Improvement of the Livelihoods of Rural Populations of Sub-Saharan Africa through Post-harvest and Cook Technologies Powered by Renewable Resources (SDG7)

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Abstract

In this research project, the thermal performance of a low-cost solar box cooker/dryer incorporating booster concentrators with optimum dimensions has been investigated. To achieve this, a double V-trough solar concentrator was designed to concentrate the incident solar irradiance onto the absorber window of the solar box cooker/dryer tray. The introduction of the solar concentrator increased the direct insolation by a factor of 2.1. In order to extend the drying/cooking time further beyond dusk, the effect of the energy storage material (basaltic rocks) was also studied. The solar cooker incorporating the rocks was found to have slightly reduced performance, as shown by the reduction in the first figure of merit F1 from 0.07 Km^{2}W^{-1} to 0.06 Km^{2}W^{-1}, an effect also predicted by (Verma et al., 2022). Experiments conducted on three system configurations (system with no basaltic rocks; system with 1 Kg of 5.6 mm pellets of basaltic rocks; system with 1 kg of 13 mm pellets of basaltic rocks) revealed that the reduction of performance (F1), due to the use of pellets of basaltic rocks, is independent of pellet size. The project is motivated by the need for low-cost, dual-function, non-intermittent cooker/dryers for use in Sub-Saharan Africa.

Keywords: Solar drying, Solar Cooker, Solar Concentrator, Double V-trough Solar Concentrator, Energy storage Materials

Introduction

Brief Review of Solar Thermal Systems and Operation

Solar Cooking

Most solar cookers currently in use are relatively cheap to operate since no fuel is required. The uptake of these cookers has a major role to play in the fight against rising fuel prices, air pollution as well as slowing down the deforestation and desertification caused by the gathering of firewood for cooking (Abd-Elhady et al., 2020). The solar cooker was first demonstrated by a Swiss Scientist in 1767 (Garg et al., 1998) and continues to attract the interest of Engineers and Scientists the world over. Despite this early discovery and the availability of low cost solar cooker versions, the uptake of solar cooker as a household cooking stove remains low (Otte, 2014, Panwar et al., 2012). Efforts are continuously being made to make solar cookers more user friendly, attractive and practicable for developing and developed countries (Nkhonjera et al., 2017). In many countries with abundant annual solar radiation, the uptake of solar cookers has been observed to increase (Mendoza et al., 2019). A comparison of solar cookers with other conventional cooking methods reported that, the solar box cookers are the most used among the different types of solar cookers.

Energy requirements for cooking food remains one of the primary factors affecting the total energy consumption and consequently greenhouse gas emission the world over. Solar cooking offers an appropriate and practical solution as an inexpensive, green and renewable energy technology. The solar cooking technology can be divided into three main categories based on the different solar cooker structures: (i) box types, (ii) concentrating types, and (iii) panel types. These three different designs are also classified according to their direct or indirect heat transfer modes and the use of optional equipment for latent heat and sensible heat type thermal storage units. The continuous rise in the level of greenhouse gas emissions and the increase in fuel prices remain the main driving forces behind efforts to seek alternative and to more effectively utilize sources of renewable energy. Apart from cooking, solar cookers could be utilized for warming food, drinks as well as to pasteurize water or milk (Panchal et al., 2018, Rossi et al., 2019). In this regard, solar cookers have been observed to significantly improve energy security as well as reduce the reliance of energy consumption on the traditional fossil fuel based options, which have serious adverse effects on the environment via the greenhouse gases they emit (Wentzel et al., 2007, Al-Soud et al., 2010). In order to effectively collect the solar energy required for the cooking process, a number of different types of solar collectors have been designed, developed and studied.

Solar cookers vary in design type and each of these designs are continually being improved over time. Some of these solar cooker types include: the solar panel cooker, solar parabolic cooker and the solar box cookers.

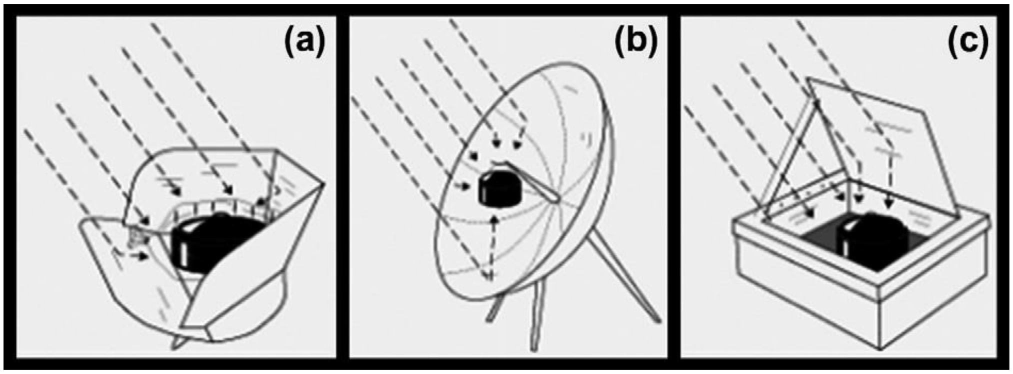

Figure 1: Types of solar cookers: (a) solar panel cooker; (b) solar parabolic cooker; and (c) solar box cooker(Cuce et al., 2013).

