Indian Journal of Advanced Physics (IJAP)
ISSN: 2582-8983 (Online), Volume-2 Issue-2, October 2022

Heat Transfer Investigation of a Flat Plate Solar Collector

R. Rame Kumar

Abstract*: *Because of the low value of the convective heat transfer coefficient between the absorber plate and the air, the thermal efficiency of a solar air heater is greatly reduced, resulting in high absorber plate temperatures and large heat losses to the surrounding environment. The analysis of heat transmission in a solar air heater is presented in this research, which makes use of Computational Fluid Dynamics. An investigation is conducted into the effect of the Reynolds number on the Nusselt number and friction factor. It is necessary to study and visually depict the nature of the flow across the duct of a solar air heater, which is done using a commercial finite volume software. The findings of the CFD simulations are found to be in excellent agreement with the experimental results. Because of this, the average Nusselt number increases as the Reynolds number grows, and the average friction factor reduces as the Reynolds number increases as well.

Keywords*: *Flat Plate Solar Collector, Heat Transfer, Pressure Drop, Solar Energy.

I. INTRODUCTION

A low convective heat transfer coefficient between the absorber plate and the air has been discovered to produce poor thermal performance in conventional solar air heaters. This is due to the low convective heat transfer coefficient between the absorber plate and the air. It has been discovered that adding artificial rib roughness to the underside of the absorber plates can significantly improve the heat transfer coefficient. As a result of their ease of use, solar air warmers are one of the cheapest and most extensively used solar energy collection devices available. They have a great deal of potential in low temperature applications, particularly in the drying of agricultural products [1-22]. The thermal efficiency of a solar air heater is significantly reduced as a result of the low value of the convective heat transfer coefficient between the absorber plate and the surrounding air, which results in a high temperature on the absorber plate and significant heat losses to the surrounding environment. It has been discovered that the creation of a laminar sub-layer on the heat-transferring surface of the absorber plate is the primary source of thermal resistance to heat transfer in this system. Projections that produce artificial roughness on the heat transfer surface, primarily near the wall, or disrupt the laminar sub-layer, increase the heat transfer coefficient by increasing the turbulence near the wall. The fan or blower, on the other hand, must provide the energy necessary to generate such turbulence. Consequently, only the laminar sub-layer, which is extremely close to the heat transfer surface, should be subjected to turbulence, while the rest of the layer should remain smooth. In an effort to improve convective heat transfer while minimising pumping losses, some researchers have sought to create a roughness element [23-44].

As a result of their ease of use, solar air warmers are one of the cheapest and most extensively used solar energy collection devices available. They have a great deal of potential in low temperature applications, particularly in the drying of agricultural products. The thermal efficiency of a solar air heater is significantly reduced as a result of the low value of the convective heat transfer coefficient between the absorber plate and the surrounding air, which results in a high temperature on the absorber plate and significant heat losses to the surrounding environment. It has been discovered that the creation of a laminar sub-layer on the heat-transferring surface of the absorber plate is the primary source of thermal resistance to heat transfer in this system. Projections that produce artificial roughness on the heat transfer surface, primarily near the wall, or disrupt the laminar sub-layer, increase the heat transfer coefficient by increasing the turbulence near the wall. The fan or blower, on the other hand, must provide the energy necessary to generate such turbulence. Consequently, only the laminar sub-layer, which is extremely close to the heat transfer surface, should be subjected to turbulence, while the rest of the layer should remain smooth. In an attempt to create a roughness element that can improve convective heat transfer while minimising pumping losses, several researchers have made attempts. Providing a system that can meet 100 percent of the energy demand all of the time would result in a system that is significantly larger for the most of the time. This would render the venture unprofitable because of the high initial cost. As a result, solar energy systems are frequently utilised in conjunction with auxiliary systems that use conventional energy. The supplemental sources assist in meeting unexpectedly high demand conditions. It also addresses the dilemma that arises when solar energy is not available in sufficient quantities due to severe weather conditions [45-77]. The goal of our research is to increase the accuracy of the flow forecast in the solar air heater. Fluent, a Computational Fluid Dynamics code, will have a near-wall function for TKE that will be implemented.

