Renewable Energy System Designs for Solar Cooker/Oven and Silicon (Si) Module Heater

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ABSTRACT –
A renewable energy system design for solar cooker/oven with different detachable reflectors and a design for Si module heater for cooking purposes are presented here. The solar cooker design is based on the principle of hot box type cooker with different detachable reflectors. The reflectors used can be mirror, stainless steel, aluminum or brass sheet/foil. Performance of cooker can be tested with different reflectors. They can be tested at different insolations in different seasons. These cookers/ovens may prove to be efficient, reliable and trouble free. The selective absorber coating used will be textured black copper coating. Different type of food can be cooked for a family of 4-5 between 9 am to 5 pm at different insolation falling on this cooker/oven. Second design is a Silicon (Si) module exposed to sun during different days. Which can be used for cooking and baking purposes. Both renewable solar systems designs can be used for making nutritious food. The solar cooker can boil, cook, roast and bake depending on insolation falling on it and the temperature obtained within cooker/oven while photovoltaic heater (oven) can boil, cook, fry and also bake. Both the cooking systems proposed are sustainable and stand alone systems respectively. They are also ecofriendly.

Keywords- Black copper selective coating, chemical conversion, high absorptance, low emittance, operating temperature, renewable energy system, reflectors, sustainable, stand alone system. Solar cooker/oven, (Si) module heater,

I INTRODUCTION

Harnessing solar energy is essential since solar energy is limitless, inexhaustable, cheap, valuable, nonpolluting, source of energy available to mankind during the day. Hence efficient utilization of solar radiation is required. It can solve our energy crises and energy shortage problems.

For this purpose selective absorber surface had been investigated by number of researches [1,2]. Black copper are most commonly investigated selective surfaces [1-4] Textured black copper selective coating had been developed [1,2] which possess high solar absorptance (α) ~ 0.97-0.98 and low thermal emittance $\epsilon_{(100)}$ ~0.15-0.2 is used in this solar cooker/oven.[1,4] Here another design of solar cooker/oven which can be made using texture black copper selective coating has been proposed. Which may prove to be reliable viable, ecofriendly, efficient and trouble free. Different type of food can be cooked for a small and medium family during different days at different insolations.

Secondly a Silicon (Si) module heater for cooking purpose which can operate at different insolation is proposed. Both green renewable solar (thermal and photo voltaic) systems can be used for cooking and baking purposes depending upon insolation falling on these systems. These solar systems are sustainable to environment and are also standalone systems. They are ecofriendly and easy to make and use. They can be shifted to any desired place when ever necessary.

II EXPERIMENT TECHNIQUES

The textured black copper selective surface had been developed by chemical conversion which can be used as industrial technique for fabrication of absorber coating [1-4]

Air annealing is carried out in a laboratory oven with accuracy $\pm$ 10^0c for 24 hour. Solar insolation had been recorded using pyranometer. Temperature of absorber plate and glass cover had been recorded using a thermo couple [1-4].
The total reflectance had been recorded by Hitachi 330 double beam spectrophotometer between 0.3-2.5 μm the integrated solar absorptance (α) has been computed. The thermal emittance had been measured using an emissometer [1-4].

III RESULT AND DISCUSSIONS

Textured black copper selective coating possessing solar absorptance (α) ~ 0.97-0.98 and emittance (ϵ_{100}) ~ 0.15-0.2 can be used to develop textured black copper solar cooker/oven.[3] And a silicon module which can be used to operate a heater are given here. Both device systems can be used for boiling, cooking and baking purposes.
Both these system are being described here in brief.
Experiment and design (Stand alone systems)

(a) **Design of renewable energy solar cooker/oven:-** Design of solar cooker/oven (Stand alone) box type solar cooker with reflector is simple to use and is presented here. Such cookers have been found to be maximum in use. Here a designs of textured black copper solar cooker/oven is shown in fig. 1.

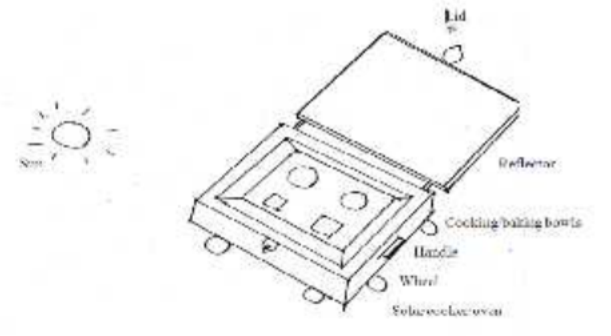

Fig. 1 Shows a design of textured black copper solar/oven.

