IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

DESIGN AND FABRICATION OF PERFORMANCE OF BOX TYPE SOLAR COOKER COMBINED WITH WATER -A RESEARCH

[1]Kavita Rajeshwar Rawale,[2]Tushar Koli

[1]Research Scholar& Lecturer,[2]Associate Professor
[1]Mechanical Engineering Department,
[1]Government Polytechnic, Jalgaon,India

Abstract: Utilizing solar cookers can help you prepare your food more sustainably and save money on fuel. Solar energy is intermittent and only available throughout the day. Therefore, thermal energy storage is crucial for indoor solar cooking needs and will guarantee continuous use. The entire system is intended to hypothetically cook 1 kg of rice in 45 minutes while only consuming 421 W of electricity, which is derived from the sun's stored energy. As seen by the experimental findings, the energy transfer to the water was somewhat slowed as a result of the numerous losses, and its temperature rose to 355 K. Even though it has little energy, putting it at a place where it can minimize TES energy can surrounding by placing it in the insulated tank during discharging. However, because the model did not take into account the fundamental losses and variations in solar radiation, there is a difference between the experiment and the analytical estimate. After being removed from the solar collector, the TES is put on the insulated tank and filled with water before the discharge process begins. As a result, the water's maximum temperature after 40 minutes is 355 K. Since non-renewable energy is becoming less and less prevalent, we must employ renewable energy sources like solar, wind, and other types of energy. Nothing is more affordable than being free. However, solar energy can be found in large quantities and for no charge in nature. so that we have the choice of using solar energy in place of non-renewable sources. The most significant energy-consuming activity at home is cooking. LPG and other energy sources are also utilised as fuel, but they are used less frequently than firewood in India. In India's urban areas, less firewood is used than in the country's rural areas. So, it is possible to think about using solar energy to replace conventional cooking methods. One of the best devices for cooking with solar energy is the solar cooker. Solar cooking is a type of outdoor cooking that is frequently employed in situations when minimizing fuel usage is vital, there is a significant risk of accidental fire, and an alternative would have serious negative health and environmental effects. A greater understanding of solar cookers, such as parabolic cookers, box-style solar cookers, panel-style solar cookers, and solar ovens, is provided by this review paper. The advantages of small optimization, good heat storage capacity, and efficient performance have elevated the box type solar cooker above its rivals. This study created and assessed the effectiveness of box type solar cooker.

I. INTRODUCTION

Engineering has historically made it possible for numerous devices and systems to make life easier and better for people on a daily basis. While keeping an effective cost of manufacturing for those systems and tools, engineers must ensure that the quality of those systems is maintained. The oven is one of the greatest engineering achievements. Humanity benefits from a variety of services provided by ovens. Ovens can be used to cook food at a lower temperature based on the temperature they can produce. A cornerstone of engineering principles is keeping costs low while maintaining good system quality. The application of natural and renewable resources has been made clear thanks to this approach. A solar cooker is one example of how renewable resources are used in ovens. A solar cooker, also called a solar oven, is a form of oven that amplifies heat from the sun and uses it to create an effective cooker that may be utilized to meet human needs.

Solar cookers have many different goals, but a few of the primary ones are as follows:

1. To offer a practical cooking substitute for those without access to gas or electricity.
2. Defending the environment from the logging of forests for fuel that causes deforestation.
3. Lessen the risk of house fires.
4. To improve human health by reducing exposure to smoke.
5. Cooking should take less time because food can be set down and forgotten while other tasks are being completed.
6. To promote renewable resources as a reliable and effective source of heat.

Energy is a capacity for action. Energy can be changed into other forms or transmitted to other objects, but it cannot be created or destroyed, according to the rule of conservation of energy. Renewable and non-renewable energy are the two basic categories. Solar, wind, and other renewable energy sources are available, while non-renewable energy sources include wood, coal, and petroleum. Use of non-renewable energy sources is constrained. The main source of energy used worldwide is wood. It has noticed that it is the most straightforward technique to get the energy. due to the fact that wood is used to produce energy. Deforestation and pollution are problems that exist. The majority of the primary energy consumed is utilised. Over 77% of rural households in India are thought to rely on fire wood and chip for cooking, according to a government poll. While just 9% used LPG, more than 7% used dung cake. LPG was the predominant energy source used in metropolitan areas to the tune of 62%. Energy production is required in order to meet our demands in the future. The best option for producing clean energy that is accessible in nature for free is solar energy. 3.84 million EJ or so of solar energy reach Earth annually. Solar energy can be used for a variety of purposes, including thermal ones like cooking, solar heaters, solar dryers, and the generation of electricity. However, given that the sun is visible in India for close to 8 to 11 hours every day throughout the year, our objective is to learn more about solar cooking. Consequently, solar energy ought to be a substitute source of energy for cooking. Solar energy is easy, secure, and practical without using fuel or harming the environment. Additionally, solar cookers can be used to safely heat milk and water for drinking. Rather than relying on non-renewable energy sources, these solar cookers harness the energy that is available straight from the sun (charcoal, wood, fossil fuels). There are many different types of solar cookers that direct the sunshine onto the cooking pot. Therefore, their use is restricted to bright days in warm climates, and evening cooking is also not an option. A heat storage device is required to solve this issue and advance the development of solar cookers. Then, in theory, cooking might be done at night or on a foggy day. When it comes to intermittent energy sources like solar energy, thermal energy storage (TES) devices can help to reduce the imbalance between energy supply and demand. Sensible heat TES (SHTES) and latent heat TES are the two leading competitors for uses of TES on a domestic scale (LHTES). For small storage quantities, SHTES is less expensive than LHTES, but it has a lower energy storage density. Phase change materials (PCMs) have additional drawbacks when compared to SHTES materials for small-scale household use, including low thermal conductivities, deterioration after many charging and discharging cycles, and production costs. Thermal oils, rocks, water, metals, and salts are all practical heat storage materials. To store thermal energy at medium to high temperatures, solid particulate matter needs a heat transfer fluid.

