor, Wolfgang Scheffler. A concentrating primary reflector tracks the movement of the Sun, focusing sunlight on a fixed place. If the reflector were a rigid paraboloid, the focus would move as the dish turns. To avoid this, the reflector is flexible, and is bent as it rotates so as to keep the focus stationary. Ideally, the reflector would be exactly paraboloid at all times. The focused light heat a very large pot, which can be used for heating, steam generation, cooking, baking breads, and water heating .The Scheffler reflector can be used for the supply of hot water for domestic purposes.The use of Scheffler reflectors can result in effective water heating by using the non-uniform distribution of solar radiation on the cylindrical absorber surface. It is used in applications such as solar cooking, where sunlight has to be focused well enough to strike a cooking pot.

A. History

The principle of parabolic reflectors has been known since classical antiquity, when the mathematician Diocles described them in his book On Burning Mirrors and proved that they focus a parallel beam to a point. Archimedes in the third century BC studied paraboloid as part of his study of hydrostatic equilibrium, and it has been claimed that he used reflectors to set the Roman fleet alight during the Siege of Syracuse.This seems unlikely to be true, however, as the claim does not appear in sources before the 2nd century AD, and Diocles does not mention it in his book. Parabolic mirrors were also studied by the physicist Ibn Sahl in the 10th century. James Gregory, in his 1663 book Optica Promota (1663), pointed out that a reflecting telescope with a mirror that was parabolic would correct spherical aberration as well as the chromatic aberration seen in refracting telescopes.

The design he came up with bears his name: the "Gregorian telescope"; but according to his own confession, Gregory had no practical skill and he could find no optician capable of actually constructing one. Isaac Newton knew about the properties of parabolic mirrors but chose a spherical shape for his Newtonian telescope mirror to simplify construction. Lighthouses also commonly used parabolic mirrors to collimate a point of light from a lantern into a beam, before being replaced by more efficient Fresnel lenses in the 19th century. In 1888, Heinrich Hertz, a German physicist, constructed the world's first parabolic reflector antenna.

The first well functioning Scheffler-Reflector was built by Mr. Wolfgan Scheffler in 1986. It is situated at a mission-station in North-Kenya and is still in use. The size of first Scheffler-Reflector was 1.1m x 1.5m.By early 2008, over 2000 larger cooker of his design had been built distributed worldwide. People happily like to use solar-cookers when the cooker is practical, delivers enough energy for their needs and when they don't have to change their cooking-habits too much.

II. MOTIVATION

India is full of Solar Energy. We are very fortunate in the sense of solar energy that we get solar energy in excess amount. So it is necessary to utilize the solar energy in proper way. As India is 2nd largest country in the world in population. With increasing population we should also fulfil the demands of people regarding the energy. In today period many villages in our country are cooking on chulas. Use of chulas creates smoke, which further leads to severe health problems specially in women. Also people in villages cuts the trees for cooking which leads to deforestation in large amount. Deforestation creates many environmental changes which are not favourable for the human as well as other living things. Deforestation caused by Increasing Firewood Consumption. Diversion of Human Resources for Fuel Gathering.

Our respected Prime Minister also promoting various schemes like UJWALA YOJNA against the use of chulas. So the Scheffler proves boon for it. Scheffler also saves the non renewable energy .Solar thermal is viable where fuel oil or electricity is being used for heating & cooling applications. Scheffler is an alternative for high cost or unavailability of commercial fuels – Kerosene, Coal, Gas, Electricity. Many industrial process like drying, heating, process heat, etc. can also done with Scheffler.

III. LITERATURE REVIEW

A. Munir presented an experimental study of transforming solar energy into thermal energy by using parabolic solar concentrator with a system of continual tracking of the sun.The experiment carried out on a prototype of concentrator of 1 m in diameter and a copper receiver, 10 cm in diameter and 20 cm length. The receiver was located at the focal plane of the parabola. This model of parabolic solar concentrator led to the levels of temperatures ranging between 2000C and 3500C.

