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International Journal of Engineering Technology Research & Management

OPTIMIZATION OF PIN FIN HEAT SINK USING TAGUCHI METHOD

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ABSTRACT

Depending on various applications, heat transfer enhancement objects such as extended surfaces, fins etc. are selected for their thermal performance as well as other design parameters. The present paper is on experimental study to investigate the enhancement of heat transfer through wire mesh fin arrays with horizontal base plate. Data used in performance analysis were obtained experimentally for the material (mild steel) for different heat inputs such as 40, 60, 80, 100 and 120 watts, by varying wire mesh diameter, fin height and spacing between two fine arrays. Optimum design parameters and their levels were investigated using the Taguchi experimental design method. Average coefficient of heat transfer was considered a characteristic parameter of performance. An orthogonal array of L9 (33) has been chosen as experimental plan. Experiments were found to find optimum results. It is observed that the diameter of the wire mesh and the height of the fines have a greater impact on the heat transfer coefficient compared to the spacing between two fines arrays.

KEYWORDS:
Pin fin heat sink, orthogonal array, annova, taguchi method.

INTRODUCTION

The improvement of heat transfer is an important topic in the field of mechanical engineering. To avoid the damaging effects of burning or overheating, removal of excessive heat from system components is vital. The heat transfer from a surface is enhanced either by increasing the coefficient of heat transfer between the surface and its surroundings or by increasing the surface heat transfer zone. The extended surface or the fins are used to enhance heat transfer in several industries. Fins with different geometries, such as square, circular pin-fins, plate fins, perforated fins etc., are used for both natural and forced convection heat transfer.

It was observed that many investigators worked on the plate fine as well as perforated fins. They studied parameters affecting the heat transfer enhancement. But none
emphasized the experimental investigation on wire mesh as a heat sink because it requires a vast number of experiments that greatly increase the experimental cost and time. The aim of this study is therefore to minimize the experimental tests using Taguchi experimental design to determine the heat transfer characteristics of the wire mesh fin arrays as a heat sink, and to determine new design parameters and their levels.

LITERATURE REVIEW

Mahmoud et al.[1] worked by natural convection heat transfer experimentally on the micro-fin geometry made up of copper material for varying fineness height and fine spacing. They concluded that the coefficient of heat transfer is directly proportional to the fin spacing and inversely proportional to the height of the fine.

Sabale et al.[2] worked experimentally with natural convection heat transfer on multiple V-fin arrays with vertical heated plate. For experimentation V-Fins are arranged for different heat inputs in two different arrangements varying in bottom spacing and fin height. They observed that heat transfer rate is enhanced by the V-type partition plate fin compared to horizontal partition plate fins.

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Pismenny[20] was based on the results of experimental data dependencies for calculations of the convective heat transfer coefficient of flat surfaces with meshed wire finning by natural convection for various spatial orientations. He studied three surface positions in space, which differed according to the fins' condition. Positions corresponding to vertical base surface washing and vertical end two position at horizontal base and vertical fins; position at vertical base and horizontal fins. The results of the experiments were approximated by the degree as dependency, widely used in theoretical and applied convective heat transfer free of problems.

TAGUCHI METHOD

Taguchi methods are statistical methods developed by Gnocchi Taguchi to improve the quality of manufactured goods and more recently also applied to biotechnology engineering Professional statisticians welcomed the objectives and improvements brought about by Taguchi methods , in particular by Taguchi 's development of designs to study variation. Following World War II , Japanese manufacturers struggled with very limited resources to survive. If it wasn't for Taguchi 's advances the country may not have stayed afloat let alone flourish as it has. Taguchi has revolutionized the Japanese manufacturing process by saving costs. Like many other engineers he understood that all manufacturing processes are affected by external influences, noise. Taguchi, however, has implemented methods to identify those sources of noise, which have the greatest effects on product variability. Successful manufacturers around the globe adopted his ideas because of their outcomes in creating superior production processes at much lower cost. Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan, has developed a method based on "ORTHOGONAL ARRAY" experiments that give much reduced "variance" to the "optimum settings" of control parameters experiments. Thus, the Taguchi Method achieves the marriage of Experiment Design with optimization of control parameters to obtain BEST results.