Manuscript received on 28 September 2022 | Revised Manuscript received on 03 October 2022 | Manuscript Accepted on 15 October 2022 | Manuscript published on 30 October 2022.
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The discretization of the governing equations was accomplished through the use of second order upwind and the SIMPLE algorithm.

In order to handle a particular physical problem, the FLUENT software must first solve the following mathematical equations, which regulate fluid flow, heat transfer, and associated phenomena.

II. PROCEDURE AND ANALYSIS

Model testing and field testing have become increasingly time-consuming due to the advent of powerful and fast computers, which have opened up new opportunities to replace them. In this case, the differential equations representing fluid motion are solved either by using a finite volume approach or, less frequently, by using a finite element method, which is more time consuming due to the greater amount of CPU time it requires. These approaches, which are used for the solution of fluid equations of motion, are referred to as computation fluid dynamics, or CFD, for short.

In Fig. 1, the 2-D computational domain utilised for CFD analysis has a height (H) of 20 mm, a width (W) of 100 mm, and a length of 461 mm, with the height (H) being 20 mm, and the width (W) being 100 mm. In the present study, a 2-dimensional computational domain of an intentionally roughened solar air heater has been used, which is similar to the computational domain used by in their previous work.

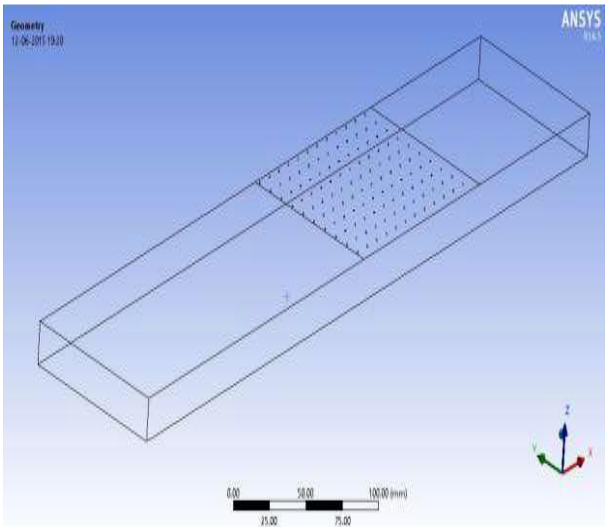

Fig. 1. 2-D computational domain

Non-uniform mesh is constructed following the definition of the computational domain. The presence of additional cells near the plate is beneficial when designing this mesh because we want to resolve the turbulent boundary layer, which is quite thin when compared to the height of the flow field, and so must be resolved.

Boundary criteria have been provided after the mesh has been generated. We will first state that the duct input is located on the left edge and the duct exit is located on the right edge. The top surface is represented by the top edge, and the bottom edges are represented by the input length, outflow length, and solar plate. Turbulator walls are defined as the internal borders of a rectangle 2D duct on all of its internal edges.

The domain meshing is carried out with the help of the ANSYS ICEM CFD V12.1 programme. Because low-Reynolds-number turbulence models are used, the grids are created in such a way that they are extremely fine. The present non-uniform quadrilateral mesh included 161,568 quad cells with a non-uniform quad grid of 0.22 mm cell size and had a non-uniform quad grid of 0.22 mm cell size. This dimension is appropriate for resolving the laminar sub-layer. The number of cells in the grid for the grid independence test is adjusted in five increments from 103,231 to 197,977. It is discovered that after 161,568 cells, an increase in the number of cells results in a variation in the Nusselt number and friction factor value of less than 1 percent, which is taken as a condition for grid independence.