Table 1Characterization Of Texture Black Copper Selective Coating Ref [1-3]

1	as deposited textured selective coating	(α)~0.97-98 ϵ_{100}~0.15-0.2
2.	exposed to 250^{0}C in electric oven (air annealed)	(α)~0.95 ϵ_{100}~0.2
3.	textured black copper coating is stable and appears black and velvety textured black copper sample was made during (1984-86)	α high, ϵ_{100} low and stable

The cooker/oven consist of textured black copper absorber coating. Which possess initial solar absorptance (α)~0.97-0.98 and emittance (ϵ_{100}) ~ 0.15-0.2 [1,2] which is stable upto 250^{0}C (Table 1) Reflector is attached to the box type cooker Reflector is attached to obtain the maximum sun rays falling on the cooker/oven Reflectors such as

(i) Mirror,
(ii) Stainless steel,
(iii) Aluminum,
(iv) Brass

can be tested in this cooker/oven. These reflectors may increase the temperature by 15-25^{0}C higher by optimizing the angle of reflector which may reduce boiling, cooking, baking time. The rays seen by the reflectors are shown in fig 2.

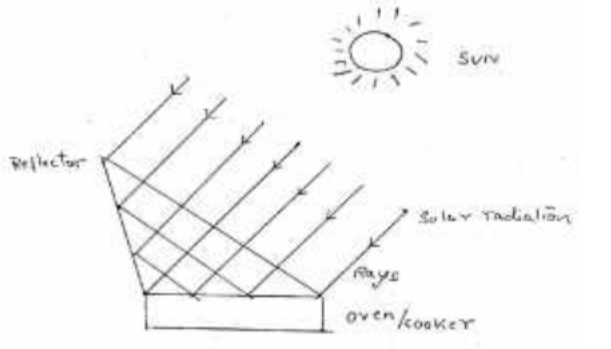

Fig. 2 Indicates solar rays falling on a reflector of cooker/oven.

The top glass cover can be single glass cover or double glass cover or Single glass cover with antireflecting coating or double glass cover with the top glass cover with antireflecting coating.

This will depend on the optimization to obtain best reflector to be used in the proposed solar cooker/oven. The cooker can be used for 250-330 days during sunshine days and semi cloud days. These are stand alone system.

(b) **Human engineering considerations**: - The food to be cooked or baked can be kept in the solar cooker to which wheels are attached to shift the cooker so that the person who is cooking/baking does not stand in sun for a longer time or the solar cooker can be shifted under covered area during rainy seasons.

The cost of such cooker will increase with increase of glass cover and anti-reflecting film/coating on it. However, the payback period may not be more than 3-4 years if used regularly for cooking/baking purposes. The longevity of such textured black copper solar cooker/oven may be more than 15-20 years as evident by a samples of the textured black copper coating developed during 1984-86 [1-4] [Table 1]. Thus textured black copper selective coating cooker can be fabricated using the design given is fig. 1.

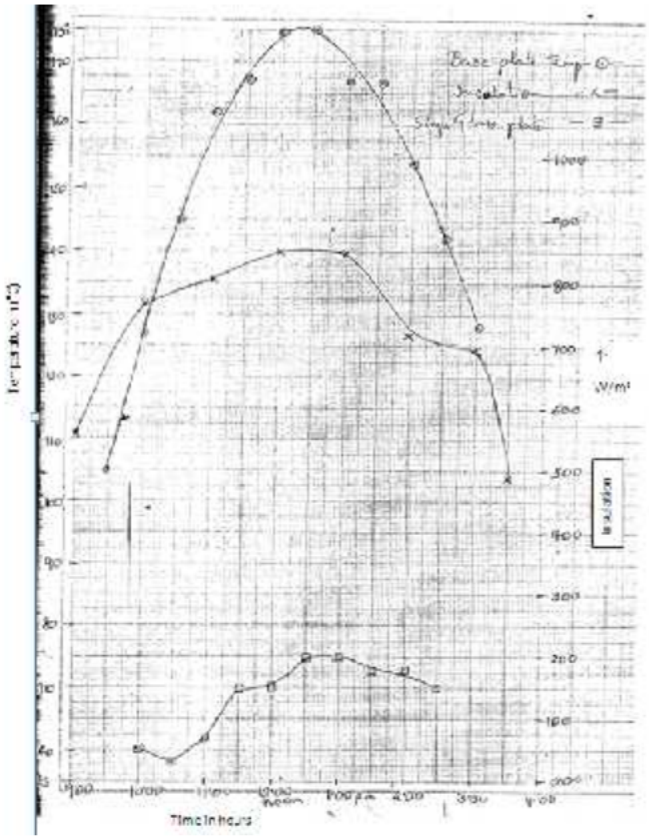

Fig. 3 Depicts the performance of solar oven/cooker on clear day (cloudy during end of the experiment).