The solar panel cookers have a simple and inexpensive construction. They can be easily folded over and stored or transported in back packs. As a result of this, they are very common among communities. These type of cookers, however, suffer from low cooking power due to the fact that they concentrate sunlight from above only. However, their easy portability and convenience makes them desirable to people who are continuously on the move. The cooking vessel in the case of a panel cooker is enclosed in a cooking bag (a transparent plastic bag).

The parabolic solar cookers have been very attractive due to their exceptional performances. Solar parabolic cookers have the capability of attaining extremely high temperatures in a very short time interval, and unlike the panel cookers and box solar cookers, they do not need a special cooking vessel. As a result of strong heating capability of parabolic cookers, the cooker can burn food if left unattended for some time because of the concentrated power delivery. A solar parabolic cooker consists of a parabolic reflector with a cooking pot which is located at the focus of the parabolic dish and a stand to support the cooking system. Parabolic solar cookers have concentration ratios as high as 50 and so can achieve high temperatures of up to 400 °C, much higher than temperatures observed in solar box cookers (Fatiha Yettou et al., 2018). The main drawbacks of the parabolic solar cooker are the dependence on solar tracking, a constant attention to prevent the burning of foods and fire out breaks during operation (Al-Soud et al., 2010).This cooker is often used in conjunction with heat storage materials to improve energy availability (Senthil, 2021). It has been through the use of automatic solar trackers in parabolic cookers that water temperatures of 90 ^{0}C could be attained easily (Al-Soud et al., 2010).

The solar box cooker is the most attractive to households in terms of cost and simplicity. A simple construction of a box type solar cooker is shown in

Figure 4 below.It is worth noting that each of the components of the box cooker has a significant influence on cooking power and performance. These components remain a subject of research to many researchers. The optimization of these parameters has been the main pathway for the improvement of the system performance. Box type solar cookers have been reported to show slow heat up to maximum temperature, but work well even in low irradiation, intermittent cloud cover, low ambient temperature and in windy conditions (Telkes, 1959). Recently, researchers have focused their attention more especially on the optimization of geometric parameters of solar box cookers since these have been found to have a dominant effect on its performance. In line with this approach, many researchers have been analyzing the effects of booster mirrors on the performance of the box-type solar cookers. Booster mirrors have been reported to have a strong influence on the efficiency of solar collectors via the provision of extra solar radiation (Dang, 1986). It was later found that the performance enhancement using booster mirrors was found to dependent strongly on the choice of the angle of the mirrors (Garg et al., 1988).

Many other researchers have focused on the glazing factor in solar box cookers as a means of performance enhancement (Mirdha et al., 2008, Eckert et al., 1996, Deubener et al., 2009, Akhtar et al., 1999). Common glazing material used in the construction of box-type solar cookers include glass, fibreglass, and acrylics. Single glazed glass and double glazed glass are the most common structures which have been demonstrated to have high transmission. Optimization of the gap between glass panes is also another significant problem since a large air gap may encourage convective heat transfer and result in higher heat loss. Air gaps in the range of 1 – 2 cm have been recommended (Saxena et al., 2011, Eckert et al., 1996, Deubener et al., 2009). The absorber plate inside the cooker emits long wavelength radiation towards the glazing glass, absorption of this radiation by the glass results in the increase in temperature, hence heat loss from the cooker to the surrounding atmosphere is possible. As a remedy to the energy loss via the glazing glass, Kalogirou proposed the use of transparent insulators for the glazing material (Kalogirou, 2004, Kalogirou, 2003).

The absorber plate at the bottom of the box-type cooker has also been found to have a significant effect on the performance of the solar box cooker. The solar radiation that enters the cooker through the glazing window is absorbed by the absorber plate which is usually painted black to improve its efficiency. An absorber plate is usually characterized by its absorptivity. The higher the absorptivity, the higher the heat energy it will be able to transfer to the food in the cooking vessel (Garg Hp et al., 2004). It has also been demonstrated that fin-like absorber plates (

Figure 2) exhibit better performance by upto 7 % (Harmim et al., 2010).

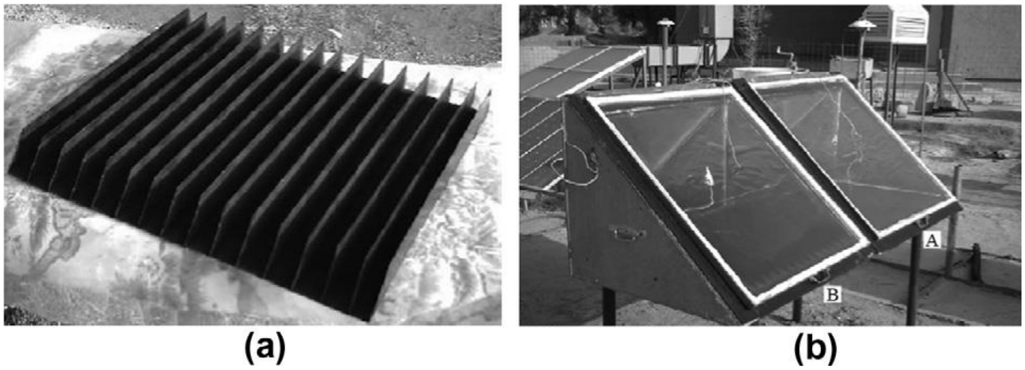

Figure 2: (a) Schematic of the finned absorber plate; (b) conventional (A) and improved (B) solar box cooker (Harmim et al., 2010).