The preceding experimental investigation is simulated using multiple low Reynolds number models, including the Standard k model, the Renormalization-group k model, the Realizable k model, and the Shear stress transport k model, in order to determine the best turbulence model to use. The results of several models are compared to those obtained by experimentation. The RNG k model is chosen because it produces findings that are more similar to those obtained experimentally.

Because the variance in the working fluid, air, is so small, it is considered to be incompressible during the entire operating range of the duct. The Reynolds number was used to compute the mean inlet velocity of the flow in the test tube. The velocity boundary condition has been considered as the intake boundary condition, and the outflow boundary condition has been considered as the outlet boundary condition. The discretization of the governing equations was accomplished through the use of second order upwind and the SIMPLE algorithm. In order to handle a particular physical problem, the FLUENT software must first solve the following mathematical equations, which regulate fluid flow, heat transfer, and associated phenomena.

III. RESULTS AND DISCUSSIONS

Graphs are used to display the average Nusselt number at various Reynolds numbers, and temperature and velocity contours are used to display temperature and velocity at specific sections with a constant Reynolds number. As shown in Fig. 2 for varied values of relative roughness height (e/D) and a fixed value of pitch, the effect of Reynolds number on average Nusselt number can be observed. The average Nusselt number is reported to grow with increasing Reynolds number, which is owing to an increase in turbulence intensity induced by an increase in turbulence kinetic energy and turbulence dissipation rate, as well as an increase in turbulence kinetic energy and dissipation rate.

At a Reynolds number of 18000, the roughened duct with a relative roughness height of 0.06 has the greatest Nusselt number (Nu= 140.4) and the highest Nusselt number (Nu= 140.4). At a Reynolds number of 3800, the roughened duct with a relative roughness height (e/d) of 0.015 has the lowest Nusselt number, while the smooth duct has the highest.

Retrieval Number:100.1/ijap.C1023041322
DOI:10.54105/ijap.C1023.101422
Journal Website: www.ijap.latticescipub.com

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At a Reynolds number of 18000, it is discovered that the maximum enhancement of average Nusselt number is 2.78 times more than that of a smooth duct for relative roughness height of 0.06 and a Reynolds number of 18000.

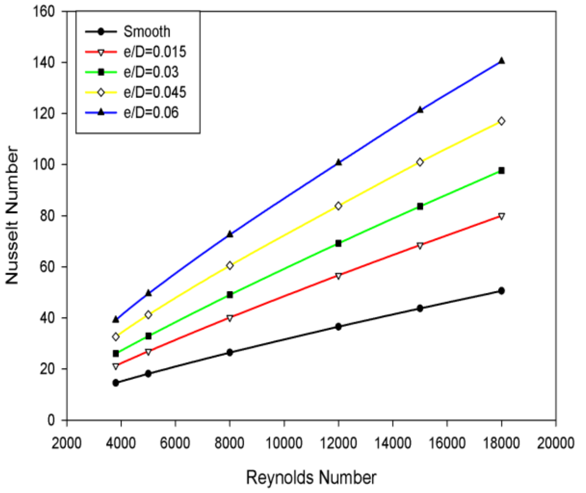

Fig. 2. Variation in Nusselt number

The friction factor reduces with rising values of the Reynolds number in all circumstances, as expected, due to the suppression of the laminar sub-layer in the duct for fully developed turbulent flow in the duct, as illustrated in Fig 3. It has been discovered that the greatest and minimum values of friction factor occur at relative roughness height (e/d) values of 0.06 and 0.015 for the range of parameters examined, respectively. Also discovered is that the greatest enhancement of average friction factor for a relative roughness height of 0.06 at a Reynolds number of 3800 is found to be 4.24 times greater than for a smooth duct at the same Reynolds number.

