Experimental Investigation of Heat Transfer through Horizontal Rectangular Fin Array with Fine and Coarse Perforated Fins under Natural Convection

Shitole Pankaj, Bhosle Santosh, Kulkarni Kishor, Joshi Sarang

Abstract*: Geometry and orientation plays an important role in natural convection heat transfer. In this paper experimental study of heat transfer from horizontal rectangular fins with fine and coarse perforations under natural convection is presented. The parameters varied for the experiment are heater inputs (Q= 52W, 61W and 73 W), fin spacing (S = 4-14 mm). The other parameters like fin length, fin height and width of array kept constant. The measurement of convective heat transfer is very critical and depends on estimation of average heat transfer coefficient (h_a). The experimentation results are presented in terms of various heat transfer parameters such as average heat transfer coefficient (ha), base heat transfer coefficient (hb). The comparison of these parameters is presented between finely perforated fins and coarsely perforated fins. It is observed that there is a significant effect of Fine perforation over coarse perforation with variation in fin spacing on average and base heat transfer coefficients. For natural convection the combination of finely perforated constant pitch

***Index Terms*: Fins, Natural Convection, Heat Transfer.**

I. INTRODUCTION

Convection is the mode of heat transfer between a surface and a fluid moving over it. The energy transfer in convection is predominantly due to the bulk motion of the fluid particles, though the molecular conduction within the fluid itself also contributes to some extent. If this motion is mainly due to the density variations associated with temperature gradient within the fluid, the mode of heat transfer is said to be due to free or natural convection. A large number of studies have been conducted on shape modifications by cutting some material from fins to make holes, cavities, slots, grooves or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient

II. LITERATURE REVIEW

A large number of studies have been conducted on shape modifications by cutting some material from fins to make holes, cavities, slots, grooves or channels through the fin body to increase the heat transfer area and/or the heat transfer coefficient.

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Jones C.D. et.al [1] experimentally investigated rectangular fin arrays for horizontal and vertical orientation under natural convection firstly. They had used four fin arrays sets positioned with base vertical, at 45° and horizontal to determine average heat transfer coefficients. Gulay Yakar et.al. [3] investigated the horizontal fin arrays to obtain relevant dimensionless parameters, the governing equations of continuity, momentum and energy were examined on the basis of similarity and a correlation was proposed. Harshap F. et.al. [2] experimentally determined average heat transfer coefficients for horizontal arrays over a wide range of spacing. A simplified correlation for average heat transfer coefficient for all the arrays tested was suggested. The following important findings reported as the heat transfer rate is maximum for an optimum fin spacing exists at the given fin height, length and ΔT and the average heat transfer coefficient increases with spacing and asymptotically approaches the flat plate value for large spacing. Shitole Pankaj [4] determined the effect of all related geometrical parameters of the fin array on its performance. The wide range of length: 127 mm < L < 508 mm. Height: 25.4 mm < H < 101.6 mm and spacing: 4.8 mm < S < 28.6 mm, with ΔT varying from 39° C to 156° C. Some important inferences of authors study are: the fin spacing is most important geometrical parameter and from a given height, length and temperature difference, an optimum spacing exists for which the heat transfer rate is maximum. The fin length is another important geometrical parameter. Short fin arrays perform better than long arrays, due to prevailing single chimney flow pattern up to L/H < 5. Sane N.K. et.al [5] solved the governing equations neglecting the velocity component normal to the fin flats in the case of single chimney flow problem and employing vorticity – stream function formulation. They concluded that beyond certain values of S/Hon lower side, the single chimney flow pattern ceases to exist due to choking effect on the entering side flow. They proved that the point of maximum heat transfer lies at the transition from single chimney flow pattern to sliding chimney and the corresponding S/H becomes the optimum spacing. Shardul Kulkarni [6] in his numerical analysis also showed that heat transfer can be enhanced using porous media, but there is an increasing in pressure drop. EI Hassan Ridouane et.al [7] investigated the horizontal rectangular fin array under natural convection by providing notch at the center and suggested the selection of optimum notch dimensions, And spacing by analyzing variety of fin arrangements for performance improvement. It is observed that total heat flux as well as the heat transfer coefficient increase as the notch depth increases. This analysis reveals that the recommended single chimney flow pattern is maintained for the notched fin arrays. The performance of notched fin arrays is 30 to 50% superior than corresponding unmatched arrays, in terms of average heat transfer coefficient. Yorweart L. Jamin et al., [8] used three-dimensional petal shaped finned tubes to enhance the heat transfer. Taji. S.G. [9] in their experimental and numerical study, investigated the effect of metallic porous material, inserted in a pipe, on rate of heat transfer. Effects of porosity, porous material diameter, thermal conductivity as well as Reynolds number on heat transfer rate and pressure drop were investigated. Starner K.E. et.al [10] experimentally investigated the perforated horizontal fin array under free convection. The authors concluded that the values of ha are 15–20% higher for PFAs giving better performance, for smaller spacing, increment in ha is small due to the flow constriction effect . The spacing giving an optimum value at about S=6 mm. Modified array is designed in inverted notched form and that has proved to be successful retaining single chimney together with removal of ineffective fin flat portion. Awasarmol et al. [11, 12, 13, 14] studied the effect of permeability of fins on natural and forced convection heat transfer. On the basis of temperature profile they experimentally and numerically found out that the permeable fins perform better than the solid fins [15, 16, 17, 18]. Research methodology is treated as the central part of the study which helps and gives direction to researchers to achieve research questions and objectives [19, 20, 21, 22, 23, 24].

