A Review on- Autoclaved Aerated Concrete Box Type Solar Cooker

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ABSTRACT

Plurality of cooking chambers is separated by partition wall. Partition and side wall are covered with reflective surface to minimize heat loss. Bottom wall is covered with insulating material further; it is covered by reflective surface to minimize heat loss. Glazing is directly fixed in frameless design. This cooker has side loading facility with separate access to each cooking compartment. Booster mirrors are used to increase the solar energy input to the cooker.

Keyword:- *Box type solar cooker, Autoclaved aerated concrete (AAC), heat transfer rate, heat loss coefficient,Thermal performance.*

1.INTRODUCTION

The pressure on global energy resources is high. Fossil sources have dominated the energy market for a long period of time. The current global warming, climate change and greenhouse gas effects like desertification, flooding and air pollution that the world is experiencing is due to the carbon emissions from this resource. To materialize this target to ensure human existence, the world needs to prioritize alternative renewable energy resource with immediate action. An everyday activity like cooking plays a very active role in implementing this goal. Cooking plays a very essential role in human life because the very existence of humans depends on the food we eat; which is cooked in one-way or the other. Studies have shown that approximately 3 billion people depend on wood, dung, charcoal and other biomass fuels for cooking. Most of these people cook on open fires, which burn incompletely thus leading to low fuel efficiency and high pollution emissions. Two to three million people die worldwide annually from cooking with traditional cook stoves and fuels, which mainly consist of firewood and charcoal; most of these victims are women and children. The World Health Organization suggests that indoor air pollution (IAP) resulting from burning solid fuels indoors in poorly ventilated conditions is responsible for 3.3% of the global Burden on disease (World Health Organization, 2009). The adverse health outcomes are chiefly caused by inhalation of fine soot particles with aerodynamic diameters less than or equal to 2.5µm. Diseases and conditions such as Acute Respiratory Infection, low birth weight in pregnant women, among others have become very predominant (WHO, 2009). The current patterns of energy use causes significant negative impact of several types, including human morbidity and mortality, outdoor air pollution, climate change and deforestation. The smoke from cooking causes significant health problems for people who rely on traditional biomass fuels for their cooking and heating needs, and then suffer from cancer, pneumonia, heart and lung diseases. In addition to these illnesses, large scale cooking using rudimentary cook stoves contributes to deforestation by using approximately 10,000 kg of fuel wood per annum, and diminishes local air quality through toxic smoke emissions like black carbon. Research has proved that the use of institutional Solar Cook stove can reduce the fuel wood by approximately 3000kg (100%) as well as cutting down pollution by 99.9 %. In addition to the negative social impacts that is normally produced by biomass stoves :It is also a wasteful way of cooking because it requires more time to cook and uses a lot of fuel, a task which is usually carried out by children and their mothers, thereby consuming most of their precious time. Local environmental degradation arises directly from the pollution of the ambient air and local forest ecosystems. Additionally, the harvest of fuelwood degrades local forests and in some cases, pollutes natural water bodies and damages reserved wildlife habitats, which leads to deforestation. Cooking with harvested biomass will definitely affect the climatic conditions of the area. This is because, inefficient fuel burning releases products of incomplete combustion which have higher global warming potential than carbon dioxide, such as methane and carbon

