IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 10, Issue 1, January 2020, ||Series -V|| PP 34-43

Comparative Study of Solar Cookers

Tharesh K. Gawande, Dr. D.S.Ingole
Assistant Professor, Department of Mechanical Engineering PRMIT&R, Badnera-Amravati India
Professor & Head, Department of Mechanical Engineering PRMIT&R, Badnera-Amravati India
Received 02 January 2019; Accepted 16 January 2020

Abstract: Now days the use of solar energy becomes very crucial because of its ample availability throughout the year free of cost, and on the contrary conventional fuels are becoming precious. So it became imperative to use this energy for maximum possible occurrences. One of the challenging areas of the use of solar energy is the solar cooking. This paper presents a comparative study of various types of solar cookers commercially available. The need of heat storage systems for solar cookers, their feasibility, materials and their properties are also discussed.
Keywords:- Solar energy, solar cookers, heat storage system, renewable energy systems.

I. INTRODUCTION

Renewable energy is always a hot talk. As the energy demand is increasing day by day with increasing population, the need of renewable energy is becoming the very essential in every field. There are various sources for the renewable energy like wind energy, geothermal energy, solar energy, etc. Among all the solar energy is very popular and easily available source of renewable energy. This energy is used for various applications like generation of electric energy, home heating, drying and cooking, etc. To run these appliances one needs to extract or convert solar energy into some useful form. This is done by using either PV cells or solar collectors, which depends on the various parameters like need, economy or durability. One of the well-known uses of solar energy is cooking of food. The solar cookers are used for cooking. These solar cookers are being used since 17^{th} century. Till now, lot of solar cookers have been developed and used. But, still it needs a lot of research before selecting any one type for its use at specific region. It depends on geographical area, heat requirement, and type of food to be cooked. The solar cookers are used for community cooking also. The adaptability of solar cookers can protect environmental pollution over the use of conventional wood cooking. At the same time, it can help to increase national economy as it will reduce the use of LPG. Hence the encouragement for use of solar cooker is very essential. This can be done only when solar cookers will show better performance than conventional cooking systems. Hence the selection and designing of solar cooker as per specific requirement becomes very crucial.

II. TYPES OF SOLAR COOKER

Solar cookers are mainly classified according to its characteristics.
i. Depending upon heat supplied
a. Direct solar cooker
b. Indirect solar cookers
ii. Depending upon heat storage
a. Solar Cookers with storage
b. Solar Cookers without heat storage
iii. Depending on application
a. House hold (Small Scale) Solar cookers
b. Community Solar Cookers

2.1. Direct Solar Cookers

Direct types are those which use the sun radiations directly to cook the food. They are
i. Box type Solar Cooker
ii. Panel Cooker
iii. Parabolic Cooker.

All these cookers of each type have been proposed by researchers. And also has been tested to investigate the performance parameters for each type. These direct cookers have advantages that these are simple in design and maintenance. They are economical and easy to operate also. Mostly these are used for the house hold purpose. But its limitation is that these can be used only in day time. Its productivity and efficiency decreases with clouds. Also these cannot be used in night.

2.1.1 Box Type Solar Cookers

Solar box cookers (sometimes also called as solar ovens) are the most common and economical type of solar cookers. The first solar box cooker was invented by a French–Swiss naturalist named Horace de Saussure in 1767. These box cookers area very simple in construction. Also they are made of low cost materials. The outer box is often made of wood or low thermal conductive material. The inner box is made of insulating material, which is covered with clear glass or with plastic, and often has a reflector of aluminum. According to Solar Cooker International, solar box cookers can accommodate multiple pots which can operate at moderate temperature. It generally operates up to 95˚C but it can reach a temperature of 140˚ C. These cookers are sometimes classified depending upon the use of glazing glass. Single or double pain glasses are the most common structures. These enable to receive a higher solar transmission. The solar box cooker needs direct sunshine to operate and produces zero emission. Its temperature range is low as well it cannot be operated after day time. Many non -profit organizations promote these cookers worldwide in order to help reduce fuel costs and to slow down deforestation caused by the use of woods used for cooking.

Fig.1:- Box Type Solar Cookers

2.1.2 Panel Cookers

The panel cooker are the next simple form of solar cooker after box type which is generally consists of a cooking pot or pan and usually is darkened or blackened. Also it has oven cooking bag or transparent glass bowl along with a reflective panel. These panels can be made from aluminium foil over corrugated carton, or from tin or sheet metal panels polished to a high sheen and also with mirrors. The oven bag or glass bowl allows the suns UV rays to penetrate towards the food in turn trapping the energy; (heat) preventing its escape.