B. Bellel studied the difference in performance of two types of solar cylindrical receivers. Bellel dealt particularly with problems of heat transfer in the absorber. In fact, the concentration of solar energy, which the absorber converts into thermal energy, allows one to meet various needs: hot water for different uses, production of electricity through the generation of steam, sterilization of objects (medical devices).

C. Bhirud and Tandale and Delaney developed concentrators that are capable of delivering temperatures in the range of 3000C and are technically suitable for medium temperature applications. With a higher concentration ratio, there is an increase in temperature at which heat is delivered. It is observed from the comparison that the two axes tracking paraboloid dish, which always faces the sun, is the most promising design for the concentrating systems justifying the use of the Scheffler concentrator for industrial process heat applications. These concentrators also provide an automatic tracking system.

D. Ruelas developed and applied a new mathematical model for estimating the intercept factor of a Scheffler-type solar concentrator (STSC) based on the geometric and optical behaviour of the concentrator in Cartesian coordinates.

E. Reinalter investigated thermal and geometric features of the 10 kW receiver CNRS-PROMES system (parabolic reflector with diameter 3.8m, focal length 4.5m). The validation process of the thermal model was performed by comparing the experimental results reported for the 10 kW cavity receiver CNRS-PROMES system to the results obtained from the simulation of incoming solar radiation in laboratory conditions by using a solar simulator.

F. Rapp and Schwartz constructed and successfully tested a 2 meter sq. parabolic dish solar concentrator (Scheffler Concentrator) to focus sunlight onto a stationary target. They described some ideas about the intricate design of the Scheffler reflectors and how they are developed. The parabolic Scheffler reflectors can provide for a high temperature heat for all types of cooking, steam generation and many Optical Model and Numerical Simulation of New Offset Type Parabolic Concentrator. This study develops and applies a new mathematical model for estimating the intercept factor of the solar concentrator based on its geometrical and optical behaviour.

G. Asmelash also designed and manufactured an offset type of solar concentrating system for cooking purposes. The concentrating offset collector had major and minor diameters of 90 by

80 cm respectively. The system was tested for its thermal performance following standard testing procedures of the American Society of Agricultural Engineers (ASAE) and it was found useful with an encouraging results. Maximum temperature of 9400C was achieved in the cooking vessel after 25 minutes.

H. Cabanillas and Kopp developed a solar parabolic dish concentrator with a diameter of 2.44 mm and focal length of 0.92 m. They studied a solar spiral heat exchanger made from carbon steel in order to measure the energy efficiency and net energy gain of the concentration system.

I. Saravanan designed solar biomass hybrid dryer for the purpose of drying 40 kg of cashew nut per batch. They have investigated the thermal performance of a solar biomass dryer. Their system consists of a solar flat plate collector, a biomass heater, a drying unit, a blower and a chimney. The solar air heating collector system consists of an absorber, a double glass cover, a back plate and insulation

IV. OBJECTIVE AND SCOPE

A. OBJECTIVE

The basic idea that lead to the development of the Scheffler-Reflectors was to make solar cooking as comfortable as possible. At the same time the device should be build in a way that allows it to be constructed in any rural welding workshop in southern countries after a certain period of training. The locally available materials must be sufficient. The Technology should be such that it can make cooking simple and comfortable. The cooking-place should not have to be moved, even better: it should be inside the house and the concentrating reflector outside in the sun. The best solution was a eccentric, flexible parabolic reflector which rotates around an axis parallel to earth-axis, synchronous with the sun. Additionally the reflector is adjusted to the seasons by flexing it in a simple way.

B. SCOPE

The Scheffler Reflector which is the basic solar concentrating device which can be use for various solar applications. The easiest way is to use Scheffler Reflector as community solar cooker for cooking the meal of 100 people within 60-90 minutes. In near future, Scheffler Reflector will be used in thousands of quantities for electricity generation by using dish stirling system. Similarly, Scheffler Reflector have wide future scope for water lifting. In numerous food, pharmaceutical and chemical industries involving heat process, Scheffler Reflector have a bright future. So in future, Scheffler Reflector used in millions of quantity in various solar applications. At present, Scheffler Reflector are used in 20 countries mainly for community cooking.

