International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.6, Nov-Dec. 2012 pp-4228-4230 ISSN: 2249-6645

Design and Fabrication Of Manually Track Parabolic Solar Disc for In-House Cooking

Yogesh R. Suple [1] N.N. Suraskar [2]
Asst. Prof. Mechanical Engineering Department,Kavikulguru Institute of Technology & Science, Ramtek (India)

Abstract: *Human civilization has been witnessing a gradual shift towards cleaner fuels-from wood to coal, from coal to oil, from oil to natural gas; renewables are the present demand. In this fabrication work a primary reflecting parabolic surface concentrates the solar radiation on it and reflects them on to the secondary reflectors. This secondary reflector then focus the incident radiation at the point of interest, thus generated heat can be used for cooking purpose. In this work the biaxial sun tracking mechanism is developed which can be operated from the cooking place (in-house).*

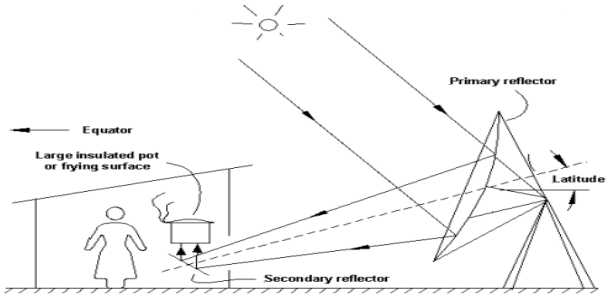
Keywords: *In-house cooking, manual bi-axial tracking, parabolic disc, solar energy.*

I. INTRODUCTION

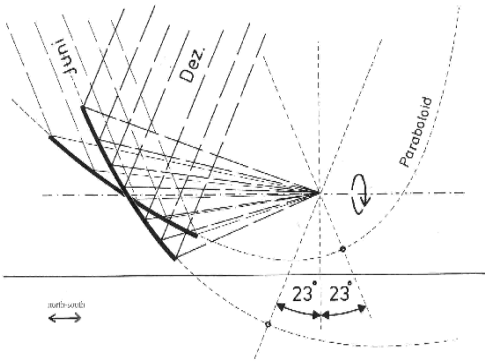
Energy crisis in today's world is the most stressed term that present day scientists are working upon. Solar energy should be the answer to the above problem. In the rural parts of the country it is observed that the sources of energy for the daily purposes are less these results in many difficulties like cooking purposes, thus the people have to use unhealthy practices like dunk cakes and charcoal it causes severe health hazards and pollution. The use of solar energy to cook food presents a viable alternative to the use of fuelwood, kerosene, and other fuels traditionally used in developing countries for the purpose of preparing food. Solar cooking can be used as an effective mitigation tool with regards to global climate change, deforestation, and economic debasement of the world's poorest people. In the concentrating type of solar collector, solar energy is collected and concentrated so that higher temperatures can be obtained. The basic idea that leads to the development of the parabolic reflector is to make solar cooking as comfortable as possible. At the same time the device should be build in such a way that it allow, it to be constructed in any rural welding workshop in a country after a certain period of training. As the conventional solar cooker is exposed to the day light therefore the operator needs to stay under direct sunlight for constantly paying attention on the cooker to maintain the temperature even. In parabolic solar cooker this problem of operator to constantly stand under direct sunlight in hot and humid condition is eliminated. The concentrating reflector provides the sunlight directly into the kitchen for preparation of food. The main objectives of this paper are: 1) To promote solar energy technologies to meet cooking energy requirements of a family in rural area. 2) Reduction in the consumption of traditional

II. Working Principle of Parabolic Solar cooker

To 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 is an eccentric, parabolic reflector which rotates around as axis parallel to earth- axis synchronous with the sun. Additionally the reflector is adjusted to the seasons by making it flexible in a simple way.



The system of parabolic cooker comprises a primary reflector, a secondary reflector, and tracking mechanism. The primary reflector produces a converging beam of sunlight aligned with an axis of rotation which is parallel to the axis of the earth, and which passes through the centers of both reflectors. The tracking unit rotates the primary reflector around its axis of rotation, keeping the reflected beam aligned with the axis of rotation as the sun moves. The fixed secondary reflector reflects the beam from the primary reflector onto a cooking pot or frying surface as shown in above figure. In the course of the seasons the incident angle of the solar radiation varies +/- 23.5^0 in relation to the perpendicular earth-axis. The paraboloid has to perform the same change of inclination in order to stay directed to 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 as shown in figure.



