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EFFECT OF INSERTED STRIP DIRECTION ON THERMAL PERFORMANCE ON EVACUATED SOLAR WATER HEATER

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ABSTRACT

The solar energy is becoming excellent energy source in 21st century mainly due to two reasons are: availability in ample amount and pollution free energy. The solar energy can be utilized for water heating, drying of agriculture products and for power generation purpose also. The hot water having various domestic as well as industrial applications and in case of domestic application of hot water almost 15-20 % energy is utilized. The objective of present research work is to fabricate two experimental set up of evacuated tube solar water heater (ETC) and by using augmentation method like twisted tape insertion with same pitch and different direction to evaluate thermal performance of ETC.

KEYWORDS: Evacuated Tube Solar Water Heater, Inserted Strip, Flow rate, Temperature, Twisted tape.

INTRODUCTION

Indeed, though the Sun is an important source of energy and sun is the most common type of energy entered by the Earth, the intensity of sun at the Earth's face is rather low. Because of the huge radial spread of light from the away Sun, this is the primary cause. Solar radiation is absorbed or scattered by Earth's atmosphere and shadows, performing in just a negligible quantum of fresh loss. Only around 45 of the sun's energy is visible light, with the rest being infrared, ultraviolet, and other types of electromagnetic radiation in trace quantities. This is the most common way to use solar energy. Generally, this includes a collection device that's

constantly exposed to sun radiation. This might be either absorbing or concentrating. In the first script, a dark face is exposed to the sun and absorbs radiation. The energy absorbed is also transmitted to a fluid in contact with the absorber. Solar radiation is a clean energy source that can be used in a number of marketable and domestic operations. The transfer of sun energy to heat is among the most straightforward and easiest operations. As a consequence, by erecting a solar flat force for heating water, the domestic sector reduces environmental impacts.

O.P Shuklaet al.[1] used CFD to evaluate the performance of a solar water heater employing a flat typed plate collector and the evacuated tubes with the fin tubes. Jichun Yanget. Al.[2] tested the influence of glass tube inserting in evacuated tube solar water heater, which causes water to be forcefully circulated in all glasses evacuated solar collector tubes, hence improving solar collector performance. Murtuzavasanwala et. Al.[3] conducted a review of previous research and various strategies for improving the thermal efficiency of evacuating solar water heaters. Experiments were carried out by Jain Pankaj K at.el.[4] in the case of an evacuated tube solar hot water utilising phase change material. A.A. Satam.[5] discussed in detailed about the construction features of evacuated tube solar water heater including its constructional and design features. Tushar Choudhary et al.[6] investigated if an evacuating U tube solar water heating system is among the most effective techniques of solar thermal power collection when mass flow variation is taken into account utilizing tape angle movement. CFD analysis of a moisture evacuated tube collector of solar was performed by Zaw Min Thant et al.[7] G.L.Morrison et al.[8] discussed about numerical study for thermal performance carried out on single long evacuated solar tube collector. I.George et al.[9] carried out optimization of evacuated tube solar water heater using response surface method (RSM). A. I. Sato.[10] employed computational fluid dynamics to do a numerical investigation of evacuated solar tube water (CFD). The effects of tube combustion at 15° and 30° with horizontal of an evacuated tube solar water heater were explored by Arpan Das et al.[11] Deshmukh K B et al,[12] reviewed about various methods in case of solar water heater including the limitation of research. Flat plated solar water heaters and evacuated tube solar water heaters were compared by P. Vijayakumar et al.[13] Selvakumar P et al.[14] detailed experimental analysis carried out on corrugated plate solar water heater under practical conditions along with mathematical validation. K Ashok Reddy.[15] critically reviewed the research work carried out by various researchers for the thermally performance improvement of evacuated solar water heater. Hitendra et al.[16,17,18] focused on thermal performance of

