iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: IX Month of publication: September 2023

DOI: https://doi.org/10.22214/ijraset.2023.55864

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue IX Sep 2023- Available at www.ijraset.com

Thermal Performance Evaluation of Trapezium Solar Cooker with Hexagonal Solar Cooker

Prakash Patel
Research Scholar, Mechanical Engineering Department, Drs. Kiran & Pallavi Patel Global University

Abstract: Energy has become the utmost necessity of our life. It is required from dawn to dusk to fuel the world. Energy is scattered everywhere around the Earth. Energy has always been an inextricable part of human life. The existence of living organisms on the earth is possible due to the solar radiations reaching the earth and the ozone layer that makes the most favorable temperature required for the functioning of enzymes and led to the existence of life and other sources required for supporting the survival of life. The present work aim on fabrication of trapezium and hexagonal cooker and their thermal performance comparison to evaluate based on their temperature values using K type thermocouples.
Keywords: Trapezium Solar Cooker, Hexagonal Solar Cooker, K-type thermocouples. Solar Energy, Temperature, Renewable Energy.

I. INTRODUCTION

Solar energy, whether directly or indirectly, represents the primary source of renewable energy available to humanity. In the field of solar engineering for thermal processes, a variety of methods are widely employed to enhance the performance of heat exchangers. However, in most cases, commercially available methods for improvement are currently inadequate. Furthermore, an effective energy management program must incorporate energy storage to accommodate shifting demands and achieve optimal performance from the primary power source. Solar-resistant water heaters are promising candidates for improving heat transfer. Recent studies have focused on the development of solar water heaters. Solar energy is derived from the sun, which generates energy through a process known as nuclear fusion. During this process, four hydrogen nuclei combine to form a helium nucleus, releasing energy in the process. This energy is emitted into space as solar radiation, with a small fraction reaching the Earth. Solar energy is utilized in various applications, including solar heating, distillation, drying, and cooking. The use of solar energy for cooking presents a viable alternative to traditional energy sources such as wood, kerosene, and other fuels commonly used in developing countries for food preparation.

The Parabolic square dish cooker has been introduced by M.M. El-Kassaby in 1991 [1]. H. Nemati et al optimized the dimension of parabolic solar cooker using 400 different materials [2]. Temperature profiling of parabolic concentrator on different climatic conditions is graphically explained by A. Claude et al [3]. Two parabolic reflectors were used in the solar cooker designed by Yogesh R Suple et al [4]. An asymmetrical compound parabolic concentrator is used in the proposed cooker as booster reflector [5]. The overall heat loss factor (FUL) of a paraboloidal solar cooker is discussed by S.R. Kalbande et al [6]. The low cost parabolic type solar cooker has been designed by Hasan Huseyin Ozturk [7]. The performance of a paraboloidal solar cooker under no load, water heating and rice cooing is discussed by S.R. Kalbande et al [8]. Shukla A [9] has been studied that the importance of energy in economic development is very critical as there is a strong relationship between energy and economic activity. Mondal [10] has been studied and investigated the advantage of latent heat that can be stored or released from a material over a narrow temperature range. Lahkar et al.[11] proposed a universal parameter for evaluating the optical and thermal performance of different cooker types called the opto-thermal ratio. Mussard et al. [12] compared a direct and an indirect concentrating solar cooker with similar characteristics, including a sun tracker system. Ammer [13] carried out research on the title, theoretical and experimental evaluation of double publicity photo voltaic cooker, respectively. D.Y Dasin [14] carried out an overall performance contrast of parabolic concentrator photo voltaic electricity cooker in tropical surroundings in Abubakar Tafawa et al [15] carried out water pasteurization using a solar box cooker. V.P. Sethi et.al [16] focused on optimally inclined box type solar cooker with parallelepiped cooking vessel design S.B. Joshi et.al [17] studied on hybrid solar cooker. H. Zamani et.al [18] fabricated of parabolic solar cooker with three adjustable mirrors, which can be placed on the parabolic path according to the sun's position. S. Mahanvar et.al [19] developed box solar cooker with electric power back up. Yunsheng Zhao et.al [20] concentrated on novel portable solar cooker using a curved fresnel loss concentrator.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue IX Sep 2023- Available at www.ijraset.com