The reflector panels concentrate the sun light onto the cooking vessel containing the food, in the same way the panels do so on the solar box cookers. A panel cooker are simpler in design and are more economical to develop also which results in the same cooking effectiveness for most all situations. Depending on the pot and the food being cooked some panel cookers can achieve comparably higher temperature. Since most foods cooked in these types of cookers usually contain more moisture (soups, stews, meats etc.) they will usually cook around 100˚C-122° C. Performance of solar panel cookers do not seem effective under cloudy conditions as it highly depend on reflected radiation .

Fig. 2:- Panel Cooker

2.1.3 Parabolic Solar Cookers

Parabolic cookers are also called curved concentrator cookers which can reach much higher temperatures and can cook more quickly. This concentrate the incident sun rays on a cooking vessel. It needs more accuracy to focus the sunlight on the vessel (i.e. food pan). If the sunlight is not correctly focused on the food in the pan, lesser will be the solar concentration which will reflect in poor food cooking quality. There are

many designs proposed by the researchers for parabolic solar cooking appliances. Because of the parabolic shapes and with the aid of reflecting material quite a lot of solar energy is concentrated in the focal point. A high temperature of the range 200˚C to 300ºC can be reached because of a combination of the circular design, the size and the better sun rays reflecting material surface. It is suitable for baking, roasting and grilling also.

Fig.3:- Parabolic Solar Cooker

Parabolic solar cookers functioning depends upon the operating skills as its sun ray tracking is require for continuous concentrated sun rays. Hence these cookers are difficult to handle and operate. Like other solar cookers, parabolic cookers also work in day time only and cannot be operated after sunshine (in evening or night time). The effectiveness of parabolic solar cooker depends upon the size of the collector as it would generate less heat in case of small size whereas may generate intense heat if it is too large.

2.2 Indirect Solar Cookers

In indirect type solar cookers, the cooking is carried or at a distance or at another place from the solar collector. And then this heat needs to be transferred to cooking vessel from collector. These indirect solar cookers are mainly sub classified as i. Flat plate collector, ii. Evacuated tube collector and iii. Concentrating type collector.

2.2.1 Flat Plate Collector Solar Cookers

A flat plate collector solar cooker was designed and tested by Schwarzer et al. having one plastic and one glass cover to study its performance. The experimental results of their study showed an increase from 0.35 to approximately 0.4 in the sensible efficiency of the solar collector. The possibility of indoor cooking with less time is the advantage of this cooker .Whereas; the main disadvantage is a non-removable vessel which makes cleaning of vessel and food difficult.

2.2.2 Evacuated Tube Collector Solar Cookers

Solar cooking system based on evacuated tube solar collector provides high thermal power and temperatures without tracking and allows cooking in the shadow. Kumar et al. has designed a solar cooker based on evacuated tube solar collector. These cookers are consists of an evacuated tubular solar collector and a pressure cooker. The heat transfer mechanism in Kumar et al.'s system may be explained as: when the incident solar radiation falls onto the collector tubes which heats up the working fluid inside these tubes. Due to which the vaporized fluid rises upwards to the heat exchanger and conveys energy by condensation to the water flowing in the secondary loop of the heat exchanger. Then this condensed fluid returns to the collector tubes where again heating is takes place and the process of heat transfer repeats again. It is observed that, the heat supplied in evacuated tube is more than normal flat plate collector which means these cookers operates at more temperature than flat plate collector cookers. The collector is made up of evacuated double-wall (concentric) glass tubes mounted on parabolic concentrating chrome-nickel reflectors. The cooking time depends on meteorological and thermo-physical properties of fluid used in a pipe.

2.2.3 Concentrating-type Collector Solar Cookers

In this type of cooker either parabolic or spherical shape dish is used to concentrate the solar radiation. It is mainly divided into two types i. Fresenel lens concentrator cooker ii. Scheffler dish Cooker

Fresnel lens Cookers:

In this type of solar cooker, a lens is used to focus the incident rays on a evacuated tubes which increases the concentration of the rays. The Fresnel lens can be designed according to the condition that the incident light is perpendicular to the surface of the lens. This cooker can provide cooking temperature more than 200˚ C.