The objective of present study is to experimentally quantify and compare natural convection heat transfer enhancement in perforated aluminum fin array with various perforation configurations, different perforation diameters, different heat inputs and at different angles of inclination, consequently to check the suitability of perforated fins (as opposed to solid fins) for industrial applications as far as the heat transfer enhancement is concerned

III. EXPERIMENTATION

For experimentation, Horizontal Rectangular fins of length 200 mm, height 40 mm, spacers of height 35 mm and thickness 2 mm is used. The types of perforations are used basically fine and coarse. The fine perforations are of 4mm diameter and coarse perforation is of 8mm diameter. The triangular geometry of perforation is provided two base angles to triangle. One is with 30^0 and another is with 45^0. Also the perforations provided are in two categories. One is with uniform pitch (Horizontally) and another with variable pitch (Horizontally). Likewise the different arrays are prepared using different combinations of spacers from 4mm to 14mm and tested experimentally. All these arrays are considered for three different inputs of 52, 61 and 73 watts. Table1 is showed in appendix for more information.

The fins with perforations in triangular shape at the fin center are as shown in Fig 1. Fin arrays of 100mm are formed by assembling fins and separate spacer pieces by tie bolts. The minimum air gap between the fins and spacers is ensured by proper tightening of the nuts. The fin array sides are insulated with Bakelite and base is housed in siporex insulating block (1200 mm × 350mm × 300 mm) in order to reduce heat loss from bottom and sides through conduction. Fin array configuration and mounting is shown in Fig 2. For temperature measurement seventeen copper constantan thermocouples are mounted at proper locations. The direct metal to metal contact between thermocouples and fin surface is ensured. Thermocouples are cut from same spool of wire and the error in the temperature is adjusted. Seven thermocouples are used to measure fin surface temperature, two are used to measure base fin temperatures, four thermocouples are also provided in siporex block temperature measurement and two thermocouples are Bakelite temperature measurement and one is used to measure ambient temperature. Digital Wattmeter is used to measure heater input of three cartridge heaters. The digital Logger is calibrated and direct temperatures are displayed by it.