II. LITERATURE REVIEW ON SOLAR COOKERS WITH THERMAL ENERGY STORAGE SYSTEMS

For the climate of India, D. Buddhi and L. K. Sahoo[4] devised and made a box-type solar cooker with latent heat storage. The experimental findings showed that a phase change material may be used as a storage medium in solar cookers and that a solar cooker with latent heat storage can be used to prepare food even in the late evening. The outcomes of the experiment were contrasted with those of a traditional solar cooker. As a PCM, industrial-grade stearic acid was utilized, which has a melting point of 55.1 °C and a latent heat of fusion of 160 kJ/kg. Phase change materials typically experience positive volumetric expansion upon melting; hence the container needs to have extra volume. Figure 1 illustrates a box-shaped solar cooker with a PCM to store solar energy for one pot. The cooker comprises of an aluminum absorbent tray "A" with vertical depth of 0.08 m and dimensions of 0.28 m x 0.28 m at the bottom and 0.40 m x 0.40 m at the top for the double glass cover. The aluminum sheet had a thickness of 0.006 m. The cooking pot was maintained snugly inside a cylindrical container that was welded into the centre of the absorbent plate and had a 0.165 m diameter and 0.02 m depth.The outer tray „B‟ of size 0.40 m x 0.40m x 0.108 m was also made from the same aluminum sheet. The distance between tray „A‟ and tray „B‟ was kept at 0.025 m on the bottom side. Tray „B‟ was filled with 3.5 kg of commercial grade stearic acid and it was made sure that the PCM should be in good contact with the bottom side of tray A‟. These two trays were placed in an aluminium box of dimensions 0.5 m x 0.5 m x 0.14 m. The space between tray B‟ and the casing was filled with glass wool to provide thermal insulation to the bottom and sides of the solar cooker. To insulate the bottom and sides of the solar cooker from heat, glass wool was placed between tray B and the casing. A double glass cover measuring 0.4 m x 0.4 m was provided for the absorption tray and hinged to one side of the enclosure at the top. The aluminium cooking pot with cover (diameter: 0.16 m; height: 0.06 m) was stored in pot container "C." The exterior of the aluminium tray "A," the cooking pot, and its cover were painted a dull black colour.

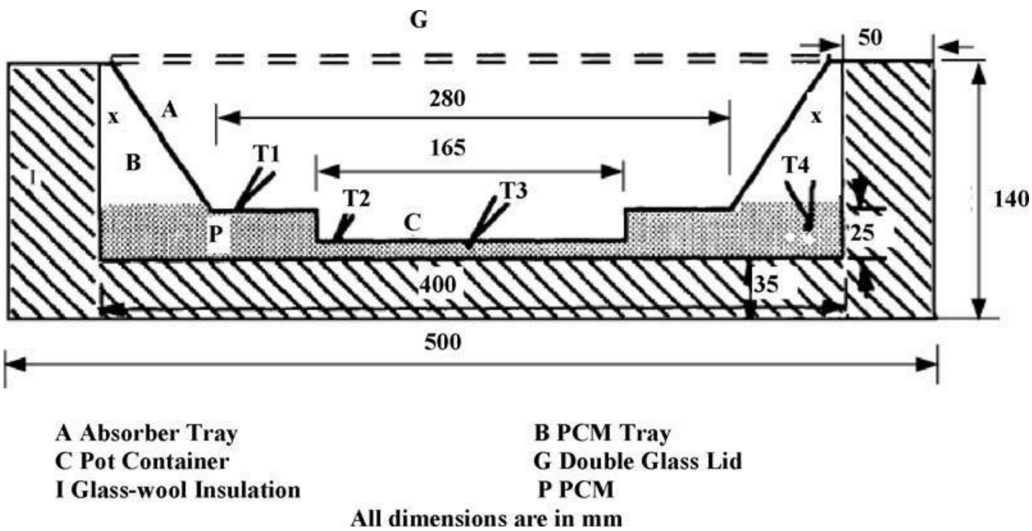

Fig. 1. Schematic diagram of the box of a solar cooker with storage. [4]

In order to cook in the late evening hours, Sharma et al. [5] constructed and tested a solar cooker with a latent heat storage unit. As a latent heat storage material, they chose commercial-grade acetamide, which has a melting point of 82 °C and a latent heat of fusion of 263 kJ/kg. In order to cook the food in the late afternoon, they designed, made, and tested a cylindrical PCM storage unit for a box-style solar cooker. This component encircles the cooking appliance. Cooking may go more quickly because of the increased rate of heat transmission between the PCM and the meal. To do this, a PCM container that would house the cooking vessel was created, as seen in Fig. 2.

