DESIGN A SOLAR COOKER FOR HIGH RISE BUILDINGS

Submitted in partial fulfillment of
the Requirements of the Degree of
Masters of Design
By

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DESIGN A SOLAR COOKER FOR HIGH RISE BUILDINGS

Design Project 2

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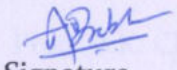
Declaration:-

I declare that this written submission represents my idea in my own words and where other ideas or words have been included. i have adequately selected and referred the original source. I also declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any idea / data/ facts/ sources in my submission. i understand that any violation of above will be cause for disciplinary action by the institute and can also evoke penal action from the sources which have just not properly sighted or from whom proper permission has not been taken when needed.



Signature

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Name

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13.11.2013

Date

Approval:-

Industrial design project 2

'Design a Solar Cooker for High rise Building'

By: Avinash Vijay Prabhune

M.Des. Industrial design 2012-14

Is approved as a partial fulfillment of requirement of post graduate degree in Industrial Design

Prof. B.K. Chakrawarthi

(Project Guide)

Internal Examiner

External Examiner

Chairperson

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1.0 ABSTRACT

The LPG price hikes every month triggered the thought on Solar Energy which could be a clean and abundant source of energy. There are many types of solar cookers available in the market, but they are not that efficient. Each one has its own pros and cons.

In a rapidly urbanizing India, the user segment this product is targeted towards are the people who live in high rise buildings because they don't have space to use solar cooker and the old solar cookers fail to match their fast-paced life style. For using present type of solar cookers, the users need to have open space where they will get continuous sun light and the users need to track the sun all day. All these usability issues are the reason why urban users are not willing to consider this as an alternative to conventional cooking methods.

This new kind of solar cooker will be mountable in the window or wall like a window AC, while facing towards south where sun is available all year round. Thus the accessibility becomes very easy from inside the house itself and the users need not go out. The cylindrical form provides uniform sunlight all day long.

The 'Dabba' perception about the box-type of solar cooker has been broken by this new design. The efficiency has been improved and the time taken for cooking is drastically reduced, as compared to any other kind of solar cooker.

2.0 INTRODUCTION

Solar Energy - The Future....

Over the past few decades, due to rapid industrialization and increased urbanization, there has been tremendous strain on our available natural resources. In such a scenario, much research and work has been focused on finding alternate sources of energy. Since the beginning of times, we as humans have looked up to the skies and worshipped the sun as a God. It is the source of all life on Earth, and now it seems that the sun itself will become our answer for all our energy needs. This project is focused on harnessing the energy of the sun for one of man's most basic needs- food. The context of metropolitan regions where high-rise buildings are the norm of the day have been considered.

Over the course of the project, a number of people were interviewed, their daily activities , their cooking patterns, the spaces in which they reside were observed . There are a lot of solar cookers available in the market, but the design insights obtained from this extensive study has led to, a truly unique solar cooking solution. The 7Cs of Innovation as guided by Prof. B.K.Chakravarthy was the design methodology adopted for this project.

3.0 THE CAUSE

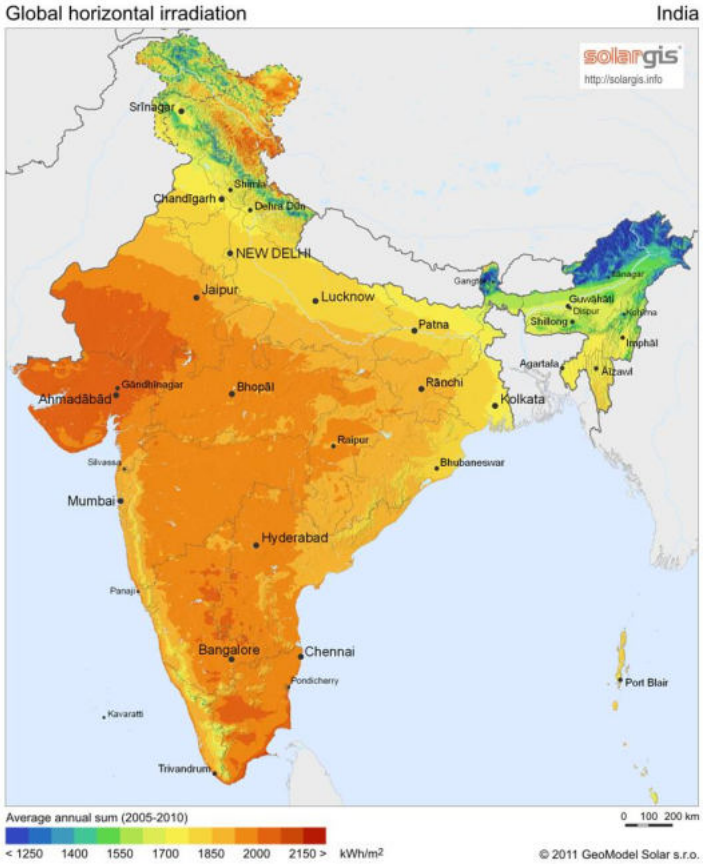


Fig.1 Solar Radiation data in India, in kWh/m2

3.1 Sun

Sun is the source of life on Earth. We get the immense energy stored in there on Earth in the form of light/radiation. Geographically India is at equatorial Sun Belt of the Earth. We get more than 250 days of clear sky in a year. Looking at the sun availability and intensity in India, the possibility of using solar cooker and heater is high.

Using sun for cooking is not a new thing. In 1600 German physicist, E.W. von Tschirnhousen tried to boil water by using large lenses. In fact in 1945 a Gandhian activist M.K.Ghosh is called the father of box type solar cooker which being promoted in India today. The first parabolic solar cooker was developed in the early 1950's by M.L.Ghai at the National Physical Laboratory (NPL) in Delhi. [http://www.indiaenvironmentportal.org.in/node/5799/]

Ref.- Fig.1 http://solargis.info_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-India-en.png

Fig. 2 High rise building at Mulund, Mumbai.

3.2 Urbanization

After independence we accepted mixed economy, the rate of urbanization was slow and according to 2001 census, 28 % population were living in urban areas. But because of rapid economic growth, the rate of urbanization is gaining pace. Currently 300 million people are living in towns and cities, within the next 20-25 years another 300 million will join the cities .
[*http://12thplan.gov.in/12fyp_docs/17.pdf*]

This creates tremendous pressure on cities as well as on resources like cooking fuel. There is no other way except going in the upward direction which can accommodate such a huge population within small areas of cities. My product targets the people living in high rise building who don't have access to open space for solar cooking but there is a need to find out another solution for this.

4.0 THE CONTEXT

Fig.3 Box type, at one of the user's house at Mulund, Mumbai

Fig.4 Parabola type, at one of the user's house at Mulund, Mumbai

4.1 Market Study

Mainly they are categorized into three types, Box type and Reflective type and combination of both.

i) Box type – Fig. 3 shows a typical Box type solar cooker. It works on black body principle. The surface which is painted black has tendency to absorb maximum amount of energy which falls on it. Ideally black body absorbs all incident electromagnetic radiation regardless of frequency or angle of incidence. The material emits energy at a fraction called emissivity; the thermal emissivity of a black body is 1.0. In box type solar cooker the inner surface is painted black so that it can absorb maximum energy and in addition to that a reflective mirror is added so that maximum solar rays can be directed to black body. Black body absorbs the sun energy by which the surrounding air starts heating up. It holds food containers which are also painted black. This heated air is trapped in between two glasses separated by air gap. Here air gap acts as a thermal insulation. The glass lid allows sun rays to come in and is exposed to black body but it traps the heat inside. The maximum temperature we can achieve in this type of cooker is around 90°c to 110°c. This product is available within the range of Rs.3000 to 5000.