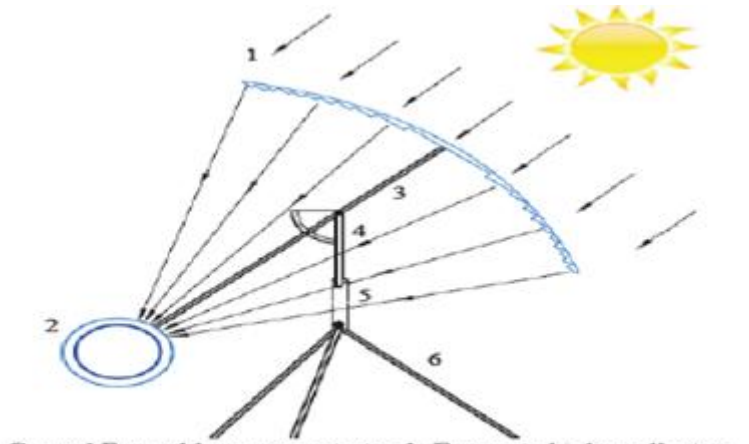

Fig.4 Fresnel lens concentrator cooker

Scheffler Dish Cooker:

A scheffler dish cookers are generally used for community cooking. In this type of solar cooker, steam is generated which is further used for cooking. It consists of the dish parabolic or elliptical which focuses the incident rays on receiver as shown in figure 5. This receiver then absorbs the incident solar energy and transfers it to the water flowing through it . The energy is sufficiently high to convert water into steam. This generated steam is then stored continuously in the steam storage tanks until the required temperature and pressure are attained. Then this Steam is transported to the kitchen through insulated pipes. This steam is either injected directly into the cooking pots or made to circulate in the jacketed wall of the cooking pots. An array of a minimum of three Scheffler dishes is required to obtain satisfactory performance from such SSC systems and therefore, these systems are suitable only for kitchens involved in the cooking of more than 200 meals at a time. This type of system is used in kitchen of temple's kitchen at Shirdi, Maharashtra and Mount Abu, Rajasthan (India).

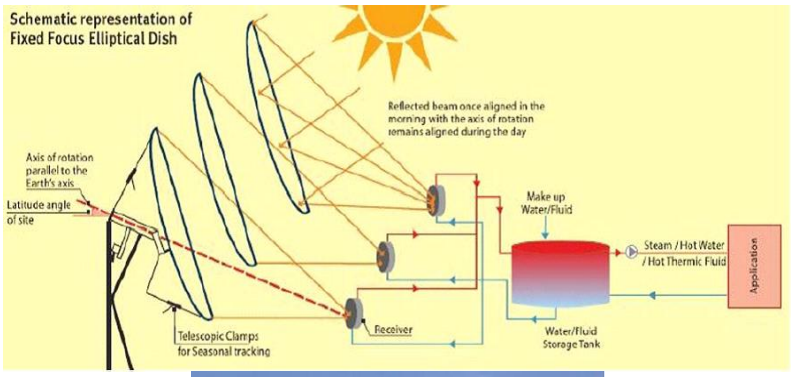

Fig.5 Scheffler Cooker

2.3. Solar Cookers with Storage

Solar cooking without storage is time limited. It cannot takes place in the evening or in cloudy environment. It can be carried out only in sun shine hours. This can be solved by providing heat storage systems. In which heat will be stored at the time of pick hours of sun shine and then this heat can be provided to cooking pot at required time by proper heat transfer system. There are some heat storage systems like sensible heat storage and latent heat storage. Specific heat capacity of the material is utilized to store the thermal energy in sensible heat storage. While storing and retrieving the thermal energy is based on the latent heat of fusion of the material, where storage medium undergoes a phase transformation which can be either solid to solid or solid to liquid is latent heat storage. These phase change material (PCM) possesses some thermal, physical & chemical properties. Like suitable phase-transition temperature, high latent heat of transition, good heat transfer, favorable phase equilibrium, high density, small volume change. Low vapour pressure, long-term chemical stability, compatibility with materials of construction, no toxicity, no fire hazard etc. .

As latent heat storage has more capacity and ability to retrieve heat, it is an area of research since last few years.

Latent Heat storage System:

It uses phase change material to store the heat which can retrieve the energy when outside temperature will be less. For cooking purpose PCM should have the following thermodynamic properties :-

- Melting temperature in the desired operating temperature range
- High latent heat of fusion per unit volume
- High specific heat, high density and high thermal conductivity
- Small volume changes on phase transformation and small vapour pressure at operating temperatures to reduce the containment problem
- Congruent melting
- Kinetic properties
- High nucleation rate to avoid supercooling of the liquid phase
- High rate of crystal growth, so that the system can meet demands of heat recovery from the storage system
- Chemical properties
- Chemical stability
- Complete reversible freeze/melt cycle
- No degradation after a large number of freeze/melt cycle
- Non-corrosiveness, non-toxic, non-flammable and non-explosive materials
- Economic properties
- Low cost
- Availability

There are number of PCM available in market. It can be classified as

- Organic – i. Paraffin compound ii. Non- paraffin compound
- Inorganic- i. Salt Hydrate ii. Metallic
- Eutectics- i. organic-organic ii. Inorganic-inorganic iii. Inorganic-organic

Organic Materials - Organic materials are further described as paraffin and non-paraffin. Organic materials include congruent melting means melt and freeze repeatedly without phase segregation and consequent degradation of their latent heat of fusion, self-nucleation means they crystallize with little or no supercooling and usually non-corrosiveness.