evacuated tube solar water heater with twisted tape insertion. P.P.Patil et al.[19] focused on design consideration of the solar water heaters to obtain hot water for the domestic and industrial applications. Chii-Dong Ho et al.[20] investigated and theoretically studied on the double pass sheet and tube solar water heater with attaching internal fins on tube walls internally. L. Chilambarasan et al.[21] worked on helical internal grooved solar flat plate collectors to enhance their conversion efficiency by reducing heat loss from the collector surface. Mr. Ganesh et al.[22] conducted experimental investigations on solar flat plate collectors by changing the geometry of the fin. Vikas Reddy Chittireddy et al.[23] studied flat plate solar collector with an air conditioning radiator as a heat absorber for a domestic Water heater. K.Balaji et al.[24] focused on thermodynamics analysis of a solar flat plate water heater using an extended surface absorber tube. He studied the effect of with and without extended surface by using a data acquisition system. S saravanan et al.[25] experimental investigation on the flat plate solar water heater with glass as an absorber material to check the thermal performance of difference absorbent such as absorber black painted clear toughened glass plate sandwich type. Hardik A. Parmar et al.[26] zeroed down on its thermal performance and derived its time-dependent efficiency value change. Besma Chekchek et al.[27] built a solar water heater out of recycled soda bottles and tested its efficiency. The number and configuration of riser tubes emanating from the current collector were investigated by Sivakumar et al.[28] Kulkarni et al.[29] looked into how different tube configurations affected the overall SWH performance. The absorber fin of both rectangular and circular SWHS piqued the curiosity of Ramasamy et al.[30] To improve heat transfer, they increased the surface area, but kept the pressure drop and the outlet speed constant. To improve the efficiency y of troughs concentrating photovoltaic SWH, Sudhakar et al.[31] used four different solar cell array types and different shaped receivers. The thermal performance of a spiral tube solar water heater, which comprises of a copper tube and a flat plate collector, was compared to that of a conventional straight tube solar water heater by Jignesh A. Patel et al.[32] The,[33-48] Patel Anand et al. for Solar Air and Water Heater.[49,50] Patel Anand for Solar Cooker,[51,52] for Heat Exchange studies include thermal performance analysis to increase heat transfer by varying the dimensions of solar collector or adding different materials to it which is similar to the current study in this article.

Experimental Set Up

Figure 1: Full Length Evacuated Tube with Coupler.

Figure 2: Twisted Tape Insertions in Evacuated Tube.

Figure 3: Right Hand and Left Hand Twisted Tape.

Figure 4: Complete Experimental Set up.

In the experimental work principally there are 2 evacuated type tubes solar water heaters set up each having three evacuated glass tubes of 1 m length and with diameter of 40 mm as outer diameter of tube and diameter of 20 mm as inner tube. No black coating is used to show strip insertion inside the evacuated tube and this is the reason why there is slightly low temperature compare to temperature obtained by other researchers. In the present experimental set up to insert the tape inside the tubes and connect those tubes with water tank coupler or reducers are used in both experimental set up.

RESULT AND DISCUSSION

In the present experimentation the observations are taken at interval of 30 min using K type thermocouples placed at inlet and outlet of water tank for slow medium and fast flow rate of water in case of both experimental models. The water flow rate is measured using conventional method of measuring flak and stop watch with flow adjustment using tape connected with storage tank.