Fig.5 foldable reflector type
http://blogs/personal-interests/solar-cooker-at-night/

Fig.6 Box type
http://solarcooking.wikia.com/wikilf_solar_cooker.jpg

ii) Parabola type - Another method to get solar energy is concentrating the solar rays at one point. Fig 4 shows the Parabola type solar cooker. Here a parabolic reflector concentrates all sun rays to the focal point. At this point we get very high temperature which is around 400˚c to 500˚c. At the focal point we have a fixture to fix the cooking pot. The drawback of this type of solar cooker is that you have to track the sun continuously and the user needs to stand outside in the sun light for cooking the food. This type of solar cooker is available within Rs. 8000 to 10000.

iii) Combination type– We can see in fig. 5 the combination type solar cooker. In this type food is cooked by using parabola reflection and black body principle. We can see that a black pot is surrounded by number of reflectors or mirrors. These are very low-cost solar cookers which can be made at home.

Fig. 7 Parabola type solar cooker at Shirdi Temple
http://solarcooking.org/newsletters/scrapr10.htm

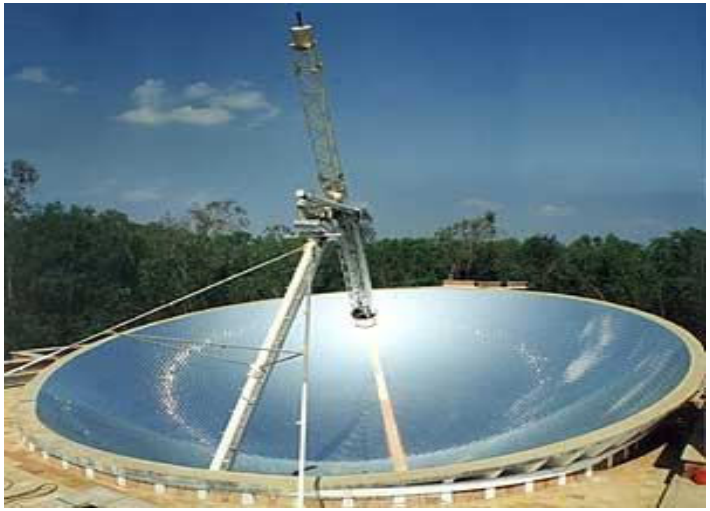


Fig.8 Massive Parabola type solar cooker at 'Auroville' - www.auroville.com

iv) Steam solar cooker- These are really effective and useful. In terms of volume and scale they are massive. The main heating element in this type of solar cooker is steam or oil which has low boiling temperature. Water or oil is heated by same parabolic reflectors and which track the sun throughout a day by solar tracking sensors. This high temperature steam or oil is pumped through pipes upto the kitchen where it is used for cooking with the help of steam or oil jacket containers.

Fig. 7 shows the parabolas on the roof of the "Shirdi Sansthan" where food has been served for devotees who comes to Shirdi. The food cost is very economic.

Similar example can be seen at 'Auroville' Pondicherry, where they have a concept of 'Solar Kitchen' .Fig. 8

There are many types of solar cookers available in the market which use one of the above methods to cook the food, but none of them address the issues faced by the users in high rise building to fulfill their needs. The users living in the high rise buildings are the potential target market for the solar cooker that was explored through this project.

Fig. 9 Solar water Heater (Tube type)
Ref. www.cnbg-solar.com

Fig. 10 Solar Panel
Ref. www.top-alternative-energy-sources.com

4.2 Other Products

There are some other products in market which run on the solar power.

Solar Water heater – This product is completely accepted by Indian consumer. Basically it uses same black body principle for heating but the air gap between the glass tubes is replaced by vacuum. Vacuum is a perfect insulator because there is no medium to transfer heat. By using simple tube in tube arrangement and natural thermo syphon of water it creates high temperature. This system is very effective and maintenance free. By regulations, government can also encourage the use of this product in urban housing societies. (Fig. 9)

Solar panels- Solar panels are used for electricity generation. The 'Photovoltaic effect' changes the sun light in to electricity. They are costly because solar cell is expensive to manufacture and currently there is no alternate for solar cell. But in future solar cell will be cheap and readily available for sure.

Solar power is ecofriendly and free, because solar power is present in Abundance.

5.0 THE COMPREHENSION

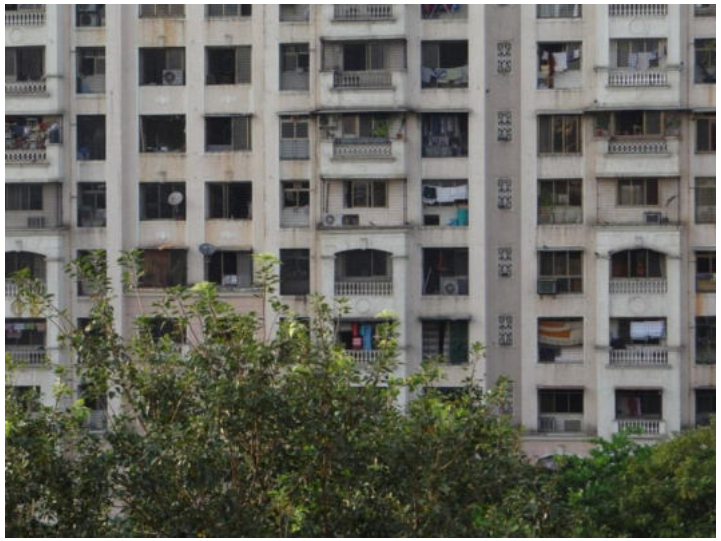


Fig. 11 Neelam Nagar, Mulund, Mumbai

5.1 User Study

The Target Users are people who live in urban areas in high rise buildings. While doing user study, users were classified into three categories viz. Not a user, User and Ex-user.

Not a user – These type of users are familiar with the solar cooker and want to use it but the usability factor has not been considered in the present solar cookers which is available in the market. They know that there is some "Box" thing available in the market which cooks food at a very slow rate, but they don't perceive it as a kitchen product. Their perception of solar cooker is that they have to go to terrace and wait the whole day for the food to get cooked. They don't perceive it as a utility or life style product either. On the other hand they are quite happy with their solar water heater which is a utility product for them. In tier-II cities, solar water heater is a status symbol. The insights obtained after interviewing a group of ladies of the "Neelam Nagar phase II" housing society at Mulund, were that they are looking for the alternative cooking sources as LPG prices are rising. But they don't like the "dabba" (Box) look since it does not match with their life style.

Fig.12 Mr.Vipin Chitare at his balcony, Thane

They will accept the product which cooks really fast but some of them are also ready to compromise on the time factor a little bit since it is free cooking. But neither of them want to go to the terrace or balcony for cooking.

Current user- Mr. Vipin Chitare (Fig.12) is a solar cooker dealer in Thane and he has been using the solar cooker regularly for 10 years now, except in the rainy season. Crucial insights about solar cooker were obtained from him and his wife.

- They save half the LPG amount and as a matter of fact they cook some part of dinner also for 6 family members.
- They used both Box and Parabola type solar cooker.
- The food tastes good and their guests also insist on solar cooked food.
- They have south facing big balcony which they utilize for cooking, although Mrs. Chitare doesn't like to cook food in the balcony.

References (from top to bottom*):*

harshaindia.com
www.bbcgoodfood.com | ovenhaven.wordpress.com

Ex-User- This was a telephonic interview with Mrs. Phadke (my friend's mother from Ahmednagar) who had an experience of using solar cooker which they have stopped using . The reasons were as follows:

- Takes too much time
- Early preparation needs to be done
- Some times food is wasted because of the cloudy atmosphere
- Don't feel like cooking in "Dabba"

From the Users inputs the main areas that need to be addressed are as follows:

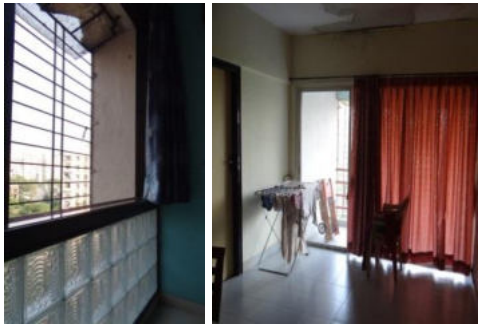
- **Time taken by solar cooker**
- **Don't want go out to the terrace or balcony**
- **"Dabba" (box) form factor**

Food:

In urban scenario, most married couples are working. But solar cookers are usable only in limited periods in the morning. Hence cooking habits of these users were considered. The users whom I have tried to target are familiar with the concept of ovens and food items that can be prepared in it. My product aims to compete with the similar food cooking products.