Inorganic materials- Inorganic materials are further classified as salt hydrate and metallics. These phase change materials do not supercool appreciably and their heats of fusion do not degrade with cycling.

The major problem in using salt hydrates, as PCMs is the most of them, which are judged suitable for use in thermal storage, melts incongruently. As n moles of water of hydration are not sufficient to dissolves one mole of salt, the resulting solution is supersaturated at the melting temperature. The solid salt, due to its higher density, settles down at the bottom of the container and is unavailable for recombination with water during the reverse process of freezing. This result in an irreversible melting–freezing of the salt hydrate goes on decreasing with each charge–discharge cycle.

Eutectic - A eutectic is a minimum-melting composition of two or more components, each of which melts and freeze congruently forming a mixture of the component crystals during crystallization.

So, As per the requirement one has to select the suitable PCM which will be best one in terms of thermal, chemical and physical suitability.

III. CONCLUSION

Various types are solar cookers are discussed in this paper. The selection of type of cooker depends upon the parameters of cooking like amount of food to be cooked, where to be cooked, time availability etc.

Also it depends on geographical condition, economical aspect also. Depending upon the literature survey mentioned cookers can be compare depending upon their performance. Table 1 gives the brief idea for the selection of solar cooker.

TABLE1:- Comparative description of solar cooker for various cookers

Type of cooker	Maximum attainable Temperature for cooking after certain time, in ˚C	Preferred for Hosue hold (small Scale)/ Community cooking	Availability	Limitation	Reference
Box Cooker	95-100˚C	Small Scale	Sun shine hours	Takes More time	
Solar Panel Cooker	100-122	Small Scale	Sun shine hours	Not useful in cloudy condition	
Parabolic Cooker	120-170	Small Scale	Sun Shine hours	Need a large aperture are of collector	
Evacuated Tube Cooker	250-300	Small scale / Community	Sun Shine hours	Too costly	
Fresnel Lens Cooker	250-300	Community	Sun Shine hours	Costlier and need skilled operator	
Scheffler Cooker	150 – 180	Community	Day Time as well sometime after it	Need large area and suitable for community cooking only	
Solar Cooker with heat storage	120	Small scale	Day time as well evening	Need a separate design for storage as well as for transfer system	

It also becomes very important to focus on the heat storage system so as to improve the efficiency and availability of cooker for cooking at any time, irrespective of the sun shine. Solar cooker with latent heat storage system looks more promising option where it needs proper designing for better efficiency and adaptability.

REFERENCES

[1]. Box type solar cookers with sensible thermal energy storage medium: A. **Cuce, Pinar Mert.** 166, 2018, Solar Energy, pp. 432-440.

[2]. A comprehensive review on solar cookers. **Erdem Cuce, Pinar Mert Cuce.** 102, 2013, Applied Energy, pp. 1399-1421.

[3]. Solar cooker realizations in actual use: An overview. **F. Yettou, B. Azoui , A. Malek , A. Gama, N.L. Panwar.** 37, 2014, Renewable and Sustainable Energy Reviews, pp. 288-306.

[4]. Characterisation and design methods of solar cookers. **Klemens Schwarzer, Maria Eugenia Vieira da Silva.** 82, 2008, Solar Energy, pp. 157-163.

[5]. Solar cookers with and without thermal storage—A review. **R.M. Muthusivagami, R. Velraj , R. Sethumadhavan.** 14, 2010, Renewable and Sustainable Energy Reviews, pp. 691-701.

[6]. Design, development and performance evaluation of a latent heat storage unit for evening cooking in a solar cooker. **S.D. Sharma, D. Buddhi, R.L. Sawhney, Atul Sharma.** 41, 2000, Energy Conversion & Management , pp. 1497-1508.

[7]. Determination of thermal performance of a box type solar cooker. **Sunil Geddam, G. Kumaravel Dinesh, Thirugnanasambandam Sivasankar.** 113, 2015, Solar Energy, pp. 324-331.