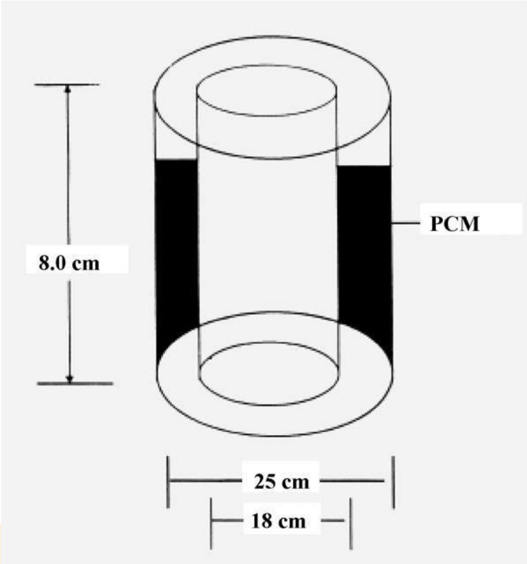

Fig. 2. Schematic diagram of latent heat storage unit. [5]

It is 0.08 m deep with a 0.002 m thickness, features two hollow concentric aluminium cylinders with sizes of 0.18 m and 0.25 m. Ace amide served as a PCM and filled the gap between the cylinders. The cooking pot had the following measurements: 0.175 m in diameter, 0.10 m in height, and it could be placed within the PCM container. In order to improve the rate of heat transmission between the PCM and the inner wall of the PCM container, eight fins with dimensions (0.01 m x 0.03 m) were also welded at the inner wall. They came to the conclusion that the second batch of food could be cooked if it is loaded with 2.0 kg of acetamide as PCM. They came to the conclusion that if the second batch of food is loaded before 3:30 p.m. during the winter, it can be cooked by utilizing 2.0 kg of acetamide as PCM. With the planned storage unit, cooking of three batches per day during the summer and two batches per day during the winter was successfully accomplished.

Thermal energy storage is the most effective type of energy storage method available. Utilizing solar energy and extra thermal energy that is produced during the day, a thermal storage device can store energy for either brief or seasonal periods. An effective method can be created by combining seasonal and nocturnal storage. In order to store thermal energy during the day at higher energy transfer rates, chilled water and ice storage is used for chilling and hot water tank storage is used for heating. By storing thermal energy when solar radiation or other energy sources are abundant or affordable, seasonal thermal storage decreases high energy costs and helps to prevent energy shortages during a time when there is little sun exposure. Consequently, combining solar power with significantly higher rates of energy transmission. By storing thermal energy when solar radiation or other energy sources are abundant or affordable, seasonal thermal storage decreases high energy costs and helps to prevent energy shortages during a time when there is little sun exposure. Therefore, it's crucial for distributed generation to combine solar energy with judicious storage for twilight and seasonal periods. [3]

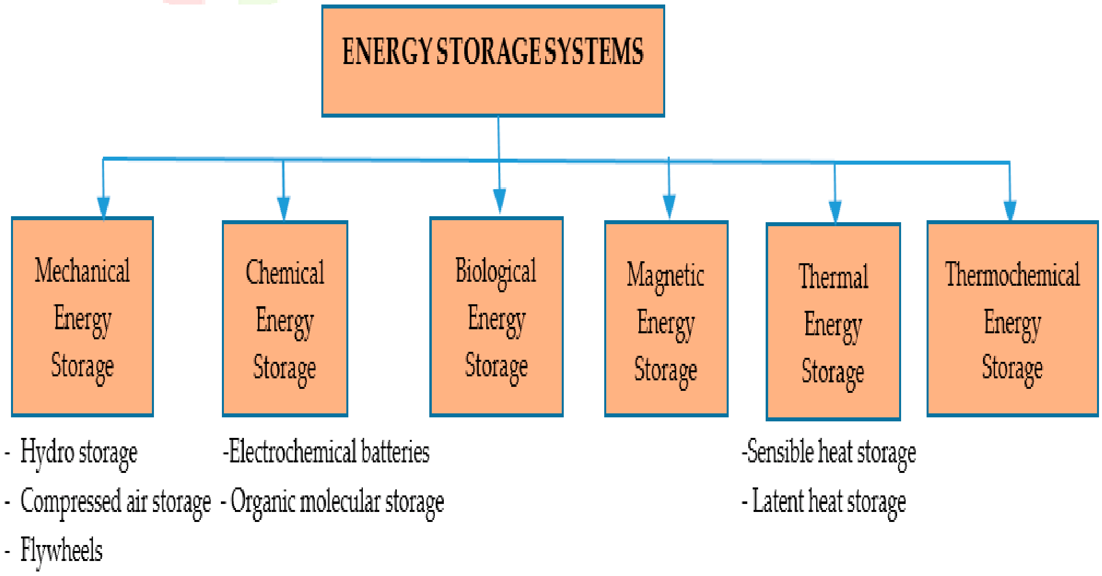

Fig. 3. Classification of energy storage systems

For domestic, industrial, and commercial use, hot water is required. Recently, interest in solar water heaters has increased due to its affordability, ease of maintenance, and ease of manufacture. PCMs can be utilised as a form of thermal storage to guarantee that hot water is accessible all day long. Two components typically make up a conventional solar water heating system, and they both work at the same time: a PCM-contained heater storage unit with a solar water heater. A water heater typically uses solar energy to heat the water during the day, and at the same time, the PCM absorbs thermal energy and stores it within the substance. The PCM is used to extract thermal energy to heat the water at night when sunlight isn't accessible. The development of solar water heaters has received significant study attention. The solar water heater can employ and develop a variety of PCMs and thermal storage technologies (LHTES). The schematic diagram of an LHTES is presented in Figure. The extensive work that has been done on improving the integrated solar water heater storage systems.