Fig. 3 shows performance of one such cooker/oven developed using textured black copper coatings performance on a clear day. The day had became semi cloudy during later hours of the experiment [4]
The conditions during experiment had been

(i) No load
(ii) Single glass cover and mirror as reflector
(iii) Maximum insolation 850w/m^2
(iv) Maximum base plate temperature was 175^{0}C
(v) Maximum ambient temperature 45^{0}C
(vi) Maximum glass cover temperature was 75^{0}C
(vii) The time was between 9 am to 4pm

This textured black copper cooker can be used for 250-300 days in sunshine and semi cloudy days and in rainy days when sun shine is present.

B. Design of Silicon (Si) solar module system (Stand alone system)

In a solar cell conversion system the solar radiation falls on solar silicon (Si) module which converts sun light directly into electricity which gets stored in a battery. Battery is connected to the heater this can be used inside the house during the day and at night. These electric appliances (heater) can be utilized for cooking, boiling and baking purposes. [Table 2] Table 2 given the operating ranges of Si module heater (oven).

Table 2 Range Of Operating Temperatures Of Appliances Of [Solar Thermal Solar Cooker And Photovoltaic Heater]

Appliances	Operating ranges
1. solar cooker	80-120^{0}C-150^{0}C
2. solar oven	120^{0}C-250^{0}C-300^{0}C
3. solar food heater/warmer	50-80^{0}C-100^{0}C
4. photovoltaic heater high watt (waltage)	50-100^{0}C
5. photovoltage oven (high watt (waltage)	150-250^{0}C-300^{0}C

The main advantage of such Silicon (Si) solar cell module device is that it can be moved to sun [if wheels are attached to a trolly on which module can be kept]. It can work quite satisfactory in sun, shade and under diffuse radiation. This is shown in fig. 4.

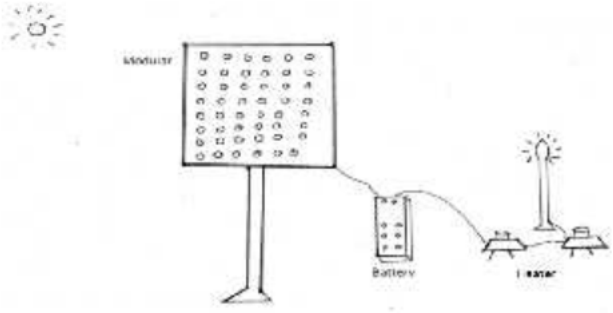

Fig. 4 Show a Silicon Si module with appliances [heaters and lamp] working using the Si module.

This may prove economical and can be used in energy crisis and light shortage days for cooking and baking purpose. Baking can also be done on such heater (oven) system.

In a solar module a solar cell may cost about Rs. 60-100. Hence depending on size of the module (wattages (watts) of module) such system can be installed and/or such Si module assembly made. Both such system can be tested, Solar cooker/oven and Si heater can be used for boiling, cooking and baking purpose in light shortage days. These can be used in sunshine days, semicloudy day and when sun is present in rainy days.

While Si module heater can be used in sunshine day, semicloudy days, cloudy days and under diffuse radiations. And by using Solar battery at nights which gets charged during the day.

Table 3 Price of Solar Cooker/Solar Cell And Utility

• solar cooker costs ~Rs 1000-1500-2000 • cooker can be used for 250-300-330 days • life ~ 15-20 years. • solar cooker/oven can be used under solar radiation and also semi cloudy days.
• Si Solar cell ~ 1-1.5W • cost ~ 60-100 Rs • solar module – (many watts (3-100 watts)) • life - long • Si module can also be used under diffuse radiation

IV CONCLUSION

Here two cooking appliances design have been presented.

(a) First is a solar cooker/oven made of textured black copper selective coating possessing solar absorptance (α)~ 0.97-0.98 and emittance (ϵ_{100})~0.15-01.2 which can be used for cooking purpose.
(b) Second is a Si module heater (oven) design for cooking boiling, and baking purposes.

In short both these solar devices can cook boil, roast, warm food and bake at appropriate temperatures under solar radiation. They are sustainable and ecofriendly and can be easily used. Solar cooker can prove efficient under solar radiation and semicloudy days. However, the silicon (Si) module heaters can be used in both sun and diffuse radiations and at night by using rechargeable battery which gets charged during the day under sun.

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