INPUT PARAMETERS

For our experiment we have taken 3 input parameters, for 3 different control units. These are wire mesh diameter, height of fins, and spacing between fins, which are analyzed by Taguchi Orthogonal Array method. For our experiment we have taken wire mesh diameters as 1mm, 1.2mm, 1.4mm. Height of fins as 50mm, 45mm, 40mm and spacing between fins as 16mm, 22mm, 30mm. Table 1 shows ORTHOGONAL ARRAY L_9 (3^3)

TABLE 1 :GEOMETRY OF FIN ARRAYS AS PER TAGUCHI METHOD ORTHOGONAL ARRAY L_9 (3^3)

Expt No.	A	Wire diameter D	B	Height of Fin H	C	Fin Spacing S
1	1	1	1	50	1	16
2	1	1	2	45	2	22
3	1	1	3	40	3	30
4	2	1.2	1	45	2	22
5	2	1.2	2	40	3	30
6	2	1.2	3	50	1	16
7	3	1.4	1	40	3	30
8	3	1.4	2	50	1	16
9	3	1.4	3	45	2	22

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RESULTS ANDDISCUSSION

Analysis of Signal to Noise Ratio (S/N)

The average S/N value for heat transfer coefficient is calculated for each parameter at different levels. The main effect of each parameter is nothing but difference between high (S/N) ratio value and low (S/N) ratio values. $\Delta R = Max\frac{S}{N} - Min\frac{S}{N}$of each parameter. The larger the Rank value for a parameter, the larger the effect the variable has on the process as shown in Table 2

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TABLE 2 :RESULT OF ORTHOGONAL ARRAY L9 (3^3) AND S/N RATIO FOR AVERAGE HEAT TRANSFER COEFFICIENT

Expt. trial	D	H	S	ha	S/N
1	1	1	1	20.05	26.04
2	1	2	2	19.65	25.98
3	1	3	3	17.84	24.96
4	2	1	2	20.18	26.31
5	2	2	3	18.53	25.36
6	2	3	1	17.20	23.66
7	3	1	3	17.78	24.68
8	3	2	1	17.50	24.56
9	3	3	2	16.01	23.14

TABLE 3 :RESULT OF S/N RESPONSE TABLE FOR MAXIMUM AVERAGE HEAT TRANSFER COEFFICIENT

Level	Wire mesh diameter	Height of the fin	Spacing between two fins
I	25.56^a	25.73^a	25.28^a
II	25.22	25.07	25.24
III	24.68	24.63	25.15
ΔR	0.88	1.1	0.13
Rank	II	I	III

[a]Optimum level

The design parameter combination for an average heat transfer coefficient is A1B1C1and the correspondingvaluesofeachparameterare:A1i.e.wiremesh diameter=1mm,B1i.e.,heightoffin=50mmandC1i.e.16 mm. spacing between two fins

ISSN: 2456-9348
Impact Factor: 4.520

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ANALYSIS OF VARIANCE (ANOVA)

It is statistical method employed to determine individual interaction of all control parameters (i.e. diameter, height & spacing between fin).This method provides the percentage and thus shows percentage contribution of each factor in the process.

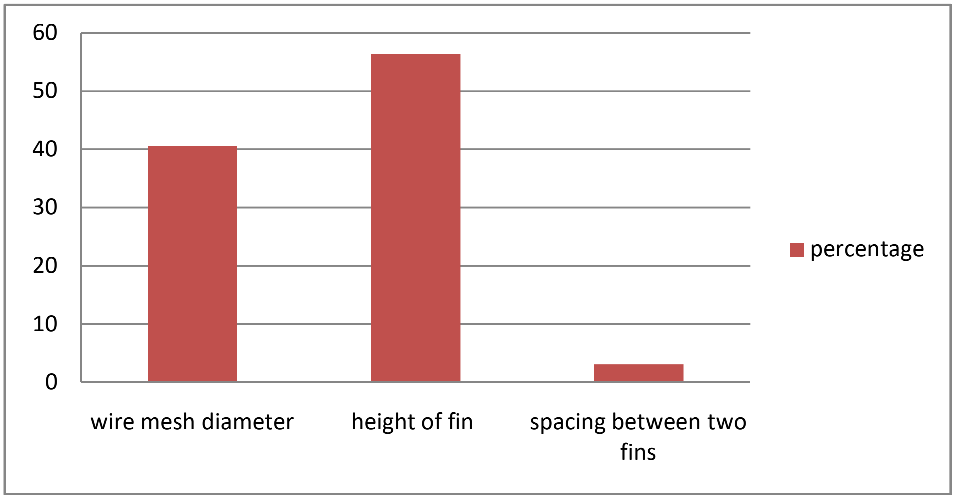

Fig. 1: Percentage contribution of each parameter to enhance the heat transfer.

CONCLUSION

From the experimental studies reported under Taguchi $L_9(3^3)$ orthogonal arrays, the height of the fine was found to be the most prominent parameter influencing the heat transfer coefficient; secondly, the wire mesh diameter and then the distance between two fins. For 1 mm wire mesh diameter and 50 mm fin height, and 16 mm spacing between fins, the maximum heat transfer limit is observed. Therefore it can be inferred that by monitoring these parameters, the heat transfer can be effectively increased.

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