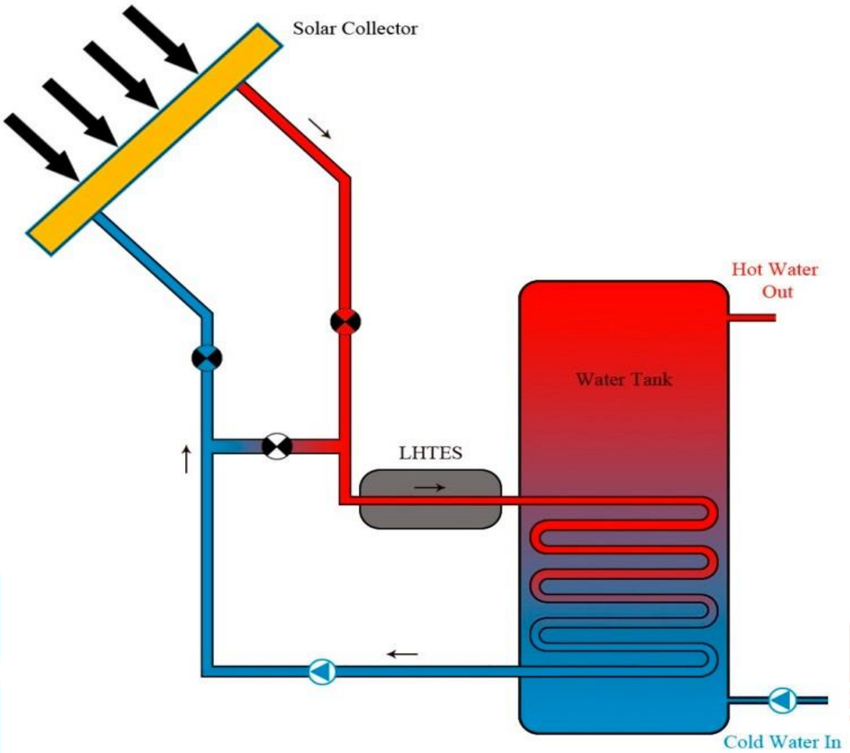

Fig.4. Solar water heater system with LHTES (latent heat thermal energy storage).

III. PROBLEM STATEMENT

A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurize drink and food materials. A Box Solar Cooker is basically an insulated box with a glass cover and a top lid which has a mirror on the inside to reflect sunlight into the box when the lid is kept open. The inner part of the box is painted black. Up to four black painted vessels are placed inside the box with the food to be cooked. The cooker takes 1 ½ to 2 hours to cook items such as rice, lentils and vegetables. The cooker has also been used to prepare simple cakes, roast cashew nuts, dry grapes, etc. It is an ideal device for domestic cooking during most of the years except the monsoon season and cloudy days. It however cannot be used for frying or chapati making.

Sensible Heat Storage: energy is storage or extracted by heating or cooling a liquid or solid without change in phase. The choice of substance depends on the temperature range. Water is used for temperature below 100 degree Celsius and refractory bricks for temperature around 1000 degree Celsius. These are simpler in design compared to latent heat storage system but they are bulky in size. Also they cannot provide heat at a constant temperature. About the experimental study, efforts have been put to enhance the cooking performance of a box cooker by increasing its efficiency and by reducing the cooking time for various cooking stuffs. For this, a long copper made cylindrical tube has been developed which carries the different TES materials for testing and configured as the most appropriate design. Experiments have been carried out in weather environments of Moradabad. The main objectives of the present study can be listed as follows:

- To improve heat transfer rate between absorber and cooking vessel
- To augment thermal efficiency of modified SBC
- To develop a competent SBC that can provide better cooking performance during poor ambient environments
- To develop a potential SBC for an uninterrupted and continuous cooking operation
- To develop a SBC for short timing cooking of different edibles at any geographical location.
- To develop an additional TES material infused element which can be easily attached or detached to the cooking unit whenever required
- To develop a solar cooker for fast thermal response and provide an economic and safe cooking

To conduct the cooking trail tests, 1 kg of fresh water has been taken in two cooking vessels in equal quantity. The cooking tests have been conducted for stagnation testing and sensible heating testing on all the configurations of modified cooker from 11:30 to 13:20 hrs during the full sunshine hours in the month of MARCH AND APRIL 2022

IV. DESIGN OF THE SOLAR COOKER

A solar cooker is a container or a device that traps solar energy and helps in heating and cooking food. It mainly works on three principles i.e. concentration, absorption and retention. A solar cooker has a mirror that helps in letting the sun's UV rays in and converts it into infrared light rays. There are four basic types of solar cookers – panel cookers, box cookers (sometimes called box ovens), parabolic cookers, and tube cookers. Each of these basic types of solar cookers meet a specific need and specific type of cooking. A solar cooker is a type of solar thermal collector. It “gathers” and traps the Sun's thermal (heat) energy. Heat is produced when high frequency light (visible and ultraviolet) is converted into low frequency infrared radiation. Green energy is an alternate form of energy that is currently being used to combat the crises of energy and global warming. Use of solar energy for cooking is better solution, but still not established as user friendliness and economic aspect. Food is the basic need of human being. Solar cooker is clean and eco friendly energy device for cooking. There are large number of solar cookers designed and developed by the scientists and researchers all over the world but still the utilization of solar cooker is not sufficient. In this project, a box type solar cooker will be designed and fabricated. A solar cooker is a container or a device that traps solar energy and helps in heating and cooking food. It mainly works on three principles i.e. concentration, absorption and retention. A solar cooker has a mirror that helps in letting the sun’s UV rays in and converts it into infrared light rays. The infrared radiation has the power to make the protein fat and water molecules present inside the food to shake vigorously which heats up the food. The sun’s heat actually does not help in heating the food, but it is the rays derived from the sun which converts into heat energy and cooks the food. A lid is used to cover the food kept inside a pot so that the heat energy doers not escape. An effective solar cooker thus helps in capturing heat and cook’s food.

