Improvements in Design and usage for Resurgence of the Technology of Fiber Reinforced Plastics (FRP) Paraboloidal Dish Type Solar Cookers-I

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Abstract

Fiber reinforced plastics (FRP) dish type solar cookers is one of the best technologies within the portfolio of solar cookers, having its own advantages. Unfortunately the only Indian company which has been producing them has stopped its manufacture since three years ago. Here we present a few ways of improving the design and usage aspects this technology for its revival and popularization in its modified forms in the larger interests of promoting renewable energy, sustainable technology and rural development.

Keywords: solar cookers, Paraboloidal cookers, renewable energy, rural development, sustainable technology

I. INTRODUCTION

A large variety of designs of solar cookers are available today supplied by manufacturers, see for example [1] and produced by amateurs or hobbyists, see for example [2]. One of the best designs among these use paraboloidal dish made of Fiber Reinforced Plastics (FRP) as shown in Fig 1and have been mass produced by one Indian company [3] which traditionally has been manufacturing other FRP products like water tanks, portable cabins etc. However since a few years ago this company has stopped its production of FRP dish cookers despite its good technical features and prospects.

The authors took up this company's solar paraboloidal dish cooker (SPDC) for study and explored improvements in design, production and usage which may sustain its industrial viability and popular use. Towards this objective use of flex sheet mirror as part of an alternative technique of fabricating solar paraboloidal dish cooker was presented earlier by the authors [4]. This could avoid damage of reflective surface of the dish cooker during transportation and permit compact and stacked transport of cookers in bulk. The alternative technique is expected to augment the portfolio of fabrication methods of paraboloidal dish cookers to promote widespread local completion of assembly and use of such cookers as local conditions may permit. Subsequent suggestions follow here.

II. DESIGN CHANGE 1: SPLIT PARABOLOIDAL DISH

The most popular and viable locations perceived for installing solar paraboloidal dish cookers is terrace in cities and open space or terrace in rural areas. A single dish of 1440 mm nominal diameter X 450 mm nominal depth with a weight of about 18 kg at FRP density of 1.35 is unwieldy for primary transport by trucks and secondary transport by auto rickshaws or carts and for carrying to/from terraces for installation/repairs. Further, as such, even after compact arrangement they are too bulky for economical utilization of full weight capacity of trucks or auto rickshaws or carts thereby adding higher incidental costs to the basic cost of the cooker.

Thus it is suggested that the single piece dish be split into two semi-paraboloidal segments as shown in Fig 2, with flanges for bolted joints and reinforcing ridges on the outside and in the middle of each segment.

The split dish segments can easily be carried even by one person and can be stacked compactly during bulk support to utilize the full weight capacity of transport vehicle. The segments can be easily assembled into full dish or dismantled for transport or for repairs.

III. DESIGN CHANGE 2: EXTERNAL REINFORCING RIDGES AND INTERNAL SMOOTH SURFACE

The present design has three circular internal ridges to reinforce the dish as shown in Fig 3 which also support each aluminum reflector strip at three points to get a parabolic profile. However this does not ensure real parabolic curve and many times while fixing the strips to dish or during transport or handling, the strip tends to be like two chords joining three points instead of a parabolic curve passing through these points. By providing reinforcing ridges outside, the reflector strips can be seated inside the dish with full and smooth solid support throughout its length.

IV. DESIGN CHANGE 3: BOLTS INSTEAD OF RIVETS

Riveting the reflector strips distorts its desirable parabolic profile many times as shown in Fig 4 and deprives the user from taking full advantage of solar radiation concentrating ability of paraboloidal dish profile. Further it makes replacing damaged reflector strip or re-using it after re-polishing cumbersome. Instead aluminum or plastic bolts and nuts may be used which will obviate the need for fixing reflector films in the factory itself and avoid the possibility of damaging the reflector strips during transport or handling. The strips may be easily bolted to the dish at user site.

V. DESIGN AND OPERATIONAL CHANGE 4: REMOTELY ASSISTED SOLAR ALIGNMENT OF DISH

Until an affordable and automatic dual axis solar tracker for domestic paraboloidal solar cooker emerges in the market one has to live with the manual sun tracking technique. Yet, the authors present here one easier way of manual solar alignment of paraboloidal dish cookers

In the commercial dish cookers as produced by Sintex Industries a short needle is provided for solar alignment as shown in Fig 5. As per guidelines the user has to adjust the position of concentrator such that the shadow of the needle falls at the foot of the needle for the dish to face the sun directly. But many times the plastic needle with plastic base gets displaced or deflected during transport or installation or operation. Thus very frequently additional visual checks referring to brightness of solar image on the focal region or on the cooking vessel and related adjustments are necessitated. But then there occurs significant differences in alignments done referring to brightness of solar image on the vessel or focal region only and that done using needle’s shadow only.