A. Saxena et.al [21] studied hybrid solar cooker with air duct. John J. TODD et al [22] fabricated solar cooker from cardboard and evaluated its testing and performance. Muluken Biadgelegn Wollele [23] designed and fabricated solar cooker and studied the effect of thermal storage system. Schwarzer K, et al. [24] conducted a performance analysis of flat plate type solar cooker with vegetable oil as the TES material. Mussard M. [25] carried out a low cost small-scale solar concentric collector coupled with a thermal energy storage unit for higher temperature cooking. Senthil R. et al. [26] proposed that the sensible heat transfer materials were found effective in the storage of heat as well as aiding conduction heat transfer during the cooking process. Sharma SD. et al. [27] had investigated a solar cooker based on an evacuated tube solar collector coupled with phase change material (PCM) commercial grade erythritol. Saxena A. et al. [28] studied several types of PCMs to check their suitability as heat storage for cooking purposes using a box type solar cooker. Rajendra C. Patil et al [29] reviewed different types of solar cooker on the basis of their thermal performance. A theoretical investigation on the performance of PCMs has also been conducted by Chen et al. [30]. The studies from [31] [32] Anand Patel et al. for solar cooker; [33-45] Patel Anand et al. Solar air & water heater, hybrid combination such as solar heater & heat exchanger, hybrid car with solar/renewable systems; [46, 47, 48, 49] Anand Patel et al. [50] Thakre, Shekhar et al for heat exchanger includes thermal performance enhancement studies by varying the design of solar absorber plate, material, integration review in an hybrid system which will help to performance comparative analysis between trapezium and hexagonal solar cooker.

II. EXPERIMENTAL SETUP

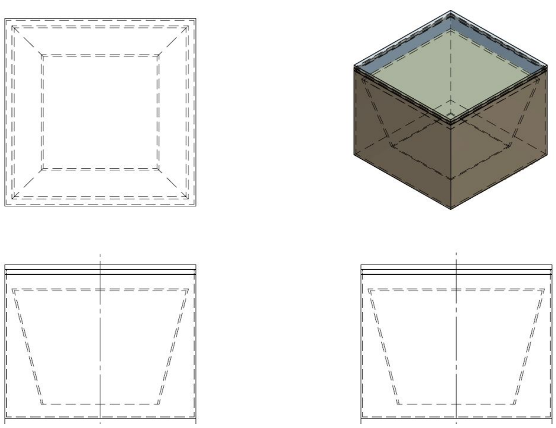

Fig. 1: CAD Model of Trapezium Solar Cooker

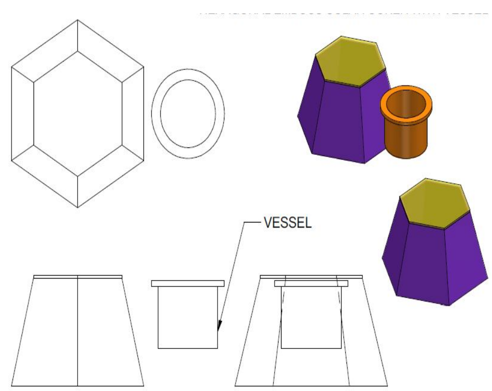

Fig. 2: CAD Model of Hexagonal Solar Cooker

Fig. 3: Trapezium Solar Cooker

Fig, 4: Hexagonal Solar Cooker

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue IX Sep 2023- Available at www.ijraset.com