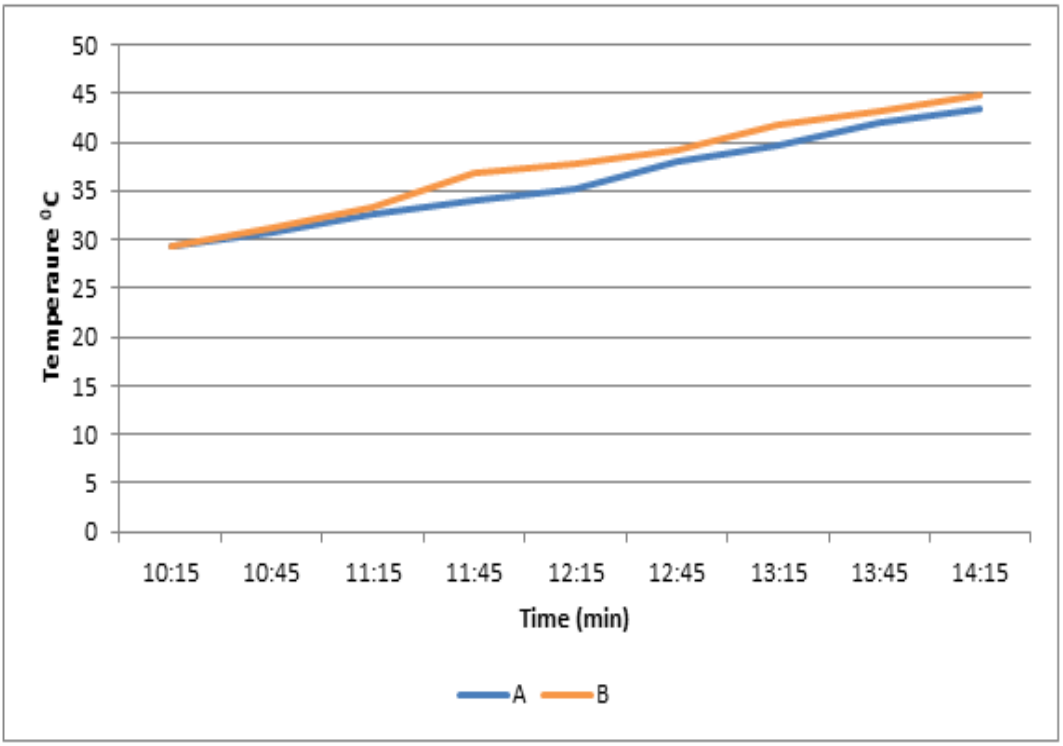

Figure 5: Temperature Variation for Low Flow Rate A: Right Hand Twisted Tape in Evacuated Tube B: Left Hand Twisted Tape in Evacuated Tube.