[8]. solar cooker with latent heat storage: design and experimental testing. **D. Buddhi, L. K. Sahoo.** 1997, Energy Convers. Mgmt, elsevier sci ltd, Vol. 38, pp. 493-498.

[9]. Institutional cooking with solar energy: A review. **Sunil Indora, Tara C. Kandpal.** 84, 2018, Renewable and Sustainable Energy Reviews , pp. 131-154.

[10]. Review on thermal energy storage with phase change materials and applications. **Atul Sharma, V.V. Tyagi, C.R. Chen, D. Buddhi.** 13, 2009, Renewable and Sustainable Energy Reviews, pp. 318-345.
[11]. Financial appraisal of using Scheffler dish for steam based institutional. **Sunil Indora, Tara C. Kandpal.** 30, 2018, Renewable Energy, pp. 1-12.
[12]. LATENT HEAT STORAGE SYSTEM FOR SOLAR THERMAL ENERGY APPLICATIONS. **Dheep., G. Raam.** 4, 2014, Voice of Research, Vol. 2, pp. 80-86.
[13]. A Review on Properties of phase change material for solar thermal storage system. **Kaushalendra Kumar Dubey, Radheshyam Mishra.** 2014, International Conference of Advance Research and Innovation , pp. 133-142.
[14]. Parametric Study on Phase Change Material Based Thermal Energy Storage System. **Kondakkagari Dharma Reddy, Pathi Venkataramaiah, Tupakula Reddy Lokesh.** 6, 2014, Energy and Power Engineering, scientific research, pp. 537-549.
[15]. Storage of Sensible Heat. **Hahne, E.** 2009, Energy Storage Systems Published by EOLSS Publication, oxford, UK, 2009, Vol. 1, pp. 1-9.
[16]. A Comprehensive Review of Thermal Energy Storage. **Ioan Sarbu, Calin Sebarchievici.** 10, 2018, sustainability, MDPI, pp. 1-32.
[17]. Parameters to take into account when developing a new thermochemical energy storage system. **Aran Solé, Xavier Fontanet, Camila Barreneche, Ingrid Martorell, A. Inés Fernández, Luisa F. Cabeza.** 30, 2012, Energy Procedia, pp. 380-387.
[18]. Experimental and numerical study of solidifying phase-change material in a triplex-tube heat exchanger with longitudinal/triangular fins. **Ammar M. Abdulateef, Jasim Abdulateef, Sohif Mat, Kamaruzzaman Sopian, Bashir Elhub, Munther Abdullah Mussa.** 90, 2018, International Communications in Heat and Mass Transfer, pp. 73-84.
[19]. A review of solar collectors and thermal energy storage in solar thermal. **Y. Tian, C.Y. Zhao.** 104, 2013, Applied Energy, pp. 538-553.
[20]. Heat transfer analysis of latent heat storage system using D-Sorbitol as PCM. **Beemkumar N., A. Karthikeyan, C. Parthasarathy, B. Bradley Bright.** 11, 2015, ARPN Journal of Engineering and Applied Sciences, Vol. 10, pp. 5017-5021.
[21]. Modeling and on-field testing of a Solar Rice Cooker. **S. Mahavar, P. Rajawat, V.K. Marwal, R.C. Punia, P. Dashora.** 49, 2013, Energy, pp. 404-412.
[22]. Evaluating the optimum load range for box-type solar cookers. **S. Mahavar, P. Rajawat, R.C. Punia, N. Sengar, P. Dashora.** 74, 2015, Renewable Energy, pp. 187-194.
[23]. Design development and performance studies of a novel Single Family Solar. **S. Mahavar, N. Sengar, P. Rajawat, M. Verma, P. Dashora.** 47, 2012, Renewable Energy, pp. 67-76.
[24]. Solar cooker of the portable parabolic type incorporating heat storage based on PCM. **Antonio Lecuona, José-Ignacio Nogueira , Rubén Ventas , María-del-Carmen Rodríguez-Hidalgo, Mathieu Legrand.** 111, 2013, Applied Energy, pp. 1136-1146.
[25]. Development and performance studies of a novel portable solar cooker using a curved Fresnel lens concentrator. **Yunsheng Zhao, Hongfei Zheng , Boyang Sun, Chenji Li, Yin Wu.** 174, 2018, Solar Energy, pp. 263-272.
[26]. Thermal performance evaluation of a latent heat storage unit for late evening cooking in a solar cooker having three reflectors. **D. Buddhi, S.D. Sharma , Atul Sharma.** 44, 2003, Energy Conversion and Management, pp. 809-817.
[27]. Solar cooking system with or without heat storage for families and institutions. **Klemens Schwarzer, Maria Eugenia Vieira da Silva.** 75, 2003, Solar Energy, pp. 35-41.
[28]. Thermal Analysis of a Thermal Energy Storage Unit to Enhance a Workshop Heating System Driven by Industrial Residual Water. **Wenqiang Sun, Zuquan Zhao, Yanhui Wang.** 10, 2017, Energies, MDPI, pp. 1-19.
[29]. Improvement of district heating network energy efficiency by pipe insulation renovation with PUR foam shells. **Vladislav Masatin, Anna Volkova, Aleksandr Hlebnikov, Eduard Latosov.** 11, 2017, Energy Procedia, pp. 265-269.
[30]. Recent Developments in Heat Transfer Fluids Used for Solar Thermal Energy Applications. **Umish Srivastva, RK Malhotra, SC Kaushik.** 6, 2015, Journal of Fundamental of Renewable Energy and application, Vol. 5, pp. 1-11.
[31]. Optimization and design of energy transport system for solar cooking application. **U.R. Prasanna, L. Umanand.** 88, 2011, Applied Energy, pp. 242-251.
[32]. Modeling and design of a solar thermal system for hybrid cooking application. **U.R. Prasanna, L. Umanand.** 88, 2011, Applied Energy, pp. 1740-1755.