Fig. 5: Aluminium Vessels

In this work totally two experimental set up are fabricated one of trapezium solar cooker and other one is of hexagonal solar cooker; and for this work 12 mm sheet wooden is used and the box of size 1’X 1’ X 1’ is fabricated and inside two boxes using mirror of 2 mm thick is stick with silicon glue inside the two solar cooker of trapezium and hexagonal shapes are fabricated. The top of the both boxes are covered with 2 mm transparent glass sheet is hinged in wooden frame of 1’X 1’. With similar box dimensions the mirrors of 2 mm thick and six numbers in pieces are placed so that the top portion makes 12” diameter and at bottom of box 4”; Similarly in case of trapezium solar cooker using four tapper mirror of 1” height with top and bottom dimensions are such so after fabricating solar cooker at bottom 4” and 12” space is available at top. The base circle will formed on size of aluminium vessel. Aluminium vessel is painted with black colour which is placed inside the cooker and K type thermocouple is placed in both set up two measure temperature inside the vessel.

III.RESULT AND DISCUSSION

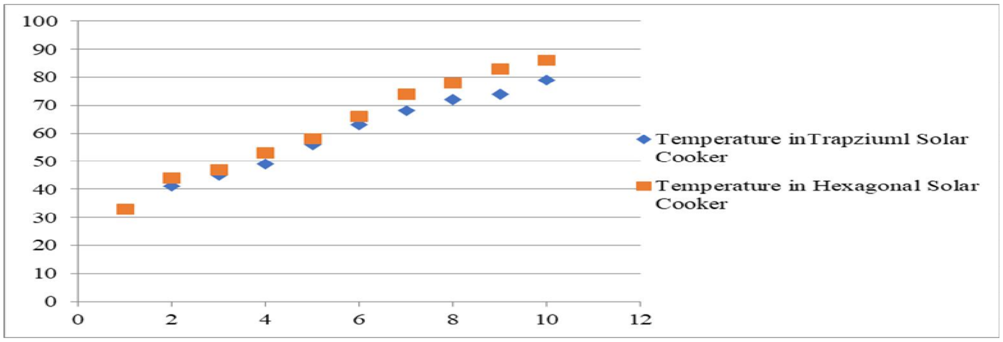

Fig. 6: Temperature Variation without Vessel

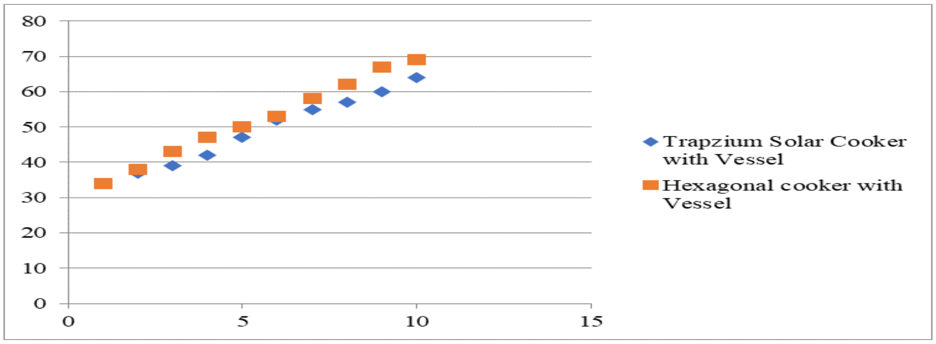

Fig. 7: Temperature Variation with Vessel

Fig. 6 and Fig. 7 show temperature variation in case of hexagonal and trapezium solar cooker without and with vessel respectively. From both figures it is obvious that compare to trapezium solar cooker in case of hexagonal the temperature values are higher as compared to trapezium solar cooker may be because of in case hexagonal solar cooker due to its shape better black body effect can be obtained and due to shape from all directions solar radiation can be penetrated inside the solar cooker.

IV. CONCLUSIONS

The major outcome of this work is that shape and orientation of solar cooker play an important role in performance of solar cooker.