Solar Drying

One of the most common post-harvest preservation techniques is by drying. Drying of food and fruits during peak seasons has the potential of improving food security throughout the year. Solar drying can be achieved by drying the food products in direct sunlight. This technique is cheap to implement, however, apart from exhibiting a slow rate of drying, it also exposes the food crops to contamination. This results in the need for controlled drying systems for different agricultural products. Most conventional dryers are operated by coal, oil or firewood. Due to the emissions of greenhouse gases by these fuels there is need for alternative controlled drying systems such as solar dryers.

Solar dryers could be classified into two main categories: direct and indirect solar dryers. The direct solar dryer involves directly exposing the material to be dried to the sun. While in the indirect dryer, the material is dried by circulating hot air over it without direct exposure to sunlight. The air circulation is achieved by use of an external fan or natural convection, resulting in active and passive solar dryers respectively (Figure 3).

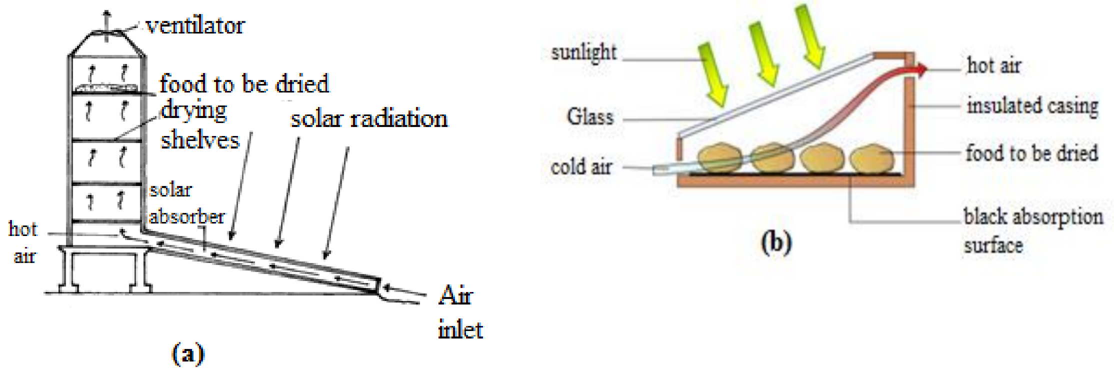

Figure 3: (a) A passive indirect solar dryer, (b) passive direct dryer(Gupta et al., 1982).

From 3 above, the solar dryers generally come in the form of a hot box, in which fruit, vegetables or other food materials can be dried. It is often made of a rectangular box made from cheap and readily available materials such as plywood, bricks, concretes and aluminium sheets - insulated at the base and sides and covered with a single and double layered transparent glazing material. Solar radiation is transmitted through the glazing surface and absorbed on the blackened interior surfaces of the dryer. Due to the insulation, the internal temperature is much higher than the external temperature. In order to facilitate convection within the dryer, holes are drilled through the base of the dryer to permit fresh air to circulate into the dryer cabinet. Outlet holes are also drilled at the upper parts of the dryer, sides and rear panels and this helps to remove the moisture from the drying chamber. When the temperature inside the dryer increases, hot moist air passes out of the upper apertures by natural convection creating a partial vacuum and creating a drag on the fresh air at the bottom, upwards through the base. This results in a constant flow of air over the drying material, which is placed on perforated trays, on the floor of the dryer, as shown in figure 4.

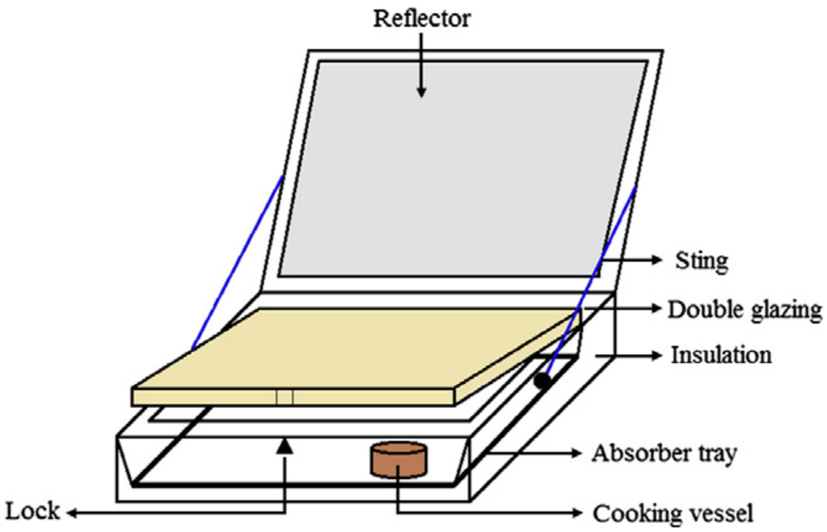

Figure 4: Components of a typical solar box type cooker (Saxena et al., 2011)