[33]. Heat transport in evacuated perlite powders for super- insulated long term storage up to 300 deg C. **Thomas Beikircher, Matthias Demhanet.** 2013, Heat Transfer, ASME Journal, Vol. 135, pp. 1-11.
[34]. vacuum super insulated heat storage up to 400 C. **Thomas Beikircher, Gloria Streib.** IRES, At Düsseldorf : s.n., 2015. International Renewable Energy Storage Conference. pp. 1-10.
[35]. SODIUM NITRATE FOR HIGH TEMPERATURE LATENT HEAT STORAGE. **T. Bauer, D. Laing, U. Kröner, R. Tamme.** Stockholm, Sweden : s.n., 2009. The 11th International Conference on Thermal Energy Storage- Effstock.
[36]. Thermal energy storage with super insulating materials: a parametrical analysis. **Stefano Fantucci, Alice Lorenzati, Georgios Kazas, Dmytro Levchenko, Gianluca Serale.** 78, 2015, Energy Procedia, pp. 441-446.
[37]. Phase change material thermal energy storage system design and optimization . **Songgang Qiu, Maurice white.** Minneapolis, MN, USA : ASME, 2013. Proceeding of ASME 2013, 7th int. conf. on energy sustainability & 11th fuel cell science, engg & tech conference, ESfuel cell 2013. pp. 1-8.
[38]. Numerical simulation of three-dimensional flow dynamics in a hot water storage tank. **Simon Ievers, Wenxian Lin.** 86, 2009, Applied Energy, pp. 2604-2614.
[39]. Design and optimization of thermal storage tank using CFD. **Satish Kumar singh, Jayant Chaudhari.** 4, 2016, International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 4, pp. 126-131.
[40]. Design of Molten-Salt Thermocline Tanks for Solar Thermal Energy Storage. **S.M. Flueckiger, Z.yang, S.V.Garimella.** 2013, CTRC Research Publications, pp. 1-50.
[41]. Enhancement of Thermal Performance of Latent heat solar storage system. **Rishindra M. Sarviya, Ashish Agrawal.** 6, 2016, world economy of science, engg & tech, Int. jour. Of energy & power engg, Vol. 10, pp. 733-738.
[42]. An Overview Study of Solar Cookers. **Rahul Aadiwal, Manish Hassani, Pradeep Kumar.** 10, 2017, International Research Journal of Engineering and Technology (IRJET), Vol. 4, pp. 1651-1655.
[43]. Transition Temperatures of the Hydrates of Na2S04, Na2HP04 and KF as Fixed Points in Biomedical Thermometry. **R. L Magin, B. W. Mangum, J. A. Statler, D. D. Thornton.** 2, 1961, Journal of Research the National Bureau of Standards, Vol. 86, pp. 181-192.
[44]. Solar cooking in Mozambique—an investigation of end- user's needs for the design of solar cookers. **Otte, Pia Piroschka.** 74, 2014, Energy Policy, pp. 366-375.
[45]. Feasibility of a solar cooker in off sunshine hours using pcm as the source of heat. **Naveen kumar, Amit Budhiraja, Sourav Rohilla.** 1, 2016, Advances in Engineering: an International Journal (ADEIJ), Vol. 1, pp. 33-39.
[46]. solar food processing- authors experience with cooking and drying in costa rica. **Nandwani, Shyam S.** Germany : s.n., 2009. International Solar Food Processing Conference.
[47]. FABRICATION AND PERFORMANCE STUDY OF SLOPE TYPE ELECTRIC CUM SOLAR OVEN. **Muhammad Azam, Yasir Jamil, M. Musadiq, Rabab Zahira and M. Yasir Javed.** 3, 2009, Pak. J. Agri. Sci., Vol. 46, pp. 228-231.
[48]. Development of cooking sector in rural areas in India—A review. **Mohit Bansal, R.P. Saini, D.K. Khatod.** 17, 2013, Renewable and Sustainable Energy Reviews , pp. 44-53.
[49]. Design, manufacturing, thermal characterization of a solar cooker with compound parabolic concentrator and assessment of an integrated stove use monitoring mechanism. **Mauricio González-Avilés, Oralia Rodríguez Urrieta, Ilse Ruiz, Omar Masera Cerutti.** 45, 2018, Energy for Sustainable Development , pp. 135-141.
[50]. On the design, modelling and analysis of multi-shelf inclined solar cooker-cum-dryer. **Manpreet Singh, V.P. Sethi.** 162, 2018, Solar Energy, pp. 620-636.
[51]. Accelerated Thermal Cycling Test of Microencapsulated Paraffin Wax/Polyaniline Made by Simple Preparation Method for Solar Thermal Energy Storage. **Mahyar Silakhori, Mohammad Sajad Naghavi , Hendrik Simon Cornelis Metselaar , Teuku Meurah Indra Mahlia, Hadi Fauzi and Mohammad Mehrali.** 2013, Materials, MDPI journals, pp. 1608-1620.
[52]. Thermal analysis of PCM containing heat exchanger enhanced with normal annular fines. **M. J. Hosseini, M. Rahimi, R. Bahrampoury.** 6, 2015, Mechanical Sciences, Published by Copernicus Publications, pp. 221-234.
[53]. Rural Solar Cookers, an alternative to reduce the timber resource extraction through the use of renewable energy sources: technology transfer and monitoring project. **Luis Bernardo López Sosa, Mauricio González Avilés, Dante González Pérez, Yuritzi Solís Gutiérrez.** 57, 2014, Energy Procedia, pp. 1593-1602.