6.0 THE CHECK

Fig. 13



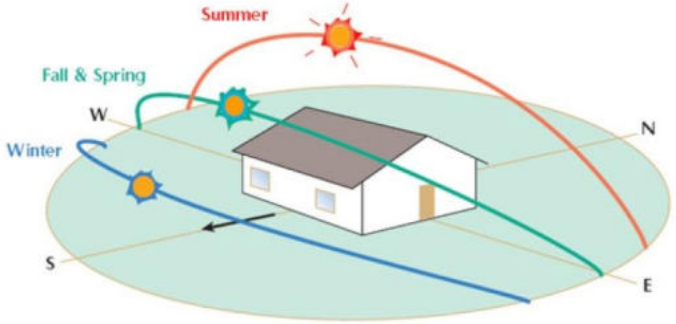


Fig. 15 Ref .http://www.homebuildinglessons.com/TDBlog/2011/06

6.1 Understanding Apartments

The main issue with the solar cooker is that the user needs to go out. The possibility of them operating their solar cooker from inside the house like they used to operate window mounted air-conditioners has been considered. (Fig.13).

6.2 Availability of Sunlight

Some apartments and windows for mounting the solar cooker were studied. Nowadays, the aluminum frames are used for windows and the standardized frame can be used to determine/fix the product size.

The location for mounting, where the sun light is available for whole day needs to be considered.

Since the Earth's axis is tilted by 23.5˚ with respect to plane of sun's orbit ecliptic, the south facing wall has the maximum sun light availability throughout the year. This will be the most appropriate location for a solar cooker.

7.0 DESIGN BRIEF

'Design a Solar Cooker for High-Rise Buildings'

- A Solar cooker which is mountable on wall/window and can be used from inside the house.

8.1 Concept 1 - One Side Mirror

The idea is inspired by a one sided mirror. Mostly these are used in Interrogation rooms.

The idea is to let the sun light pass through it restrict the outgoing path. One side mirror has a reflective layer at one side so that the person on the reflective side can see his own image while the person on the other side can see through it.

Because of the maximum retention of the sun rays inside the Black body it gets quickly heated up. The visibility is dependent on the ambient light intensity at both sides. Because of the reflective layer, glass prevents its transference. It allows less sun rays inside.

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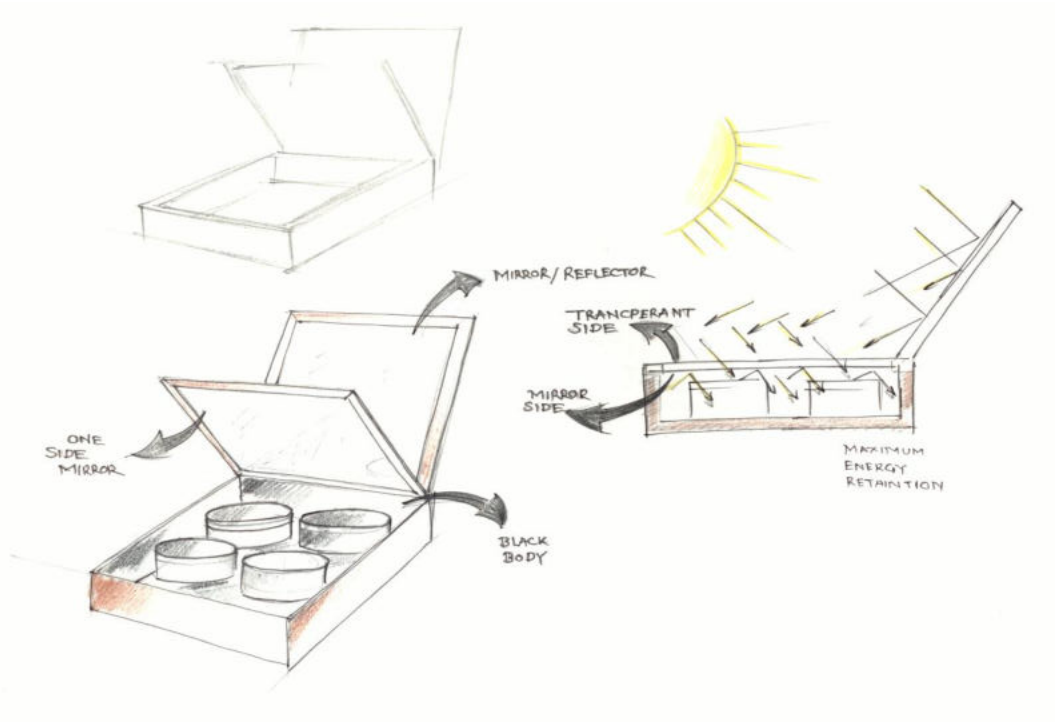
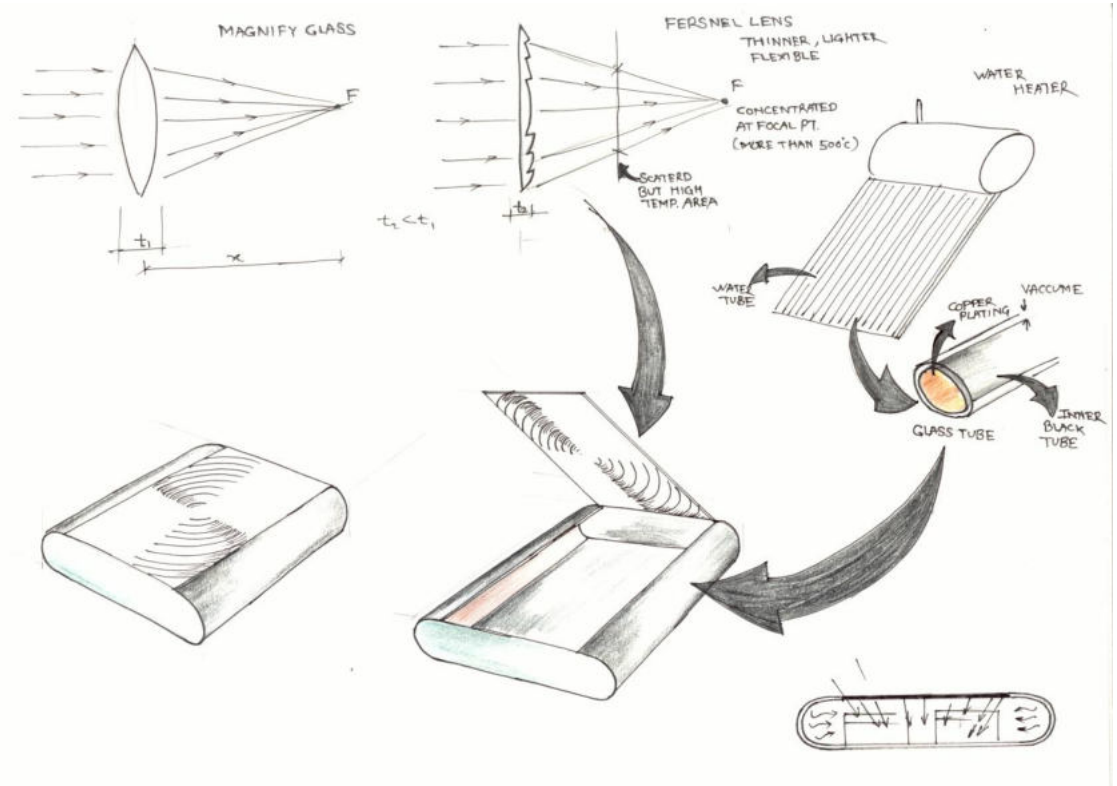


8.2 Concept 2 - Fresnel Lens

The Fresnel lens is the thinner version of a magnifying glass. It's not transparent but it allows the rays to concentrate at focal point. It is also available in thin flexible sheets. These lenses are used in LED TVs. By replacing the glass lid in the solar cooker, more sun rays can be concentrated in to the cooking chamber. But the issue is that it has to be aligned with the sun to get the high temperature. Focal point distance will decide the depth and volume of the container. The aim is not to concentrate sun rays at bottom of the container since it creates a very high temperature. From general observation it was seen that solar cookers start working only after sun beams are vertical to the surface(during noon) since they have opening only from the top side. If the sides of the cooker can be made transparent, it is possible to get the sun light even when sun is at the horizon.

