Natural Convection Heat Transfer by Heated Plate using DifferentTypes of Notched Fin Arrays–A Review

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ABSTRACT:*The purpose of fin is to increase heat transfer from the surface to surrounding by increasing the product of the surface area and the heat transfer coefficient. Fins offer an economical and trouble free solution in many situations demanding higher natural convection heat transfer. The main controlling variables generally available to the designer are the orientation and the geometry of the fin arrays. In case of short horizontal arrays, it is observed that the air entering symmetrically from both the ends gets heated as it moves towards the centre of the fin channel, as well a s it rises due to decrease in density. So, a stagnant zone is created at the central bottom portion of fin array channel and hence it does not contribute much in heat dissipation. Hence it is removed in the form of notch from the central bottom portion of fin in the form of notch to modify its geometry for enhancement of heat transfer. Many researchers have been studied the heat transfer rate through without notch and notched fins by using different types of material and different types of notch by experimental setup or computational methods to study the effect of natural convection. In this review paper, the main objective of this paper is to give brief overview of enhancement of heat transfer rate with the help of notched fins.*

Keywords: *Fin Array, Natural convection, Notch fin array,Single chimney flow*

Conference Stream :- Mechanical Engg

1. INTRODUCTION

Now days we want compact devices which makes overheating problem possibility more, because of reduction in surface area available for Heat Transfer. So Optimization of fin heat transfer area and geometry becomes very important. Generally in natural convection heat transfer with vertical fin array on horizontal fin base, it is observed that single chimney flow pattern as shown in fig. 1 is observed. In single chimney flow pattern, there is sideway entry of the air in case of natural convection cooling of fin array. The air coming inwards gets heated as it moves towards the centre of the fin and this heated air it rises up due to decrease in density.

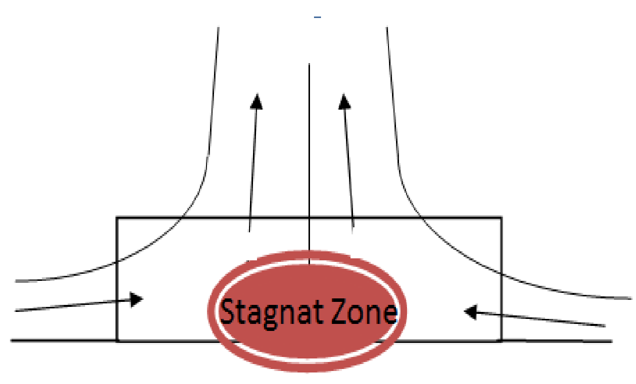


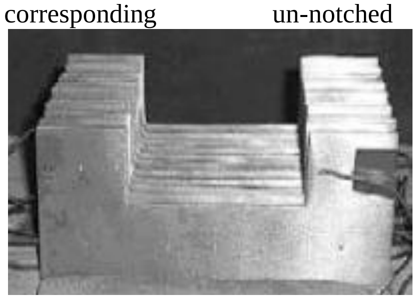
Fig.1: Single Chimney Flow Pattern

So, the central portion of the fin becomes ineffective because hot air-stream passes over that part and therefore it does not bring about large heat transfer through that portion. To optimize the fin geometry some portion of this stagnant zone is r emoved in various shapes and sizes and its effec t on other parameters are studied in this investigation.

2. LITERATURE SURVEY

S. D. Wankhede, C. B. Meshram made Experimental setup to carry out the investigation on horizontal rectangular fin array with and with out inverted notch for different fin spacing under nat ural and force convections [1]. They used Normal array of length 250 mm, width 100 mm, height 50 mm and INFAs having inverted notch of 10%, 20%, 30% and 40% area removal were tested keeping height and length of fin constant. Four different spacing were tried from a small spacing of 6 mm to larger spacing of 12 mm with increase of 2mm spacing. They used number of fins as 7, 8, 9, and 11. They used power input ranging from 25 watts to 100 watts in steps of 25 watt in this work. They concluded that, 40% notched configurations yield 55–75% higher values of heat transfer and coefficient of heat transfer compared with the un-notched fin for both natural and force convection. The values of average heat transfer coefficient ha increases as percentage of area removed increases. Near about 25 to 75% rise is achieved as compared to normal fin array in natural and force convection. The average surface temperatures of INFA are less than normal fin arrays. Though surface area of INFA decreases its ΔT decreases, indicates its superiority.