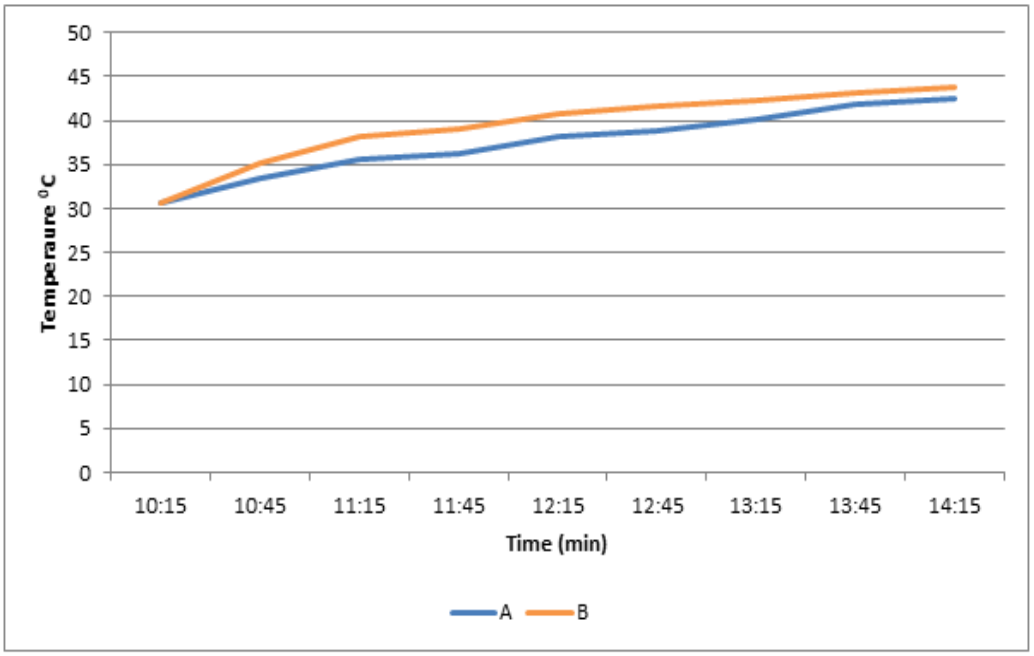

Figure 6: Temperature Variation for Medium Flow Rate.

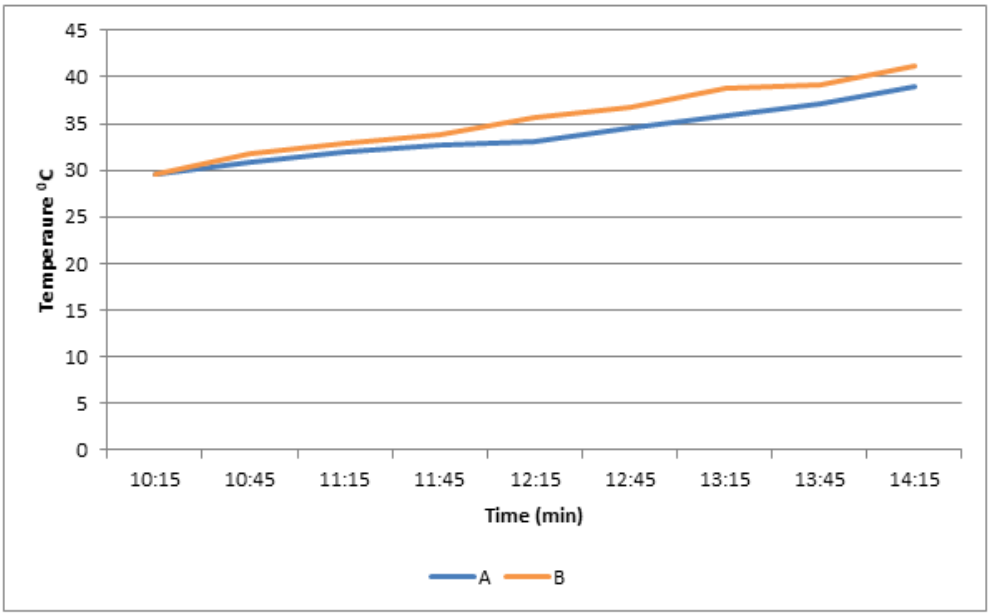

Figure 7: Temperature Variation for High Flow Rate.

From observations it is clear that flow rate is the influencing factor and at high flow rate the gain in temperature is low due to less retention time for water. Most interesting observation in the present work is as the direction of flow of water is from left to right and so in case of left twisted tape inserted in the more increment in water temperature which may due to opposite direction of rotation of flow which may cause more holding period of water inside the tube and more solar radiation is absorbed by water.

CONCLUSION

The conclusion of this work is that not only due to insertion of twisted tape the thermal performance is improved but due to direction of twisted tape insertions is equally important in comparison of direction water entry.