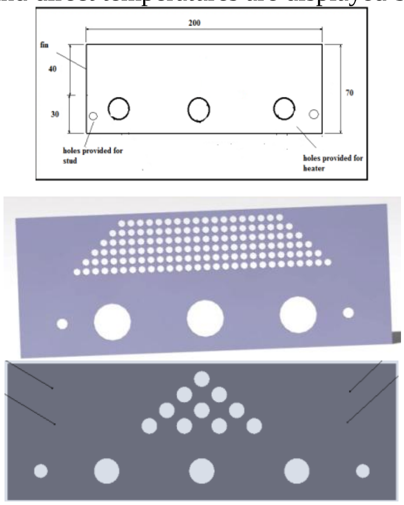

Fig.1. a) Plane Fin, b) Fin with Fine Perforations, c) Fin with Coarse Perforations

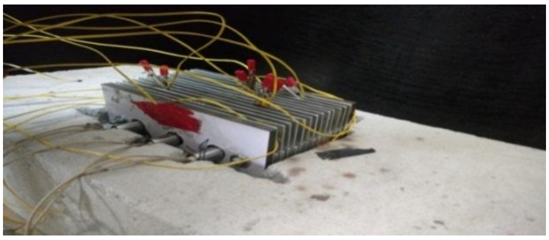

Fig.2. Photograph of Fin Array

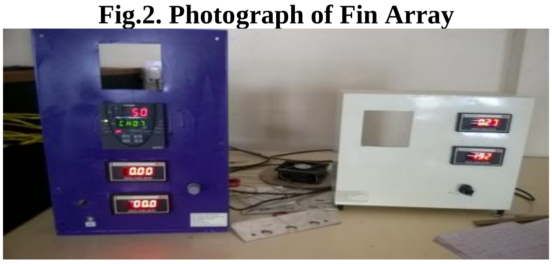

Fig.3. Data Logger and Digital Wattmeter

The measurement of convective heat transfer is very vital and depends on estimation of average heat transfer coefficient. The accurate average heat transfer can be calculated by finding losses through conduction and radiation correctly. The losses through conduction are reduced by placing the array in siporex block. The heat loss through conduction is also measured in two directions (along vertically below array and along horizontal) of the siporex block.

The end fins have bakelite strips to reduce end loss. The radiation losses from array and bakelite end plates are also measured. Likewise the losses through conduction and radiation are measured. As mentioned in above points the setup has provisions for measurements of temperature at bottom siporex and side siporex with respect to fin array for conduction loss estimation. For calculation of radiation losses temperatures of end bakellite plate and fin surfaces are noted. The conduction and radiation losses are calculated as above method.

IV. RESULT AND DISCUSSION

4.1. Temperature Distribution in Fin Set Up

Fig 4 shows temperature distribution along the fin array. It reveals that heating of fin array is uniform throughout the section which leads to confirmation of experiments at mentioned surface points of fin array.

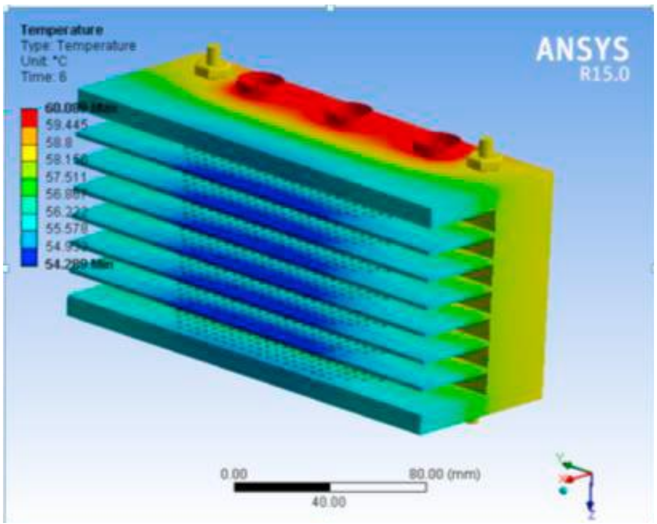

Fig. 4. Temperature Distribution in Fin Set Up

The experimental investigation carried out for the different horizontal rectangular fin array with perforations in triangular form as mentioned in Table no. 1 for different heater inputs (52, 61 and 73W) under natural convection. The objective is to investigate possible heat transfer characteristics. The results obtained from the observations for both experiments are presented here in the form of graphs. The fin spacing, heater input and air flow velocity are the key parameters of an experimental investigation. The heater inputs are selected so as to achieve actual working range temperature of the application for which the array can be used. The heat is supplied to fins by cartridge heater; majority of heat transfer is by convection (Q_{conv}). To find Heat transfer through convection (Q_{conv}), the losses through conduction (Q_{cond}) and through radiation (Q_{rad}) are also calculated. The results are presented in terms of various heat transfer parameters such as average heat transfer coefficient (h_a), base heat transfer coefficient (h_b). Dimensionless parameters such average Nusselt number (Nu_a), base Nusselt number (Nu_b), Rayleigh number (Ra) For determination dimensionless parameters fluid properties such as thermal conductivity, kinematic viscosity of air and volumetric thermal expansion coefficient are evaluated at mean film temperature T_{mf}.