V. METHODOLOGY AND DESIGN PROCESS

A. Principles

The Scheffler dish system works on the following principles:

1. The parabolic reflective dish turns about north-south axis parallel to earth's axis, tracking the
Sun's movement from morning (East) to evening (West), maintaining gravitational equilibrium
of the dish.

2. The parabolic reflector also performs change in inclination angle while staying directed to sun,
in order to obtain sharp focal point.

3. Focus lies at the axis of rotation. It remains at a fixed position, where concentrated heat is
captured and transferred to water through the receiver to generate hot water or high pressure
steam.

4. Water from header pipe passes to receiver (thermosyphon principle). At the receiver, the
hot water or steam generated water and collected in the header pipe flows to the end use
application.

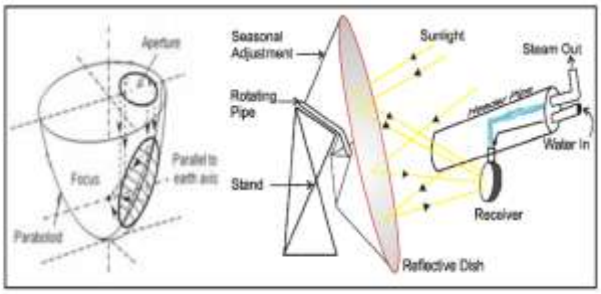

Figure 5.1: Solar Scheffler Dish Concentrator

B. Components

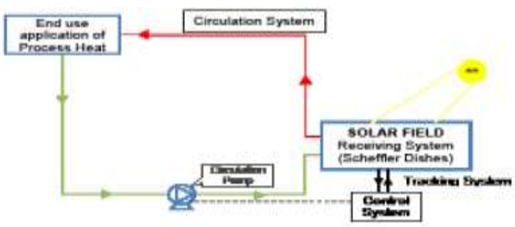

Figure 5.2: Components of Scheffler reflector

1. Receiving system

The receiving subsystem collects solar radiation in the solar field from parabola shaped reflecting collectors and transfers it to working fluid such as water or oil.

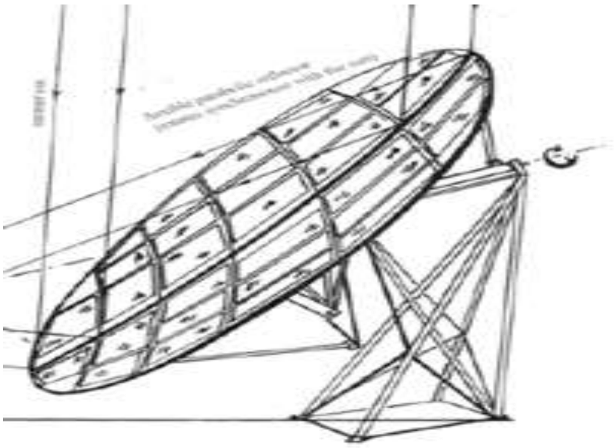

Figure 5.2.1: Receiving dish

2.Tracking system

The tracking subsystem acts as a support to the receiving subsystem. It maximizes the solar energy captured by moving solar collectors towards the sun for complete day. Some tracking systems also track the sun as it changes its position during the seasons.

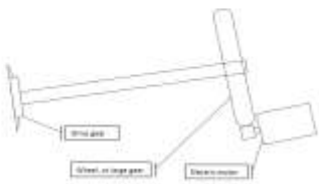

Figure 5.2.2: Tracking System

3. Circulation system

The circulation subsystem carries fluid and transfers the heat received by it to the end use application. Fluid has to circulate in the system at a certain rate to quickly and efficiently transfer the received heat from solar field to end use application. Circulation subsystem has a number of components such as pipes, pumps and valves to control fluid flow and temperature.

4. Thermal storage system

The thermal storage subsystem is a part of the circulation system. It extracts heat from the circulating fluid when the temperature becomes too high. When the temperature is too low, it supplies stored heat to the fluid.