Thermal Energy Storage Materials

Due to the intermittent nature of solar energy, thermal energy heat storage materials form an important part of the construction of solar cookers/dryer systems (Nkhonjera et al., 2017, Buddhi et al., 2003, Anilkumar et al., 2022). In particular, solar cookers without heat storage materials have a major drawback that food can only be cooked during sunshine hours. This means that food which is near completely cooked cannot be cooked to completion once night falls or when there is a sudden change in weather condition such as rain and cloud cover. Thus, the large scale utilization of this form of energy is not possible unless there is effective implementation of an efficient storage technology that can be developed with minimal capital and running costs. The incorporation of phase change materials (PCMs) in solar box cookers as thermal energy storage (TES) media has been found to show significant improvement in the performance of the cooker mainly due to their high energy storage density capability (Mullick et al., 1987, Sharma et al., 2000). However, sensible heat storage materials have been found to be readily available and at minimal cost. Such materials may exist in either liquid or solid form and include materials such as sand, locally available rocks (basalts, granite, bricks, clay, pebbles, concretes, wood and limestone) and water (liquid form). (Muthusivagami et al., 2010), Nkhonjera et al., 2017) have demonstrated that there was no significant difference in cooking power between cookers made with sensible heat storage materials and PCMs. The effectiveness of these storage materials is strongly dependent on their specific heat capacities and densities. Table 1 below shows the thermal properties of some of the aforementioned sensible thermal storage materials. In addition to these, properties, these materials have long term chemical stability and non-toxic.PCM. They are vulnerable to degradation by loss of water or hydration, chemical decomposition or incompatibility with materials of the cooker construction while some can be potentially flammable and explosive in nature, posing a serious safety challenge.

Table 1: Thermal Properties of some Common Heat Storage Materials

Medium	Density ρ (kgm^{-3})	Specific heat capacity ($Jkg^{-1}K^{-1}$)
Basalts	3000	840
Granite	2750	890
Sand	2200	712
Bricks	1698	840
Pebbles	2700	880
Concretes	2200	750
Wood	700	2390
Limestone	2500	900
Water	1000	4190
Clay	1458	879

Health and Economic Benefits of Solar Cookers/Dryers

Apart from the enormous environmental benefits that solar energy cookers offer, they also offer economic, health and productivity benefits to the end users (Achudume, 2009, Heltberg, 2004, Pattanayak et al., 2009, Nandwani, 1996). Households using solar cookers/dryers are expected to make savings on cooking fuel as well as reduce their dependency on wood. It has been estimated that up to 36% savings can be made (Farhar, 1998). It is believed that solar cookers will increase fuel security amongst underprivileged households (Wentzel and Pouris, 2007). Despite these benefits, the penetration of solar cookers as an alternative cooking method depends strongly on the cost of the system. Thus, the vulgarisation of solar cookers in any community depends strongly on the cost of the solar cooker system compared to the available alternative solid fuels (Otte, 2013).

As an alternative to cooking with biomass, a common fuel in developing countries, a solar cooker/dryer presents itself as a healthy alternative (Matinga, 2010, Schlag et al., 2008). Health hazards related to biomass such as firewood include the production of smoke and trekking over long distances to gather firewood. Furthermore, solar cooker/dryers improve energy security, leading to improvement in overall welfare (De Lange et al., 2002, Clancy, 2002, Bates et al., 2005). Exposure to smoke pollutants has the potential to cause serious respiratory damage and cancer. Transporting firewood by head, a common practice in developing countries can lead to physical injuries and (Sovacool, 2012, Wentzel and Pouris, 2007).

Purpose

Solar cookers can serve three important purposes: reduction in domestic cooking costs by decreasing the need for purchase or collection of fuel especially done by women; reduction in postharvest losses hence aiding in value addition and food processing activities such as drying, blanching, pasteurization, boiling, stewing, frying and conservation of fuels for other uses, such as fertilizer in the case of dung, forest protection and erosion control in the saving of wood and charcoal. A major challenge to delivering on solar based stoves and technologies is using locally available materials and capacity building programmes to fabricate and implement these technologies and innovations at grass root level while assuring quality, cross-learning, resource sharing and rationalized use. While efficient harnessing of solar energy can mitigate many of SSA's energy problems, this paper focuses on exploitation of solar energy for cooking using solar cookers.

The Sustainable Development Goals (SDGs) are designed to improve on the welfare of the world's population. The majority of the population of Sub-Sahara Africa (SSA) resides in the rural areas. To these people, food security and sufficiency are the most impactful factors in their wellbeing. The form of energy used by this rural population for cooking and post-harvest preservation is predominantly firewood and charcoal. Their continuous use of firewood leads to the creation of greenhouse gases (GHGs), deforestation, health related issues as a result of smoke inhalation and the loss of quality free time by especially women and children who have to trek long distances to fetch firewood. The sustainable development of Sub-Saharan Africa is greatly undermined by the needs of the rural inhabitants. A large proportion of harvested crops perish because of the absence of basic post-harvest technologies for their preservation. Amongst the renewable energy alternatives, the application of solar-thermal energy to domestic cooking and post-harvest crop preservation appears to be the most promising alternative to firewood use. Therefore in this work, we propose a concrete realization of an aspect of Sustainable Development Goal Number 7 (SDG7),to provide affordable and clean energy, by the application of solar-thermal energy to cooking and post-harvest crop preservation.