Table 1. Specification of solar cooker

Size of the cooker	UV resistant model Aluminium body 480 x 480 x170 MM (19.2x19.2x7 Inch.)
Cooking Capacity	4-6 Kg per day
Total weight	Approx. 14 Kg including cooking pots.
Tray Material & coating	Aluminium sheet, black painted of high heat absorption and low emission.
Cooking pots	Stainless steel, hard black coated cooking pots. Size = All Boxes are 1Litres.
Energy source	Solar.
Power consumption	Approximately 0.1 to 0.4 kWh. Depending on food quantity and ambient

Fig.5. box type solar cooker

V. DESIGN OF EXEPERIMENTAL SETUP

While designing project, there are multiple geometrical constraints to put into consideration. The major constraint that we might face is moisture that occurs on wood. Wood approximately absorbs 20% of moisture air, for that we are still reviewing all possible options for wood to build with, the higher the moisture resistance the better for the long-term durability of the project. The second design constraint that is just as important is finding the amount of load that the chosen type of wood can withstand before creep occurs.

Main Aim:

Increase heat input to the pot

1) Heat by convection radiation
2) Heat supplied to cooking pots through conduction.
3) Heat is added to water and hot water is circulated through tubes.

Objective of Work:

1) To improve heat transfer rate between absorber and cooking vessel
2) To augment thermal efficiency of modified SBC
3) To develop a competent SBC that can provide better cooking performance during poor ambient environments
4) To develop a potential SBC for an uninterrupted and continuous cooking operation
5) To develop a SBC for short timing cooking of different edibles at any geographical location
6) To develop an additional TES material infused element which can be easily attached or detached to the cooking unit whenever required
7) To develop a solar cooker for fast thermal response and provide an economic and safe cooking

VI. EXPERIMENTATION

The design of experimentation has given a road map of how the experimentation is planned but implementation of experimental plan and conduction of actual test run requires a systematic detailing of execution. Presentation of those details is the main substance of this chapter. Keeping these points in mind this chapter is divided into two main parts namely

- Experimental procedure
- Observations

The following procedure is adopted for the experimentation:

1. The box type solar cooker size of 480 x 480 x170 MM (19.2x19.2x7 Inch.) is used for modification.
2. Taking reading of temperature by using box type solar cooker.
3. Connect thermal detector with J type thermocouple and taking reading of pot 1and pot 2 temperature reading.
4. Taking reading for two days and note down for further calculation.
5. Thermal conductivity of cooper tube is high so used at the base of solar cooker whose diameter is 6mm.
6. On cooper tube one cooper plate having thickness of 1mm is used for heat transfer by conduction to cooking pot.
7. The cooper tube inlet and outlet is connected to water tank. Tank material also coopers having capacity 900ml.
8. Now water is heated from the tank and it circulated in cooper tube by thermo symphonic effect. Due to conduction heat is transfer to cooking pot through cooper plate having less thickness.
9. Hence temperature of water in pot is increase fast as compared to box type solar cooker without modification.
10. Now taking temperature reading using thermocouple and temperature detector. Temperatures are recorded at the time interval of 15min for 2hr. and calculate the efficiency of cooking.

The predetermined water is inserting in water tank and in cooking pot. Keep solar cooker in sunlight. Tank is heated and circulates hot water in cooper tube. By using thermocouple take reading of cooking pot for time interval of 15min for 2hr. ambient temperature were recorded at the time intervals of 15 min. up to steady condition. Generally it takes around 2 hours to attain high temperature. Observations were recorded and used for calculation. Four thermocouples were used.

Parameters used for the study are as given below.

- Pot temperature: T1, T2, T3, T4,.
- Ambient temperature: T5.

Fig.6. copper tube connected with cooper plate

Fig.7. solar cooker before modification with cooking pot

Table 1 Temperature Test Box Type Solar Cooker on (3/3/2022**)**

Time(hrs)	Pot 1 temp.	Pot 2 temp	Ambient temp $T_a(o_c)$	Insulation I(W/m^2)
12.00	30	30	29	623.81
12.10	38	37	29	652.12
12.20	48	49	30	698.34
12.30	58	54	32	700.08
12.40	68	67	33	700.11
12.30	75	74	34	705.03
12.40	83	83	35	700.12
12.50	89	89	34	690.45
01.00	95	94	32	650.56

Table 2 temperature test box type solar cooker on (5/4/2022)

Time(hrs)	Pot 1 temp.	Pot 2 temp	Ambient temp T_a(	Insulation I(W/m^2)
12.00	32	32	29	624.81
12.10	35	38	29	625.12
12.20	42	49	30	625.34
12.30	49	56	32	627.08
12.40	68	67	33	728.11
12.30	76	75	34	730.03
12.40	82	84	35	731.12
12.50	90	89	34	740.45
01.00	98	95	32	735.56

Table 3 temperature test of box type solar cooker with water tank on (7/05/2022)

Time(hrs)	Pot 1 temp.	Pot 2 temp	Ambient temp T_a(	Insulation I(W/m^2)
12.00	32	32	30	624.81
12.10	40	41	32	630.12
12.20	49	50	33	735.34
12.30	60	61	35	700.08
12.40	72	71	36	700.11
12.30	86	85	38	700.03
12.40	101	100.5	39	705.12
12.50	116	117	40	710.45
01.00	130	129	40	710.56

VII. EXPERIMENTAL RESULTS

Following reading are taken from experimentation

Calculations

Load (sensible) test

The set up for the Load (sensible) test is as shown in figure 1.The atmospheric temperature recorded was 30degree celcius.1ltr of water was put into the pot and left there for about 30 minutes.

Performance analysis of the cooker

Experimental runs were conducted at no-load and sensible heating to evaluate the performance of the cooker. Efficiency and heating-power are parameters used for this analysis.