Usually solar dish concentrators have been solar aligned manually by looking at the solar image and moving it towards the focal plane instead of using the needle indictor. The difficulties associated with this method are as follows:

1) There is a need to move the concentrator simultaneously for both solar altitude and azimuth alignment for sun focusing by trial and error and to lock the concentrator simultaneously on both the rotational axes once the focus is achieved.
2) Observing the cooking vessel to check that it is indeed in the brightest spot is complex since the apparent shape and size of cooking vessel as seen by the dish and the shape and size of solar image as observed by the user are not identical throughout the day even when the dish is solar aligned. This is due to the oblique incidence of concentrated solar radiation (except the instant when the sun is directly overhead) on the cooking vessel which remains suspended to avoid its tilting, irrespective of concentrator orientation. Only when the sun is exactly overhead and the concentrator is aligned with it, the concentrated radiation will form a nearly circular image over the circular vessel with nearly uniform intensity, that too on horizontal plane only and not on the vertical walls of the vessel.
3) Health risks associated with regular exposure to stray concentrated solar radiation which can cause injuries to skin and eyes due to user’s tendency not to wear safety devices.

Current work proposes some remotely assisted ways of manual solar alignment to avoid the above difficulties.

VI. COMMON REQUIREMENT FOR ALL ALTERNATIVE TECHNIQUES OF SOLAR ALIGNMENT

First the concentrator’s bottom frame needs to be pivoted at the centre as shown in Fig 6. Then the ground should have a semicircular scale graduated in degrees and centered at vertical axis, i.e., at pivot point. Similarly there has to be a graduated quadrant or semicircular scale attached to the horizontal axis of the base frame as shown in the same figure. Then the user shall access the data of solar altitude and azimuth angles through SMS or internet on his mobile phone from remote sources for his location on given day. Subsequently he shall align the dish at given solar angles and lock it one by one.

VII. BENEFITS OF REMOTELY ASSISTED SOLAR ALIGNMENT

Manual solar alignment of any paraboloidal dish cooker along two axes inherently comprises of four steps: (1) Solar altitude alignment (2) Locking dish on horizontal axis at the desired altitude (3) Solar azimuth alignment (4) Locking dish on vertical axis at the particular azimuth. It is relatively more difficult to solar align and lock dish concentrator simultaneously in two directions. The reason is when a user adjusts conventional base frame of dish cooker (which has three degrees of freedom) for azimuthal alignment, or locks it at that position, for example, altitude alignment is disturbed and vice versa as the dish without any pivot also moves linearly this or that way irregularly while being turned. Pivoting ensures that dish can have only one degree of freedom ie., to turn and does not get linearly displaced. Further it is easy to align for one angle, lock the dish at it , then proceed to align for second angle, and then lock the dish at it, than simultaneous bi-axial alignment by trial and error. There is also no need to look into the focal region to get exposed to stray radiations frequently and straining one’s vision.

VIII. SOURCES FOR SOLAR ALTITUDE AND AZIMUTH DATA

A. Internet Sites

The user shall visit one of the solar sites for instance [5] on the internet which offers online computation of sun's position in terms of altitude and azimuth. The user must input required data about the location, date, desired time intervals and then can get the values printed out as a table of data of time of the day and angles, see, Table 1 for sample data for Junagadh, Gujarat for June 21st 2014.

B. Non-Government Organization (NGO) or Government Organization

Like Indian Space Research Organization (ISRO) or Indian Meteorological Department (IMD) can provide these values for requested place and times through SMS to user's mobile phone or through e-mail. These data for different places can also be supplied for particular month or year by these agencies just like tide tables for different ports being supplied to pilots of boats and ships for navigation and berthing or meteorological information provided to agriculturists.

C. Mobile Phone Applications

A small application can be developed for mobile phones, based on Android or iOS, to provide solar altitude and azimuth angles for current location and current day. Day and time data for the application can be input by the mobile phone itself. A typical display on the phone for solar alignment may look as follows:

1	*Location (Input)*	*Junagadh, Gujarat INDIA*
2	*Date*	*21st Jan 2014*
3	*Day*	*Tuesday*
4	*Time (hh:mm:ss)*	*11:00:00*
5	*Sol Azimuth*	*80.5^o*
6	*Sol Altitude*	*67.4^o*
7	*Ambient Temp*	*24.5^oC*
8	*Humidity*	*45%*
9	*Cloudy/Sunny/Rainy*	☺
10	*Wind speed*	*5.5 kmph*

First row shows input data, 2nd to 4th row data are already displayed in conventional phones, 5th and 6th row data are to be output and rest of the data displayed may be optional. The displays on mobile phone can be accompanied by three or four beeps at the start of every interval and change of angle data to alert the user about intermittent alignment.
Location information needs to be registered only once until the phone shifts to another place.

D. Telecom companies

Alternatively the telecom company can provide these data as a free or premium add-on service. In addition to currently available display of location, date, day, time, wind speed and humidity data, the phone then would display simultaneously altitude and azimuth of the sun which can be updated periodically, say, every 15 min.

The user can align the concentrator by setting the angle values using graduated horizontal and vertical scales. He need not look at the focal region of the concentrator at all.