monoxide. Biomass and fossil fuel cooking-stoves also emit 22% and 7% of global black carbon (BC) emissions, respectively. These emissions are the second highest contributors to the current global warming on our planet. Unlike the naturally distributed greenhouse gases, such as carbon dioxide, the shorter 8 – 10 day atmospheric lifetime of black carbon results impacts. This causes a darkening of the atmosphere making visibility difficult. Solar cooking of food presents a better option to using charcoal and other fuels used for preparing food. The usage of solar cookers cannot entirely curtail the use of biomass for food preparation, but if correctly and appropriately applied, solar cooking can be used as one of the most efficient ways of reducing deforestation, global climate change, and poverty. A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink. Many solar cookers currently in use are relatively inexpensive, low-tech devices, although some are as powerful or as expensive as traditional stoves and advanced, large-scale solar cookers can cook for hundreds of people. Because they use no fuel and cost nothing to operate, many nonprofit organizations are promoting their use worldwide in order to help reduce fuel costs and air pollution, and to slow down the deforestation and desertification caused by gathering firewood for cooking. Solar oven, or solar cooker, uses sunlight to heat meals or drinks. Today‟s solar ovens are cheap and popular solutions to prepare meals in parts of the world where access to electricity is limited. These devices are only reliant on sunlight to work – there is no fuel required. Most solar cookers follow this basic principle: sunlight is converted to heat energy that is retained for cooking. For a third of humanity, a hot meal means cooking over an open fire. Solar cooking is done by means of the sun UV rays. A solar cooker lets the UV light rays in and then converts them to longer infrared light rays that cannot escape. Infrared radiation has the right energy to make the water, fat and protein molecules in food vibrate vigorously and heat up. It is not the sun‟s heat that cooks the food, nor is it the outside ambient temperature, though this can somewhat affect the rate or time required to cook, but rather it is the sun rays that are converted to heat energy that cook the food; and this heat energy is then retained by the pot and the food by the means of a covering or lid. This occurs in much the same way that a greenhouse retains heat or a car with its windows rolled up. An effective solar cooker will use the energy of the sun to heat a cooking vessel and efficiently retain the energy (heat) for maximum cooking effectiveness.

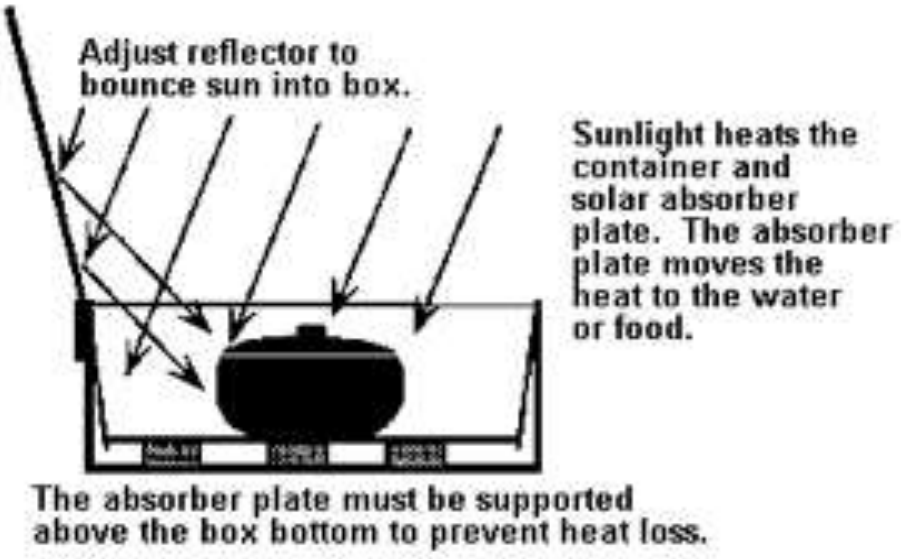


Figure 1: Schematics of a solar box cooker.

2. LITERATURE REVIEW

Nilesh Deore et al. (2019) is present that It is very difficult to calculate and analyze the thermal behavior of the side walls of different materials attached to each other. The study of composite materials thermal behavior is useful for th determination of heat transfer rate. These composite materials which can be implemented to many applications such as thermal Insulators, multiwall thermal protection systems, etc. In this study the thermal behavior of composites materials side wall of box type solar cooker is analyzed. The experimental test is carried out for finding heat loss coefficient of autoclave aerated concrete (AAC) brick box type solar cooker.[1]

