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Comparative Thermal Performance Investigation of Box Typed Solar Air heater with V Trough Solar Air Heater

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ABSTRACT: *The energy which is available in the form of heat or thermal energy from sun is having wide application for heating and cooking. The solar energy can be utilized for water heating and air heating and that hot air can be used of drying also for humidification and dehumidification too in food process industries. The present work concentrated on the comparative thermal performance analysis of conventional solar air heater with proposed V trough solar air heater corresponding to variable air velocity.*

KEYWORDS – Air Velocity, Air Outlet Temperature, Body Temperature, Solar Air Heater, V Trough and Sun

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I. Introduction

The energy crisis seems to be getting worse every year. The need for both thermal energy and electrical power rises as industrial production does. It is generally accepted that the burning of various solid, liquid, and gaseous fossil fuels accounts for a sizable fraction of the world's overall energy consumption. Heating with sun energy has been around since ancient times. In the past, solar heat was collected and transferred via passive methods, meaning no mechanical aids like pumps, fans, or heat exchangers were utilized. Heat is collected and transferred through passive solar heating techniques such as radiation, natural convection, thermo syphon flow, and the thermal characteristics of materials. However, pumps and fans are used in active solar heating systems to expedite fluid flow and heat transfer. By definition, passive systems are those in which heat is transferred solely through unaided processes including conduction, radiation, and natural convection. Solar energy may be used to provide heating and lighting, and natural air can be used to provide cooling, thanks to passive design elements. According to research by TabishAlam [1], using winglets in air heaters is an effective way to generate turbulence and hence boost the heater's heat transfer rate. According to research conducted by Anil Singh Yadav [2], adding artificial roughness to the ducts of a solar-powered air heater improves its effectiveness by increasing the rate at which heat is transferred to the fluid flowing through the duct. The thermal performance of a double-pass solar-powered air heater with fins and baffles was tested by Chii-Dong Ho [3] in a recycling operation. Using a novel solar collector design, FouedChabane [4] was able to achieve the transfer of heat in a solar based air heater. Experiments have been conducted to compare the collector efficiency of a solar air heater with and without fins connected under the absorbing plate. The purpose of this research, conducted by AlirezaZendehboudi [5] in a warm and humid region of Iran, is to evaluate the efficiency of a Solar Desiccant Cooling System manufactured by TRNSYS. M. A. Aravindh et al. [6] looked at creating a solar air heater using wire mesh as the absorber due to its nominal porosity and its potential use in drying applications. Air is permitted to circulate via a double-layered wire mesh that was employed as absorber material in this innovation. The impact of various obstructions on the thermal performance of a solar air heater was experimentally investigated by EbruKavakAkpinarit et al. [7]. In this work, we evaluated four different solar air collectors and compared their first and second-law efficiencies. The layout of a solar powered air heater featuring offset strip fins has been optimized using numerical modeling by Ming Yang, Xudong, et al. [8]. A.A. El-Sebaii et al. [9] investigated how changing the coating on the absorber plate of a solar air heater affected its efficiency. Using exergy analysis, M. Sabzpooshani et al. [10] looked into the efficiency of solar air heaters. Exergy efficiency was studied by changing variables such as fin and baffle dimensions, glass cover count, bottom insulation thickness, and inlet air temperature across a range of mass flow rates. Solar air heaters using granular carbon as the absorbing media were developed and tested by Abhishek Saxena et al. [11]. The thermal performance of a solar air heater using a compound parabolic concentrator was investigated by Rene Tchinda [12]. The thermal performance of a fin-covered solar air heater was the primary focus of Patel Anand et al. [13]. Patel Anand et al [14] centered their attention on developing and testing a spiral solar air heater. [15] [16] [17] [19] [56] Anand Patel et al [18] HD Chaudhary et al. thermal performance evaluation due to different geometries and dimension changes within a solar heater. Solar Heater heat transfer enhancement methodology and practical feasibility are

conceptualized using [20] [21] [22] [23] [24] [25] [31] [33] [34] along with different similar renewable applications [29] [30]. The thermal performance enhancement for solar heater is studied in [26] Cylindrical Solar Water Heater [27] Different type of turbulators in solar ware heater [28] historical solar water heating system work review paper [32] glass evacuated solar water heater [35] solar air heater for low temperature applications. [36] literature review of CFD analysis application in Solar Air Heater [37] [38] [39 [40] [41] experimental and thermal analysis of V-trough solar air heater. [42] [43] [44] [45] [46] [47] [48] [49] [50] U-shaped heat exchangers in parabolic trough solar collector for air heating applications. Thermal performance evaluation of V-trough solar air heater along with a drying storage [51] [52] [53] [54] [55].