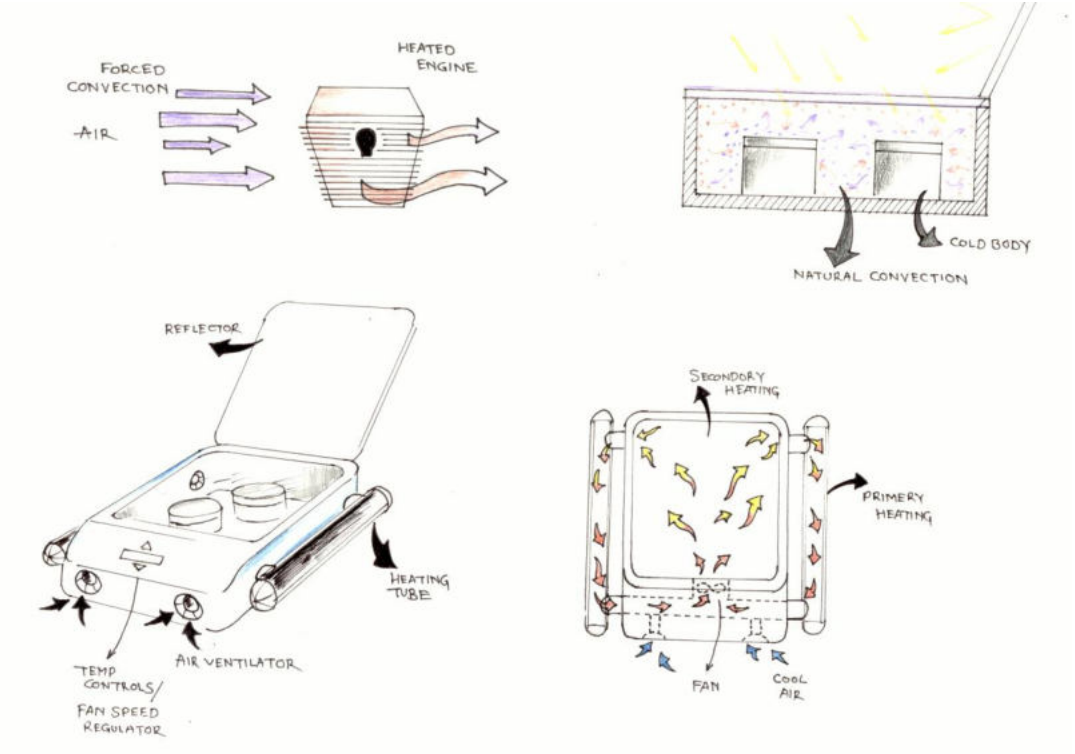


Tubes which are used in solar water heater for heating the water have been considered here. If cut into half and stuck to the side, it will start collecting heat from 9 O clock in the morning and hence can be used for a longer time.
But there are many issues to resolve for ease of manufacturability in this concept.

8.3 Concept 3 – Force Convection

This idea came from the observation that air inside the chamber is heated by black body surface and the air inside the chamber is almost stagnant. There is no movement at all.

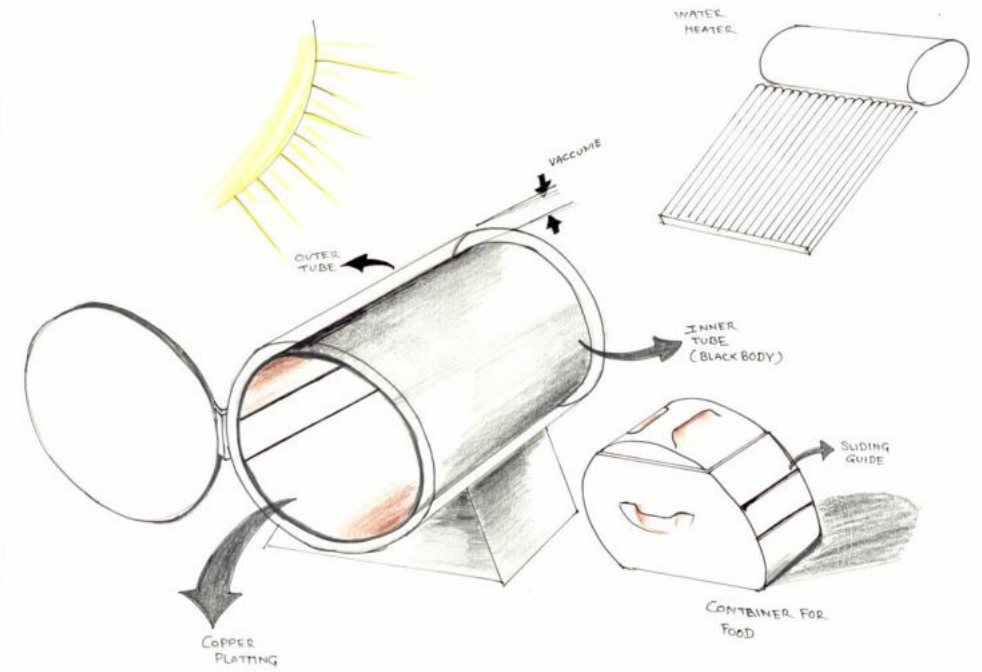
Just like two wheeler engine is cooled down by air which is blowing around the engine,the same way we can heat up any object by blowing hot air on it. So the same water heater tubes were used because they can achieve 200˚c temperature within 10 minutes depending on the sun light. They were then arranged on the sides of the cooker and connected to the inside of the chamber. A small fan can be used on solar cell to force the air on the food containers. They will certainly heat up quickly.



The scenario is as follows: Air continuously circulates through tubes which on collecting heat from the sun, transmits the heat to the food containers. But again manufacturability will be an issue which gets complicated.