[54]. Influence of operational and design parameters on the performance of a PCM based heat exchanger for thermal energy storage – A review. **Lokesh Kalapala, Jaya Krishna Devanuri.** 20, 2018, Journal of Energy Storage , pp. 497-519.
[55]. A review of thermal energy storage designs, heat storage materials and. **Lameck Nkhonjer, Tunde Bello-Ochende, Geoffrey John, Cecil K. King'ondu.** 75, 2017, Renewable and Sustainable Energy Reviews, pp. 157-167.
[56]. Energy-Saving Analysis of Solar Heating System with PCM Storage Tank. **Juan Zhao, Yasheng Ji, Yanping Yuan, Zhaoli Zhang, Jun Lu.** 11, 2018, Energies, MDPI, pp. 1-19.
[57]. Combined heat loss analysis of trapezoidal shaped solar cooker. **Jayashree Nayak, Mohit Agrawal, Saumyakanta Mishra, Sudhansu S. Sahoob.** 12, 2018, Case Studies in Thermal Engineering, pp. 94-103.
[58]. Design, optimization and control of a thermal energy storage system. **Jaluria, Yogesh.** 1989, Energy storage systems, kluwer academic publishers, pp. 89-116.
[59]. Selection of Phase Change Material for Thermal Energy Storage in Solar Air Conditioning Systems. **Haoxin Xu, Jia Yin Sze, Alessandro Romagnolia, Xavier Py.** 105, 2017, Energy Procedia, pp. 4281-4288.
[60]. Various Aspects of Solar Energy Utilization: Review. **Hajian, Mehdi.** 2013, International Journal of Advanced Science and Technology, Vol. 58, pp. 41-50.
[61]. Experimental investigation of novel indirect solar cooker with indoor PCM thermal storage and cooking unit. **H.M.S. Hussein, H.H. El-Ghetany, S.A. Nada.** 49, 2008, Energy Conversion and Management, pp. 2237-2246.
[62]. THERMAL MODEL OF A SOLAR COOKER JORHEJPATARANSKUA. **González Avilés, José Juan, González-Avilés, Mauricio.** 57, 2014, Energy Procedia, pp. 1623-1631.
[63]. Eutectic mixtures of sugar alcohols fo rthermal energy storage. **G. Diarce, I.Gandarias, Á.Campos-Celador, A.García-Romero, U.J.Griesser.** 134, 2015, Solar Energy Materials & Solar Cells , pp. 2115-226.
[64]. Performance analysis of latent heat storage unit with packed bed system- an experimental approach for discharging process. **Dharati Patel, Krunal Khiraiya.** 4, 2015, International Journal of Engineering Research-Online, Vol. 3, pp. 1-7.
[65]. Solar thermal energy storage in power generation using phase change material with heat pipes and fins to enhance heat transfer. **D.J. Malan, R.T. Dobson, F. Dinter.** 69, 2015, Energy Procedia, pp. 925-936.
[66]. Solar water heaters with phase change material thermal energy storage medium: A review. **Anant Shukla, D. Buddhi , R.L. Sawhney.** 13, 2009, Renewable and Sustainable Energy Reviews, pp. 2119-2125.
[67]. Review on solar cooker systems: Economic and environmental study for di erent for Lebanese scenarios. **Amal Hereza, Mohamad Ramadana, Mahmoud Khaleda.** 81, 2018, Renewable and Sustainable Energy Reviews , pp. 421-432.
[68]. A thermodynamic review on solar box type cookers. **Abhishek Saxena, Varun, S.P. Pandey, G. Srivastav.** 15, 2011, Renewable and Sustainable Energy Reviews, pp. 3301-3318.
[69]. Heat storage materials, geometry and applications: A review. **Abhay Dinker, Madhu Agarwal , G.D. Agarwal.** 90, 2017, Journal of the Energy Institute , pp. 1-11.
[70]. Design, construction and study of a hybrid solar food processor in the climate of Costa Rica. **Nandwani, Shyam S.** 32, 2007, Renewable Energy, pp. 427-441.
[71]. Charging of a heat storage coupled with a low-cost small-scale solar parabolic trough for cooking purposes. **Maxime Mussard, Ole Jørgen Nydal.** 95, 2013, Solar Energy, pp. 144-154.
[72]. Development of a Thermal Energy Storage for the Integrated Solar Energy Project. **S.A. Sulaiman, F.L.Inambao.** 2011, R & D Journal of the South African Institution of Mechanical Engineering, pp. 6-11.
[73]. Advanced Heat Transfer and Thermal Storage Fluids. **L. Moens, D.M. Blake.** Denver, Colorado : National Renewable Energy Laboratory, 25-28 oct 2004. DOE Solar Energy Technologies of the U.S. Department of EnergyOffice. pp. 1-5.
[74]. Sodium nitrate for high temperature latent heat storage. **T. Bauer, D. Laing, U. Kröner, R. Tamme.** Stockholm, Sweden : s.n., 2009. The 11th International Conference on Thermal Energy Storage – Effstock. pp. 1-8.
[75]. Phase Change Material Selection for Thermal Processes Working under Partial Load Operating Conditions in the Temperature Range between 120 and 200 C. **Jaume Gasia, Marc Martin, Aran Solé, Camila Barreneche, Luisa F. Cabeza.** 7, 2017, applied Sciences, MDPI, p. 722.