Nilesh Deore et al. (2018) In many villages of our nation people are diverting towards LPG and gober gas for preparation of their food, still firewood is the basic fuel used for cooking purpose. There are several drawbacks of burning wood as fuel, such as it creates lot of smoke, clinkers, un-burnt carbon due to which carbon monoxide is liberated which is highly dangerous to living organisms this causes suffocation too. Also extensive cutting of trees, leading to deforestation increases pollution to large extent; depletion of ozone layer by increase in global warming is very harmful for environment. The main purpose of the present study is to develop low cost, eco-friendly solar cooker. Commercial solar cookers are costlier since made from high grade materials which a common man cannot afford. To overcome this problem an innovative low cost, eco-friendly autoclave aerated concrete (AAC) brick box type solar cooker with side loading arrangement is developed. It has been tested and parameters like efficiency, cooking power and figure of merits are evaluated.[2]

Baviskar et al. (2016) is presents thermal performance of an innovative box type solar cooker constructed by using Autoclaved Aerated Concrete(AAC) blocks.AAC has less thermal conductivity, high strength, low density, long lasting, and good machinability. These promising properties find its application in construction. Also its durability is proven. Review of properties of AAC invites its use in solar cooker manufacturing.AAC solar cooker was tested to cook rice, khichadi and for drying also. The maximum temperature achieved was 970C. [3]

S.Talbi et al.(2018) is presents the work presented concerns the design and the simulation of the operation and the experimentation of of the box type solar cooker with three reflectors. In order to improve the efficiency of the cooker, we integrated the heat storage of the temperature with the salt placed at the base of the cooker. The first obtained results show a thermal resistance of the cooker of the order 0.51K.W-1 , under an solar radiation of 1000 W/m2 , temperatures, powers and efficiencies respectively reach 140°C, 225.49W and 93%. Regarding the temperature storage, we showed that after one hour without solar radiation, the storage ensures the maintenance of the temperature of the order 40% of the value with illumination. The comparison between the experimental results and those simulated shows a good agreement and consequently the validation of the operation.[4]

Mulu Bayray Kahsay et al (2013) is present the Box solar cookers are commonly built with internal sheet metal painted black as an absorber. In order to increase the performance, a design which incorporates internal reflection is proposed in this paper. The aim of this paper is to report comparisons made between box solar cookers with and without internal reflector. Theoretical modeling of the two types of cookers has been made by considering the radiation, convection and conduction heat transfer employing the thermal network method. The theoretical analysis made was based on steady state heat transfer analysis of the cookers. Experimental comparisons were also made on two cookers having the same aperture area and made from the same type of materials except the internal absorber. The tests were made as per the American Society of Agricultural Engineers (ASAE) procedure. The result of the theoretical analysis predicts that the performance will be higher in the cooker with internal reflector than the same cooker without reflector. The steady state analysis shows that for the cooker with reflection the temperature of the bottom absorber plate is higher than the cooker without reflector. Similarly, results of dry test and water boiling test show better performance by the cooker with reflector. The standard stagnation temperature and the cooking power were higher in the cooker with reflector as compared to the cooker without reflector. In conclusion, the performance of box solar cookers can be enhanced by making appropriate angle side walls of the absorber and providing internal reflection. [5]

Geeteshwar Sharan Varshney, Praveen Parihar (2017) is present the Lid of cooking vessel intercepts maximum energy but it is not effectively transferred to food material because of thermal contact resistance due to uncertain contact between lid and cooking vessel. In order to utilize effectively the energy intercepted by lid in cooking food, two designs of lid have been developed. In first design, a circular ring of aluminium strip has been welded to the lid‟s inner side such that the ring is penetrating into the pot contents (water here). In second design, a frustum of cone shaped lid has been used in which the surface of lid is in direct contact with pot contents (water here). Temperature of water in the pot in which first lid is fitted, leads by 8-9 ˚C over pot with normal lid when the water temperature in this pot reaches 90 ˚C. This is a significant improvement. Temperature of water in the pot in which frustum of cone shaped lid is fitted, leads by 3-4 ˚C over pot with normal lid when the water temperature in this pot reaches 90 ˚C. [6]