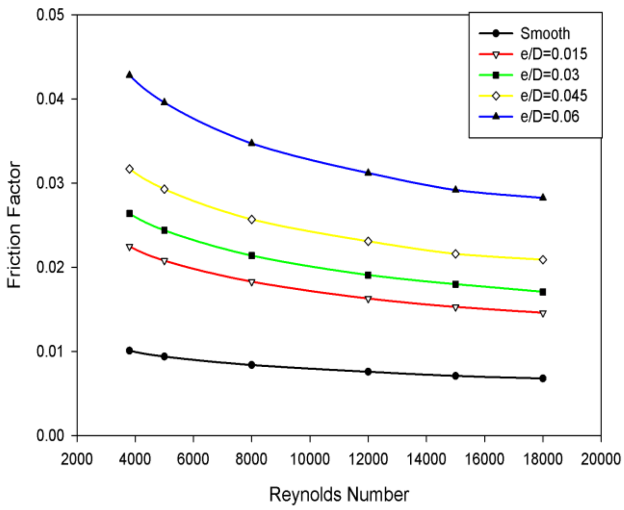

Fig. 3. Variation in Friction factor

IV. CONCLUSION

The An investigation has been carried out into the influence of relative roughness pitch and Reynolds number on the heat transfer coefficient and friction factor. In the medium Reynolds number flow (Re = 3800–18,000), computational fluid dynamics (CFD) investigations have been carried out. The following results were reached as a result of computational fluid dynamics (CFD) research of heat and fluid flow in a rectangular duct with protrusions as roughness elements on one broad wall subjected to a uniform heat flux:

1. In this work, the Renormalization-group (RNG) k-turbulence model predicted findings that were very close to the experimental results, providing confidence in the predictions made by CFD analysis. The RNG k-turbulence model has been validated for smooth ducts, and a grid independence test has been performed to examine the variation as the number of cells increases.
2. The average Nusselt number grows as the Reynolds number rises in the equation. The maximum value of average Nusselt number is discovered to be 140.4 for a relative roughness height of 0.06 at a higher Reynolds number of 18000, with a relative roughness height of 0.06 at a higher Reynolds number of 18,000. According to the results, the greatest improvement in average Nusselt number is 2.78 times more than that of a smooth duct for a relative roughness height of 0.06.
3. Increases in the Reynolds number result in a decrease in the average friction factor. The greatest value of average friction factor is discovered to be 0.0428 for a relative roughness height of 0.06 at a lower Reynolds number of 3800, with a relative roughness height of 0.06 and a Reynolds number of 3800. Using a relative roughness height of 0.06, it is discovered that the maximum improvement in average friction factor is 4.24 times greater than that of a smooth duct.

REFERENCES

1. Webb RL, Eckert ERG. Application of rough surfaces to heat exchanger design. International Journal of Heat and Mass Transfer. 1972;15(9):1647-58. [CrossRef]
2. Webb RL, Eckert ERG, Goldstein RJ. Generalized heat transfer and friction correlations for tubes with repeated-rib roughness. International Journal of Heat and Mass Transfer. 1972;15(1):180-4. [CrossRef]
3. Lewis MJ. Optimising the thermohydraulic performance of rough surfaces. International Journal of Heat and Mass Transfer. 1975;18(11):1243-8. [CrossRef]
4. Duffie JA, Beckman WA. Solar Engineering of Thermal Processes. New York: Wiley, 1980.
5. Patankar S. Numerical heat transfer and fluid flow. Boca Raton: CRC Press, 1980.
6. Webb RL. Performance evaluation criteria for use of enhanced heat transfer surfaces in heat exchanger design. International Journal of Heat and Mass Transfer. 1981;24(4):715-26. [CrossRef]
7. Prasad K, Mullick SC. Heat transfer characteristics of a solar air heater used for drying purposes. Applied Energy. 1983;13(2):83-93. [CrossRef]
8. Prasad BN, Saini JS. Effect of artificial roughness on heat transfer and friction factor in a solar air heater. Solar Energy. 1988;41(6):555-60. [CrossRef]
9. Cortés A, Piacentini R. Improvement of the efficiency of a bare solar collector by means of turbulence promoters. Applied Energy. 1990;36(4):253-61. [CrossRef]
10. Yadav AS, Shukla OP, Sharma A, Khan IA. CFD analysis of heat transfer performance of ribbed solar air heater. Materials Today: Proceedings. 2022;In press. [CrossRef]
11. Yadav AS, Shukla OP, Bhadoria RS. Recent advances in modeling and simulation techniques used in analysis of solar air heater having ribs. Materials Today: Proceedings. 2022;In press.
12. Yadav AS, Gattani A. Revisiting the influence of artificial roughness shapes on heat transfer enhancement. Materials Today: Proceedings. 2022;In press. [CrossRef]