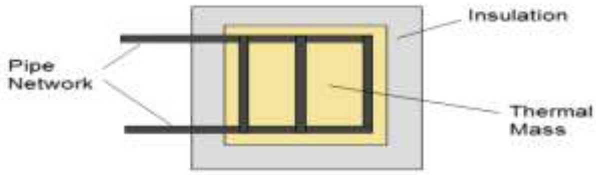

Figure 5.2.3**:** Thermal storage

5. Control system

Finally, the control mechanism is the brain behind tracking and circulation system. It sends signals to these systems to control the tracking of the receiver and the pressure and flow rate of the circulating fluid.

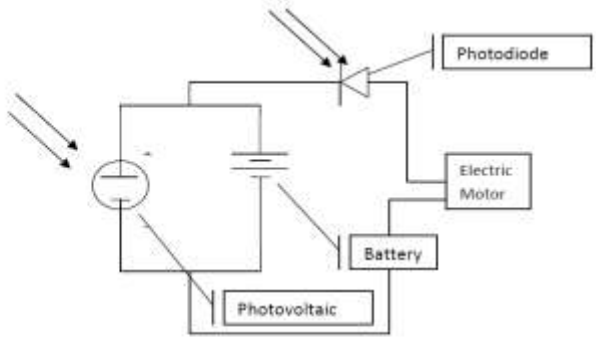

Figure5.2.4: Control system

The table below shows a sample specification that describes each subsystem in more detail. The values provided are examples only. Please note that the format for technical specifications will vary by manufacturer.

5.2.1. Subsystem Specification (Case Study of a Scheffler Steam Cooking System)

C. Scheffler Concentrator Design

1. Selecting a parabola

The first step in constructing a Scheffler concentrator is to decide the equation of the parabola and the start and end points of our dish section for equinox (Scheffler, Hensel and Munir).These parameters are defined by the ratio between the area of the dish and the position of the focus with respect to the dish. Once this ratio is defined, the dimension of the parabola can be adjusted for smaller or bigger dish areas by simply scaling everything up or down. To simplify calculations the parabola is set to have the vertex at the origin, taking the form,

$$yp = mpx^2 \quad (1)$$

which will then be revolved around the y-axis to form the three dimensional paraboloid. The

paraboloid must then be sliced by a plane to define the dish section. The slice will create the dish
with an elliptical rim, see Figure 3.1. The following calculation will be made on the 2-D x/y-plane, illustrated in Figure 3.2, using Equation 3.1 to represent the intersecting plane.
The intersection points between the parabola and the line, *A* and *B*, represent the lowermost and uppermost ends of the dish section and the slope of the line is represented by the angle β with respect to the x-axis. In this representation, the sun rays are incoming parallel to the y-axis and reflect off the paraboloid toward the focus on the y-axis, see Figure 5.3.1

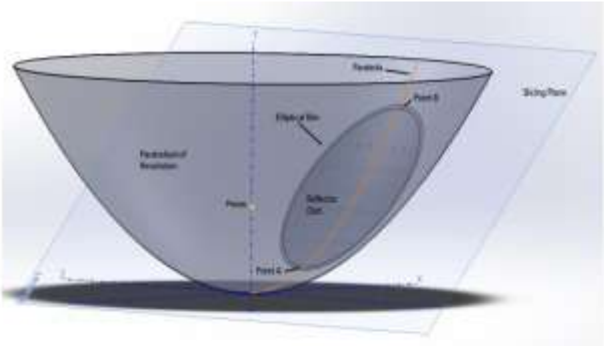

Figure 5.3.1: The parabola is revolved around the y-axis to form a paraboloid of revolution, which is the slices by the plane connecting points A and B to form the reflector dish.