II. EXPERIMENTAL METHODOLOGY

Plate 1 Base plate

Plate 2 Base plate with V Trough

Plate 3 Blower

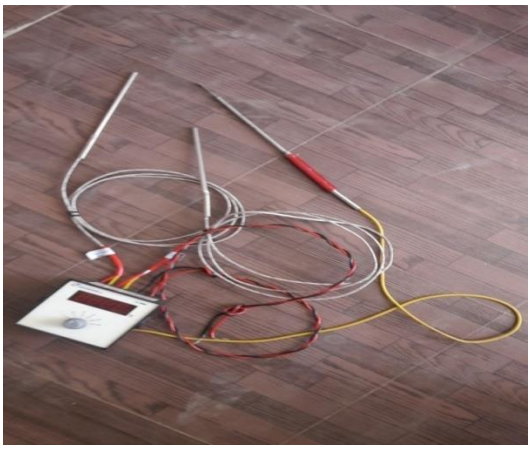

Plate 4 Temperature Indicator

Plate 5 Anemometer

Plate 6 Experimental Set up of Conventional and V trough Solar Air Heater

In the existing work two solar air heaters are fabricated with dimensions of 1m*0.5m*0.025mof woodenstructure and the whole assembly of wooden of wooden structure is covered with bottom blackcoated base plate in conventional solar air heater and in one set up and in other set up V trough base plate is used; while 2 mm transparent glass sheet is used to cover top of both solar based air heater. The individual blower is connected with each set up to supply air and anemometer is used for air velocity measurement and K type thermocouple is for temperature measurement purpose. The special electric arrangement is used to reduce the air velocity by regulating blower speed.

III. EXPERIMENTAL PROCEDURE

Initially both experimental set up placed in north south orientation and then start air flow of using blower and take observation of body temperature and air outlet temperature in both set up at interval of 7 minutes.

IV. RESULT AND DISCUSSION

Table 1 Observation Table

V3=6.1 m/s & t=7 mint						
	Simple			V trough		
Time	T1 (IN)	T2 (BODY)	T3 (OUT)	T4 (IN)	T5 (BODY)	T6 (OUT)
7	39	100	67	39	106	79
14	39	71	60	39	73	67
21	39	75	61	39	79	66

28	39	77	60	39	79	68
35	39	75	60	39	77	65
42	39	72	60	39	76	65
49	39	73	61	39	76	66
56	39	72	60	39	75	65
63	39	71	59	39	76	65
70	39	73	60	39	76	66
77	39	71	60	39	75	66
84	39	74	60	39	75	65
91	39	73	61	39	76	65
98	39	70	58	39	75	64
105	39	72	58	39	75	65
112	39	71	58	39	74	65
119	39	70	57	39	72	63
126	39	68	57	39	71	63
133	39	67	57	39	70	62
140	39	67	56	39	71	62

Table 2 Result Tables

	Simple	V trough		Simple	V trough
Ma	Qa	Qa	Qi	Efficiency	Efficiency
0.004	0.10	0.14	0.83	12.25	17.50
0.004	0.08	0.10	0.83	9.19	12.25
0.004	0.08	0.10	0.83	9.62	11.81
0.004	0.08	0.10	0.83	9.19	12.69
0.004	0.08	0.09	0.83	9.19	11.37
0.004	0.08	0.09	0.83	9.19	11.37
0.004	0.08	0.10	0.83	9.62	11.81
0.004	0.08	0.09	0.83	9.19	11.37
0.004	0.07	0.09	0.83	8.75	11.37
0.004	0.08	0.10	0.83	9.19	11.81
0.004	0.08	0.10	0.83	9.19	11.81
0.004	0.08	0.09	0.83	9.19	11.37
0.004	0.08	0.09	0.83	9.62	11.37
0.004	0.07	0.09	0.83	8.31	10.94
0.004	0.07	0.09	0.83	8.31	11.37
0.004	0.07	0.09	0.83	8.31	11.37
0.004	0.06	0.09	0.83	7.87	10.50
0.004	0.06	0.09	0.83	7.87	10.50
0.004	0.06	0.08	0.83	7.87	10.06
0.004	0.06	0.08	0.83	7.44	10.06