S. R. Dixit, Dr. D. P. Mishra, Dr. T. C. Panda did experimental analysis of heat transfer and Average heat transfer coefficient through fin Array with or without notch using free convection [2]. They used copper as fin material for the experimental analysis. The dimensions of the fin used for analysis are length 127 mm, height 38 mm and spacing in fins is 9 mm and the thickness of the plate is 1 mm. They kept length, height and spacing of fin array constant and he shape of the notch is rectangular as shown in fig. 2. From the experimental study it is found that the heat transfer rate in notched fins is more than the un-notched fins. The average heat transfer coefficient increases with the heater input. It is seen that at particular heater input, the average heat transfer coefficient of notched array is 30 to 40% higher than that of un-notched array. The average heat transfer coefficient for notched fin is better than un-notched fins. Also the copper gives more heat transfer rate than aluminum plate. As notch area of increases the heat transfer rate also increases. In this experimental study, an attempt is made to improve the performance of horizontal rectangular fin array by removing the less effective portion of stagnant zone of the fin flat in the form of a rectangular notch. Greater amount of fresh cold air to come in contact with hot fin surfaces because area removed from the fin is compensated at the air entry ends of the fin. The average heat transfer coefficient of notched fin arrays is 30 to 50% superior to corresponding un-notched arrays.



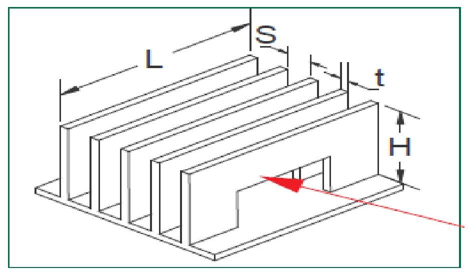


Fig.2: Notched fin array

Fig.3: Inverted notched fin array

SalilaRanjan Dixit, Dr. Tarinicharana Panda did Numerical Analysis of Inverted Notched Fin Array Using Natural Convection [3]. They used Length of fin array 150 mm, Height 75 mm, Spacing, 4 to 13 mm, No. of fins -15, 13, 12, 9, 7 and Heater input as 50, 100, 150, 200 watts. They have optimized above fin array based on natural convection heat transfer numerically using CFD package fluent with laminar model. There model has been validated with existing experimental result of Suryavanshi et al. They have measured heat transfer coefficients and other non dimensional parameters as a function of heat transfer coefficient. They find that Nusselt number is increasing if we increase the fin spacing from 4 mm to 13 mm at constant heat flux for plane fins, Because as fin spacing increases, resistance to the flow decreases. Nusselt Number increases with increase in notch size from 10% to 40% for constant heat flux, because the fin area decreases retaining constant heat transfer rate. The Grashoffs Number is almost remaining same with no notch condition to 40% notch condition.

S.S. Sane, N. K. Sane, G.V.Parishwad did "Computational analysis of horizontal Rectangular notched fin arrays dissipating Heat by natural convection" [4]. They found that both total heat flux and the Heat transfer coefficient increases as the notch depth increases. Due to area removed from the fin is added at the air entry ends of the fin it provides chance to get greater amount of fresh cold air getting sucked into the array through single chimney pattern and come in contact with hot surface of fins. CFD analysis was completed for two cases these are (a) Un-notched fin Array and (b) Fin Array with Notch of 20 % and 40% area removed. This study found that the performance of Notched array is better by up to 41.82%.

Shivdas S. Kharche, Hemant S. Farkade did "Heat Transfer Analysis through Fin Array by Using Natural Convection"[5]. Fin material used by them was copper. The fin dimensions for experimental work are length 127 mm, height 38 mm and fin spacing 9 mm. The plate used is of 1 mm. The length, height and fin spacing is kept constant. From experimental study it is found that in notched fins the heat transfer rate is more than the unnotched fins. As the notch area of fin increases the heat transfer rate also increases. The average heat transfer coefficient for without notched fin is 8.3887 W/m^{2}K whereas for 20% notched fins it is 9.8139 W/m^{2}K. Also the copper gives more heat transfer rate than aluminum plate. Copper plate gives better heat transfer rate than aluminum plate.