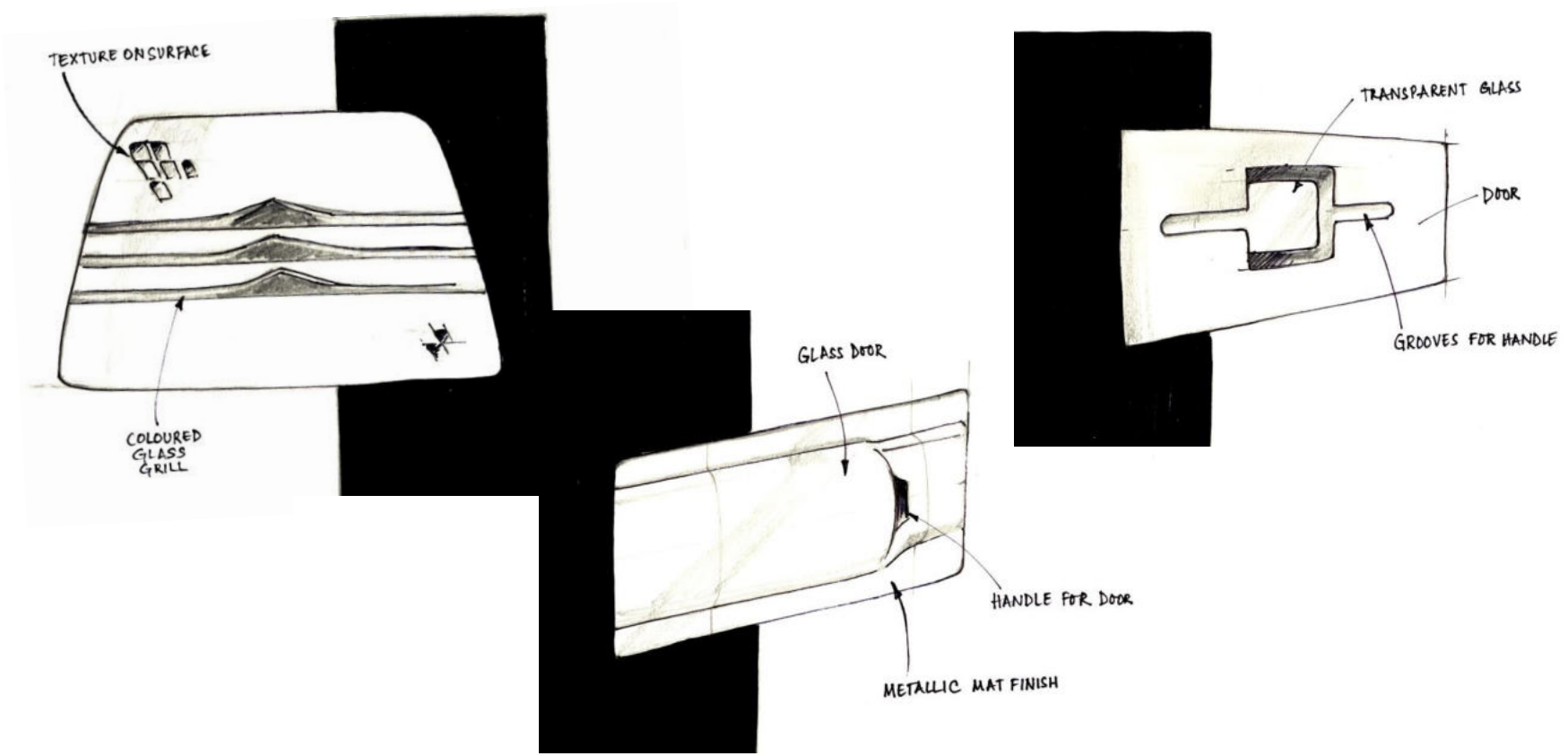
8.4 Concept 4 – Solar Tube

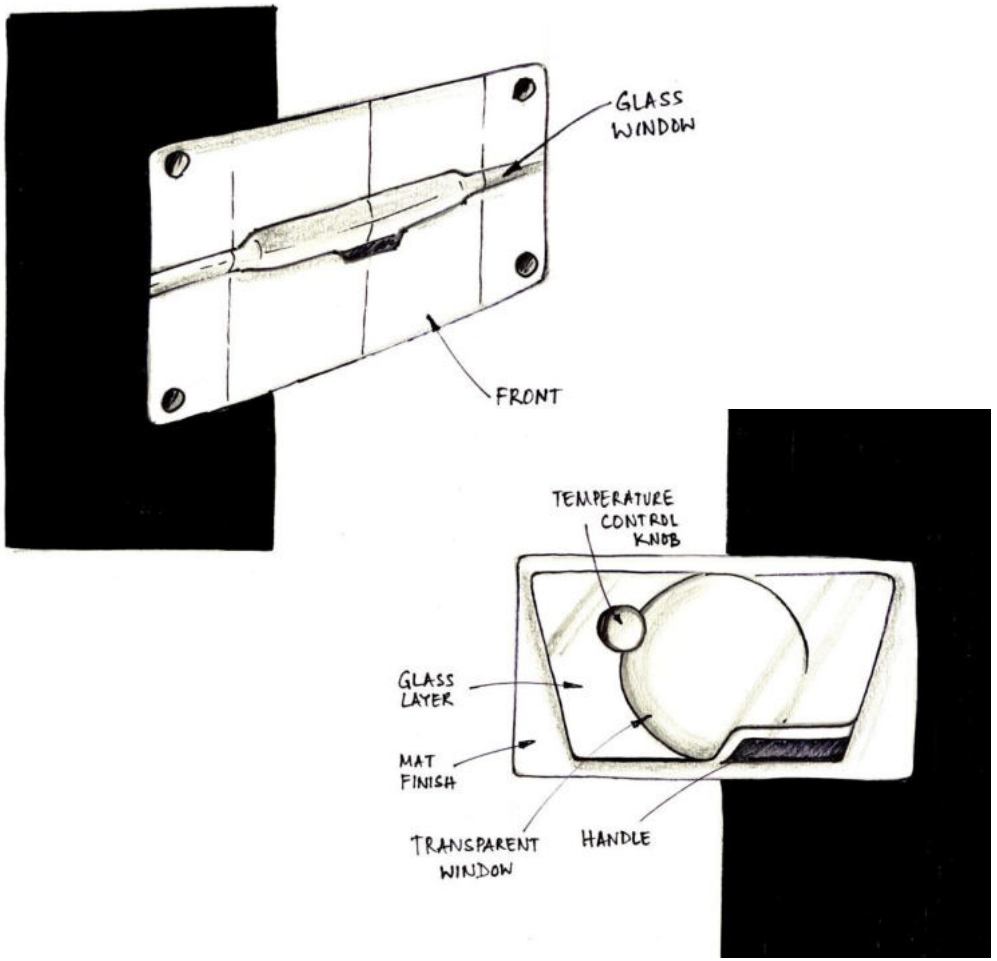
Solar water heater tubes were used in all the concepts. These tubes could also be used as it is but magnified in scale, which use vacuum as an insulator. This tube can achieve up to a 200°c stagnation temperature. The function remains unaffected irrespective of outside whether. The tubes contain selective absorbing material on the inner tube which helps to absorb solar radiation.

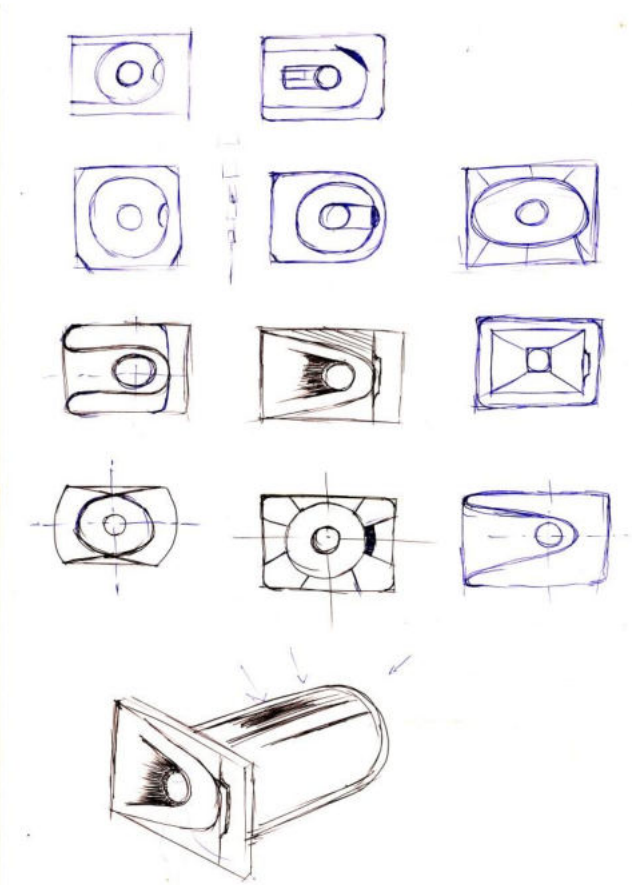


9.0 THE CRAFTING

9.1 Sketches




GLASS WINDOW
FRONT
TEMPERATURE CONTROL KNOB
GLASS LAYER
MAT FINISH
TRANSPARENT WINDOW
HANDLE



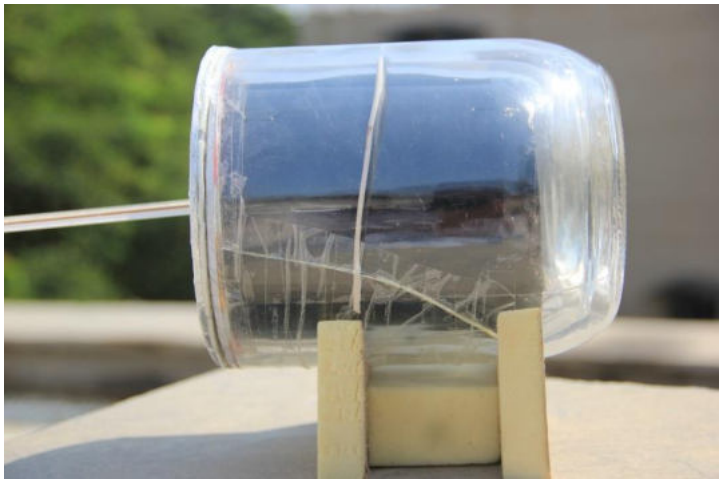
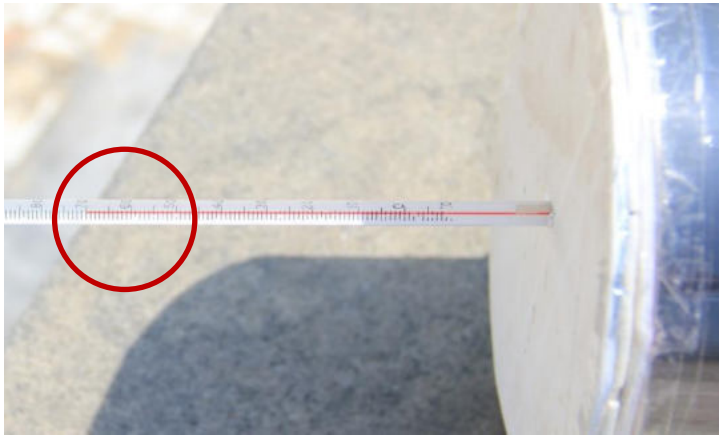


Fig. 16 tube in to tube



70˚c temperature remained stagnant throughout the day.