REFERENCES

1. O.P Shukla, Deepanjal Kumar Gupta, Performance Evaluation of Solar Water Heater by Using Flat Plate Collector and Evacuated Tubes with Fin Tube Using CFD, IJIRT, 2018; 5.
2. Jichun Yang, Qingyang Jiang, JingxinHou, and ChenglongLuo, A Study on Thermal Performance of a Novel All-Glass Evacuated Tube Solar Collector Manifold Header with an Inserted Tube, International Journal of Photoenergy, 2015.
3. Murtuzavasanwala, Shah yash, Virangpathak, Mehulgolarana, Parimalpatil, A Review Paper on Solar Water Heater by Evacuated Tube, International Journal of Advance Engineering and Research Development, Special Issue SIEICON, 2017.
4. Jain Pankaj K, MutalikdesaiSachin V, Bharambe Ganesh P, Performance Evaluation of Evacuated Glass Tube Solar Collector With Latent Heat Storage Material, IJEDR, 2016; 6.
5. A.A. Satam, A Descriptive Study of the Constructional Features of Evacuated Tube Solar Water Heating System, OSR-JMCE, 2013.
6. Tushar Choudhary, Kumar Shridhar Experimental Investigation and Fabrication of An Evacuate Tube Solar Collector, IJSR, 2013.
7. Zaw Min Thant, MyatMyatSoe, Maw MawHtay Numerical Study on Temperature Distribution of Water-In-Glass Evacuated Tubes Solar Water Heater, 2015; 2.
8. G.L. Morrison, I. Budihardjo, M. Behnia, Water-In-Glass Evacuated Tube Solar Water Heaters, Solar Energy, 2004; 76.
9. I.George, R.Kalaivanan, Optimization of Thermal Performance on Evacuated Tube Solar Collector Water Heating System, Int. Journal of Engineering Research and Application, 2017; 7.
10. A. L.Sato, V. L. Scalon and A. Padilha, Numerical Analysis of A Modified Evacuated Tubes Solar Collector, International Conference on Renewable Energies and Power Quality Santiago de Compostela (Spain), 2012.

11. Arpan Das, Arindam Saha, Study of Influence of Tilt Angle And Flow Rate on the Performance of Evacuated Tube Solar Collector, International Journal of Engineering Research & Technology, 2019; 8.
12. Deshmukh K B, S V Karmare, Review on Augmentation of Convective Heat Transfer Techniques in Solar Water Heating, Journal of Thermal Energy Systems Volume 4, 2019.
13. P.Vijayakumar, S.Sathish Kumar, S.Sakthivelu, R.Shanmuga Prakash, Comparison of Evacuated Tube And Flat Plate Solar Collector – A Review, World Wide Journal of Multidisciplinary Research and Development, 2017; 3.
14. Selvakumar P, Somasundaram, Experimental Analysis on Solar Water Heater with Corrugated Absorber for Enhanced Heat Transfer, Journal of Thermal Energy Systems, 2016; 1.
15. Dr K Ashok Reddy, A Critical Review of Solar Evacuated Tube Collector Used for Enhancement of Heat Transfer Rates, International Journal of Engineering Technology Science and Research, 2018; 5.
16. Hitendra Chudhary and Sadanand Namjoshi, A paper titled Comparative Thermal Performance Evaluation of Single and Double Twisted Tape Inserted in Evacuated Solar Water Heater, Asian Journal of Organic & Medicinal Chemistry, ISSN: 2456 -8937, 2022; 7.
17. Hitendra Chudhary and Sadanand Namjoshi, A paper titled ― Experimental Investigation and Fabrication of an Evacuate Tube Solar Water Heater with and without Twisted Tape Holes on Surface of Twisted Tape Stochastic Modeling & Applications, 2022; 26.
18. Hitendra Chudhary and Sadanand Namjoshi, National Virtual Conference on Recent Advances in Technology & Engineering (CRATE 2021) on 13th & 14th Aug, paper titled ―Experimental Investigation of Inserted Twisted tape Pitch effect in Evacuated Solar Water Heater Rishi's Online National Conference on Manage, 2021.
19. P. P.Patil, Dr.D.S.Deshmukh. Design Considerations for Flat Plate Solar Water Heater System, 2015; 3.
20. Chii-Dong Ho,Tsung-Ching ChenCollector Efficiency of Double-Pass Sheet-and-Tube Solar Water Heaters with Internal Fins Attached, 2007.
21. L.Chilambarasan, G. Niranjan and Raja Sekhar Y Performance study of Flat Plate Collector with Internally Grooved tubes, 2018.