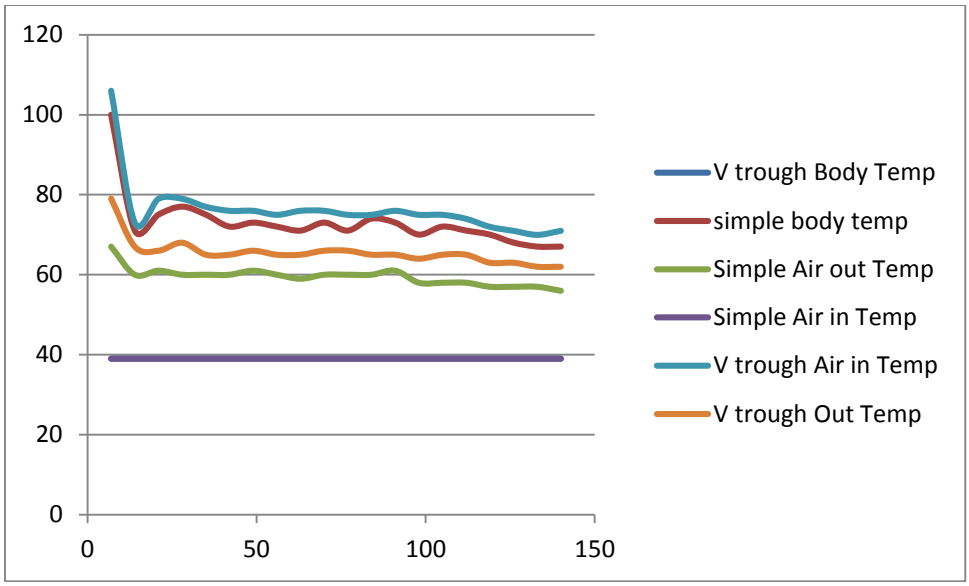

Fig 1 Temperature Variation with Respect to Time

In the existing work compare to simple solarized heater in case of V trough solar powered air heater, air temperature at outlet is high which may be because due to V trough turbulence in the flow is created which enhances rate of heat transfer also in V trough radiation network form which leads to increase the outlet temperature value.

V. CONCLUSION

The major outcome of the present work is that in case of solar powered air heater with the artificial surface roughness or due to modified geometry of base plate of solar powered air heater thermal effectiveness of solar powered air heater can be improved.

FUTURE SCOPE

In case of solar air heater creating more artificial surface of V and W shapes on base plate and by varying air velocity thermal effectiveness of solar powered air heater can be evaluated.

REFERENCES

[1]. TabishAlam , R.P.Saini , J.S.Saini, Heat and Flow characteristics of air heater ducts provided with tabulators —A review, Renewable and Sustainable Energy Reviews Volume 31 2014

[2]. Anil SinghYadav , ManishKumarThapak, Artificially roughened solar air heater: Experimental investigations, Renewable and Sustainable Energy Reviews Volume 36 2014

[3]. Chii-Dong Ho, Hsuan Chang, Rei-Chi Wang, Chun-Sheng Lin, Performance improvement of a double-pass solar air heater with fins and baffles under recycling operation, Applied Energy Volume 100 2012

[4]. FouedChabane, Noureddine Moummi, Said Benramache, Djamel Bensahal, and OkbaBelahssen , Collector Efficiency by Single Pass of Solar Air Heaters with and without Using Fins, Engineering Journal Volume 17, 2013

[5]. AlirezaZendehboudi , Abbas Zendehboudi1,2 and Ramin Hashemi, A Study on the Performance of a Solar Desiccant Cooling System by TRNSYS in Warm and Humid Climatic Zone of IRAN, International Journal of Advanced Science and Technology Volume 69, 2014

[6]. M. A. Aravindh and A. Sreekumar, Experimental and economic analysis of a solar matrix collector for drying application, Current Science, VOL. 107, NO. 350 3, 10 AUGUST 2014

[7]. EbruKavakAkpinar , FatihKocyig it Energy and exergy analysis of a new flat-plate solar air heater having different obstacles on absorber plates Applied Energy Volume 87, 2010

[8]. Ming Yang , Xudong Yang , Xing Li , Zhifeng Wang, Pengsu Wang Design and optimization of a solar air heater with off set strip fin absorber plate Applied Energy Volume 113, 2014

[9]. A.A. El-Sebaii, H. Al-Snani Effect of selective coating on thermal performance of flat plate solar air heaters Energy Volume 35 ,2010