Gonzalez Aviles et al (2014) in this paper we obtain a mathematical thermal model to explain the behavior of the solar cooker. The model is shown in terms of a coupled system of three non-linear differential equations. We

calculate temperatures for the fluid, the reflectors and the container of the solar cooker, and then compare the numerical results obtained with the model to measurements in field-testing operations and obtained results that agree with the experimental data. Finally, we use numerical results to calculate the cooking power and standardized cooking power of the solar cooker for two different containers. [7]

Farhana M. Saiyed et al (2015) is present Autoclaved Aerated Concrete (AAC) is an ultralight concrete masonry product. It can weigh as little as 1/5 as much as ordinary concrete due to its distinct cellular structure featuring millions of tiny pockets of trapped air. This cellular structure gives AAC a number of exceptional physical characteristics. AAC consists of basic materials that are widely available. These include sand, cement, lime, fly ash, gypsum, aluminium powder paste, water and an expansion agent. Silica sand, the raw material used in the greatest volume in AAC, is one of the world's most abundant natural resources. The finished product is up to five times the volume of the raw materials used, with an air content of 70% to 80% (depending on the required strength and density.) Due to this large increase in volume, AAC is very resource efficient. The high consumption of raw materials by the construction sector, results in chronic shortage of building materials and the associated environmental damage. In the last decade, construction industry has been conducting various researches on the utilization of easily available raw materials in construction. AAC is one of the materials which can cope up with the shortage of building raw materials and can produce a light weight, energy efficient and environmentally friendly concrete. This study deals with the introduction to the process of the autoclaved aerated concrete and its advantages compared to the normal concrete. [78

N.Narayanan, K. Ramamurthy (2000) is present Aerated concrete is relatively homogeneous when compared to normal concrete, as it does not contain coarse aggregate phase, yet shows vast variation in its properties. The properties of aerated concrete depend on its microstructure (void paste system) and composition, which are influenced by the type of binder used, methods of pore-formation and curing. Although aerated concrete was initially envisaged as a good insulation material, there has been renewed interest in its structural characteristics in view of its lighter weight, savings in material and potential for large scale utilization of wastes like pulverized fuel ash. The focus of this paper is to classify the investigations on the properties of aerated concrete in terms of physical (microstructure, density), chemical, mechanical (compressive and tensile strengths, modulus of elasticity, drying shrinkage) and functional (thermal insulation, moisture transport, durability. [9]

Dr.R.Uday Kumar et al (2015) is presents Heat is a form of energy in transmits due to temperature difference. Heat transfer is transmission of energy from one region to another region as a result of temperature difference between them. Whenever there is temperature difference in medium or within a media, heat transfer must occur. The amount of heat transferred per unit time is called heat transfer rate. The composite structures are the combination of different materials to form a single component. These components are used to study of heat transfer through it. The composite structures for heat transfer are cylindrical shells, spherical shells and plane walls. They have wide range of applications in heat transfer are cold storage walls, internal combustion engines chambers, steam pipes and, metallic multi wall thermal protection systems. Heat transfers through the systems are in radial flow and inline flow direction. The heat transfer occurs in composite structures are conduction, convection and radiation. In this paper, the methodology for evaluation and study of convective heat transfer coefficient and convective resistance of composite structure. The influence of these parameters on performance of composite system is analyzed. Heat transfer is increased with decreases in convective resistance and increases with convective heat transfer coefficient of composite structure obtained. [10]

Rajendra P. Patil et al (2015) is presents it is very difficult to calculate and analyze with precision the thermal behavior of the walls of different materials attached to each other. The study of composite materials thermal behavior is useful for the determination of heat transfer rate and heat flux. These composite materials which can be implemented to many applications such as thermal ventilations, Insulators, metallic multiwall thermal protection systems, etc. In this study we are going to analyze the thermal behavior of two composites. For finding heat flux and heat flow rate the finite element program ANSYS is used. The experimental test is carried out for heat flux and heat flow rate of composite materials. Experimental Results are compared with the finite element ANSYS results and the validation is done. [11]