S. M. Wange, R. M. Metkar did "Computational Analysis of Inverted Notched Fin Arrays Dissipating Heat by Natural Convection" [6]. Experimentation is carried out for four different cases of inverted notch fin arrays. For experimental setup, they made base plate and fins are from 1.2 mm thick rolled aluminum sheet to form the required fin array. The parameters of the fin arrays for experimental work are shown below in table. In this investigation experimental and computational analysis of fin array is done. For Computational analysis they used Ansys Fluent-12 software.

Table 1: Different parameters of fin array used

Sr. No.	L (mm)	H (mm)	S (mm)	No. Of Fins	Depth of Notch
1	127	38	8	7	Without Notch
2	127	38	8	7	40%
3	150	75	8	7	40%
4	175	85	8	7	40%

It is concluded that the in notch fin arra y the heat transfer coefficient is more than without notch fin array. The value of average heat transfer coefficient is more for case 2 fin array than other fin arrays. The heat transfer rate is also more for case-2 itself. Heat transfer coefficient values are higher for inverted notch fin arrays giving better performance than n ormal fin arrays. As single chimney flow pattern is more in notched fin so the inverted notch fin array performs better.

S. H. Barhatte, M. R. Chopade did "Experimental and Computational Analysis and Optimization for Heat Transfer through Fins with Triangular Notch"[7]. In this investigation, the fin arrays were made by removing the central fin portion by cutting a not ch of different geometrical shapes and adding this removed material at the entrance of arrays on the two sides, where it is more effe ctive and thereby keeping fin surface area same. For Computational analysis models of different aspect ratios (L/H) were created and meshed in ANSYS ICEM CFD's meshing modules and solved using the Fluent 6.3 solver. Solution for sets of fins of different aspect ratio was obtained. Aspect ratios used are 0.866, 1.00, 1.333, 1.266, and 1.400. They found that heat transfer coefficient increases with increasing aspect ratio and then decreases after a threshold value of 1.266. This has been shown by the CFD analysis.

S. D. Suryavanshi, N. K. Sane they did study on natural convection heat transfer through rectangular inverted notched fin arrays [8]. For experimental setup, they used fin flats of length 150 mm, height 75 mm, fin spacing's from 4-13 mm, number of fins 7-15, notched portion 10-40 % and heat input supplied from 50-200 W. They kept length & height of fin constant & vary the notched portion, fin spacing, heat input, and number of fins. They concluded that the value of heat transfer coefficient increases as notch area increases and at fin spacing 6mm. In case of single chimney flow pattern, the stagnant bottom portion becomes ineffective. So the array is modified and designed in inverted notched form and that has proved to be successful retaining single chimney together with the removal of ineffective fin flat portion. Also The values of ha, are 40 to 45% higher for INFAs giving better performance.

According to S. D. Suryavanshi, N. K. Sane, Ashish A. Kulkarni they did Parametric Study of Rectangular Inverted Notched Fin Arrays in Natural Convection Heat Transfer [9]. They used fin arrays similar to above. Over all work reported in there paper is for lengthwise short fin arrays, having single chimney flow pattern, which is important in heat transfer standpoint. Contours of surface heat transfer coefficient ha, show that central bottom portion of fin flat is inferior in heat transfer standpoint that can be removed in the form of inverted notch. Due to removal of this surface area, performance of the fin array with inverted notch is better. The fin array with notch performs better in all the configurations. It is observed that as percentage of area removed increases h_a increases. At higher heater input, values of h_a are higher. It is also concluded that experimental and CFD results are well matching, the variation is within 7%.The values of ha, are 50 to 55 % higher for INFAs as compared with normal fin arrays. In other words, more heat is dissipated with a less fin surface area by effective utilization of fin surface. At higher heater input ha is higher. Also concluded that Nu_a is higher for higher percentage of area removed i.e. 40% notched array gives best performance. It is also concluded as percentage of area removed increases heat dissipation rate increases

3.COMPARISON OF RESULTS OF LITERATURE AND SCOPE FOR FUTURE WORK

In this section I used the dimensions of fin arrays used by researcher and have calculated two ratios this are Occupancy ratio and V/A ratio which equations are given below,

Fin Occupancy area ratio = Area occupied by fin baseSurface area of base plate = L*t*NL*t*N +L*S (N-1) (1)

V/A ratio = Total volume of fin materialSurface area of base plate = L*H*t*NL*t*N +L*S (N-1) (2)