[76]. Non-Conventional Energy Sources: Current Scenario and Future Trends, a key-note address. **Kale, D. M.** Hyderabad : s.n., 2012. 9th Biennial International conference & Exposition on petroleum Geophysics. pp. 520-524.
[77]. Review on solar water heater collector and thermal energy performance of circulating pipe. **M.S. Hossain, R. Saidur, H. Fayaz, N.A. Rahim, M.R. Islam, J.U. Ahamed, M.M. Rahman.** 15, s.l. : Elsevier ltd., 2011, Renewable and Sustainable Energy Reviews, pp. 3801-3012.
[78]. Solar thermal collectors and applications. **Kalogirou, Soteris A.** 30, 2004, Progress in Energy and Combustion Science, pp. 231-295.
[79]. **Yogesh, JAluria.** Design and Optimization of Thermal Systems. Singapor : The McGraw-Hill Companies, INC, 1998.
[80]. Material Selection for Shell and Tube Heat Exchanger Using. **Permatasari, Rosyida and Yusuf1, Adhi Muhammad.** s.l. : AIP Publishing, 1977. AIP Conference . pp. 060005-1–060005-6.
[81]. Thermal stability test of sugar alcohols as phase change materials for medium temperature energy storage application. **Solé, Aran and H Neumann, S Niedermaier, L F. Cabeza, El Palomo.** 48, 2014, Energy Procedia, elesevier, pp. 436-439.

Tharesh K. Gawande . "Comparative Study of Solar Cookers". *IOSR Journal of Engineering (IOSRJEN)*, 10(1), 2020, pp. 34-43.