Thus, a pre-condition for food security in Africa is the development and deployment of effective and affordable cooking and post-harvest technologies for rural communities. The deployment of such technologies, on a continental scale, will break the perennial cycle of relative abundance and waste in one season and acute scarcity and hunger in another season as well as provide a clean alternative to the traditional use of firewood for cooking and post-harvest preservation (Toonen, 2009). Such innovation will also directly or indirectly impact the attainment of three other Sustainable Development Goals: SDG3, to ensure healthy lives; SDG8, to promote sustained, inclusive and economic growth; SDG15, to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt biodiversity loss. The potential to impact SDG15 results from a reduction of the pressure on forest exploitation for firewood used in cooking and drying of a variety of crops.

In this paper, an affordable and effective solar cooker/dryer for post-harvest preservation is proposed. A review of different solar cooker designs finds the solar box type(Muthusivagami et al., 2010, Geddam et al., 2015, Harmim et al., 2012) to be the most promising design in terms of cost, usability, safety and the ready availability of local materials for construction. However, long cooking times and solar intermittency have traditionally hindered the uptake of solar cooking technologies. We approach this by maximizing the absorption area exposed to the sun via the incorporation of a simple solar concentrator while ensuring an optimum, user-friendly design. This design will be adapted to generate heat required for drying: a common post-harvest preservation method. The combined effect of the solar concentrator and energy storage materials in the design has the potential of improving cooking and crop drying times as well as extending heat availability after dusk (Verma et al., 2022).

Design and Methodology

Truncated Double V-trough Solar Concentrator

The truncated double V-trough solar concentrator (see 5a) has been reported as the optimum design in terms of cost when compared to the truncated pyramidal design (Al-Najideen et al., 2019). In addition, both the truncated pyramid and V-trough solar concentrator designs are expected to be less dependent on solar tracking(Kumar et al., 2008). The inclusion of solar concentrators is aimed at boosting the energy collection without increasing the absorption window which could increase energy loss from the cooker. This is expected to achieve higher temperatures, an important requirement for cooking and drying.

Figure 5: (a) Double V-trough solar concentrator (b) the truncated pyramid box solar cooker (Verma et al., 2022)

Truncated Pyramid-type Solar Cooker

The truncated pyramid design for the solar cooker is used. This ensures that an optimum heating volume is used for the cooking process. The cooker used was constructed using 9 mm thick plywood with dimensions as shown in 6. The inner walls of the cooker were lined with 1 cm thick Styrofoam as a thermal insulator and inner surface finally dressed with highly reflective aluminium foil while the absorber plate at the bottom was made of a 1 mm cast iron (specific heat capacity of 550 Jkg^{-1}k^{-1}), painted black. The absorber window was double glazed 5 mm glass. This ensures that a higher temperature is achieved at the bottom and that heat loss is minimal.

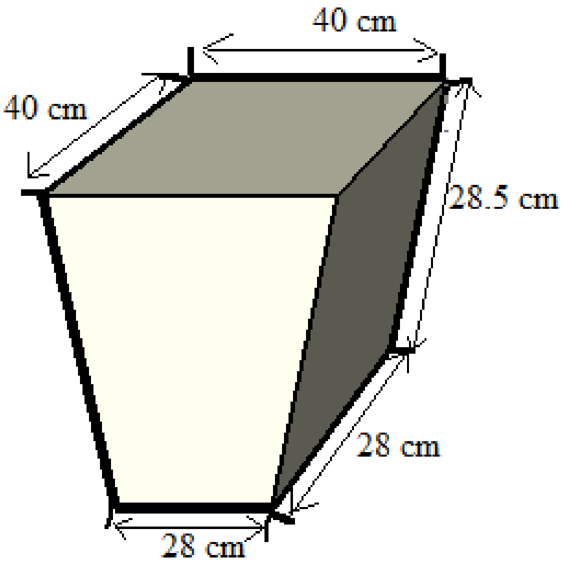

Figure 6: Truncated pyramid-type solar cooker.

Energy Storage Materials

The use of solar energy for cooking/drying food is a well-known and attractive, clean method. Open solar drying for instance has a number of drawbacks most of which can be overcome by the solar box dryer. Introduction of thermal energy storage materials into these dryers/cookers has the potential of extending the cooking/drying period beyond dusk as well as improving the performance of these systems. Some of the common, natural and inexpensive thermal energy storage materials readily available to the rural communities include basaltic rocks and sand. The performance analysis of solar dryers/cookers with and without basaltic rocks as energy storage materials is investigated experimentally.

Experimental

The double-sided solar concentrator was used in this study. Four booster mirror reflectors used were each of dimensions 40 cm by 60 cm, thus the total area was 0.96 m^2. The reflectors were setup in a double V-trough configuration as shown in 5, with a grazing angle of 25^0. This design has been found to produce optimum concentration of solar irradiance at minimal cost of reflectors (Al-Najideen et al., 2019). The absorption area of the solar-box cooker was designed to match the output area of the double V-trough solar concentrator (40 by 40 cm). The cooker was designed to take the shape of a truncated pyramid as shown in 6. This design has been found to produce a minimized cooker volume that would reduce energy wastage within. Combining the advantages of a double V-trough solar concentrator with those of the truncated pyramid-type cooker produces a single design with enhanced performance. Owing to the geometry of the solar cooker design, rays from the concentrator hitting the inner sidewalls (made of highly reflective aluminium foil) of the truncated pyramid cooker are reflected downward, so as to create a zone of high temperature at the bottom, resulting in improved convection during the cooking process (Kumar, 2004).