With the help of a simple mechanical tracking system the solar disc rotates in the direction of the movement of the Sun to give continuous and accurate solar energy concentration. For a fully tracking the sun normal to the primary reflector must be normal to the solar beam.

Therefore, the reflector's azimuth and altitude angles must coincides with the sun's azimuth angle and the compliment to the sun's altitude angle. The incidence angle is equal to zero. Therefore,

Inclination angle (β) = Cos^{-1}[sinδ sin ϕ + cos δ cos ϕ cos ω]

And surface azimuth angle

$$\gamma = \sin^{-1}\left[\frac{\cos\delta \sin\omega}{\sin\beta}\right]$$

where
Ø is the latitude of location,
δ is the declination angle and
ω is the hour angle.

III. Fabrication of Experimental Set up

The various elements of the setup (Parabolic Concentrating Solar Cooker) are as follows:

- Primary Reflector
- Cooking unit with secondary reflector
- Manual tracking mechanism

3.1 Primary Reflector

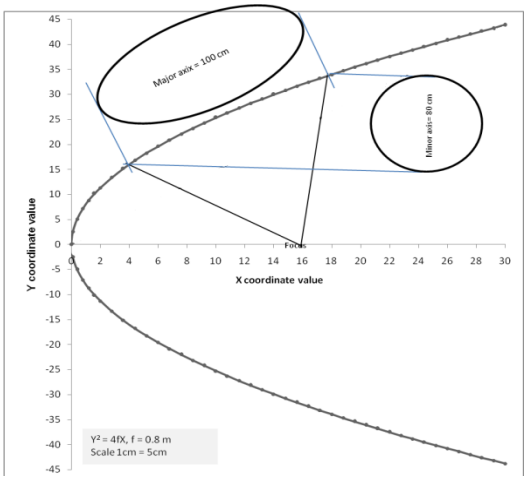
The primary reflector is the basic element of the revolutionary concept developed by Wolfgang Scheffler.

3.1.1Design Considerations

The various factors taken into consideration for formulating the primary reflector are

- Focal distance from the primary reflector (vertical as well as horizontal)
- Concentration ratio to be achieved.
- Aperture area of the primary reflector.
- Central depth.
- Elliptical area of primary reflector.

The general equation of parabola is $Y^2 = 4 \times f \times X$
Where, X and Y are polar co-ordinates and f is the distance of focus from origin.(f = 80 cm)



Ap = π/4 × major axis × minor axis, where Ap is the aperture area.

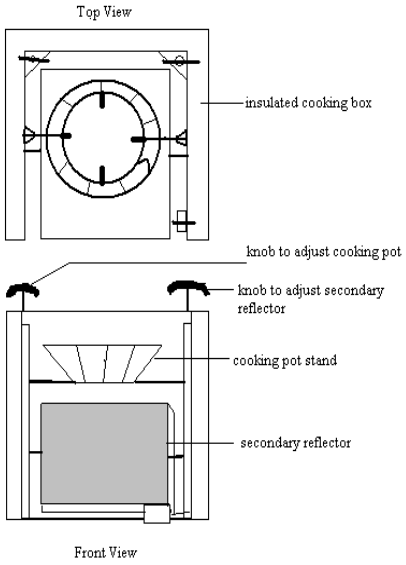
3.1.2 Primary Reflector Specifications

The various specifications of primary reflector with its frame are shown in table 1.

1.	Concentrator type	paraboloidal
2.	Aperture area	0.628 m^2
3.	Aperture diameter	0.8 m
4.	Length of circumference	3 m
5.	Focal length	0.8 m
6.	Receiver diameter	14 cm
7.	Receiver area	0.015 m^2
8.	Optical concentration ratio	40

3.2 Cooking Unit with Secondary Reflector

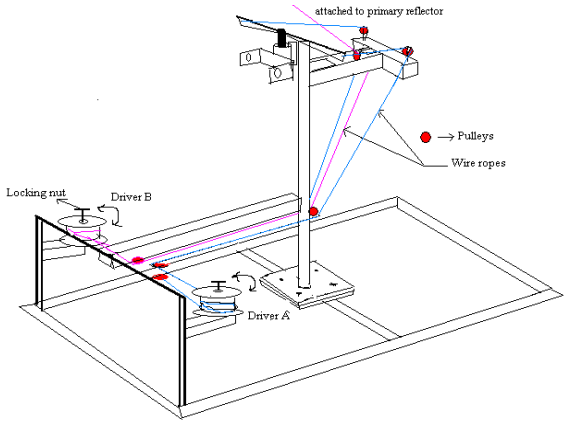
The main purpose of secondary reflector is to trap the incoming heat at the focal point & onto a well defined point under the vessel placed at a certain height. The design of the secondary reflector plays an vital role to the over all objective of heat entrapment. The provision of the adjustment of the cooking pot height as per the requirement and secondary reflector position and inclination with respect to the position of primary reflector is the unique feature of the cooking unit fabricated as shown in figure.