22. Vikas Reddy Chittireddy, Ahmed ElSawy and Stephen Idem study of a flat plate solar collector with an air conditioner radiator as a heat absorber for a domestic water heater, 2018.
23. Ganesh K. Badgujar, Sachin Nimbulkar and Rajesh Dahibhate Experimental investigation on solar flat plate collector by changing geometry of fin, 2017.
24. K.Balaji , S.Iniyan and A.Idrish khan Thermodynamic analysis of a solar flat plate water heater using extended surface absorber tube, 2015.
25. S. Saravanan, N. Krishna Mohan Experimental investigation on the flat plate solar water heater with glass as absorber material, 2016.
26. Hardik A. Parmar, Ravi K. Dayata, Dr. Sadanand Namjoshi, Experimental Investigation of Thermal Performance of Serpentine Solar Water Heater, International Journal for Scientific Research & Development, 2015; 3.
27. Besma Chekchek, Mohamed Salm, Abdelhakim Boursas, Giulio Lorenzini, Hijaz Ahmad, Younes Menni, Houari Ameur, Merzaqa Merrah, Djamal Fridja, Experimental Study of the Efficiency of a Solar Water Heater Construction from Recycled Plastic Bottles ,International Journal of Design & Nature and Ecodynamics, 2021; 16.
28. Sivakumar, P., Christraj, W., Sridharan, M., Jayamalathi, N, Performance improvement studies of solar water heating system. ARPN J. Eng. Appl. Sci., 2012; 7.
29. Kulkarni, M.M., Deshmukh, D, Design of experiment for solar water heater performance analysis. Pratibha, International Journal of Science, Spirituality, Business and Technology, 2015; 3.
30. Ramasamy, S., Balashanmugam, P. Thermal performance analysis of the solar water heater with circular and rectangular absorber fins. International Journal of Innovative Science, Engineering and Technology, 2015; 21.
31. Sudhakar, M., Prasad, R., Ravinthiran, A., Dutt, P.,Chakaravarthi, M.A , Performance improvement of trough concentrating photovoltaic thermal system: A review. Materials Today: Proceedings, 2019; 16.
32. Jignesh A. Patel, Tejendra B. Patel, Sadanand Namjoshi,Comparative Study of Thermal Performance of Spiral Tube Solar Water Heater with Straight Tube Solar Water Heater, International Journal for Scientific Research & Development, publication)," *IEEE J. Quantum Electron.*, submitted for publication, 2015; 3.
33. Patel, A. Thermal Performance of Combine Solar Air Water Heater with Parabolic Absorber Plate. International Journal of All Research Education and Scientific Methods

(IJARESM), 2023; 11(7): 2385–2391. http://www.ijaresm.com/uploaded_files /document_file/Anand_Patel3pFZ.pdf