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13. Yadav AS, Dwivedi MK, Sharma A, Chouksey VK. CFD based heat transfer correlation for ribbed solar air heater. Materials Today: Proceedings. 2022;In press. [CrossRef]
14. Yadav AS, Agrawal A, Sharma A, Sharma S, Maithani R, Kumar A. Augmented artificially roughened solar air heaters. Materials Today: Proceedings. 2022;In press. [CrossRef]
15. Yadav AS, Agrawal A, Sharma A, Gupta A. Revisiting the effect of ribs on performance of solar air heater using CFD approach. Materials Today: Proceedings. 2022; In press. [CrossRef]
16. Shrivastava V, Yadav AS, Shrivastava N. Thermal performance assessment of greenhouse solar dryer. In: Kumar R, Pandey AK, Sharma RK, Norkey G, editors. Recent Trends in Thermal Engineering, Lecture Notes in Mechanical Engineering Singapore: Springer; 2022. p. 75-82. [CrossRef]
17. Kumar R, Verma SK, Mishra SK, Sharma A, Yadav AS, Sharma N. Performance Enhancement of SAH using Graphene/Cerium Oxide and Graphene -Black Paint Coating on Roughned Absorber Plate: A Comparative Study. Int J Vehicle Structures & Systems. 2022;14(2): 273-279. [CrossRef]
18. Alta D, Bilgili E, Ertekin C, Yaldiz O. Experimental investigation of three different solar air heaters: Energy and exergy analyses. Applied Energy. 2010;87(10):2953-73. [CrossRef]
19. Bhushan B, Singh R. A review on methodology of artificial roughness used in duct of solar air heaters. Energy. 2010;35(1):202-12. [CrossRef]
20. Hans VS, Saini RP, Saini JS. Heat transfer and friction factor correlations for a solar air heater duct roughened artificially with multiple v-ribs. Solar Energy. 2010;84(6):898-911. [CrossRef]
21. Karmare SV, Tikekar AN. Analysis of fluid flow and heat transfer in a rib grit roughened surface solar air heater using CFD. Solar Energy. 2010;84(3):409-17. [CrossRef]
22. Karwa R, Chauhan K. Performance evaluation of solar air heaters having v-down discrete rib roughness on the absorber plate. Energy. 2010;35(1):398-409. [CrossRef]
23. Promvonge P. Heat transfer and pressure drop in a channel with multiple 60° V-baffles. International Communications in Heat and Mass Transfer. 2010;37(7):835-40. [CrossRef]
24. Sun W, Ji J, He W. Influence of channel depth on the performance of solar air heaters. Energy. 2010;35(10):4201-7. [CrossRef]
25. Yadav AS, Shrivastava V, Sharma A, Sharma SK, Dwivedi MK, Shukla OP. CFD simulation on thermo-hydraulic characteristics of a circular tube having twisted tape inserts. Materials Today: Proceedings. 2021;47:2790-5. [CrossRef]
26. Yadav AS, Shrivastava V, Sharma A, Dwivedi MK. Numerical simulation and CFD-based correlations for artificially roughened solar air heater. Materials Today: Proceedings. 2021;47:2685-93. [CrossRef]
27. Yadav AS, Shrivastava V, Ravi Kiran T, Dwivedi MK. CFD-Based Correlation Development for Artificially Roughened Solar Air Heater. In: Kumar A, Pal A, Kachhwaha SS, Jain PK, editors. Recent Advances in Mechanical Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2021. p. 217-26. [CrossRef]
28. Yadav AS, Shrivastava V, Dwivedi MK, Shukla OP. 3-dimensional CFD simulation and correlation development for circular tube equipped with twisted tape. Materials Today: Proceedings. 2021;47:2662-8. [CrossRef]
29. Yadav AS, Shrivastava V, Chouksey VK, Sharma A, Sharma SK, Dwivedi MK. Enhanced solar thermal air heater: A numerical investigation. Materials Today: Proceedings. 2021;47:2777-83. [CrossRef]
30. Yadav AS, Sharma SK. Numerical Simulation of Ribbed Solar Air Heater. In: Sikarwar BS, Sundén B, Wang Q, editors. Advances in Fluid and Thermal Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2021. p. 549-58. [CrossRef]
31. Yadav AS, Gattani A. Solar thermal air heater for sustainable development. Materials Today: Proceedings. 2021;In press. [CrossRef]
32. Shrivastava V, Yadav AS, Shrivastava N. Comparative Study of the Performance of Double-Pass and Single-Pass Solar Air Heater with Thermal Storage. In: Kumar A, Pal A, Kachhwaha SS, Jain PK, editors. Recent Advances in Mechanical Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2021. p. 227-37. [CrossRef]