Heating-Power

The first step is to calculate the cooking power P_i for every 10 min interval i.

$$Pi = \frac{(T2-T1).m.cv}{\Delta t}$$

Pi=cooking power for interval *i* [W]
T2=final water temperature [°C]
T1=initial water temperature [°C]
M=water mass [kg]
Cv=heat capacity of water =4186[J/(kg ·°C)]
Δt =time of interval *i* =600 [s]

$$= \frac{(38-30)*1*4186}{600}$$

P_i= 55.81W

Efficiency

The optical efficiency characterizes a property of the system without any thermal losses and it is determined from the value of heating-power near ambient temperature. It was evaluated as indicated by and computed using the expression outlined in equation (2).

$$= \frac{Pi}{I*A} = \% \qquad (2)$$

$$= \frac{55.81}{623*0.164}*100=54.71\%$$

where, Pi , I and A are the efficiency, heating power (353J/s), solar radiation (1000 W/m2)and collector surface (0.164m2). Solar radiation is the global radiation on the surface for f lat plate collectors.

VIII. Results Calculated from Experimental Data

Table 4 calculation heat power and efficiency

Time(hrs)	**Pot 1 temp.**	P_i(w)	**Efficiency (%)**
12.10	38	55.81	54.71
12.20	48	69.76	61.19
12.30	58	70	62
12.40	68	71	62.28
12.30	75	49	43
12.40	83	56	49
12.50	89	42	45
01.00	95	42	46

Table 5 calculation heat power and efficiency after modification

Time(hrs)	**Pot 1 temp.**	P_i(w)	**Efficiency (%)**
12.10	40	56	54.6
12.20	49	66	64
12.30	60	77	67
12.40	72	88	76
12.30	86	100	86
12.40	101	105	90
12.50	116	106	91
01.00	130	107	91

IX. RESULTS AND DISCUSSIONS

Cooking experiments were conducted using the ‘Reference Cooker ‘with the same quantity of load. On March 03 2022, and may 07 2022. For solar cooker before modification and after modification. Solar cooker were exposed to the sun for 2 hr in every 10min. were loaded with 1 kg water at 12PM. The temperature of both solar cookers was taken in every 10min. and found to be temperature of pot after modification is more. More heat transfer due to cooper tube by conduction. Repeated for two days.

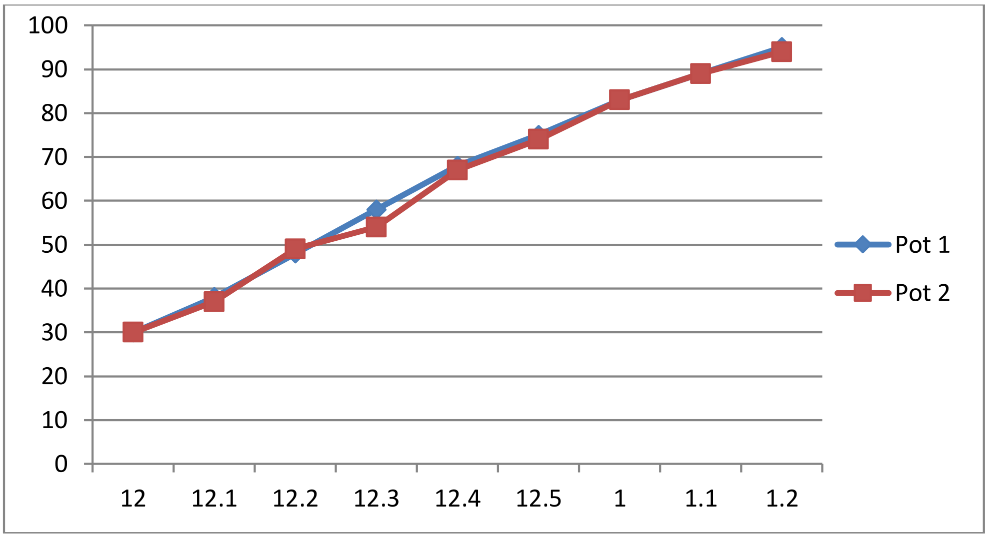

Fig 8 Time versus temperature without modification for day 1

Fig 8 represent a box type solar cooker with no water heater with 0.164m^2 flat plate collector and cooking pot with no storage tank. The cooker is indirect types that permit indoor and outdoor cooking. Fig 2 depicts the relationship between time and temperature of water inside the pot. The temperature of water increase.

Fig 9 Represent a box type solar cooker with no water heater with 0.164m^2 flat plate collector and cooking pot with storage tank. The cooker is indirect types that permit indoor and outdoor cooking. Fig 7.3 depicts the relationship between time and temperature of water inside the pot. Reading was taken after modification and it's seen that temperature was increase more as compared to without water tank. Due to conduction from copper plate pot get more heat.