Nitin Saxena et al (2014) this paper is presents to carry out the study of implementation issue of box type solar cookers in India. Cooking is a rather compulsory exercise which is bound to be performed in each of the household for at least two times a day. In order to make the cooking exercise clean, cooking fuel plays an important role. An

attempt has been made to carry out a literature survey on the developments of cooking sector in a developing country like India. It was found that the income of household is the main determining factor for the selection of fuel for cooking. This income disparity clearly made LPG and other cleaner fuels popular in urban and sub-urban areas leaving fuel wood and biomass as fuel options for rural areas. The various aspects of solar cooker are discussed including its basic mechanism, construction, financial evaluation, the assumption, validity and main reason for not opting solar cooker in India. [12]

3. DESIGN OF SOLAR COOKER BOX:

3.1 Principle

There are a variety of types of solar cookers:

over 65 major designs and hundreds of variations of them.

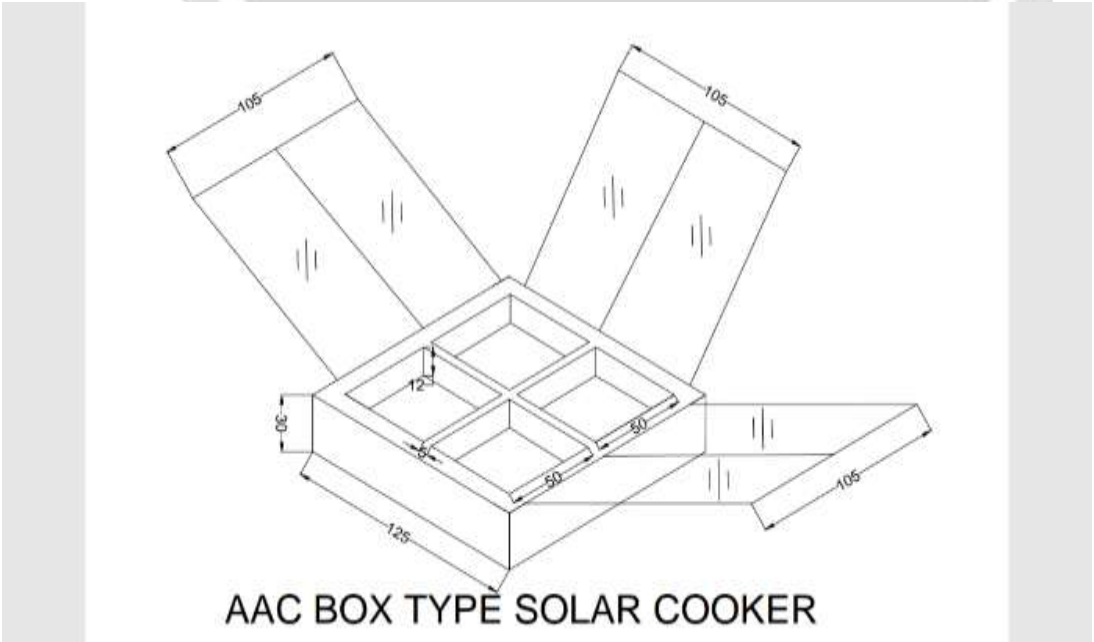
The basic principles of all solar cookers are: Concentrating sunlight:

Some device, usually a mirror or some type of reflective metal, is used to concentrate light and heat from the sun into a small cooking area, making the energy more concentrated and therefore more potent.

Converting light to heat: Any black on the inside of a solar cooker, as well as certain materials for pots, will improve the effectiveness of turning light into heat. A black pan will absorb almost all of the sun's light and turn it into heat, substantially improving the effectiveness of the cooker. Also, the better a pan conducts heat, the faster the oven will work.