REFERENCES

[1] M.M.El-Kassaby, New solar cooker of parabolic square dish: design and simulation, Renewable energy Volume 1, 1991.
[2] H. Nemati and M. J. Javanmardi, Exergy optimization of domestic solar cylindrical-parabolic cooker," J. Renewable Sustainable Energy Volume 4, 2012.
[3] M. Balakrishnan, A. Claude and D. R. Arun Kumar, Engineering, design and fabrication of a solar cooker with parabolic concentrator for heating, drying and cooking purposes," Archives of Applied Science Research, Volume 4 2012
[4] Yogesh R. Suple and N.N. Suraskar, Design and Fabrication Of Manually Track Parabolic Solar Disc for In-House Cooking, International Journal of Modern Engineering Research (IJMER) Volume 2, 2012.
[5] A. Harmim et al., Mathematical modeling of a box-type solar cooker employing an asymmetric compound parabolic concentrator, Solar Energy, Volume 86, 2012.
[6] S.R.Kalbande et al., "Design Theory and Performance Analysis of Paraboloidal Solar Cooker," Applied Solar Energy, Volume 44, 2008.
[7] Hasan Huseyin Ozturk, Experimental determination of energy and exergy efficiency of the solar parabolic-cooker," Solar Energy, Volume 77, 2004.
[8] S.R.Kalbande et al., Design, Development and Testing of Paraboloidal Solar Cooker," Karnataka J. Agric. Sci., Volume 20, 2007.
[9] Shukla A., Buddhi D., Sawhney R.L., Solar Water Heaters with Phase Change Material Thermal Energy Storage Medium: A Review, Renewable and Sustainable Energy Reviews, Volume 13, 2009
[10] Mondal S., Phase Change Materials for Smart Textiles AnOvervie, Volume 28 2008
[11] A.K. Pandey, V.V. Tyagi, S.R. Park, S.K. Tyagi, Comparative experimental study of solar cookers using exergy analysis, Journal of Thermal Analysis and Calorimetry Volume 109 2011
[12] H. Zamani, M. Moghiman, A. Kianifar, Optimization of the parabolic mirror position in a solar cooker using the response surface method (RSM), Renewable Energy Volume 81, 2015
[13] Ammer E.H, Theoretical and experimental assessment of double exposure solar cooker, Energy Conservation and Management Volume 44, 2003.
[14] Dasin D.Y, Habou D, Rikoto , Performance evaluation of parabolic solar 1concentrator against international standard procedure in the tropical Environment. Nigerian Journal of Renewable Energy, Volume 15, 2011.
[15] Aramesh Mohamad, Galebani Mehdi, Kaseian Alibakhsh, Zamani Hosein , Lorenzini Giulio, Mahian Omid and Wongwises Somchai A Review on Recent Advances in solar cooking technology Renewable Energy Volume140, 2019.
[16] Joshi S B , Jani A R Design, development and testing of a small scale hybrid solar cooker Solar Energy Volume, 122, 2015
[17] Zamani Hosein, Moghiman Mohammad, Kianifar Ali Optimization of the parabolic mirror position in a solar cooker using the response surface method (RSM) Renewable Energy Volume 81, 2015
[18] Mahavar S, Sengar N, Dashora P Analytical model for electric back-up power estimation of solar box type cookers Energy Volume 132, 2017
[19] Zhao Yunsheng, Zheng Hongfei, Sun Boyang, Li Chenji and Wu Yin Development and performance studies of a novel portable solar cooker using a curved Fresnel lens concentrator Solar Energy Volume 174, 2018