4.2 Effect of Fin Spacing (S) on Average Heat Transfer Coefficient (ha)

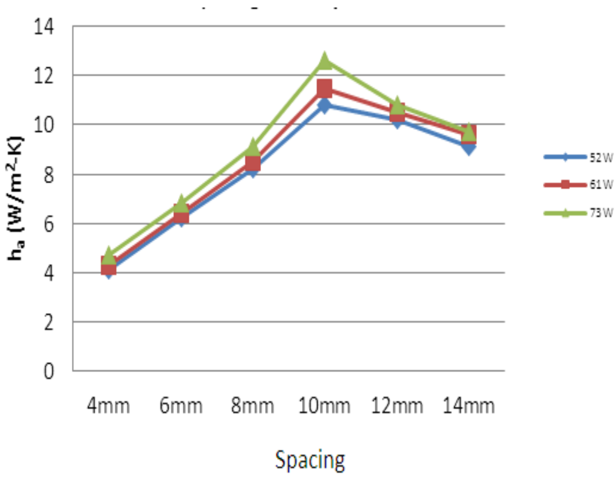

Fig.5. Effect of Fin Spacing (S) on Average Heat Transfer Coefficient (ha)

Heat transfer coefficient or film coefficient, in thermodynamics and in mechanics is the proportionality constant between the heat flux and the thermodynamic driving force for the flow of heat (i.e., the temperature difference, ΔT). h_a is average heat transfer coefficient which can be calculated by

$$ha = Q_{conv} / (A_e \text{x}\ \Delta T)$$

In convection, average heat transfer coefficient (h_a) is an important parameter. Fig. 5 shows the effect of fin spacing on average convective heat transfer (h_a) with heater inputs. It can be clearly seen that, for higher heater inputs, h_a values are more. As the fin spacing increases, the average heat transfer coefficient (h_a) increases for the fin array, as expected. In the beginning, h_a values are very small for S= 4, 6 and 8 mm. The smallest value of h_a is 4.12 W/m^{2}K at 4 mm spacing with constant pitch perforations of 4mm diameter having triangular perforation geometry with 45^0 angle. The highest value of h_a is 12.61 W/m^{2}K at 10 mm spacing with constant pitch perforations of 4mm diameter having triangular perforation geometry with 45^0 angle. The increasing trend of h_a is steep up to spacing that about 10 mm after which h_a is gradually decreases to 9.71 W/m2K for S=14 mm and 100 W. This trend is same for all heater inputs. For smaller fin spacing flow between fin spacing get blocked hence less fin surface area is effective in convective heat transfer hence small value of h_a. Whereas, for larger fin spacing, the fluid through the fin channel is flowing more freely without fin array interference so value of h_a increases. But this rise in h_a with increase in fin spacing is up to particular spacing beyond that air moves out without contacting fin surface so temperature increases hence h_a decreases. Thus, there is a significant effect of variation in fin spacing on average heat transfer coefficient.

4.3 Effect of fin spacing (S) on Average Heat Transfer Coefficient (ha) for different geometries of perforation

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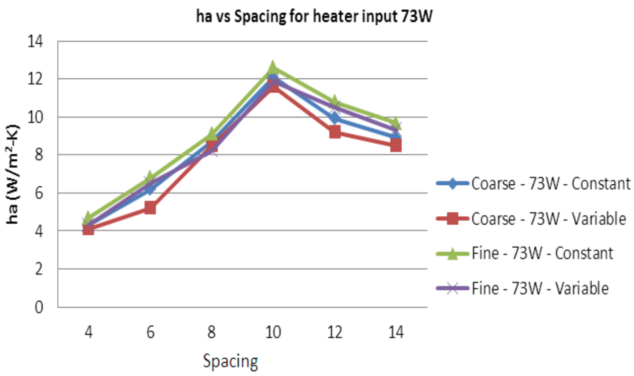

Fig. 6. Comparison of ha vs. Spacing Between Fine and Coarse Perforations with Constant and Variable Pitch.