Fig. 17

9.2 Working Prototypes

Fig. 18

The solar tube concept is proved by this small mockup model. Some small glass jars which used for keeping pickles were used. The inner tube contains the aluminum sheet of 0.5 mm thickness Painted by black color. The outer and inner tube are having small air gap in between. It was kept at 1.30 p.m. and after 20 mins a temperature of 70 C was obtained.

Fig. 19

In this model I get only 56˚c at same time

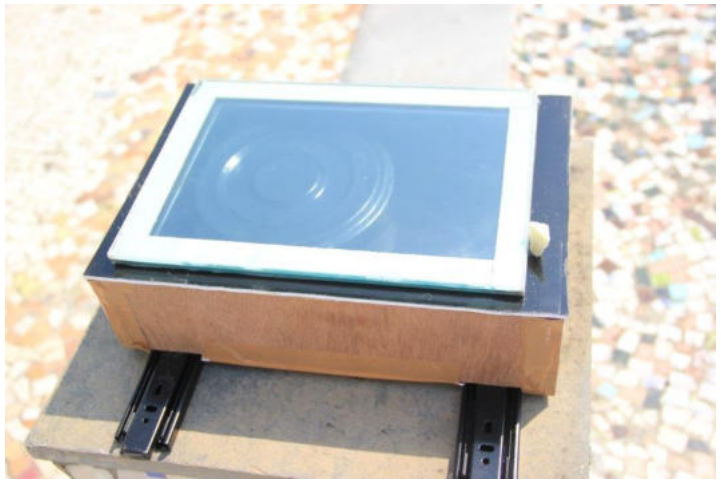


Fig. 20 box type solar cooker, attached with slider mountings.

Fig. 21

Fig. 22

This time the 20 litres of water container was used. The inside volume is approx. 18 litres. The idea is to use polycarbonate for making tubes. This can be easily manufactured by blow molding process. It is light in weight and cheaper than the glass. It will be cantilevered outside the window. It will be safe if the material is polycarbonate.

Fig. 23

The temperature achieved from this model is more than previous one irrespective of increased volume. It reached 82˚c within 20 min.

10.0 THE CONNECTION

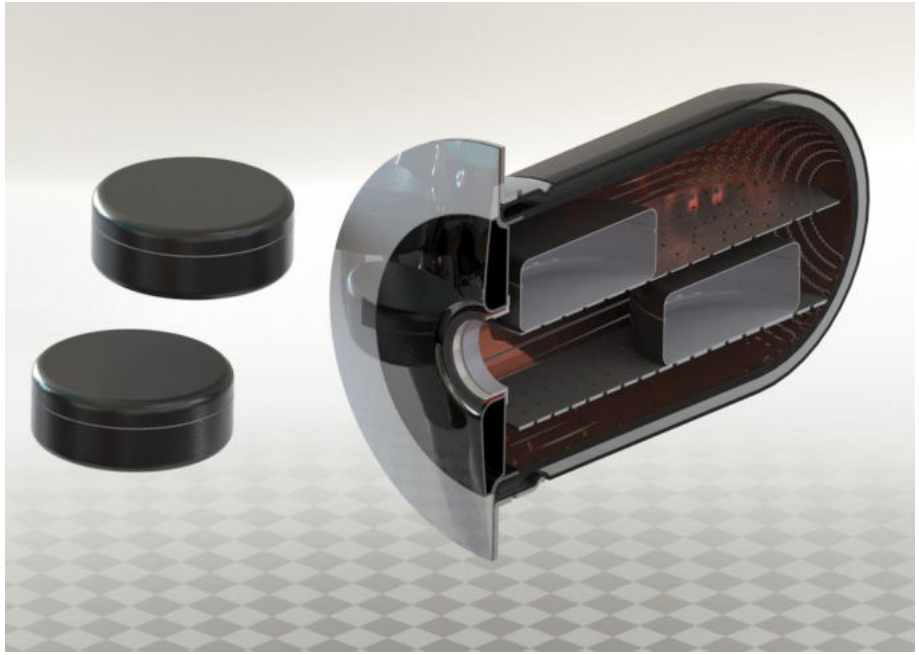


Fig. 24 the cross section view.

The fig. 24 shows the cross section of the first concept of solar cooker which can accommodate four aluminum round food containers which has a capacity of 1.5 liter each. These are standard boxes which are presently used in general Box type solar cooker. These boxes are placed on a sliding tray inside the solar cooker. To improve its efficiency it is colored in black, although its not mandatory to used one.

Fig 25 shows the door mechanism which has a facility of temperature control knob. Its basically a vent which allows the air circulation as we increase or decrease the air circulation temperature can be control.