Taking the derivative of yields the equation for the slope, β

$$\frac{dy}{dx} = 2\mathrm{m_p x} \quad (2)$$

Point *C* is defined on the parabola as the point with slope of 45 degrees. This point is of interest
because it represents the point where the incoming vertical light rays will reflect by 90 degrees
and proceed horizontally to the focus. The horizontal light ray from point C to the focus defines
the axis of rotation of the physical reflector for the daily tracking of the sun. This characteristic
point should be placed very close to the centre of the dish to create a balanced frame with respect
to the daily rotation axis. If *C* is located near the centre of gravity of the reflector then it will be
very easy to rotate the reflector, minimizing the need to counter balance.
The most important point in the analysis is the focus of the parabola, *F*, is located on the
y-axis at a height

$$\mathrm{yF} = \frac{1}{4\mathrm{m}} \quad (3)$$

Since the vertex was positioned at the origin Equation (3) also represents the focal length of the parabola which is defined as the distance between the vertex and focal point along the axis of
symmetry.
Since we reserve the ability to scale the reflector at a later point, at this stage we will choose parameters that simplify the design of the reflector. For mathematical simplicity, mp was
then chosen to be 0.25, which positions the focus at = (0,1)

$$y = \frac{1}{4 - 0.250} = 1 \quad (4)$$

and the 45° point at C = (2,1) from Equation(1). Yielding a very elegant equation for the parabola to be used in the rest of the project,

$$y_p = 0.25x^2 \quad (5)$$

The start and end point of the dish section, point A and B respectively, are then chosen to be equidistant from C, their distance from each other determines the ratio between the size of
the reflector and the distance to the focus. If A and B are placed farther apart, the ratio between
the distance CF to the area of the dish will decrease. This increases the curvature of the dish and
makes it easier to focus the light at the focus. This is desirable because it will allow for looser
tolerances in the manufacturing of the dish making it easier and less expensive to make. If points
A and B are chosen to be closer, the focus will be effectively farther away and the dish less curved.
This will require tighter tolerances in the production of the dish but will give various advantages
such as the ability to focus the sunlight a greater distance away, such as inside a house.
The x-coordinate of A and B were then chosen to be xA = 1 and xB = 2.8 so that the
arclength between them was about 25% more than the distance from C to the focus. Since the
biggest challenge in reducing the cost of the Scheffler design is producing a good reflective dish,
we chose to keep the focus closer to the dish. The y-coordinates of A and B can be calculated using the parabola equation (4). The equation for the arc length on an upright parabola is,

$$h = \frac{x}{2}$$

$$q = \sqrt{f^2 + h^2} \quad (6)$$

where *h* and *q* are parameters for describing the two points confining the arc on the parabola,
defined by x_1 and x_2. The length of the arc between points 1 and 2 is defined as,

$$\Delta s1,2 = \frac{h_1 q_1 - h_2 q_2}{f} + f \ln\left(\frac{h_1 + q_1}{h_2 + q_2}\right) \quad (7)$$

where $\Delta s_{1,2}$ is the arc length between point 1 and 2 and f is the focal length of the parabola. The line that connects points A and B is defined as

$$y_l = m_l x + b_l$$

with a slope angle of

$$\beta = \tan^{-1}(m_l)$$

With the known coordinates of A and B, the slope and y-intercept are calculated with,

$$m_l = \frac{y_B - y_A}{x_B - x_A}$$

$$b_l = y_A - m_l x_A$$

Yielding the following function,

$$y_l = 0.95x_l - 0.7$$

2. SEASONAL CHANGES

One of the greatest advantages of the Scheffler design is that is allows for simple adjustments to maintain the same focus as the seasons change. The Scheffler is built and optimized for the equinox, when the sun is positioned half way between summer and winter 30 solstices. While the adjustments are simple and are well approximated by simply flexing the reflector inward or outward, the engineering analysis of the new reflector shapes can be instrumental to optimizing the concentrator. The solar declination, $\delta\odot$, is the angle of the sun at noon with respect to the aforementioned y-axis, or the plane of the equator, where north is positive (Duffie and Beckman).

