Innovative Methods to Enhance the Performance of Solar Cooker—A Review

Praveen Math[1], Dr. Rhushi Prasad[2]
[1, 2] Department of Thermal Power Engineering
[1, 2] REVA University Bangalore

Abstract- *Cooking is the one of the primary energy application for people all over the world and most of the w orld population lives in region where abundant solar energy is available. Under the current scenario,the world is facing two problems, on one side the global population is increasing at a faster rate and on other sidethe conventional energy sources are depleting at an exponential rate. With the increasing crisis of fossil fuel, scientists are looking for renewable energy sources for various applications. Amongst all renewable energy sources, solar energy is the major and most abundant source of energy sources. In the rural area, cooking largely depends on the conventional natural resources such as wood, cow dung etc. But use of natural resources in crude manner causes indoor pollutions. To control indoor pollution due burning of cow dung and wood, many methods have been proposed for rural areas. Solar cooker is one of the best methods to prevent indoor pollutions. This paper present the review work that has been made to study the research and development work carried out to increase the performance of a solar cooker. This paper explain some techniques to increase the performance of solar cooker to modify conventional solar cooker.*

Keywords- Cooking, Solar Cooker, Solar Energy, Fossil Fuels, Renewable Energy

I. INTRODUCTION

Solar cooking is among the several methods available for domestic and institutional cooking. Like other cooking devices, it has merits and demerits. Meritoriously, it offers ecological benefits through savings on conventional fuels (firewood and fossil fuel) and reducing environmental pollution. It also provides social-economic benefits such as employment created through the production of the cookers as well monetary savings on cooking energy expenditures [1]. Conventional solar cooker has very low efficiency and requires more time to cook hence people are not interested to make food in solar cooker. Considerable research work has been done to increase the performance of conventional solar cookers. By using modern innovative methods, it is possible to achieve good efficiency and decrease the time of cooking.

II. HISTORY

In 12th century people start to have sun dried food, vegetable, fish and meats. After since 16th century a German physicist, E.W. von Tschirnhousen, made large lenses to boil water in a clay pot. In 1767 Saussure's was first recorded effort to solar cook food. He built a miniature greenhouse with 5 layers of glass boxes turned upside down on a black table and reported cooking fruit. He later built a cooker of 2 pine boxes topped with 3 layers of glass, and later still added wool insulation between the two boxes. Which probably had no idea his invention would help people prepare their dinner two and a half centuries into the future.In 1830s English astronomer Sir John Herschell cooked food in a similar insulated box on an expedition to South Africa. 1860s and 70s-AugustinMouchot was the first to combine the box/oven heat trap and burning mirrors concepts to create a solar oven, a solar still, a solar pump and ultimately the first solar steam engine. He saw great commercial potential in France's sun-rich, fuel-poor colonies in North Africa and Asia.

1876 In India, W. Adams developed an octagonal oven with 8 mirrors which cooked food for 7 soldiers in 2h. Dr. Charles G. Abbot Secretary of the American Smithsonian Institution, was the first recorder inventor of solar cookers in which the heat collector was outside but the cooker was inside house, with heat carried from collector to cooker by circulating oil. In 1945 Indian pioneer Sri M.K Ghosh has designed the first solar box cooker for commercial produced. In 1973 Barbara Kerr, USA built many types of concentring and box solar cookers from descriptions, including Ghosh box cooker in India. She used simplest materials inspired by retained heat cookers and developed low cost, simple solar cooker using recycled material and aluminium foil [2,3]. Considering all efforts made in last 50 to 60 years, today it is possible to build low cost and effective solar cooker.

III. SOLAR COOKER WITH MODIFIED VESSEL

USING FINNED VESSEL

This type of vessel has number of fins on it and this vessel is modified to increase heat transfer rate as shows fig 1.

Solar cooker is not increases any output or extra heat but the vessel is receive more heat than normal vessel. Solar cookerincreases the heat transferring rate through the vessel and hence the vessel reduces the cooking time. The experiment conducted on this vessel load of 0.5kg. The experiment temperatures are note down by finned and un-finned vessels and plot on a graph fig 2. [4].

Figure 1. Finned Vessel

Comparing finned and un-finned vessel another author found [4] some temperature variations shows Fig. 2. Comparing of both vessels, finned vessel reach higher temperature than conventional vessel. Hence finned vessels are more efficient than conventional vessels.