Where,

L, H, t are length, height and thickness of fin used

S = spacing between fins

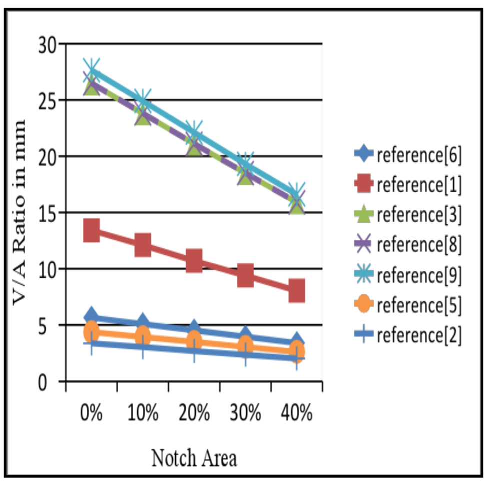
N = number of fins in array

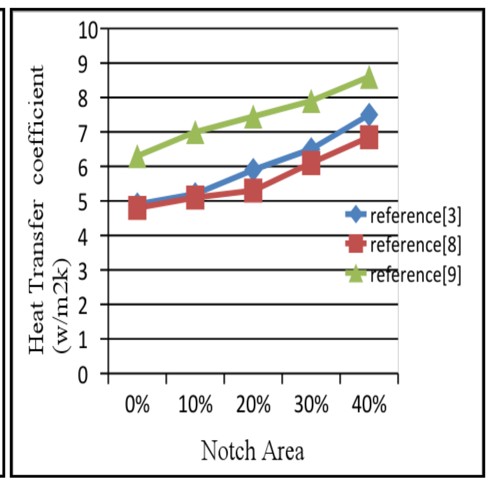
Table 2: Comparison of Occupancy factor and V/A factor

Shape of Notch	Author Name	Spacing between fins	No. of fins	Fin Occupancy area ratio different notch area					V/A ratio for different notch area				
				0 %	10 %	20 %	30 %	40 %	0 %	10%	20%	30%	40%
Inverted rectangular Notch (notch with face down)	Wange, et. al. [6]	6	7	0.15	0.08				5.66	5.09	4.53	3.96	3.40
	Wankhede et. al. [1]	6	11	0.27	0.13				13.41	12.1	10.7	9.40	8.05
	Dixit,et. al. [3]	6	12	0.35	0.18				26.47	23.8	21.1	18.5	15.9
	Suryawanshi et. al. [8]	8	12	0.35	0.18				26.47	23.8	21.1	18.5	15.9
	Suryawanshi, et. al. [9]	13	7	0.37	0.18				27.63	24.9	22.1	19.3	16.6
Rectangular Notch (notch with face up)	Kharche, et. al. [5]	9	7	0.12					4.37	3.93	3.50	3.06	2.62
	Dixit, et. al. [2]	12	7	0.09					3.37	3.04	2.70	2.36	2.03

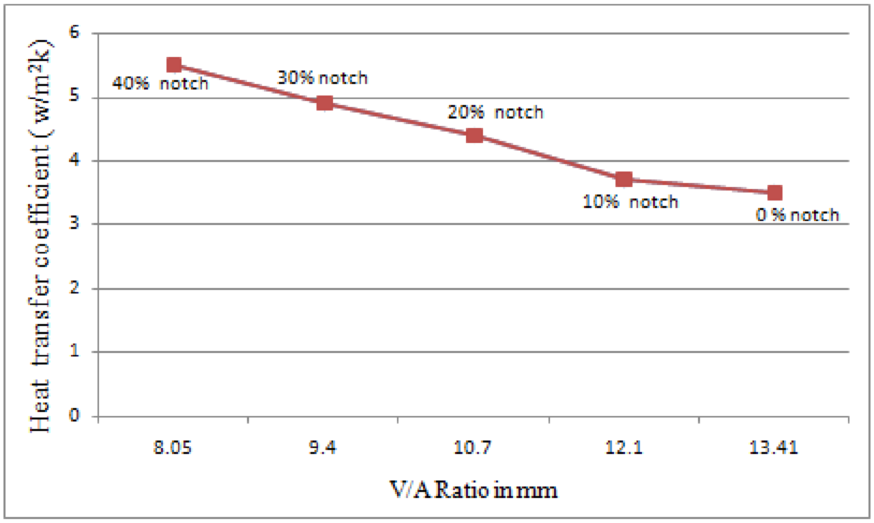
From this table and graph it is found that,