[20] Cuce Edrem Improving thermal power of a cylindrical solar cooker via novel micro/nano porous absorbers: A thermodynamic analysis with experimental validation Solar Energy Volume 176, 2018
[21] Saxena Abhishek, Agarwal Nitin Performance characteristics of a new hybrid solar cooker with air duct Solar Energy Volume 159 2018
[22] John J. TODD and Sunny MILLER, Performance Testing of Cardboard, Solar Box-Cookers, Environment Science,1999
[23] Muluken Biadgelegn Wollele and Abdulkadir Aman Hassen, Design and experimental investigation of solar cooker with thermal energy storage, AIMS Energy, Volume 7, 2019
[24] Schwarzer K, Da Silva MEV Solar cooking system with or without heat storage for families and institutions. Solar Energy Volume 75, 2003.
[25] Mussard M. A solar concentrator with heat storage and self-circulating liquid. Norwegian University of Science and Technology, Norway, 2013.
[26] Senthil R, Cheralathan M Thermal performance of solid and liquid energy storage materials in a parabolic dish solar cooker. Int J Chem Sci Volume 14, 2016.
[27] Sharma SD, Iwata T, Kitano H, et al. Thermal performance of a solar cooker based on an evacuated tube solar collector with a PCM storage unit. Sol Energy Volume 78, 2005.
[28] Saxena A, Lath S, Tirth V Solar cooking by using PCM as thermal heat storage. MIT Int J Mech Eng Volume 3, 2013.
[29] Rajendra C. Patil Mahesh M. Rathore Manojkumar Chopra, An Overview of Solar Cookers, 1st International Conference on Recent Trends in Engineering & Technology, Mar-2012
[30] Chen, C.R., et al., Numerical Heat Transfer Studies of PCMs Used in a Box-Type Solar Cooker, Renewable Energy, Volume 33 2008.
[31] Anand Patel, "Comparative Thermal Performance Analysis of Circular and Triangular Embossed Trapezium Solar Cooker with and without Heat Storage Medium", International Journal of Science and Research (IJSR), Volume 12 Issue 7, July 2023, pp. 376-380, https://www.ijsr.net/getabstract.php?paperid=SR23612004356.
[32] Patel, Anand.""Comparative Thermal Performance Analysis of Box Type and Hexagonal Solar Cooker"", International Journal of Science & Engineering Development Research (www.ijsdr.org), ISSN:2455-2631, Vol.8, Issue 7, page no.610 - 615, July-2023, Available :http://www.ijsdr.org/papers/IJSDR2307089.pdf".
[33] Patel, A (2023). ""Comparative analysis of solar heaters and heat exchangers in residential water heating"". International Journal of Science and Research Archive (IJSRA),09(02), 830–843. https://doi.org/10.30574/ijsra.2023.9.2.0689."
[34] Patel, A. (2023). Enhancing Heat Transfer Efficiency in Solar Thermal Systems Using Advanced Heat Exchangers. Multidisciplinary International Journal of Research and Development (MIJRD), 02(06), 31–51. https://www.mijrd.com/papers/v2/i6/MIJRDV2I60003.pdf.
[35] Patel, Anand "Optimizing the Efficiency of Solar Heater and Heat Exchanger Integration in Hybrid System", TIJER - International Research Journal (www.tijer.org), ISSN:2349-9249, Vol.10, Issue 8, page no.b270-b281, August-2023, Available :http://www.tijer.org/papers/TIJER2308157.pdf