Fig. 6 indicates the change in average heat transfer coefficient is also depends on types of perforation provided. In this comparison, the heater input considered is of 73W. For this heater input, the variable parameters are spacing, type of perforation (fine and coarse) and type of pitch of perforations are compared. For 73W heater input, the fine and coarse perforations with constant and variable pitch are experimented against fin spacing of 4mm, 6mm, 8mm, 10mm, 12mm and 14mm. The results clearly show that h_a is greater for the array having fine perforations with constant pitch of perforation. From fig. 5 the results of fine perforations (4mm dia.) are better as compared to the coarse perforations (8mm dia.). The maximum h_a value is for 73W heater input, perforation diameter 4mm, constant pitch of perforation and spacing of 10mm i.e. 12.61W/m^2-K. At the same time fins with perforation of 8mm diameter having slightly less value of h_a i.e. 12.1W/m^2-K.

4.4 Effect of Fin Spacing (S) on Base Heat Transfer Coefficient (hb) for Different Geometries of Perforation

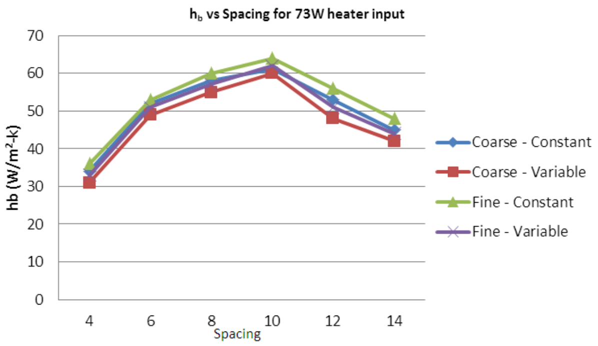

Fig.7. Effect of Fin Spacing (S) on Base Heat Transfer Coefficient (hb)

Base heat transfer coefficient (h_b) is also the significant parameter in study of the convection heat transfer. It can be determined as dividing convection heat transfer Q_{conv} by product of base area for heat transfer and temperature difference between average fin surfaces, ambient. The base area for heat transfer remains constant with increase in fin spacing. Fig. 7 shows the effect of variation in fin spacing "S" on base convective heat transfer (h_b) with 73W heater input. The variable parameters are spacing, type of fin (finely perforated and coarsely perforated) and pitch of perforation. As the fin spacing increases, the base heat transfer coefficient h_b increases for the fin array up to maximum value at S = 10 mm then and then h_b decreases sharply with the increase in fin spacing (S = 12 and 14 mm). The h_b values for S = 4 with different types of fin perforation geometries varies from 30.02 to 35.54 W/m^2-K for 73W. The highest value of h_b is 64.22 W/m^2-K at 73W and 10 mm fin spacing for fine perforations and constant pitch of perforations. The increasing trend is steep up to spacing that about 10 mm after which there is sharply decreases to 47.25 W/m^{2}K for S=14 mm and 73W. This trend is almost similar for all heater inputs.

For all the types of fin perforation geometries, the values of h_a and h_b are increasing with increase in the spacing. The increasing rate of values of h_a and h_b are almost in the similar pattern for different heater inputs. The increase in the values of h_a and h_b is up to certain spacing of 10mm. beyond that h_a and h_b values are reducing.