Part	Material	Specifications
Cooking unit with Secondary Reflector	Stainless steel	300 x 250 x 1.5 mm
	MS sheet	1250 x 750 x 1 mm
	MS bar	10 mm, 06 mm
	MS Angle	20 x 20 x 2 mm
	Insulation	Glass wool

3.3 Manual Tracking Mechanism

The main purpose of the tracking mechanism is to trace the path of sun movement through the entire day. This is achieved by manual or automated tracking mechanism. In this paper manual tracking mechanism is developed, which will be operated from the cooking place (kitchen). Manual sun tracking arrangement is designed to track both the axis by using the wire ropes and pulleys. Two
Rotating drivers are provided to which the wire ropes are attached as shown in figure.



Out of two one rotating driver is for adjusting or setting primary reflector as per the solar altitude angle and another one is to adjust azimuth angle. The operator has to rotate these two rotating drivers to set the orientation of primary reflector normal to the sun once in 10 to 15 minutes. The material used for the fabrication of manual tracking mechanism is shown in table 2 with its specifications.

Part	Material	Specifications
Drivers (Rotating)	MS sheet MS	203 mm OD, 152 mm ID
Pulley	MS	30 mm ID,10 mm thick
Wire rope	Steel	2 mm Ø
Thrust bearing	51104	20 ID x 35 OD x 10 mm
Bushes & Pins	MS round bar	20 ID & 20 OD

IV. Working of Parabolic Solar Cooker

The parabolic disc is installed in an open area facing the South. The cooking place and vessels faces the North. A 0.628 m^2 area parabolic solar concentrator is used for concentrating solar radiation on a focal area where the secondary reflector is placed. The reflector disc can be
Easily rotated to adjust the reflector according to sun orientation. The secondary reflector diverts the solar energy on the cooking vessel and the heating begin. With the help of a wire ropes and pulleys manually operated simple mechanical tracking arrangement the solar disc rotates in the direction of the movement of the Sun to give continuous and accurate solar energy concentration. These wire ropes are attached to rotating drivers. By rotating this drivers regulated tracking motion to follow the path of the sun throughout the day.

V. Conclusion

In an age where domestic fuel costs are rising each year, the solar cooker is a real boon. Reasonably priced, easy-to-use and completely trouble-free, the solar cooker is an ideal supplement to the conventional cooking appliances. Solar cooking is entirely non-polluting and has no ill effects on health. Unique feature of cooker is the sun tracking arrangement. Though it is manually operated but fully controlled within the kitchen only. That means the operator doesn't need to go in sunny place to set primary reflector normal to sun rays every time.

References

[1] Sukhatme, S.P.*Solar Energy Principles of Thermal Collection and Storage* Tata McGraw-Hill publishing company Ltd., New Delhi2005.
[2] Garg HP, Parkash J. *Solar Energy fundamentals and applications* New Delhi: Tata McGraw-Hill, 2000.pp 166-175.
[3] Pohekar SD, Ramachandran M. *Multi-criteira evaluation of cooking energy alternatives for promoting parabolic solar cooker in India.* Renew Energy 2004;29:1449–60.
[4] A.V.Sonune, S.K.Philip *Development of a domestic concentrating cooker* Renewable energy 28 (2003) 1225-1234
[5] Jose M.Arenas *Design, development and testing of a portable parabolic solar kitchen* Renewable energy 32 (2007) 257-266.
[6] S. R. Kalbande, A. N. Mathur, S. KothariI & S. N. Pawar. *Design, Development and Testing of Paraboloidal Solar Cooker* Karnataka J. Agric. Sci.,20(3), (571-574): 2007
[7] U.S.Mirdha, S.R.Dhariwal. *Design optimization of solar cooker* Renewable energy 33 (2008) 530-544.