33. Chouksey VK, Yadav AS, Raha S, Shrivastava V, Shrivas SP. A theoretical parametric analysis to optimize the bed depth of packed bed solar air collector. International Journal of Green Energy. 2021:1-11. [CrossRef]
34. Yadav AS, Singh DK, Soni G, Siddiqui DA. Artificial Roughness and Its Significance on Heat Transfer of Solar Air Heater: An Assessment. International Journal of Scientific Research and Engineering Development. 2020;3(2):1134-49.
35. Prasad R, Yadav AS, Singh NK, Johari D. Heat Transfer and Friction Characteristics of an Artificially Roughened Solar Air Heater. In: Saha P, Subbarao PMV, Sikarwar BS, editors. Advances in Fluid and Thermal Engineering, Lecture Notes in Mechanical Engineering. Singapore: Springer; 2019. p. 613-26. [CrossRef]
36. Yadav AS, Agrawal V. Renewable Energy Sources-An Application Guide. Republic of Moldova: LAMBERT Academic Publishing, 2018.
37. Qureshi TA, Yadav AS, Jain A. Recent alternative sources of energy- A brief review. RGI International Journal of Applied Science & Technology. 2017;12 & 13(01 & 02):70-1.
38. Dwivedi S, Yadav AS, Badoniya P. Study of Thin Walled Cone by Using of Finite Element Analysis in Deep Drawing. International Journal of Advanced Technology in Engineering and Science. 2017;5(5):587-91.
39. Yadav AS, Thapak MK. Artificially roughened solar air heater: A comparative study. International Journal of Green Energy. 2016;13(2):143-72. [CrossRef]
40. Yadav AS, Singh S. A CFD analysis of an artificially roughened solar air heater. RGI International Journal of Applied Science & Technology. 2016;10 & 11(01 & 02):1-6.
41. Yadav AS, Khan IA, Bhaisare AK. CFD Investigation of Circular and Square Sectioned Rib Fitted Solar Air Heater. International Journal of Advance Research in Science and Engineering (IJARSE). 2016;5(01):386-93.
42. Qureshi TA, Yadav AS. Heat transfer enhancement by swirl flow devices. International Journal of Current Engineering And Scientific Research. 2016;3(1):122-7.
43. Yadav AS, Bhagoria JL. Numerical investigation of flow through an artificially roughened solar air heater. International Journal of Ambient Energy. 2015;36(2):87-100. [CrossRef]
44. Yadav AS. CFD investigation of effect of relative roughness height on Nusselt number and friction factor in an artificially roughened solar air heater. Journal of the Chinese Institute of Engineers. 2015;38(4):494-502. [CrossRef]
45. Diani A, Mancin S, Zilio C, Rossetto L. An assessment on air forced convection on extended surfaces: Experimental results and numerical modeling. International Journal of Thermal Sciences. 2013;67:120-34. [CrossRef]
46. Chung HS, Lee GH, Nine MJ, Bae K, Jeong HM. Study on the Thermal and Flow Characteristics on the Periodically Arranged Semi-Circular Ribs in a Rectangular Channel. Experimental Heat Transfer. 2013;27(1):56-71. [CrossRef]
47. Choi EY, Choi YD, Lee WS, Chung JT, Kwak JS. Heat transfer augmentation using a rib–dimple compound cooling technique. Applied Thermal Engineering. 2013;51(1-2):435-41. [CrossRef]
48. Arslan K, Onur N. Experimental investigation of flow and heat transfer in rectangular cross-sectioned duct with baffles mounted on the bottom surface with different inclination angles. Heat and Mass Transfer. 2013;50(2):169-81. [CrossRef]
49. Ansari MR, Gheisari R, Azadi M. Flow pattern change in horizontal rectangular laterally ribbed ducts through alteration of the ribs thickness and pitch. International Journal of Multiphase Flow. 2013;54:11-21. [CrossRef]
50. Wongcharee K, Eiamsa-ard S. Heat transfer enhancement by using CuO/water nanofluid in corrugated tube equipped with twisted tape. International Communications in Heat and Mass Transfer. 2012;39(2):251-7. [CrossRef]
51. Tang X, Zhu D. Experimental and Numerical Study on Heat Transfer Enhancement of a Rectangular Channel with Discontinuous Crossed Ribs and Grooves. Chinese Journal of Chemical Engineering. 2012;20(2):220-30. [CrossRef]
52. Smith E-a, Koolnapadol N, Promvonge P. Heat Transfer Behavior in a Square Duct with Tandem Wire Coil Element Insert. Chinese Journal of Chemical Engineering. 2012;20(5):863-9. [CrossRef]