4.5 Effect of (S/H) on Average Nusselt Number (Nua)

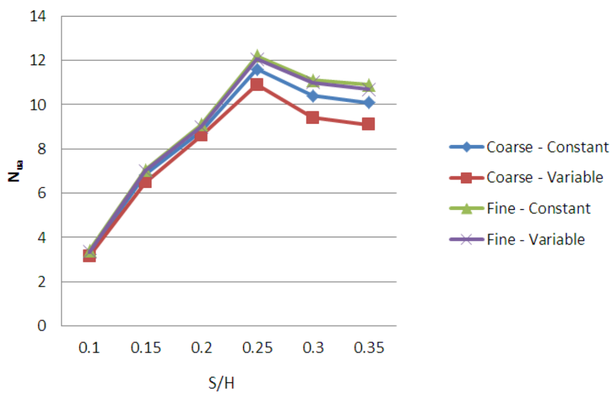

Fig.8. Effect of (S/H) on Average Nusselt Number (Nua) for Different Geometries of Perforations with73W Heater Input.

Fig. 8 shows variation of dimensionless parameter average Nusselt number (Nu_a) with(S/H).Determined from average heat transfer coefficient (h_a), fin height (H) and thermal conductivity (k) of air which depend on temperature. Trends obtained for Nu_a are same as that of h_a because the fin height is constant and thermal conductivity not vary drastically. The effect of variation of "S/H" on average Nusselt number (Nu_a) for various fin fins is shown in Fig 8. As the "S/H" increases, the average Nusselt number (Nu_a) increases for the fin array up to maximum value at S/H = 0.25 and then (Nu_a) decreases with the increase in fin spacing S/H = 0.3 and 0.35. At beginning, Nu_a values are very small for S/H = 0.1 (2.9 to 3.2 for 73W). The highest value of Nu_a is 12.2 at 73W for an array having fins with fine perforations and constant pitch and S/H = 0.25. The increasing trend is steep up to spacing that about 10 mm after which there is gradual decreases to 10.9 for S/H=0.35 and 73 W for the same. This trend is same for all heater inputs.

4.6 Effect of (S/H) on Base Nusselt Number (Nub)

Variation of dimensionless parameter base Nusselt number (Nu_b) with (S/H) is as shown in Fig. 9. The base heat transfer coefficient (h_b), fin height (H) and thermal conductivity (k) of air are the parameter from which Nu_b is determined. Nature of graph for Nu_b is same as that of h_b because the fin height is constant and thermal conductivity not varies drastically.

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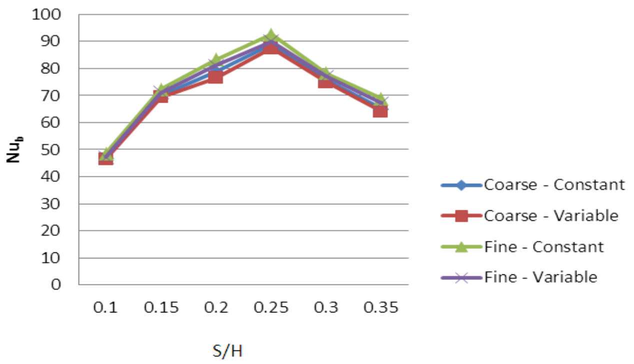

Fig. 9. Effect of (S/H) on Base Nusselt Number (Nub) for Different Types of Perforations with 73W Heater Input.

Fig. 9 shows the effect of variation of "S/H" on average Nusselt number (Nu_b) with various heater input. It is observed that as the "S/H' increases, the base Nusselt number (Nu_b) increases for the fin array up to maximum value at S/H = 0.25 and then (Nu_b) decreases with the increase in fin spacing (S/H = 0.3 and 0.35). The highest value of Nu_b is 92.5 at 73W and S/H = 0.25. This value of Nu_b is for the specific combination of Fin array i.e. the size of perforation is fine and pitch is constant. The increasing trend is steep up to spacing that about 10 mm after which Nu_b drastically decreased to 68.9 for S/H=0.35 and 73W. This trend is same for all heater inputs.