1. For inverted rectangular notch Fin Occupancy area ratio is more in un-notch fin than in notched fin and remains constant for different notch area
2. For rectangular notch (notch face is upside) Fin Occupancy area ratio is same for notched as well as un-notch fin array.
3. For un-notched fin array V/A ratio is more than notched fin array and goes on reducing with increase in notch area as shown in graph 1. It is found by all researchers that heat transfer increases with increase in notch area as shown in graph 2, so there is scope for future work to find optimum value of V/A factor at which maximum heat transfer can be achieved.
4. For rectangular notch (notch face is upside) both V/A ratio and Fin Occupancy area ratio are lower than inverted notch fin array.
5. Also there is work remaining to compare whether vertical notch is better or inverted notch. From construction point of view making of inverted notch is so difficult than vertical notch.
6. Graph 3 and 4 shows Heat transfer coefficient (at 150w heat input) Vs Notch area drawn using result of previous researcher. In graph 4 there is much deviation in value of h for reference 3 & 9 this is due to different dimensions of fin used and different fin spacing and no. of fin used.

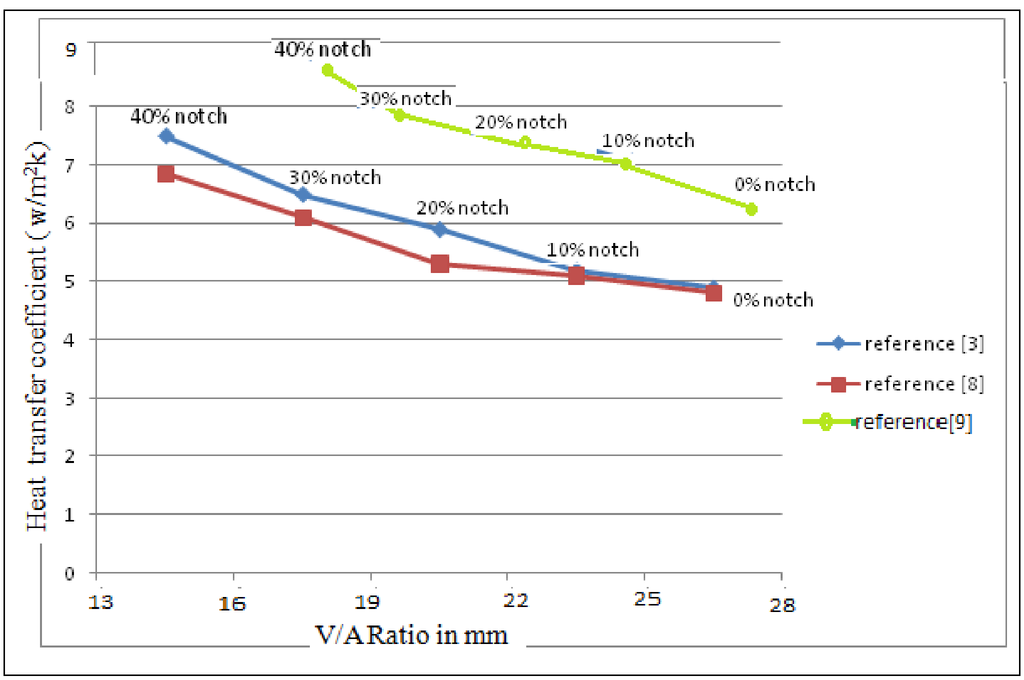




Graph 1: V/A Ratio Vs Notch Area



Graph 3: V/A Ratio Vs Heat transfer coefficient (at 100 w heat input) for reference [1]



Graph 4: V/A Ratio Vs Heat transfer coefficient (at 150w heat input) for reference [3], [8] & [9]

4. CONCLUSION

There is single chimney flow pattern in case of natural convection heat transfer which reduces heat transfer from surface. So making notch is effective method for increasing heat transfer. The values of heat transfer coefficient are higher for notched fin arrays giving better performance. For same heat flux heat transfer coefficient increases as area removed increases. It is also found that heat transfer coefficient increases as aspect ratio increases up to certain value and then reduces.The single chimney flow pattern is also present in notched fin arrays, but with a wider chimney zone. It is found that material removed from fin reduces weight and saves fin material keeping surface area same. Also removed material if added to top or sides more channel area is available for inflow from both sides which improves the average heat transfer coefficient.

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