IX. CONCLUSION

It is expected that by implementing the design and operational changes suggested here, the technology of solar FRP dish cookers can be invigorated and sustained. The use of solar cookers with FRP dish can be further popularized on a larger scale by using a proper mix of factory produced critical components, local production of rest of the system and its assembly with cheaper rural labor. The proposed design and operational changes are under implementation, and quantitative results of the same would be presented in a subsequent paper.

ACKNOWLEDGMENT

The authors appreciate and thank Prof. Dipak D. Patel of Dr. Subhash Technical Campus, Junagadh, Gujarat INDIA and the campus management for facilitating experimental work at their site and Mr Jasmin Bhimani, Technical Assistant in the Campus for assisting in fabrication and testing jobs.

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[5] http://www.nrel.gov/midc/solpos (as accessed on 21st Dec 2014)

Fig. 1: Solar paraboloidal dish cooker manufactured by Sintex Industries

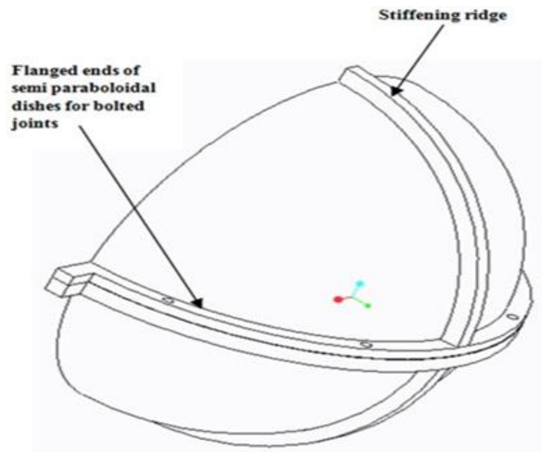

Fig. 2: Split paraboloidal dish with flange joints

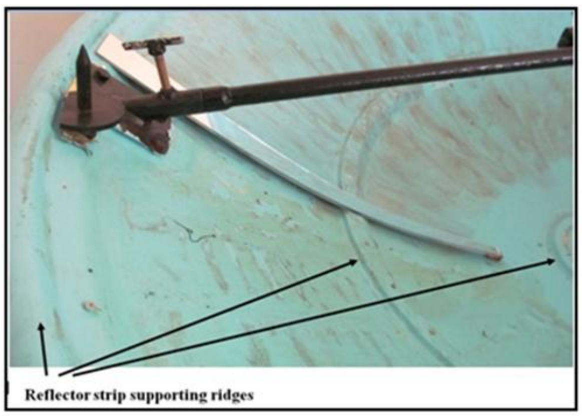

Fig. 3: Inside ridges for reflector support and rigidity of dish

Fig. 4: Distortions in reflectors due to riveting to three circular ridges

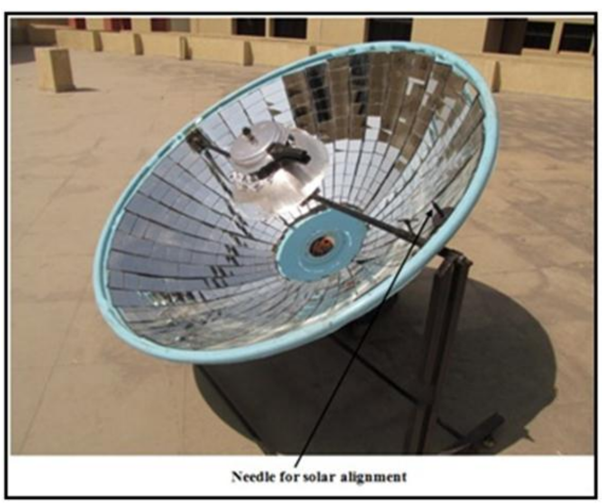

Fig. 5: Needle indicator for solar alignment of commercial cooker

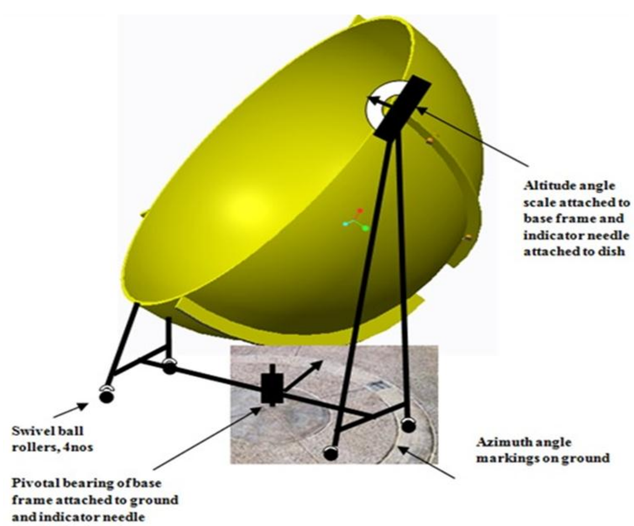

Fig. 6: Split paraboloidal dish with modified support frame for solar alignment