System Characterization

Stagnation Test (First Figure of Merit F1)

A number of no load tests were carried out on the solar box cooker to determine its stagnation parameters and the increase in temperature inside the cooker. The test was carried out for the different temperatures: stagnation temperature, ambient temperature ($T_{amb.}$) and absorber plate temperature (T_{plate}) were measured daily between 11:00 and 15:00 during the operation of the cooker in time intervals of 30 minutes. One of the figures of merit often used to characterize solar box cookers is the first figure of merit (F1) for the stagnation (see equation (1)) (Mullick et al., 1987). F1 is a parameter that is unique for every cooker and provides a means to measure the cooker performance.

$$F_1 = \frac{\eta_o}{U_L} = \frac{T_P - T_a}{I_s} \quad \text{……………………………………………………………………………} (1)$$

Concentration Ratio

The solar cooker depends principally on sunlight for its operation. Hence the need to collect the sun's rays over a large area and concentrate them to a small but optimum surface of the cooker grazing area. The maximum collection occurs when the collection surface is perpendicular to the sun's rays. For countries near/at the equator, this condition is achieved at midday with maximum solar intensity. Solar concentrators are characterised by the geometric concentration ratio (CR). The CR is often defined as in equation 2.

$$CR = \frac{A_t}{A_{as}} \qquad \text{………………………………………………………………………………………} \quad (2)$$

where A_t is the total perpendicular collector area and A_{as} is the area of the absorber surface.

Estimation of Optimum Solar Reflector Dimensions

The base of the double V-trough truncated solar concentrators was designed to be 40 cm by 40 cm to match the absorption surface of the solar-box cooker used. However, in order to minimize the cost of the reflectors, the length (L) of each of the four reflectors used was optimized for normal incidence that gives rise to minimal ray rejection. Using the design diagram shown in 7 (the angles *i* and *r* represent the incident and reflected angles respectively), the relationship between the grazing angle (α), the absorber width (b) and L is given by equation 3.

$$b = L(\cos(\alpha)\tan(2\alpha) - \sin(\alpha)) \qquad \text{…………………………………………………………………} \quad (3)$$

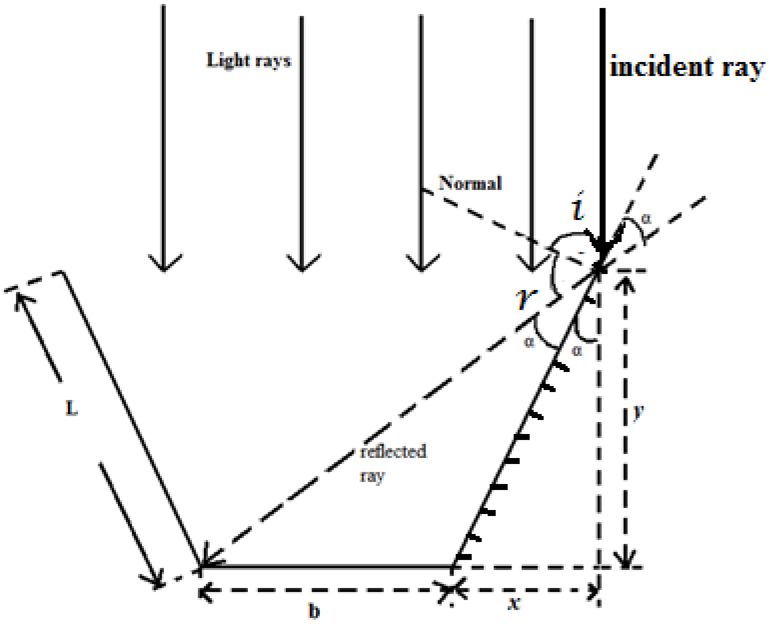

Figure 7: Design structure of the optimal truncated V-trough solar concentrator

Results

The results of stagnation temperature test (8) for the designed solar box cooker without energy storage material shows a maximum no load achievable temperature of about 93 ^{0}C. This cooker maintains a high temperature (above 80 ^{0}C) for duration of 2 hours between 11:30 and 13:30. Using equation (1), F1 is calculated to be about 0.07 Km^{2}W^{-1}.