[10]. M. Sabzpooshani, K. Mohammadi, H. Khorasanizadeh Exergetic Performance Evaluation Of A Single Pass Baffled Solar Air Heater Energy 64 (2014) 697e706

[11]. AbhishekSaxena , Nitin Agarwal , Ghansyham Srivastava Design and performance of a solar air heater with long term heat storage International Journal of Heat and Mass Transfer, Volume 60 2013

[12]. Rene Tchinda Thermal behaviour of solar air heater with compound parabolic concentrator Energy Conversion and Management Volume 49, 2008

[13]. Anand Patel, Divyesh Patel, Sadanand Namjoshi (2018); Thermal Performance Evaluation of Spiral Solar Air Heater; Int J Sci Res Publ 5(9) (ISSN: 2250-3153). http://www.ijsrp.org/research-paper-0915.php?rp=P454598

[14]. Patel, Anand K., and Sadanand Namjoshi. "International Journal of Engineering Science and Futuristic Technology" (2017) "Thermal Performance Analysis of Fin Covered Solar Air Heater", Volume 03, Issue 01, Page 9-12.

[15]. Anand Patel and Sadanand Namjoshi, "Phase change material based solar water heater," International Journal of Engineering Science Invention., vol. 5, no. 8, August 2016.

[16]. Patel A, Parmar H, Namjoshi S 2016 Comparative thermal performance studies of serpentine tube solar water heater with straight tube solar water heater. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 13 79–83.

[17]. Anand Patel, Divyesh Patel, Sadananad Namjoshi Thermal Performance Analysis of Helical Solar Water Heater, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-5 Issue-3, August 2015.

[18]. HD Chaudhary, SA Namjoshi, A Patel, Effect of Strip Insertion on Thermal Performance Evaluation in Evacuated Tube Solar Water Heater with Different Inner Tube Diameter REVISTA GEINTEC-GESTAO INOVACAO E TECNOLOGIAS, Volume 11, Issue 3, Page- 1842-1847.

[19]. Anand Patel. "Effect of Inclination on the Performance of Solar Water Heater." International Journal for Scientific Research and Development 11.3 (2023): 413-416.

[20]. Anand Patel, "Thermal Performance Investigation of Twisted Tube Heat Exchanger", International Journal of Science and Research (IJSR), Volume 12 Issue 6, June 2023, pp. 350-353, https://www.ijsr.net/getabstract.php?paperid=SR23524161312, DOI: 10.21275/SR23524161312.

[21]. S. Jaisankar, J. Ananth, S. Thulasi, S.T. Jayasuthakar, K.N. Sheeba, A comprehensive review on solar water heaters, Renewable and Sustainable Energy Reviews,Volume 15, Issue 6, 2011, Pages 3045-3050, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2011.03.009.

[22]. A review of solar water heating systems, N. V. Ogueke; E. E. Anyanwu; O. V. Ekechukwu Crossmark: Check for Updates Author & Article Information Journal of Renewable and Sustainable Energy 1, 043106 (2009) https://doi.org/10.1063/1.3167285.

[23]. Ruchi Shukla, K. Sumathy, Phillip Erickson, Jiawei Gong, Recent advances in the solar water heating systems: A review, Renewable and Sustainable Energy Reviews, Volume 19, 2013,Pages 173-190,

[24]. ISSN 1364-0321, https://doi.org/10.1016/j.rser.2012.10.048.

[25]. Patel et al., IJAET/Vol.III/ Issue IV/Oct.-Dec. 2012/146-149, REVIEW OF SOLAR WATER HEATING SYSTEMS

[26]. Patel, AK, & Zhao, W. "Heat Transfer Analysis of Graphite Foam Embedded Vapor Chamber for Cooling of Power Electronics in Electric Vehicles." Proceedings of the ASME 2017 Heat Transfer Summer Conference. Volume 1: Aerospace Heat Transfer; Computational Heat Transfer; Education; Environmental Heat Transfer; Fire and Combustion Systems; Gas Turbine Heat Transfer; Heat Transfer in Electronic Equipment; Heat Transfer in Energy Systems. Bellevue, Washington, USA. July 9–12, 2017. V001T09A003. ASME. https://doi.org/10.1115/HT2017-4731.

[27]. Hussain Al-Madani, The performance of a cylindrical solar water heater, Renewable Energy, Volume 31, Issue 11, 2006, Pages 1751-1763, ISSN 0960-1481, https://doi.org/10.1016/j.renene.2005.09.010.