Retrieval Number:100.1/ijap.C1023041322
DOI:10.54105/ijap.C1023.101422
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Published By:
Lattice Science Publication (LSP)

53. Yadav AS, Thapak MK. Evaluation of Turbulence Intensity in Rectangular Duct of A Solar Air Heater Attached with Repeated Ribs. In: Verma A, Kumar A, Pradhan MK, editors. Advancements And Current Trends In Industrial, Mechanical And Production Engineering. New Delhi India: Excellent Publishing House; 2014. p. 108-15.
54. Yadav AS, Thapak MK. Artificially roughened solar air heater: Experimental investigations. Renewable and Sustainable Energy Reviews. 2014;36:370-411. [CrossRef]
55. Yadav AS, Bhagoria JL. A Numerical Investigation of Turbulent Flows through an Artificially Roughened Solar Air Heater. Numerical Heat Transfer, Part A: Applications. 2014;65(7):679-98. [CrossRef]
56. Yadav AS, Bhagoria JL. Heat transfer and fluid flow analysis of an artificially roughened solar air heater: a CFD based investigation. Frontiers in Energy. 2014;8(2):201-11. [CrossRef]
57. Yadav AS, Bhagoria JL. A numerical investigation of square sectioned transverse rib roughened solar air heater. International Journal of Thermal Sciences. 2014;79:111-31. [CrossRef]
58. Yadav AS, Bhagoria JL. A CFD based thermo-hydraulic performance analysis of an artificially roughened solar air heater having equilateral triangular sectioned rib roughness on the absorber plate. International Journal of Heat and Mass Transfer. 2014;70:1016-39. [CrossRef]
59. Thapak MK, Yadav AS. Analysis approaches of an artificially roughened solar air heater. Corona Journal of Science and Technology. 2014;3(2):23-7.
60. Thapak MK, Yadav AS. A comparative study of artificially roughened solar air heater. Corona Journal of Science and Technology. 2014;3(2):19-22.
61. Yadav AS, Qureshi TA. A CFD analysis of an artificially roughened solar air heater. TIT International Journal of Science and Technology. 2013;2(2):70-3.
62. Yadav AS, Bhagoria JL. Modeling and Simulation of Turbulent Flows through a Solar Air Heater Having Square-Sectioned Transverse Rib Roughness on the Absorber Plate. The Scientific World Journal. 2013;2013:827131. [CrossRef]
63. Yadav AS, Bhagoria JL. Heat transfer and fluid flow analysis of solar air heater: A review of CFD approach. Renewable and Sustainable Energy Reviews. 2013;23:60-79. [CrossRef]
64. Yadav AS, Bhagoria JL. A CFD (computational fluid dynamics) based heat transfer and fluid flow analysis of a solar air heater provided with circular transverse wire rib roughness on the absorber plate. Energy. 2013;55:1127-42. [CrossRef]