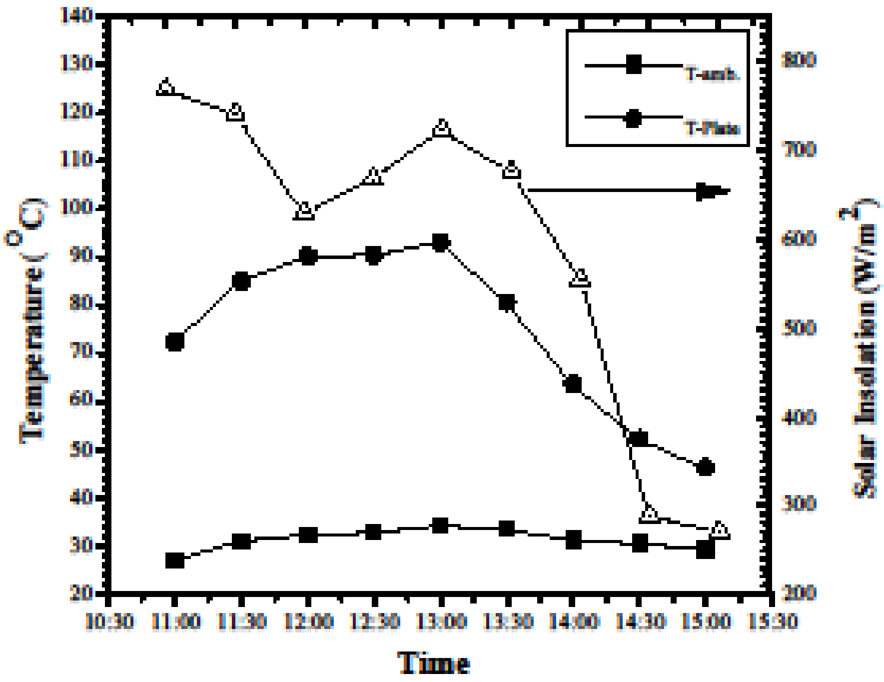

Figure 8: Stagnation temperature test of solar cooker without energy storage material for first figure of merit (F1), measured on the 13th of March 2022.

Figure 9 shows the plot of concentration ratio of the solar concentrators. A maximum ratio of 2.1 is obtained in a typical experiment. This is less than the geometric concentration ratio of 3.5 for this system as calculated using equation (2). From Table 2, it can be seen that the optical efficiency of the concentrators estimated by dividing the intensity ratios by the geometric concentration ratio varies between 30 and 60 %. The optical efficiency peaks at 12:00 as the system design was optimized for maximum concentration at normal incidence (see equation (3). This condition would be satisfied at around 12:00 for Buea, location of experiment (Latitude 4° 9' 33.4872'' N and Longitude 9° 14' 36.7296'' E).

Table 2 Typical Data Obtained from the Operation of the Solar Concentrator

Time	T_{amb}**(0C)**	T_{plate} **(0C)**	**Is (W/m2)**	**Is-C/Is**	**Optical efficiency (%)**
11:00	27.1	72.4	767	1.17	33.26
11:30	31.1	85	740	1.69	47.75
12:00	32.4	90.1	628	2.11	59.59
12:30	32.8	90.4	667	1.72	48.53
13:00	34.2	93.2	722	1.91	54.03
13:30	33.4	80.6	675	1.46	41.32
14:00	31.3	63.6	554	1.07	30.26

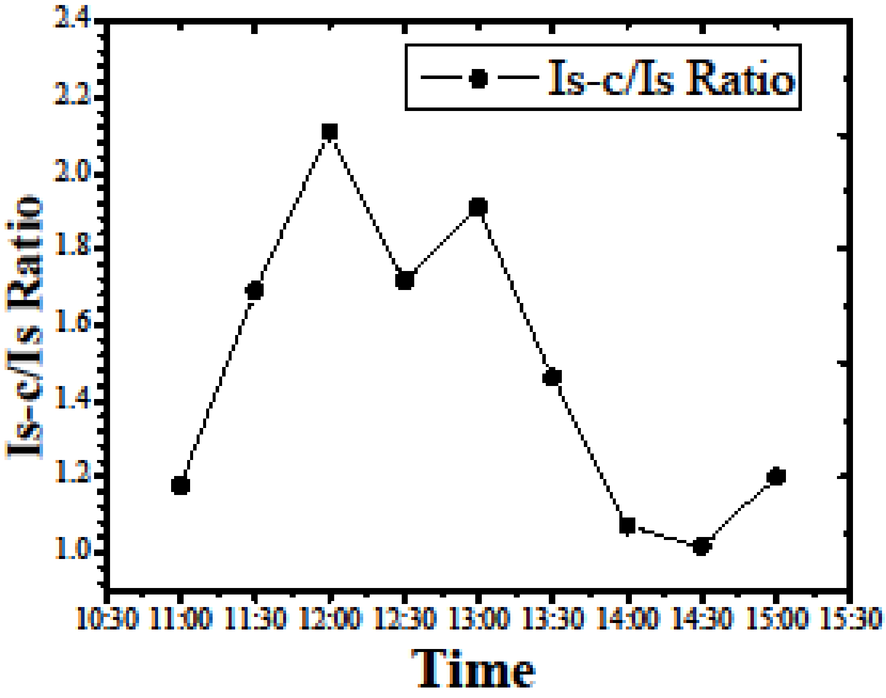

Figure 9: The plot of the ratio of the solar insolation obtained from the concentrators (Is_c) to the insolation (I_s)

Figures 10 and 11 show the graphs for the stagnation temperature tests with solar-box cooker containing 1 kg of basaltic rocks pellets with average diameters of 13 mm and 5.6 mm respectively. An estimation of the figure of merit F1 gives the same value of 0.06 in both cases. This suggests that cooker performance was likely to be independent of the pellets size. The incorporation of the storage material into the solar cooker however resulted in a reduction in F1 by about 14%. Similar observation has been made by (Verma et al., 2022). In all cases, effective cooking could be possible between 11:30 and 13:30 when the temperature within the cooker remains fairly high.