The declination is 0° at the equinoxes, it reaches a maximum angle equal to the Earth's axial tilt of 23.44 degrees during the summer solstice after moving north, then decreases to a minimum of 23.44 degrees during the winter solstice after moving south. The plot of the solar declination resembles a sine curve but is actually much more complex. For instance, the curves at the maximum and minima are more acute and the Earth moves slower about the sun on July 4th, close to the northern hemisphere summer solstice, because it's at the aphelion (point farthest to the sun in the elliptical orbit) making the declination change slower during the summer. Two equations for the solar declination are to be considered. The first has a lower accuracy, with an error of about +1.5° at the autumn equinox, but is simpler to use and can be instrumental when adjusting the reflector in developing nations. The low fidelity equation uses a parameter N which represents the day of the year at GMT,

$$\delta_\theta = -23.44°.\cos\left(\frac{360°}{365}(N+10)\right) \quad (8)$$

where the number 10 represents the number of days from the winter solstice to the first day of the year (Sproul) (Szokolay). The second equation is more accurate, with a maximum error of 0.035°, but considerably more complicated (Duffie and Beckman).

$$\delta_\theta = \frac{180°}{\Pi}\left[0.006918 - 0.399912\cos(B_{day}) + 0.070257\sin(B_{day}) - 0.006758\cos(2B_{day})\right] \quad (9)$$

Where B_{day} is defined by the day of the year as,

$$B_{day} = \frac{2\Pi}{365}(N-1) \quad (10)$$

The Scheffler concentrator is positioned with the axis of rotation (which passes through the middle of the reflector and the focus) pointing north/south and parallel to the axis of rotation of the Earth. This is easily achieved by tilting the axis of rotation by the current latitude angle with respect to the ground. This insures that during the equinox, when the solar declination is zero, the sun's rays are coming in perpendicular to the rotation axis regardless of where the Scheffler concentrator is positioned in the world. It is also necessary so that the reflector rotates about the same axis as the Earth as it tracks the sun throughout the day. With these constraints, the Scheffler can be positioned standing up or laying down. This geometry is reversed when moving between the northern and southern hemisphere. We arbitrarily define our direction as follows: a concentrator which "points north" has the focus on the north side and the reflector on the south side. A "vertical" Scheffler concentrator points towards the equator (pointing south in the northern hemisphere and pointing north in the southern hemisphere) and a "horizontal" points towards the closest pole (pointing north in the northern hemisphere and pointing south in the southern hemisphere), Figure (9) Visual representation of a horizontal north facing reflector and a vertical south facing reflector in the northern hemisphere. While a physical concentrator can be relatively easily rotated or flipped to match any configuration, mathematically the sign of the solar declination changes between configurations as shown in Table 3.5. For this project, we choose to consider the horizontal configuration in the northern hemisphere as it matches the configuration of the reflector built in 2010 at Cal Poly. Moving forward, all references to summer and winter configurations refer to a horizontal configuration in the northern hemisphere.

D. Working

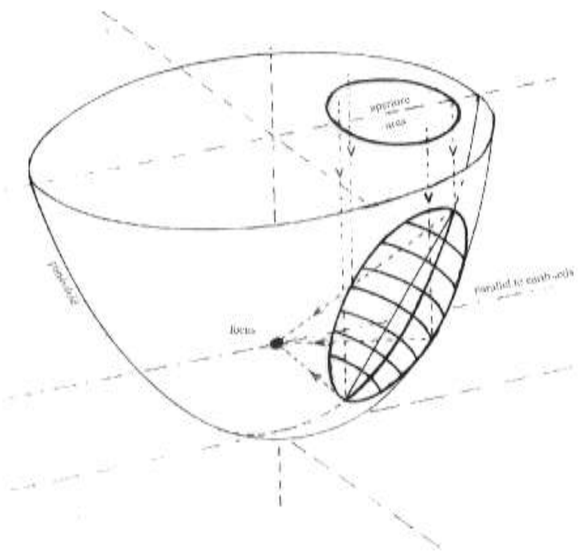

Figure 5.4.1 Sun rays reflecting from dish

The reflector is a small lateral section of a much larger paraboloid. The inclined cut produces the typical elliptical shape of the Scheffler-Reflector. The sunlight that falls onto this section of the paraboloid is reflected sideways to the focus located at some distance of the reflector.