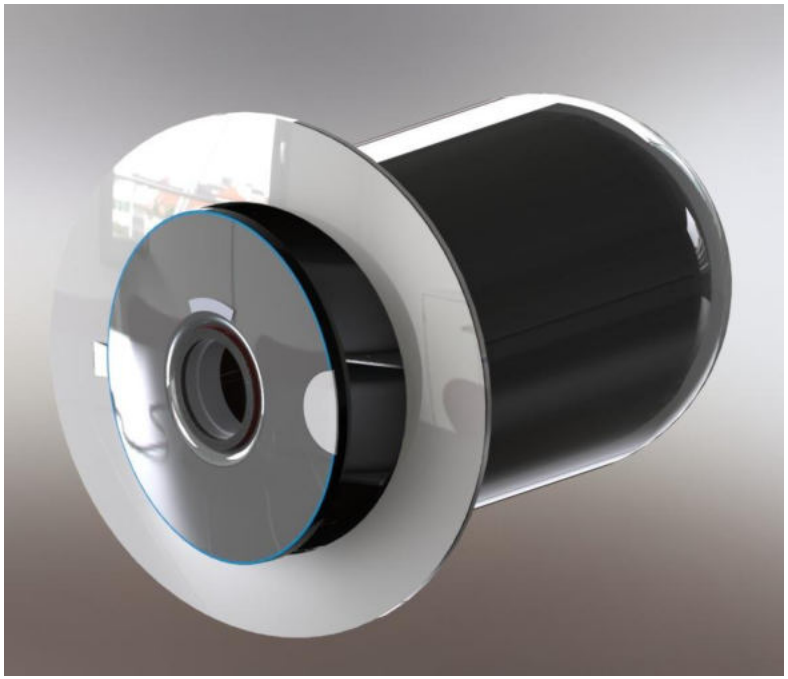
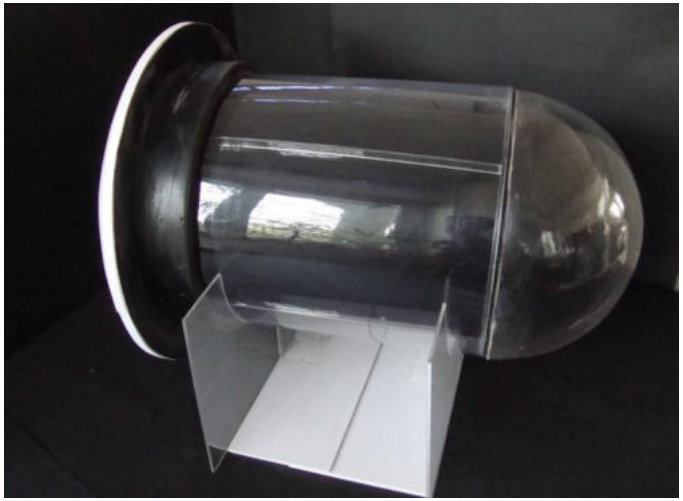
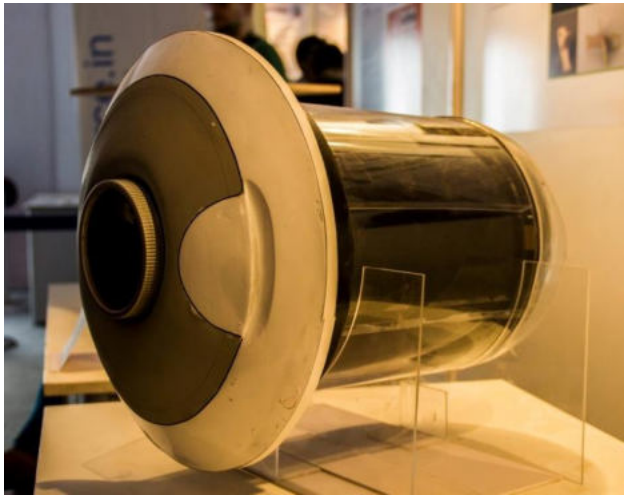
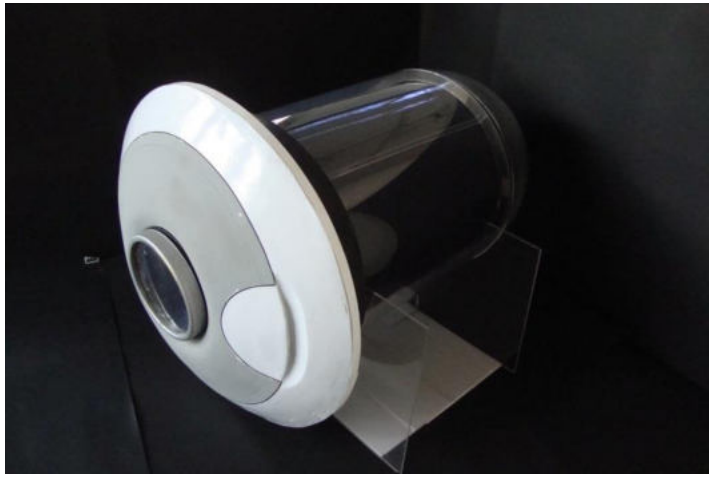
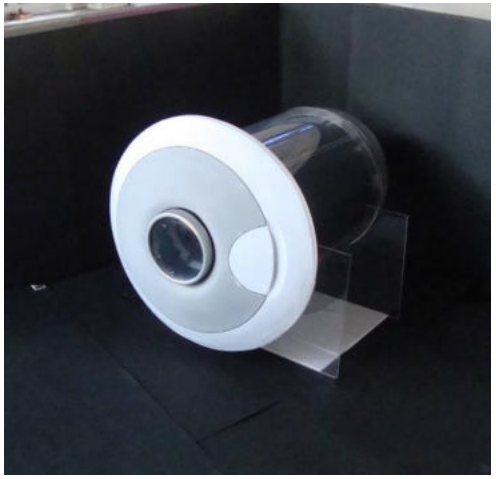


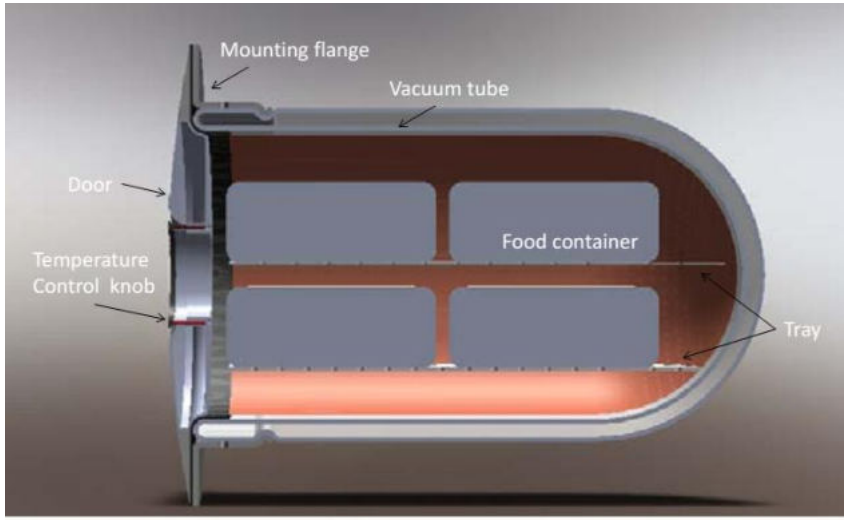
Fig. 25 the cross section view.