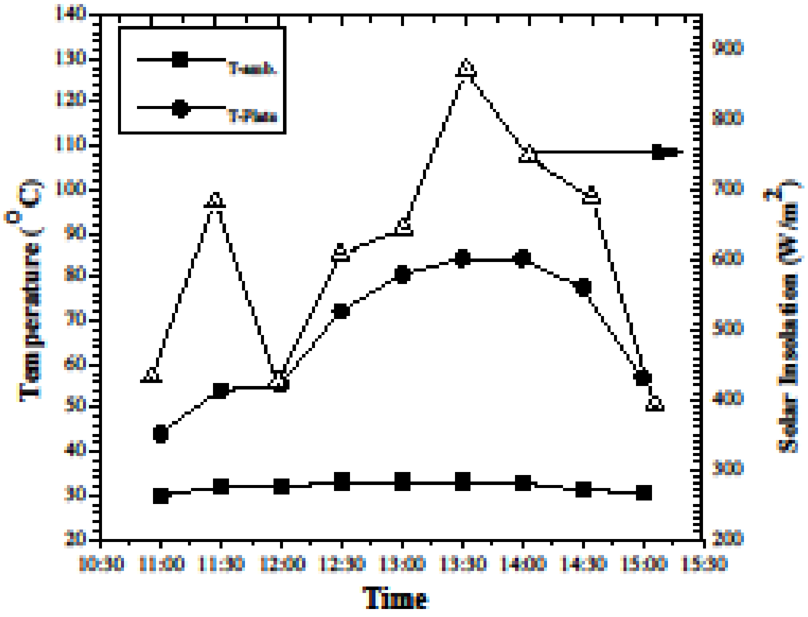

Figure 10: Stagnation temperature test of solar cooker with 13 mm diameter basaltic pellets of energy storage material for first figure of merit (F1), measured on the 15th of March 2022.

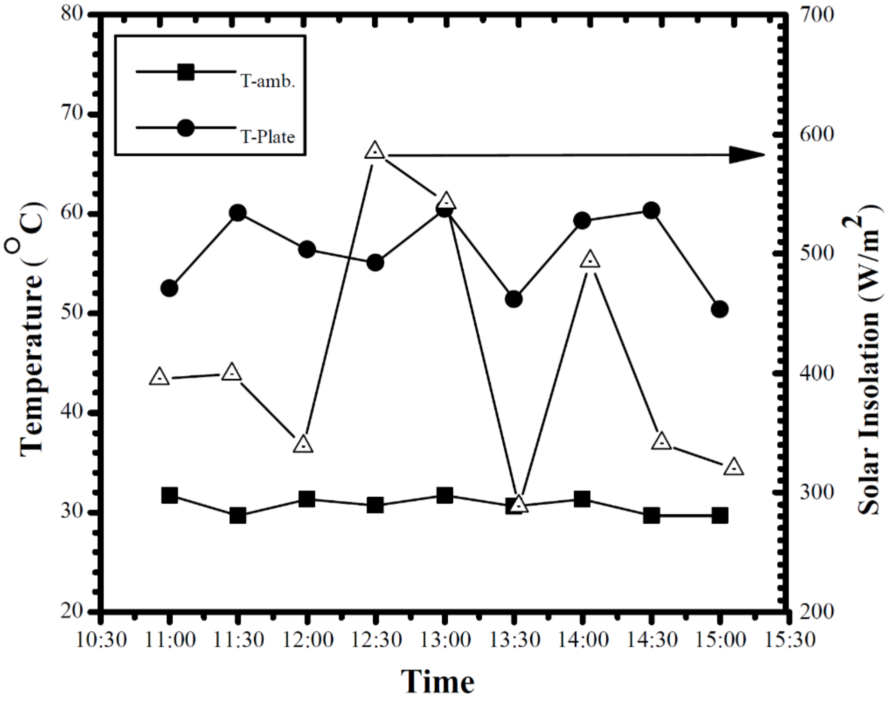

Figure 11: Stagnation temperature test of solar cooker with 5.6 mm diameter basaltic pellets of energy storage material for first figure of merit (F1), measured on the 16th of March 2022.

The perspectives for further work include:

- Production of one hundred prototypes for partner NGOs to use in sensitizing rural communities in the South-West Region of Cameroon
- Partnership with a Cameroon-based company for mass production

Conclusions

The solar-box cooker design proposed in this work has the potential to reduce cooking time due to the incorporation of the concentrator. The prototype is designed for low cost so that it can be affordable in SSA. It attains its maximum output when the solar intensity is maximum, a common characteristics shared by most Sub-Saharan African countries. This ensures that maximum thermal energy is extracted during periods of maximum intensity. The double V-trough solar concentrator design used has been found to show minimal dependence on tracking. A drawback with this design is that the solar concentrators are optimized for maximum concentration at noon and contribute minimally at other times. The experimental results obtained from the thermal performance tests F1 show that the performance of the solar-box cooker is not affected by the size of pellets of storage materials. In addition, the work provides an experimental support to the observations made by (Verma et al., 2022) via simulations.

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