Trapping heat:

Isolating the air inside the cooker from the air outside the cooker makes an important difference. Using a clear solid, like a plastic bag or a glass cover, will allow light to enter, but once the light is absorbed and converted to heat, a plastic bag or glass cover will trap the heat inside. This makes it possible to reach similar temperatures on cold and windy days as on hot days.



AAC BOX TYPE SOLAR COOKER

3.2 DESIGN METHODOLOGY

The cooker is based on the hot box principle having a single reflector. The cooker has been designed in square shape, with six reflectors (mirror of 4mm thickness) such as combining two reflectors on one side. So maximum radiation falls on the glass window. This cooker is always kept fixed, facing the equator. Cooker has 4 chambers with an AAC partition. The device (Fig. 1) consists of aerated autoclave concrete walled hot box.

The inner tray of aluminium. The space between bottom frame and base of cooker is filled with glass wool insulation. The inner tray is painted black by blackboard paint. Two clear toughen glass panes of 4 mm thickness with 10mm apart have been fixed directly in a groove made on AAC walls of cooker. Four doors have been provided in the rear side for loading and unloading the cooker. The doors have been made leak proof by rubber gaskets. The absorber area of the cooker is 1 m^2. Whole cooker is going to be constructed on a square shape frame made up of iron angles of size 35×35 ×5mm. Another square shape frame made up of angles 25×25 ×5mm will be fixed on top of cooker. Upper and lower frames are bolted through clits. Plane reflectors, doors are also supported by an angle frame. Reflectors fixed on GI Sheet which is fixed in rectangular frame. To avoid destruction of mirror due to vibration or shock it is fixed in rubber gasket. Mirror is fixed with the help of clamps.

4. PROJECT SCOPE

The box solar cooker must be of high quality, light weight, affordable, user friendly, stackable. The basic purpose of solar cooker is to heat things up - cook food, purify water, and sterilize instruments. A solar cooker cooks because the interior of the box is heated by the energy of the sun. Sunlight enters the solar cooker through the aperture glass. It turns to heat energy when absorbed by the dark absorber plate and cooking pots. This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain that is thermal equilibrium with surrounding. Autoclaved aerated concrete (AAC) blocks are light weight, environmental friendly. These blocks consist of 80% air by volume. These blocks are made using Portland cement, quartz (silica), and water and aeration agent. The mixture of these constituents is poured in mould. These blocks formed as a result of reaction of aluminium on a proportionate blend of lime, cement and fly ash, the hydrogen gas that escapes creates millions of tiny air cells giving it a strong honeycomb like structure. It is further strengthened by high pressure steam curing in autoclaves. The water-cementitious materials ratio is related to the amount of aeration obtained and thus the density. For a given density, water-cement ratio increases with proportion of sand. For AAC with pozzolans, water-solids ratio appears to be more important than the water-cementitious ratio, irrespective of the method of pore-formation. For gas concrete, a lesser water-solids ratio leads to insufficient aeration while a higher one results in rupture of the voids, increase in density being the consequence in both the cases. Thus the water requirement is to be gauged by consistency of the fresh mix rather than by a pre-determined water-cement or water-solids ratio. Thus its density can be varied. Due to high porosity; it has low density and excellent insulation. Due to these promising properties (low density, good insulation, light in weight and easy to cut) of AAC blocks, it can be used to construct box type solar cooker. AAC solar cooker is made with low grade material such as AAC blocks and binding material. Glass, aluminium sheet, black paint, angle plates, black painted aluminium utensils. AAC solar cooker has bottom loading and innovative fixation of glass.

5. CONCLUSION:

The main objective of the project is that, after studying all the papers it is found that in AAC box type solar cooker there are heat losses from side wall as well as from bottom surfaces,due to which it affect the effiencicy of solar cooker , for recovering this losses new designing of Solar cooker with heat storage have plurality of pockets in side wall and tubing in bottom wall. Plurality of pockets and tubing uses part of heat lost through side and bottom of the cooker to heat the fluid stored in it, to be used for cooking and other purposes as and when required through proper arrangement of cock and tap.

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