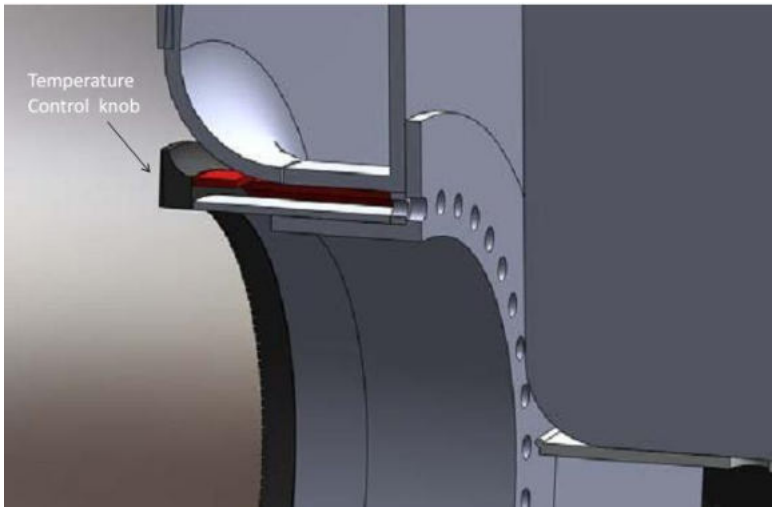


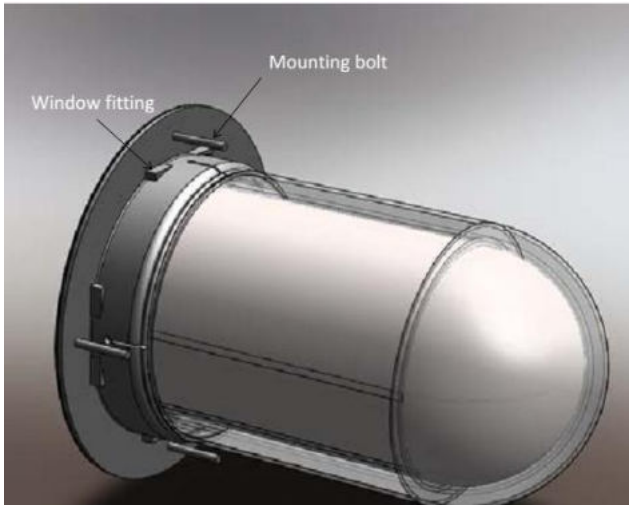







Mounting flange
Vacuum tube
Door
Food container
Temperature
Control knob
Tray


Temperature
Control knob


Mounting bolt
Window fitting

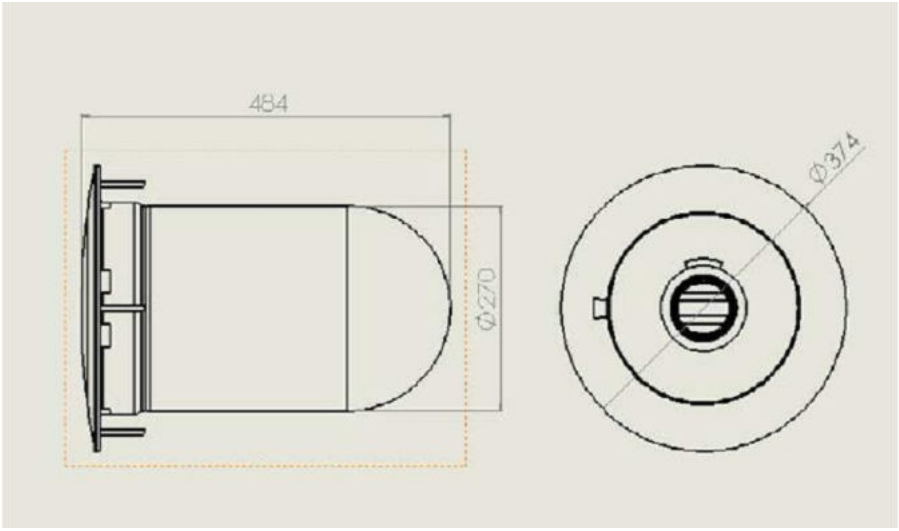

484
Ø270
Ø374

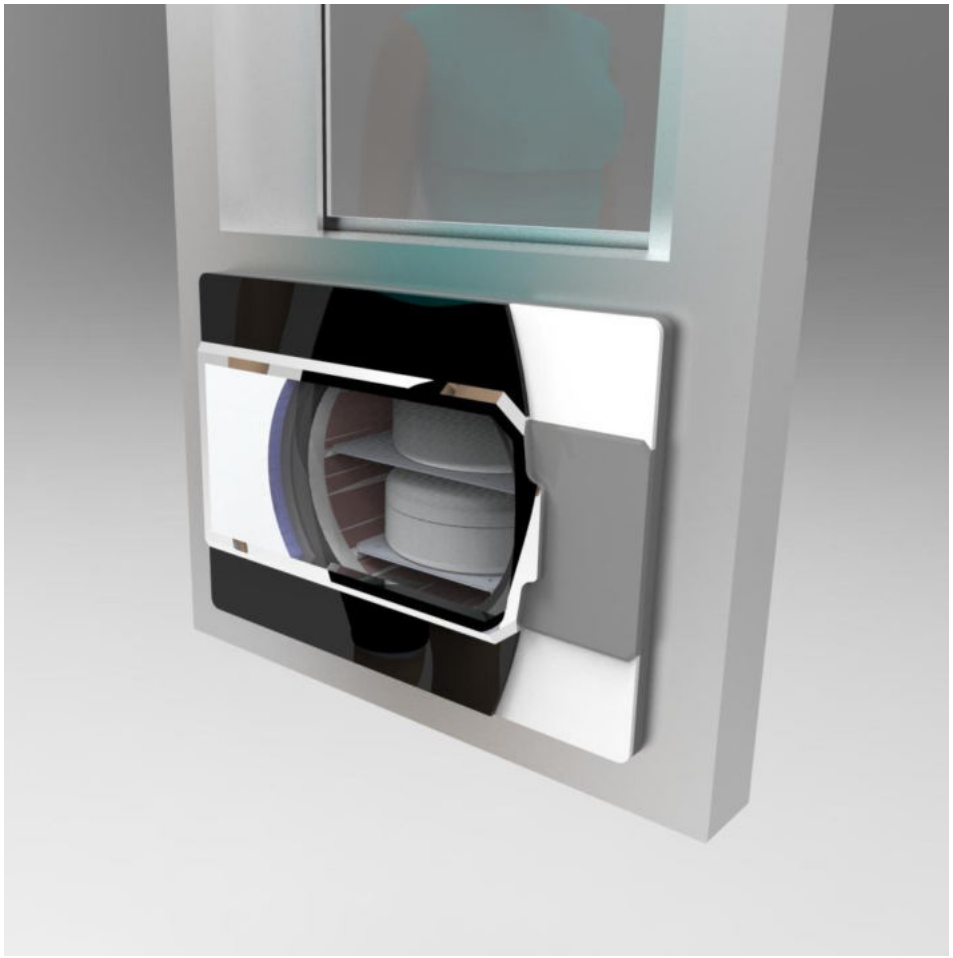
Fig. 26 solar cooker fitted into south facing window

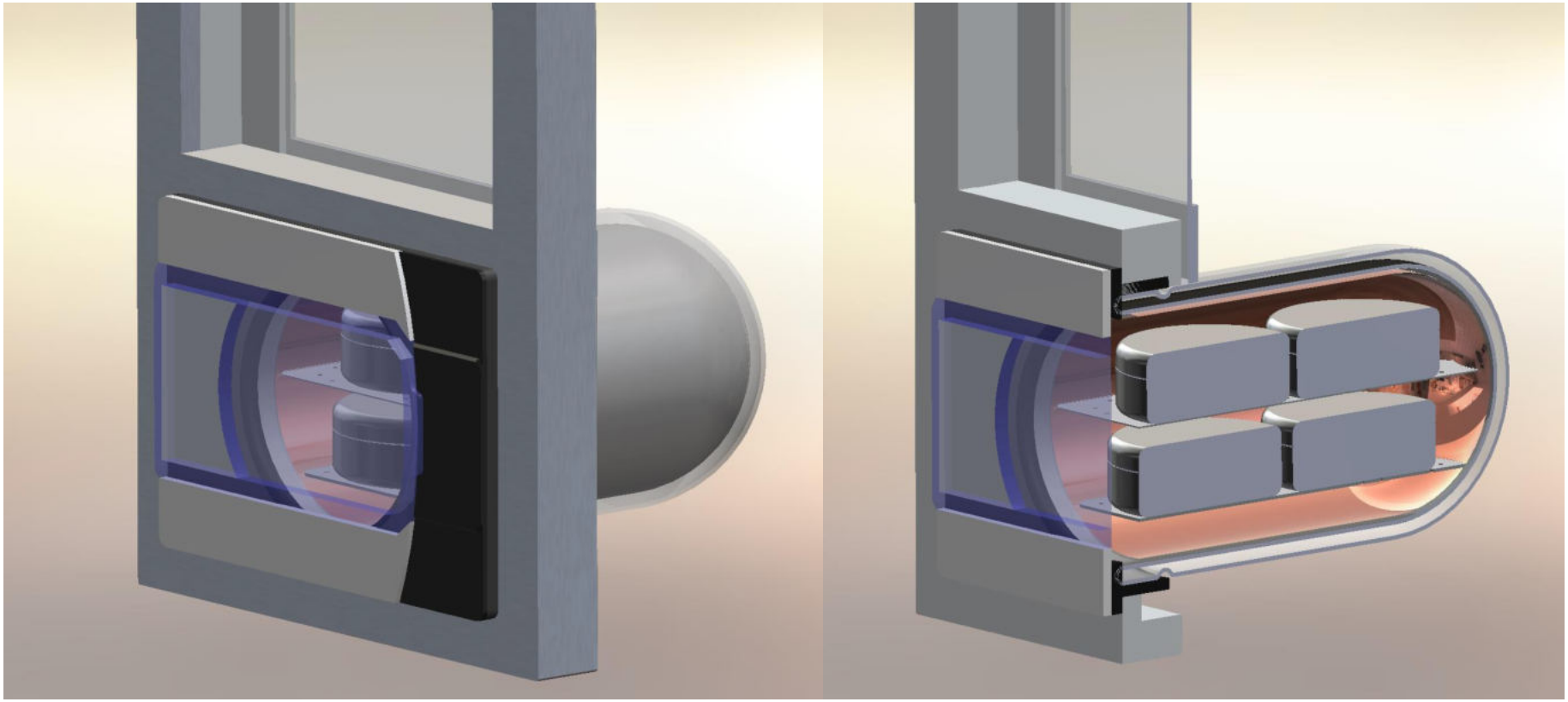
This can be fitted into a window or wall, the same way as window ACs are mounted.

The main constraint is that this has to be fixed onto a south facing wall or window so that maximum and all year round sun light is received. Fig 26 shows the context.

Maintenance – The only maintenance user has to do is to keep outer surface clean and dust free. User can easily access the outer body of the cooker by opening the window, which absorbs the sun light.

11.0 FINAL RENDERING





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