65. Yadav AS, Bhagoria JL. A CFD analysis of a solar air heater having triangular rib roughness on the absorber plate. International Journal of ChemTech Research. 2013;5(2):964-71. [CrossRef]
66. Yadav AS, Bhagoria JL. A CFD based heat transfer and fluid flow analysis of a conventional solar air heater. Journal of Engineering Science and Management Education. 2013;6(2):137-46.
67. Yadav AS, Bhagoria JL. Renewable Energy Sources-An Application Guide: Energy for Future. International Journal of Energy Science. 2013;3(2):70-90.
68. Yadav AS, Bhagoria JL. An Economic Analysis of a Solar System. Corona Journal of Science and Technology. 2013;2(1):3-7.
69. Yadav AS. Effect of half length twisted-tape turbulators on heat transfer and pressure drop characteristics inside a double pipe u-bend heat exchanger. Jordan Journal of Mechanical and Industrial Engineering. 2009;3(1):17-22.
70. Yadav AS. Experimental investigation of heat transfer performance of double pipe U-bend heat exchanger using full length twisted tape. International Journal of Applied Engineering Research. 2008;3(3):399-407.
71. Yadav AS. Augmentation of heat transfer in double pipe heat exchanger using full & half-length twisted tape inserts. CSVTU Research Journal. 2008;1(1):67-73.
72. Sharma N, Dev Gupta R, Sharma RC, Dayal S, Yadav AS. Graphene: An overview of its characteristics and applications. Materials Today: Proceedings. 2021;47:2752-5. [CrossRef]
73. Modi VA, Kumar P, Malik R, Yadav AS, Pandey A. Analysis of optimized turning parameters of Hastelloy C-276 using PVD coated carbide inserts in CNC lathe under dry condition. Materials Today: Proceedings. 2021;47:2929-48. [CrossRef]
74. Kumar P, Darsigunta A, Chandra Mouli B, Sharma VK, Sharma N, Yadav AS. Analysis of intake swirl in a compression ignition engine at different intake valve lifts. Materials Today: Proceedings. 2021;47:2869-74. [CrossRef]
75. Khan IA, Yadav AS, Shakya AK. Prognosis and diagnosis of cracks of cantilever composite beam by vibration analysis and hybrid AI technique. International Journal of Advanced Technology in Engineering And Science. 2016;4(1):16-23.
76. Bhaskar B, Bhadoria RS, Yadav AS. Transportation system of coal distribution: a fuzzy logic approach using MATLAB. Corona Journal of Science and Technology. 2013;2(3):20-30.
77. Kumar A, Maithani R, Yadav AS, Sharma S. Effect of 45° protruded and dimpled rib height on the performance of triangular duct solar heat collector. Materials Today: Proceedings. 2022; In press. [CrossRef]

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