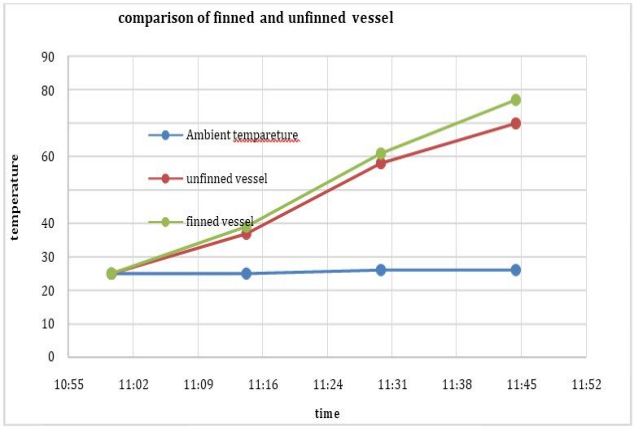

Figure 2. Comparison of Finned and Un-finned Vessel Temperatures [4]

USING TRAPEZOIDAL SHAPE VESSEL

The trapezoidal shape vessel is used to absorb more amount of radiation. This type of vessels is expose more area than conventional vessels to increase the heat transfer rate. This type of vessels has smaller bottom surface area than upper surface area as shown fig.3. The bottom surface of the vessel has number of curvature to increase the heat transfer rate [2].

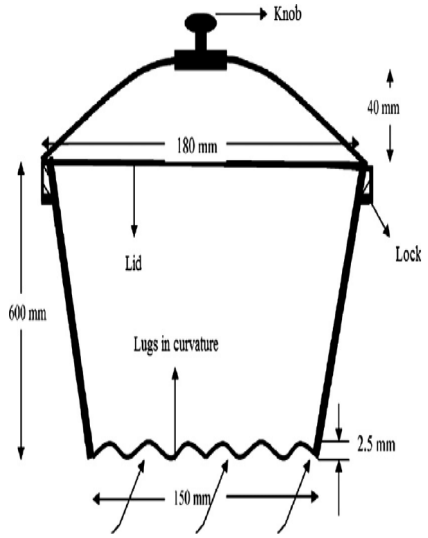

Figure 3. Trapezoidal Shape Vessel [2]

This types of vessels expose more area and has more heat transferring rate than conventional vessels. And hence this type of vessel took requires less time to cook food compared to conventional vessel [2].Hence, using this type of vesselit is expected to get good performance of solar cooker.

HYBRID SOLAR COOKER

In this type, conventional solar cooker was connected to PV panels. FewPV panels are connected to each other with hinges. DC heater is placed in the bottom of the solar cooker and connected to the PV panels. PV panels supply the power to battery and battery stores the DC current. The battery supplies the current to heater at cooking time. This type of solar cooker minimizes the cooking time using the stored DC current. At cooking time conventional solar cooker operates on its own principal and that time additional heat is supplied by the battery to the solar cooker through heater [5]. Hence, time required to reachtherequired temperature is very less and cooking time become minimum.

Figure 4. Solar Cooker with 5 PV Panels [5]

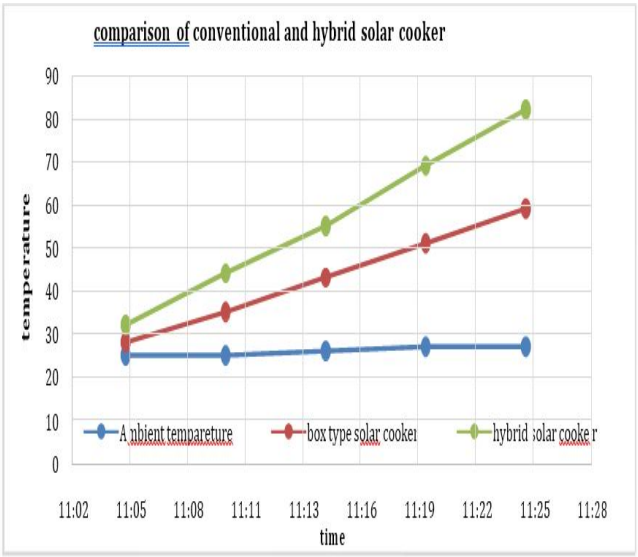

Figure 5 Comparison of Hybrid and Conventional solar Cooker Temperatures [5]

Figure 5 showsthehybrid and conventional solar cooker temperatures. For this experiment, the author [5] used 75W load PV panels to heat the 1kg water.Than it is found the variations in temperature. Using that data graph is plotted as shown fig 5. From results the hybrid solar cooker temperature was maximum due installation of PV panels and hence cooking time is minimized.

THERMAL ENERGY STORAGE (TES) SOLAR COOKER

Conventional solar cookers are useful only at sunshine duration. It is not good for other conditions such as late evening, cloudy climates to cooking food. At this condition, storage device is required to store the energy. Different storage materials are available that can be used in solar cookers. Different materials have different heat capacity thatdepends on the amount of heat that materials can hold. Some materials or fluid can hold large amount of heat such as heavy pan, water, engine oil which can increase the effectiveness of the solar cooker. These materials have used in solar cooker to stores the energy. Thermal energy can be stored as change in internal energy of a material as sensible heat, latent heat, thermo- chemical or combination of this. This thermal storage materials placed in the solar cooker and heated at sunshine time to store the energy. That energy can be used for cooking [6, 7].