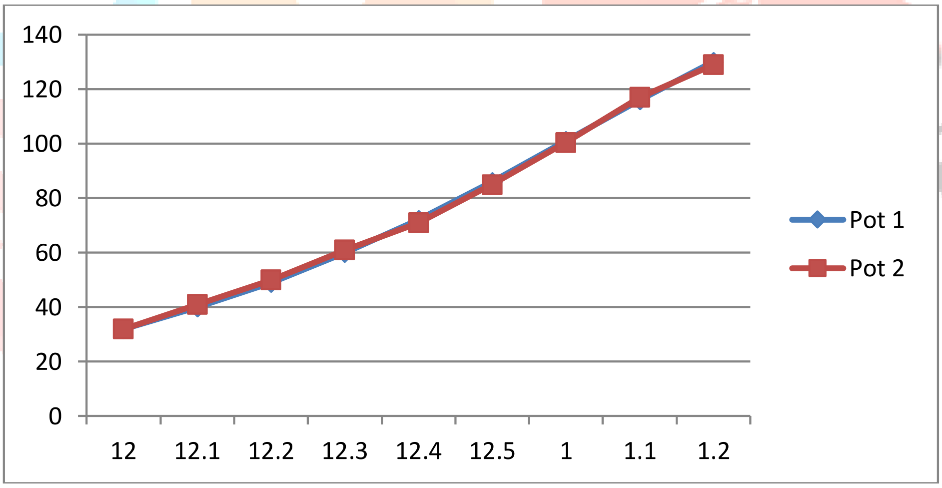

Fig 9 Time versus temperature after modification with water tank

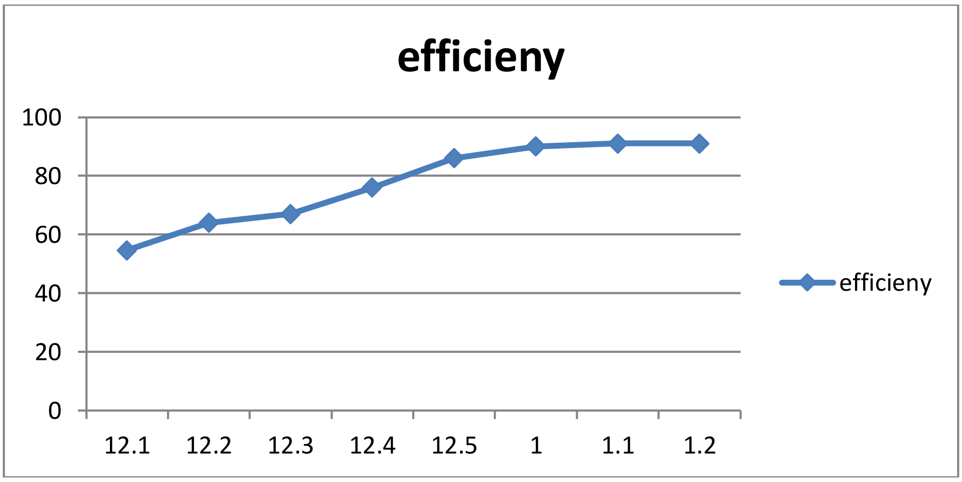

Fig 10 Time versus Efficiency with water tank

Fig 10 shows relationship between times versus efficiency. This graph for with water tank and copper tube here temperature is increase more compare to before modification. Efficiency is increases because heat power increases more continuously. Efficiency reached from 56% to 90% .

Temp v/s Efficiency and Heat power

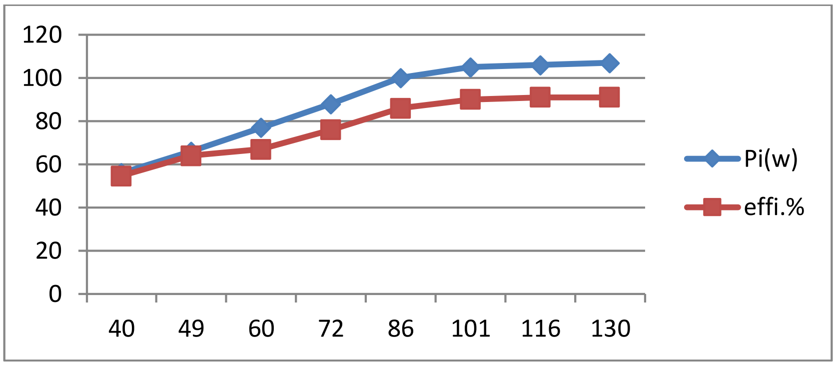

Fig 11 Temperature versus Efficiency with water tank

Fig 11 shows relationship between times versus efficiency. This graph for with water tank and copper tube here temperature is increase more compare to before modification. Efficiency is increases because heat power increases more continuously. Efficiency reached from 56% to 90%. Hot water circulated through copper tube due to conduction heat is transfer to copper plate and copper plate gets heated and heat transfer to cooking pot and hence cooking time reduced.

Discussions

A box type solar cooker was designed and developed indigenously using locally available materials. A cooper tube of 6mm diameter connected with water tank is attached with cooper tube that's why temperature of cooking pot increases as compared to without cooper tube. Solar concentrator was also designed to be included in near to water tank the solar cooker which was found to ultimately increase the retention ratio and quantum efficiency of the infra-red radiations collected. The solar cooker was tested for its efficiency with and without the cooper tube with water heater concentrator whereby the results proved that the after using cooper tube with water heater concentrator played a major part in increasing the collection ratio and thereby the ambient temperature inside the solar cooker. After studying different type of solar cooker we can say that box type solar cooker with cooper tube solar cooker has better performance than that of simple box type solar cooker. Because of it reaches extremely high temperature (130 Degree Celsius) than that of other type. Two variations of the water masses have been tested in this study. The results obtained by heating the water until boiled in the box of solar cookers, and the efficiency of solar collectors.

Energy of radiation intensity

In calculating the heat loss that occurs in the box solar cookers, can be done by measuring temperature inside of box and surround of the box cooker. The increasing temperature depends on the radiation intensity. The maximum radiation is 750 W/m^2 at 01.10 PM

Efficiency solar cooker

The efficiency of a solar cooker in heating water by the water volume of 1 lit 56-90%.

X. CONCLUSION:

In the current study, the design, fabrication, and thermal evaluation of a solar cooking system integrated with tracking device and sensible heat storage materials has been presented. The objective was to address majorly health challenge that is predominant among the people living in the rural area who in most cases use fire wood and other biomass product for cooking. Locally sourced materials were used to fabricate the cooker. Thereafter, water boiling and cooking trials were adopted to evaluate the performance of the cooking system. From the results, the following major conclusions were drawn:

The obtained maximum solar radiation and water temperature during the water boiling tests with water as sensible heat storage material at 14:00 h were 650.2 W/m^2, while with cooper tube at this period were 750.4 W/m^2 and 130.5°C.