The axis of daily rotation is located exactly in north-south-direction, parallel to earth axis and runs through the centre of gravity of the reflector. That way the reflector always maintains it's gravitational equilibrium and the mechanical tracking device (clockwork) doesn't need to be driven by much force to rotate it synchronous with the sun. The focus is located on the axis of rotation to prevent it from moving when the reflector rotates. The distance between focus and centre of the reflector depends on the selected parabola. During the day the concentrated light will only rotate around its own centre but not move sideways in any direction. That way the focus stays fixed, which is very useful, as it means the cooking-pot doesn't have to be moved either.

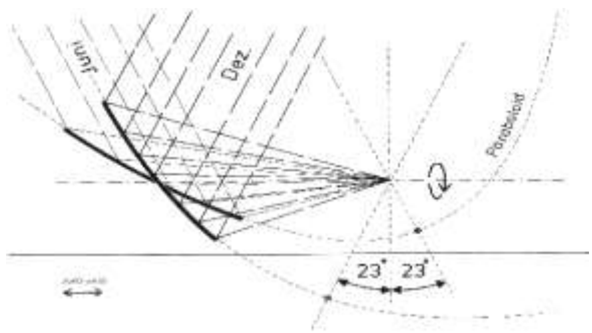

Figure 5.4.2: Seasonal angle changes

In the course of the seasons the incident angle of the solar radiation varies + / - 23,5° in relation with the perpendicular to earth-axis. The paraboloid has to perform the same change of inclination in order to stay directed at the sun. Otherwise it's not possible to obtain a sharp focal point. But the centre of the reflector and the position of the focus are not allowed to move.

This is only possible by shaping the reflector after an other parabola for each seasonal inclination-angle of the sun, i.e. for each day of the year. This means the reflector has to change its shape.

The reflector-frame is build for equinox. By inclining and elastically deforming the reflector-frame all other parabolas can be achieved with sufficient accuracy.

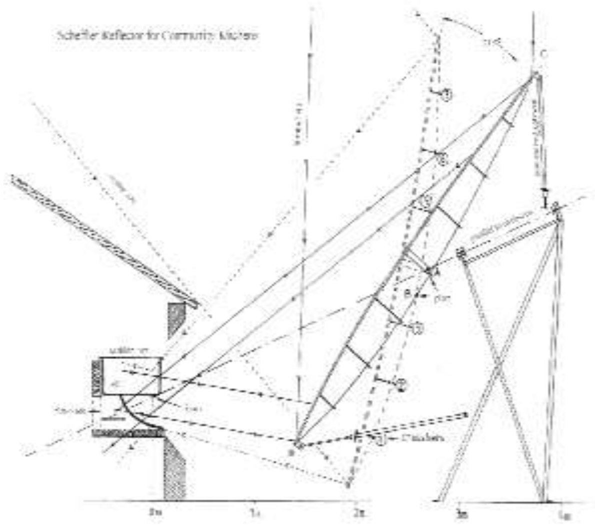

Figure 5.4.3: Scheffler reflector for community kitchen

Changing the inclination and deforming the reflector are mechanically combined: the two pivots A, at each side of the reflector-frame, and pivot B, in the centre of the reflector, do not form a line, but B is located below. That way inclining the reflector leads to a change in its depth, the centre of the reflector is lifted up (big radius of crossbars) or pressed down (small radius of crossbars) relative to the reflector-frame. It's enough to adjust the upper and lower end of the reflector (C and D) to their correct position to obtain a sufficiently exact reflector-shape. The setting is done by a telescopic bar at each end of the reflector.

Adjusting the reflector-shape has to be done manually every 2-3 days. When all concentrated light enters the opening of the cooking-place installed at the focal point the correct reflector-shape is achieved.