REFERENCES

1. Jones C.D. and Smith L.F., „Optimum arrangement of rectangular fins on horizontal surfaces‟, J of Heat Transfer, ASME, 92, pp.6-10, (1970).
2. Harahap F. and McManus H.N., 'Natural convection heats transfer from horizontal rectangular fin arrays‟, Journal of Heat Transfer, ASME, 89, pp.32–38, (1967).
3. Gulay Yakar and Rasim Karabacak, Effects of holes placed on perforated finned heat exchangers at different angles on the Nusselt and Reynolds numbers, Scientific Research and Essay 5 (2) (2010) 224-234.
4. Shitole Pankaj, Experimental Investigation of Heat Transfer by Natural Convection with Perforated Pin Fin Array, ScienceDirect, Procedia Manufacturing 20 (2018) 311–317.
5. Sane N.K. and Sukhatme S.P., „Natural convection heat transfer from horizontal rectangular fin arrays‟, Int Proc. of 5th Int Heat Transfer Conference, Tokyo, Japan, Vol. 3, NC3.7, pp.114–118 (1974).
6. Shardul kulkarni, Experimental Analysis of Heated Horizontal Rectangular Fin Array (HRFA) Under Forced Dominating Mode of Mixed Convection (FCDMM), IJEDR | Volume 4, Issue 2 | ISSN: 2321-9939.
7. EI Hassan Ridouane, Antonio Campo, Heat Transfer Enhancement of air flowing Across Grooved Channels: Joint Effects of channel height and Grooved Depth, ASME J. Heat Transfer 130 (2008) 1-7.
8. Yorweart L. Jamin, A.A. Mohamad Natural Convection Heat Transfer Enhancement from Fin Using Porous Carbon Foam ASME J. Heat Transfer 130 (2008) 1-6.
9. Taji. S.G., Parishwad G.V., and Sane N.K "Enhanced performance of horizontal rectangular fin array heat sink using assisting mode of mixed convection" International Journal of Heat and Mass Transfer 72C (2014), pp. 250-259.
10. Starner K.E. and McManus H.N., „An experimental Investigation of free convection heat transfer from rectangular fin arrays‟, Journal of Heat Transfer, ASME, 85, pp.273-278 (1963).
11. [11] Awasarmol U.V., Pise A.T., "Investigation of Enhancement of Natural Convection Heat Transfer from Engine Cylinder with Permeable Fins" International J. Mechanical Engineering and Technology, 1(1) 2010 238-247.
12. Awasarmol U.V., Pise A.T., , "Experimental Study of Effect of Angle of Inclination of Fins on Natural Convection Heat Transfer through permeable fins" International Conference on Thermal Energy and Environment (INCOTEE) 2011, Krishnankoil, India.
13. Awasarmol U.V., Pise A.T., Sandikar A.N., "Numerical Analysis Of Heat Transfer Enhancement Using Perforated Fins At Different Base Inclinations And Base Temperatures" 21st National & 10TH ISHMT-ASME Heat and Mass Transfer Conference December 27-30, 2011, IIT Madras, India.
14. Awasarmol U.V., Pise A.T., Bhosale S.Y., Desai A.D., "Experimental Investigation Of Forced Convection Heat Transfer Enhancement Using Permeable Fins" 21st National & 10TH ISHMT-ASME Heat and Mass Transfer Conference December 27-30, 2011, IIT Madras, India.
15. Mr. Harshad N. Deshpande, Experimental Study of Heat Transfer from Horizontal Rectangular Fins with Perforations under Natural Convection, International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 2, February – 2014 IJERTIJERT ISSN: 2278-0181.
16. Ahn H.S., Lee S.W., Lau S.C., Heat Transfer Enhancement For Turbulent Flow Through Blockages With Round and Elongated holes in a Rectangular Channel ASME J. Heat Transfer 120 (2007) 1611-1615.
17. S. D. Suryawanshi and N K Sane, Natural Convection Heat Transfer from Horizontal Rectangular Inverted Notched Fin Arrays, ASME J. Heat Transfer 131 (2009) 082501-082506.
18. Rama Subba Reddy Gorla , A.Y. Bakier, Thermal analysis of natural convection and radiation in porous fins, International Communications in Heat and Mass Transfer 38 (2011) 638–645.
19. Joshi, Sarang, Manoj Kharat, Rakesh Raut, Sachin Kamble, and Sheetal Kamble. "To examine the relationships between supplier development practices and supplier-buyer relationship practices from the supplier's perspective." Benchmarking: An International Journal 24, no. 5 (2017): 1309-1336.
20. Joshi, Sarang P., Pankaj Shitole, Rajendra Chavan, and P. P. Joshi. "Strategies for Buyer Supplier Relationship Improvement: Scale Development and Validation." Procedia Manufacturing 20 (2018): 470-476.
21. Sarang, Joshi P., H. V. Bhasin, Rakesh Verma, and Manoj Govind Kharat. "Critical Success Factors for Supplier Development and Buyer Supplier Relationship: Exploratory Factor Analysis." International Journal of Strategic Decision Sciences (IJSDS) 7, no. 1 (2016): 18-38.
22. Joshi, Sarang Prakashrao, Rakesh Verma, Harsh Vardhan Bhasin, Manoj Govind Kharat, and Mukesh Govind Kharat. "Structural Equation Modelling of Determinants of Buyer–Supplier Relationship Improvement Strategies: Case of Indian Manufacturing Firms." Asia-Pacific Journal of Management Research and Innovation 12, no. 2 (2016): 95-108.
23. Joshi, Sarang Prakashrao, HarshVardhan Bhasin, Rakesh Verma, and Manoj Govind Kharat. "Strategic buyer-supplier relationship improvement: development of constructs and measurement." International Journal of Supply Chain and Inventory Management 1, no. 4 (2016): 306-341.
24. Joshi, Sarang, Rakesh D. Raut, Manoj G. Kharat, and Sheetal J. Kamble. "Optimisation of cutting parameter for surface finish and hole accuracy in drilling of EN31: a Taguchi approach." International Journal of Management Concepts and Philosophy 9, no. 4 (2016): 330-346.