[28]. (https://www.sciencedirect.com/science/article/pii/S0960148105002648).

[29]. S. Vasanthaseelan, P. Manoj Kumar, R. Anandkumar, K. Hari Ram, Ram Subbiah, V. Suresh, A.S. Abishek, R. Anith, P. Aravinth, S.V. Balaji, Investigation on solar water heater with different types of turbulators, Materials Today: Proceedings, Volume 47, Part 15, 2021, Pages 5203-5208, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2021.05.530.

[30]. (https://www.sciencedirect.com/science/article/pii/S2214785321041390).

[31]. S. Sadhishkumar, T. Balusamy, Performance improvement in solar water heating systems—A review,

[32]. Renewable and Sustainable Energy Reviews, Volume 37, 2014, Pages 191-198, ISSN 1364-0321,

[33]. https://doi.org/10.1016/j.rser.2014.04.072. (https://www.sciencedirect.com/science/article/pii/S1364032114003104).

[34]. Nikul K. Patel, Anand K. Patel, Ragesh G. Kapadia, Shailesh N. Shah, Comparative Study of Production and Performance of Bio-fuel Obtained from Different Non-edible Plant Oils, International Journal of Energy Engineering, Vol. 5 No. 3, 2015, pp. 41-47. doi: 10.5923/j.ijee.20150503.01.

[35]. Nikul K Patel, Padamanabhi S Nagar , Shailesh N Shah , Anand K Patel , Identification of Non-edible Seeds as Potential Feedstock for the Production and Application of Bio-diesel, Energy and Power, Vol. 3 No. 4, 2013, pp. 67-78. doi: 10.5923/j.ep.20130304.05.

[36]. Patel, Anand, and Nikul Patel. "Engineering Science and Futuristic Technology." (2016) "Techique to Measure Convective Heat Transfer", Volume 02 Issue12, Page 01-08.

[37]. G.L. Morrison, I. Budihardjo, M. Behnia,Water-in-glass evacuated tube solar water heaters,

[38]. Solar Energy, Volume 76, Issues 1–3, 2004, Pages 135-140, ISSN 0038-092X,

[39]. https://doi.org/10.1016/j.solener.2003.07.024 (https://www.sciencedirect.com/science/article/pii/S0038092X03002925).

[40]. R.S. Gill, Sukhmeet Singh, Parm Pal Singh, Low cost solar air heater, Energy Conversion and Management, Volume 57, 2012, Pages 131-142, ISSN 0196-8904, https://doi.org/10.1016/j.enconman.2011.12.019.(https://www.sciencedirect.com/science/article/pii/S0196890412000027).

[41]. A.A. Mohamad, High efficiency solar air heater, Solar Energy, Volume 60, Issue 2, 1997,

[42]. Pages 71-76, ISSN 0038-092X, https://doi.org/10.1016/S0038-092X(96)00163-6.

[43]. (https://www.sciencedirect.com/science/article/pii/S0038092X96001636).

[44]. C. Choudhury, S.L. Andersen, J. Rekstad, A solar air heater for low temperature applications,

[45]. Solar Energy, Volume 40, Issue 4, 1988, Pages 335-343, ISSN 0038-092X,

[46]. https://doi.org/10.1016/0038-092X(88)90006-0. (https://www.sciencedirect.com/science/article/pii/0038092X88900060).

[47]. Anil Singh Yadav, J.L. Bhagoria, Heat transfer and fluid flow analysis of solar air heater: A review of CFD approach, Renewable and Sustainable Energy Reviews, Volume 23,

[48]. 2013, Pages 60-79, ISSN 1364-0321, https://doi.org/10.1016/j.rser.2013.02.035.

[49]. (https://www.sciencedirect.com/science/article/pii/S1364032113001378).

[50]. G. Kalaiarasi, R. Velraj, M.N. Vanjeswaran, N. Ganesh Pandian Experimental analysis and comparison of flat plate solar air heater with and without integrated sensible heat storage, Renewable Energy, 150 (2020), pp. 255-265

[51]. C.-E. Bensaci, A. Moummi, F.J. Sanchez de la Flor, E.A. Rodriguez Jara, A. Rincon-Casado, A. Ruiz-Pardo, Numerical and experimental study of the heat transfer and hydraulic performance of solar air heaters with different baffle positions, Renew. Energy, 155 (2020), pp. 1231-1244.