After passing the opening the light is redirected by a small reflector (secondary reflector) to the black bottom of the cooking pot. There it is absorbed and transformed into heat. The efficiency for cooking, i.e. heating water from 25°C to 100°C, can reach up to 57% and depends on the cleanliness of the reflector-surface and the state of insulation of the cooking-pot. At the focal-point itself we have measured optical efficiency of up to 75% (with 2mm ordinary glass mirrors). Depending on the season an elliptical reflector of 2,8m x 3.8m (standard size of 8m² Scheffler-Reflector) collects the sunlight of a 4,3m² to 6,4m² area, measured perpendicular to the direction of the incident light (aperture). That way the cooking power varies with the season. As an average a 8m² Reflector can bring 22 litres of cold water to boiling temperature within one hour (with 700W/m² direct solar radiation).

There are many options for the design of the cooking-place. Mostly it is integrated into a kitchen building and provides the possibility to use firewood for cooking when the sun doesn't shine. Depending on the type of food which is cooked there is no need for a secondary reflector. This increases the efficiency and simplifies maintenance. Instead of a cooking-place a backing-oven, steam-generator or heat-storage can be installed at the focal-point.

VI. OBSERVATION

A. Performance Evaluation

The efficiency was calculated with the following equations:

Where, *Ep* is the total heat energy, *t* – the time; *Radiation* – the beam radiation at time *t*, and *Aperture area* – the aperture area of the Scheffler reflector which is also a variable function whose value can be determined for any day of the year by the formula.

1. Aperture area = ἡ × Design area × cos[

(43.23) $$\eta_{overall} = \frac{Heat\ gain \times 10^5}{\int (radiation \times Aperture\ Area \times dt)}$$

2. seasonal angle deviation of the Sun)/2]

Where, ἡ is the area efficiency (ratio actual area on which mirrors could be placed to the design area) which in our cases 91% , seasonal angle deviation of the sun which in our case 90,design area is 2.7m2.

We have used water for the evaluation of the cookers in terms of power. For the performance test with water only, following equation was used:

$$\text{Heat Gain} = m_w c_w(\Delta T/3600)$$

Where m_w is mass water which in our case in 2 litres. C_w is the specific heat at constant pressure (for water 4.187 kJ/kgK). ΔT is the difference between two consecutive temperatures of
water recorded.

3. Power is Evaluated by :

$$P = Ep / tp$$

Where, tp time for which temperatures are recorded.
In between the beam radiation range of 750 to 900 W/m2, Scheffler reflector showed that about half of the solar power collected by the reflector becomes finally available in the cooking vessel.

VII. CONCLUSION AND DISCUSSION3

Maximum temperature reached at focal-point	1020°C
Maximum optical efficiency (reflector-surface from clear-glass/ordinary glass)	84% 75%
Average cooking-power at 700W/m² insolation, with normal glass-mirrors (8m² Reflector)	2,2Kw (1,7kW in summer and 2,5kW in winter)
Maximum number of pots per reflector	3
Number of reflectors of the largest kitchen	106
Largest number of people catered for by one kitchen	18000
Cost of materials for one reflector (in India)	approximately 550,-Euro
Overall number of world-wide installed reflectors (2004)	over 750
Used materials	Steel-profiles, glass-mirror

A. Conclusion

In order to utilize the non polluting and freely available source of reversible nature i.e. solar energy, its intensity must be maximum. In order to maximize its effectiveness, the 2.7m2 Scheffler Reflector is one of the most promising sources available. This system mainly finds its application in household cooking. Small systems use a well insulated solid iron-block which is heated to about 400°C at the focal-point which can be used for cooking for a family.

Dimensional correlations for generated water temperature, heat gain, efficiency and various other independent variables have been developed based on experimental results. The dimensional analysis shows that generated water temperature is determined primarily by ratio of product of angle and Dish area to the wind speed.

B. ADVANTAGES

- No any type of pollution.
- Renewable source of energy.
- Saves wood, electricity and other fuel.
- Use even at night.
- Adaption to changing season.
- Highly durable.

C. DISADVANTAGES

- Initial cost is high.
- Requires maintaince.
- Replacement of parts are not easily available.
- Not locally available

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