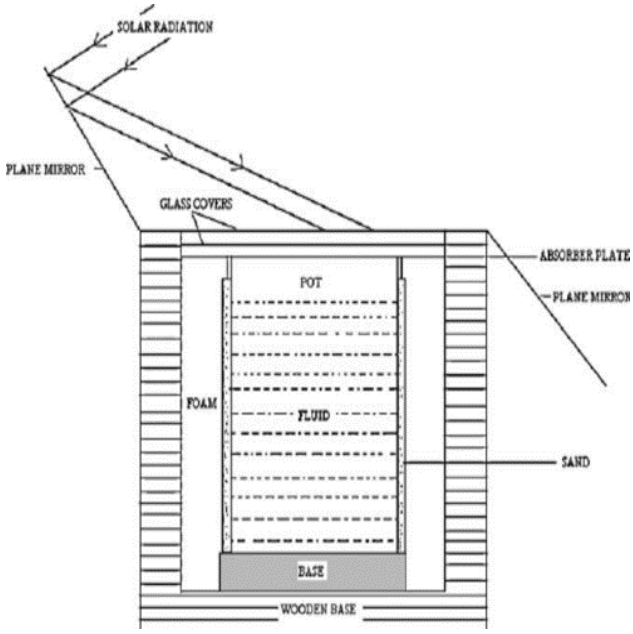

Figure 6. Thermal Energy Storage Solar Cooker [7]

Using above technique it is easy to cook when sun is not shine. Another advantage is, it can store the energy when not using solar cooker. In rainy days it is useful to indoor cooking.

SOLAR COOKER WITH SUN TRACKING SYSTEM

Sun is not stay at a point and always move east to west in a specific direction. This is the one of the major problem for the solar cooker to continuously follow the sun along two direction- azimuth and altitude. If the position of the solar cooker is not changed, there is a loss in the efficiency of the solar cooker and it requires readjustment the solar cooker every 15-30 min, to get better performance. Number of tracking mechanisms are available [8].One of the method is gravity based tracking system (Farooqui, 2013) this method is illustrated in Fig. 7.

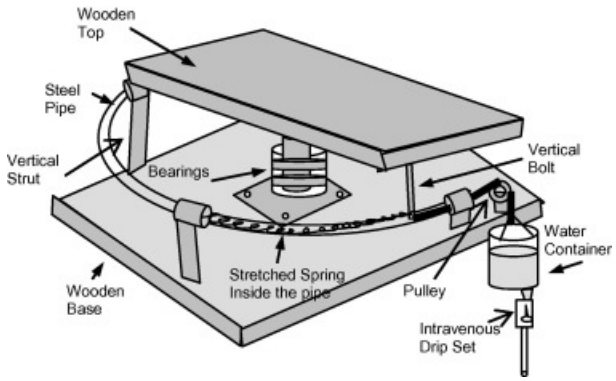

Figure 7. Sun Tracking System [8]

The solar cooker is placed on the wooden top and this system tracks up-to six hours. The spring start to stretch or contract when water start to discharge and vertical bolt move outward. Vertical movement of bolt changes the position of solar cooker. The rate of rotation of solar cooker starts slower from first three hour and faster after the session [8].

VACUUM TUBE SOLAR COOKER

Vacuum tube solar cooker is designed for an effective solar cooking. Vacuum tube solar cookers generally usesa vacuum sealed between two layers of glass. Vacuum allows the tube to act both as a supper greenhouse and an insulator. The central cooking tube is made from borosilicate glass, which has resistant to thermal shock, and has a vacuum beneath the surface to insulate the interior. The inside of the tube is lined with better conductive material such as copper, stainless steel, and aluminium nitrile to better absorb and conduct heat from the sun's rays. This type of solar cookers attains record temperature up to 371° C [9].

Figure 8. Vacuum Tube Solar Cooker

IV. CONCLUSION

This paper present the performance of the various innovative solar cookers. Implementing above any innovative technique or combine both innovative techniques help to increase the performance of solar cooker and decrease the cooking time.

REFERENCES

[1] Biermann E, Grupp M, Palmer R. Solar cooker acceptance in South Africa: results of a comparative field-test. SolEnergy 1999;66:401–7.

[2] Abhisheksaxena et al, a thermodynamic review on solar box type solar cooker; renewable and sustainable energy review 15 (2011) 3301-331

[3] History of solar cooker;http://www.solarcooker-at-cantinawest.com/solarcooking-history.html

[4] SunnilGeddam, Determination of thermal performance of a box type solar cooker; solar energy 113 (2015)324-331.

[5] S.B. Joshi, A.R. Jani, Design development and testing of a small scale hybrid solar cooker; solar energy 122 (2015) 148-155.

[6] LameckNkhonjera et al, A review of thermal energy storage designs, heat storage materials and cooking performance of solar cookers with heat storage; renewable and sustainable energy review.

[7] R. M. Muthusivagani et al, Solar cookers with and without thermal storage—A review; renewable and sustainable energy review 14 (2010) 691-701

[8] SohailZakiFarooqui, An improved power free tracking system for box type solar cookers; Solar Energy 120 (2015) 100–103

[9] Vacuum tube solar cooker; http://newatlas.com/gosun-stove-portable-solar-cooker/29072/