34. Patel, Anand. “Effect of W Rib Absorber Plate on Thermal Performance Solar Air Heater.” International Journal of Research in Engineering and Science (IJRES), July 2023; 11(7): 407–412. Available: https://www.ijres.org/papers/Volume-11/Issue-7/1107407412.pdf.
35. Patel, Anand. "Performance Evaluation of Square Emboss Absorber Solar Water Heaters." International Journal For Multidisciplinary Research (IJFMR), 2023; 5(4). https://doi.org/10.36948/ijfmr.2023.v05i04.4917.
36. Anand Patel. “Thermal Performance Analysis of Wire Mesh Solar Air Heater”. Eduzone: International Peer Reviewed/Refereed Multidisciplinary Journal, 2023; 12(2): 91-96. https://www.eduzonejournal.com/index.php/eiprmj/article/view/389.
37. Patel, A. "Thermal performance analysis conical solar water heater". World Journal of Advanced Engineering Technology and Sciences (WJAETS), 2023; 9(2): 276–283. https://doi.org/10.30574/wjaets.2023.9.2.02286.
38. Anand Patel. "Effect of Inclination on the Performance of Solar Water Heater." International Journal for Scientific Research and Development, 2023; 11(3): 413-416.
39. Patel, Anand. "The Performance Investigation of Square Tube Solar Water Heater", International Journal of Science & Engineering Development Research (www.ijsdr.org), ISSN:2455-2631, June-2023; 8(6): 872 – 878. Available :http://www.ijsdr.org /papers/IJSDR2306123.pdf
40. Anand Patel. ""Comparative Thermal Performance Investigation of Box Typed Solar Air heater with V Trough Solar Air Heater"". International Journal of Engineering Science Invention (IJESI), 2023; 12(6): 45-51. Journal DOI- 10.35629/6734.
41. Patel, Anand, et al. “Comparative Thermal Performance Evaluation of U Tube and Straight Tube Solar Water Heater.” International Journal of Research in Engineering and Science (IJRES), June 2023; 11(6): 346–352. www.ijres.org/index.html.
42. Patel, A., Namjoshi, Dr. S., & Singh, S. K. Comparative Experimental Investigation of Simple and V-Shaped Rib Solar Air Heater. International Journal of All Research Education and Scientific Methods (IJARESM), 2023; 11(6): 2993–2999. http://www.ijaresm.com/uploaded_files/document_file/Anand_PatelYHv7.pdf
43. Patel, Anand. “Experimental Investigation of Oval Tube Solar Water Heater With Fin Cover Absorber Plate.” International Journal of Enhanced Research in Science, Technology & Engineering, July 2023; 12(7): 19–26. doi:10.55948/IJERSTE.2023.0704.

44. Patel, Anand. “Comparative Thermal Performance Evaluation of V-shaped Rib and WShape Rib Solar Air Heater.” International Journal of Research Publication and Reviews, July 2023; 14(7): 1033–1039.
45. Patel, Anand. “Experimental Evaluation of Twisted Tube Solar Water Heater.” International Journal of Engineering Research & Technology (IJERT), vol. 12, issue no. 7, IJERTV12IS070041, July 2023; 30- 34. https://www.ijert.org/research /experimental-evaluation-of-twisted-tube-solar-water-heater-IJERTV12IS070041.pdf.
46. Patel, Anand.“Comparative Thermal Performance Investigation of the Straight Tube and Square Tube Solar Water Heater.” World Journal of Advanced Research and Reviews, 2023; 19(01): 727–735. https://doi.org/10.30574/wjarr. 2023.19.1.1388.
47. Patel, A. ""Comparative analysis of solar heaters and heat exchangers in residential water, 2023. heating"". International Journal of Science and Research Archive (IJSRA), 09(02): 830–843. https://doi.org/10.30574/ijsra.2023.9.2.0689.
48. Patel, A. Enhancing Heat Transfer Efficiency in Solar Thermal Systems Using Advanced Heat Exchangers. Multidisciplinary International Journal of Research and Development (MIJRD), 2023; 02(06): 31–51. https://www.mijrd.com/papers /v2/i6/MIJRDV2I60003. pdf.
49. 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), 2023; 12(7): 376-380, https://www.ijsr.net/getabstract.php?paperid=SR23612004356.
50. 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, July-2023; 8(7): 610 – 615. Available :http://www.ijsdr.org/papers/IJSDR2307089.pdf".
51. Anand Patel, "Thermal Performance Investigation of Twisted Tube Heat Exchanger", International Journal of Science and Research (IJSR), 2023; 12(6): 350-353, https://www.ijsr.net/getabstract.php?paperid=SR23524161312, DOI: 10.21275/SR23524 161312
52. Patel, Anand "Performance Analysis of Helical Tube Heat Exchanger", TIJER - International Research Journal (www.tijer.org), ISSN:2349-9249, 2023; 10(7): 946-950. Available :http://www.tijer.org/papers/TIJER2307213.pdf.