[52]. H.K. Ghritlahre, P.K. Sahu, S. Chand, Thermal performance and heat transfer analysis of arc shaped roughened solar air heater – An experimental study, Solar Energy, 199 (2020), pp. 173-182.

[53]. M. Abuşka, Energy and exergy analysis of solar air heater having new design absorber plate with conical surface, Applied Thermal Engineering, 131 (2018), pp. 115-124.

[54]. B.A. SunilRaj, M. Eswaramoorthy,Performance study on forced convection mode V-trough solar air heater with thermal storage: An experimental approach, Materials Today: Proceedings, Volume 72, Part 3, 2023, Pages 1664-1672, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2022.09.450.

[55]. (https://www.sciencedirect.com/science/article/pii/S2214785322062678).

[56]. Sunil Nain, Vishal Ahlawat, Sanjay Kajal, Parinam Anuradha, Ashutosh Sharma, Tej Singh,

[57]. Performance analysis of different U-shaped heat exchangers in parabolic trough solar collector for air heating applications, Case Studies in Thermal Engineering, Volume 25, 2021, 100949,
[58]. ISSN 2214-157X, https://doi.org/10.1016/j.csite.2021.100949.
[59]. (https://www.sciencedirect.com/science/article/pii/S2214157X2100112X).
[60]. S. Nain, P. Anuradha, S. Kajal, Experimental study and analysis of air heating system using a parabolic trough solar collector, Int. J. Ambient Energy, 39 (2018), pp. 143-146.
[61]. E. Bellos, C. Tzivanidis, D. Tsimpoukis, Optimum number of internal fins in parabolic trough collectors, Appl. Therm. Eng., 137 (2018), pp. 669-677.
[62]. J. Muñoz, A. Abánades, Analysis of internal helically finned tubes for parabolic trough design by CFD tools, Appl. Energy, 88 (2011), pp. 4139-4149.
[63]. K.S. Reddy, G.V. Satyanarayana, Numerical study of porous finned receiver for solar parabolic trough concentrator, Eng. Applic. Comput. Fluid Mech., 2 (2014), pp. 172-184.
[64]. A. Yadav, M. Kumar Balram, Experimental study and analysis of parabolic trough collector with various reflectors, Int. J. Math. Comput. Nat. Phys. Eng., 7 (2013), pp. 1659-1663.
[65]. A. Caglar, Design of a parabolic trough solar collector using a concentrator with high reflectivity
[66]. Proceedings of the 2nd World Congress on Mechanical, Chemical, and Material Engineering (MCM'16) Budapest, Hungary - August 22–23, 2016 (2016), 10.11159/htff16.152, Paper No. HTFF 152.
[67]. N.A. Kumbhar, S.R. Shinde, V.S. Shinde, Performance investigation of parabolic trough solar collector integrated with thermal energy storage system, International Journal of Current Engineering and Technology (2016), pp. 424-430.
[68]. D. Njomo, M. Daguenet, Sensitivity analysis of thermal performances of flat plate solar air heaters, Heat Mass Tran., 42 (2006), pp. 1065-1081.
[69]. Eswaramoorthy, M. Thermal performance of V-trough solar air heater with the thermal storage for drying applications. Appl. Sol. Energy 52, 245–250 (2016). https://doi.org/10.3103/S0003701X16040071.
[70]. Sukhante, S.P. and Nayak, J.K., Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill Education Inc., 2014.
[71]. Klychev, Sh.I., Bakhramov, S.A., Ismanzhanov, A.I., et al., Thermo technical efficiency of two-channel solar air heater, Appl. Solar Energy, 2008, vol. 44, no. 3, pp. 169–171.
[72]. Iskandarov, Z.S., Rakhmatov, O., Salomov, M.N., et al., Double chamber solar and fuel drying unit for agricultural products, Appl. Solar Energy, 2011, vol. 47, no. 1, pp. 24–26.
[73]. Isaev, S.M. and Sadykov, Zh.D., A mathematical model of heat-exchange control in solar green houses, Appl. Solar Energy, 2014, vol. 50, no. 2, pp. 103–109.
[74]. "The Performance Investigation of Square Tube Solar Water Heater", International Journal of Science & Engineering Development Research (www.ijsdr.org), ISSN:2455-2631, Vol.8, Issue 6, page no.872 - 878, June-2023, Available:http://www.ijsdr.org/papers/IJSDR2306123.pdf.

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