The average cooking duration of rice with cooking system ranged between 144 and 151 min using cooper tube with water heater SHS materials. The maximum cooking power and thermal efficiency obtained from the cooking trials of rice were 80 W and 90% respectively. The developed cooker is expected to perform better when the solar intensity is higher Adoption of the developed solar cooking system will reduce environmental pollution that occurs when fire wood, fossil fuel etc. are used.With minor design medications, there will be an improvement on the performance of the developed cooking system

XI. REFERENCES

[1] Mani A, Rangarajan S. Solar radiation over India. Allied Publishers: New Delhi; 1982.

[2]AshmoreMawire, Abigail Phori, Simeon Taole. 2014"Performance comparison of thermalenergy storage oils for solar cookers during charging". Applied Thermal Engineering (73) :1321-1329

[3] Sunil Geddam, G. Kumaravel Dinesh, ThirugnanasambandamSivasankar. 2015"Determination of thermal performance of a box type solar cooker". Solar Energy (113) : 324–331

[4] D. Buddhi and L. K. Sahoo. 96"Solar cooker with latent heat storage: Design and experimental Testing". PII: S0196-8904 00066-0

[5] Prasanna,U.R. and Umanand, L 2011 modelling and design of a solar thermal system for hybrid cooking application Appl. Energy. 88 1740-1755.

[6] Ramadam, M. Aboul-Enein S. and EI-sebai A model of an improved low cost indoor solar wind Technoi 5(4):387-393.

[7] .Schwartzer,K and silva, M.E.V. 2003 solar cooking system with or without heat storage for families and institutions . Solar Energy 75 : 35-41.

[8] Sharma, A. chen c. R. Murty V.V.S. and Shulka. A2009. Solar cooker with latent heat storage system A review.Renew Sustain Energy 13 1599-1605.

[9] Sharma S.D.and Sagara K. 2005 laten heat storage materials and system A Review int J Green Energy 2 1- 56.

[10] L. R. Fagbenle, "Estimation of total solar radiation in Nigeria using meteorological data," *Journal of Renewable Energy*, vol. 1, no. 1, pp. 1–10, 1990.

[11] B. Garba, A. J. Atiku, and A. K. Madukwe, "Solar cookers," *Nige- rian Journal of Renewable Energy*, vol. 4, no. 2, pp. 1–11, 2000.

[12] United Nations Industrial Development Organization [UNIDO], *Technology for Solar Utilization*, vol. 5 of *Develo- pment and Transfer of Technology series*, New York, NY, USA, 1978.

[13] Adisa, A.B. and Baba, A (2009). Solar cooker technology development in Nigeria. Journal of Nigerian Institution of Mechanical Engineers, 1, 1-10.

[14] Ugochukwu, C.U., Anthony, O.O., Christian, E.O (2018). Thermal Performance of a developed Solar Box Cooker for Awka Metropolis. Journal of Engineering and Applied Sciences, 12, 64-75.

[15] Dauda, S. and Ejembi N.A (2009). "Experimental Evaluation of a Box Type Solar Cooker" Journal of the Nigeria Institute of Mechanical Engineers, 1, 40-45.

[16] Kalogirou SA (2004) Solar thermal collectors and applications. *Prog energ combust* 30:231–295.

[17] Bensenouci A, Medjelled A (2016) Thermodynamic and efficiency analysis of solar steampower plant cycle. *Int J Renew Energy Res* 6: 1556–1564.

[18] Kalogirou SA, Karellas S, Badescu V, et al. (2016) Exergy analysis on solar thermal systems: abetter understanding of their sustainability. *Renew Energy* 85: 1328–1333.

[19] Singh B, Mishra AK (2015) Utilization of solar energy for driving a water pumping system. *IntRes J Eng Technol* 2: 1284−1288.

[20] Thakkar V (2013) Status of parabolic dish solar concentrators. *Int J Enhanc Res Sci TechnolEng* 2: 42–50.

[21] Yahuza I, Rufai Y, Tanimu L (2016) Design, construction and testing of parabolic solar oven. *JAppl Mech Eng* 5.

[22] McCormick, K.; Neij, L.; Mont, O.; Ryan, C.; Rodhe, H.; Orsato, R. Advancing Sustainable Solutions: An Interdisciplinary andCollaborative Research Agenda. *J. Clean. Prod.* **2016**, *123*, 1–4.

[23] Fiorati, A.; Bellingeri, A.; Punta, C.; Corsi, I.; Venditti, I. Silver Nanoparticles for Water Pollution Monitoring and Treatments:Ecosafety Challenge and Cellulose-Based Hybrids Solution. *Polymers* **2020**, *12*, 1635.

[24] Sampat, A.M.; Ruiz-Mercado, G.J.; Zavala, V.M. Economic and Environmental Analysis for Advancing Sustainable Managementof Livestock Waste: A Wisconsin Case Study. *ACS Sustain. Chem. Eng.* **2018**, *6*, 6018–6031.

[25] Venditti, I. Engineered Gold-Based Nanomaterials: Morphologies and Functionalities in Biomedical Applications. A Mini Review.

[26] Siddika, A.; Hajimohammadi, A.; Mamun, M.A.; Alyousef, R.; Ferdous, W. Waste Glass in Cement and Geopolymer Concretes: AReview on Durability and Challenges. *Polymers* **2021**, *13*, 2071.