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Appendix:

Array No.	Type of Perforation	Angle of Triangular Geometry of Perforation	Pitch of Perforation	Spacer Thickness in mm	Array No.	Type of Perforation	Angle of Triangular Geometry of Perforation	Pitch of Perforation	Spacer Thickness in mm
1	Fine	30^0	Constant	4	25	Fine	45^0	Constant	4
2	Fine	30^0	Constant	6	26	Fine	45^0	Constant	6
3	Fine	30^0	Constant	8	27	Fine	45^0	Constant	8
4	Fine	30^0	Constant	10	28	Fine	45^0	Constant	10
5	Fine	30^0	Constant	12	29	Fine	45^0	Constant	12
6	Fine	30^0	Constant	14	30	Fine	45^0	Constant	14
7	Fine	30^0	Variable	4	31	Fine	45^0	Variable	4
8	Fine	30^0	Variable	6	32	Fine	45^0	Variable	6
9	Fine	30^0	Variable	8	33	Fine	45^0	Variable	8
10	Fine	30^0	Variable	10	34	Fine	45^0	Variable	10
11	Fine	30^0	Variable	12	35	Fine	45^0	Variable	12
12	Fine	30^0	Variable	14	36	Fine	45^0	Variable	14
13	Coarse	30^0	Constant	4	37	Coarse	45^0	Constant	4
14	Coarse	30^0	Constant	6	38	Coarse	45^0	Constant	6
15	Coarse	30^0	Constant	8	39	Coarse	45^0	Constant	8
16	Coarse	30^0	Constant	10	40	Coarse	45^0	Constant	10
17	Coarse	30^0	Constant	12	41	Coarse	45^0	Constant	12
18	Coarse	30^0	Constant	14	42	Coarse	45^0	Constant	14
19	Coarse	30^0	Variable	4	43	Coarse	45^0	Variable	4
20	Coarse	30^0	Variable	6	44	Coarse	45^0	Variable	6
21	Coarse	30^0	Variable	8	45	Coarse	45^0	Variable	8
22	Coarse	30^0	Variable	10	46	Coarse	45^0	Variable	10
23	Coarse	30^0	Variable	12	47	Coarse	45^0	Variable	12
24	Coarse	30^0	Variable	14	48	Coarse	45^0	Variable	14

Table No.01: The different combinations of the Horizontal Rectangular Perforated Fin Arrays.

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