[36] Patel, A. (2023). Thermal Performance of Combine Solar Air Water Heater with Parabolic Absorber Plate. International Journal of All Research Education and Scientific Methods (IJARESM), 11(7), PP: 2385–2391. http://www.ijaresm.com/uploaded_files/document_file/Anand_Patel3pFZ.pdf

[37] Patel, Anand. "Effect of W Rib Absorber Plate on Thermal Performance Solar Air Heater." International Journal of Research in Engineering and Science (IJRES), vol. 11, no. 7, July 2023, pp. 407–412. Available: https://www.ijres.org/papers/Volume-11/Issue-7/1107407412.pdf

[38] Patel, Anand. "Performance Evaluation of Square Emboss Absorber Solar Water Heaters." International Journal For Multidisciplinary Research (IJFMR), Volume 5, Issue 4, July-August 2023, PP 01-09. https://doi.org/10.36948/ijfmr.2023.v05i04.4917

[39] Anand Patel. (2023). Thermal Performance Analysis of Wire Mesh Solar Air Heater. Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal, 12(2), 91–96. Retrieved from https://www.eduzonejournal.com/index.php/eiprmj/article/view/389

[40] Patel, A (2023). "Thermal performance analysis conical solar water heater". World Journal of Advanced Engineering Technology and Sciences (WJAETS), 9(2), 276–283. https://doi.org/10.30574/wjaets.2023.9.2.02286

[41] Patel, A (2023). "Efficiency enhancement of solar water heaters through innovative design". International Journal of Science and Research Archive (IJSRA),10(01), 289–303. https://doi.org/10.30574/ijsra.2023.10.1.0724.

[42] Anand Kishorbhai Patel, 2023. Technological Innovations in Solar Heater Materials and Manufacturing. United International Journal for Research & Technology (UIJRT), 4(11), pp13-24.

[43] Patel, Anand. "OPTIMIZING SOLAR HEATER EFFICIENCY FOR SUSTAINABLE RENEWABLE ENERGY." CORROSION AND PROTECTION, ISSN: 1005-748X, vol. 51, no. 2, 2023, pp. 244–258, www.fsyfh.cn/view/article/2023/02-244.php.

[44] Patel, Anand. "SOLAR HEATER-ASSISTED ELECTRIC VEHICLE CHARGING STATIONS: A GREEN ENERGY SOLUTION." Hangkong Cailiao Xuebao/Journal of Aeronautical Materials (ISSN: 1005-5053), vol. 43, no. 02, 2023, pp. 520–534, www.hkclxb.cn/article/view/2023/2-520.html.

[45] Patel, A. (2023). ENHANCING SUSTAINABILITY: A REVIEW OF HYBRID VEHICLE TECHNOLOGIES POWERED BY RENEWABLE ENERGY. Yantu Lixue/Rock and Soil Mechanics (ISSN: 1000-7598), 44(06), 386–400. https://doi.org/10.5281/zenodo.8056589.

[46] Patel, Anand "Performance Analysis of Helical Tube Heat Exchanger", TIJER - International Research Journal (www.tijer.org), ISSN:2349-9249, Vol.10, Issue 7, page no.946-950, July-2023, Available :http://www.tijer.org/papers/TIJER2307213.pdf.

[47] Patel, Anand. "EFFECT OF PITCH ON THERMAL PERFORMANCE SERPENTINE HEAT EXCHANGER." INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING (IJRAME), vol. 11, no. 8, Aug. 2023, pp. 01–11. https://doi.org/10.5281/zenodo.8225457.

[48] Patel, Anand. "Advancements in Heat Exchanger Design for Waste Heat Recovery in Industrial Processes." World Journal of Advanced Research and Reviews (WJARR), vol. 19, no. 03, Sept. 2023, pp. 137–52, doi:10.30574/wjarr.2023.19.3.1763.

[49] Patel, Anand. "Heat Exchanger Materials and Coatings: Innovations for Improved Heat Transfer and Durability." International Journal of Engineering Research and Applications (IJERA), vol. 13, no. 9, Sept. 2023, pp. 131–42, doi:10.9790/9622-1309131142.

[50] Thakre, Shekhar, Pandhare, Amar, Malwe, Prateek D., Gupta, Naveen, Kothare, Chandrakant, Magade, Pramod B., Patel, Anand, Meena, Radhey Shyam, Veza, Ibham, Natrayan L., and Panchal, Hitesh. "Heat transfer and pressure drop analysis of a microchannel heat sink using nanofluids for energy applications" Kerntechnik, 2023. https://doi.org/10.1515/kern-2023-0034.