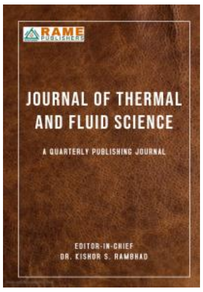

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Optimization of Pin Fin Heat Sink Using Taguchi Method

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Abstract — **The ever-increasing need to reduce the cost of production due to intensified competition has forced engineers to search for robust decision-making approaches such as optimization. As a result, architecture optimization was designed to help engineers build systems that are both more effective and less costly, and to introduce innovative approaches to improve the efficiency of existing systems. Optimization of engineering can best be defined as a systematic mathematical approach to define and choose the best choice from a set of possible alternative designs (Rao, 1996). Optimization can be extended to solve any technical problem in its widest context Techniques for optimization are currently being used in a wide variety of sectors, including the aerospace, automobile, MEMS, pharmaceutical, electrical and industrial sectors. The difficulty of problems being solved using optimization techniques is no longer a issue in the advancement of computing technologies. Optimization approaches combined with advanced Computer Aided Design (CAD) techniques are also used to facilitate the innovative process of imaginative and complex engineering systems design.**

Keywords— Heat transfer, Micro fin array, MEMS, micro-fin, heat transfer, Computer Aided Design (CAD), heat sink, micro heat sinks.

I. Introduction

Extended Surface (Fin) is used to improve the heat transfer from surfaces in a wide variety of applications. The fin content is usually high in thermal conductivity. A circulating fluid is exposed to the tail, which cools or heats with it. The high thermal conductivity allows additional heat to be brought across the fine from the wall. Fins are used in a wide variety of engineering applications to improve convective heat transfer and provide realistic means to achieve a significant total heat transfer surface without the use of unnecessary primary surface area. Fins are typically used in electrical devices such as electronic power supplies or substation transformers for heat control. Many uses require cooling of the IC engine; including Fins in a car radiator [1].

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There is no particular approach or strategy that can successfully solve all optimization problems. Therefore, a variety of optimization approaches were developed to solve various forms of optimization problems. It is in the engineer's own choice to select a solution which is computationally effective, reliable and ideal for his problem of architecture. Because a good design point is often the result of a trade-off between various objectives, the exploration of a given design cannot be performed by using only direct optimization algorithms leading to a single design point. This is necessary to collect enough knowledge about the new design so that the so-called "what-if" questions can be addressed – quantifying the effect of design variables on product output in an exhaustive manner. By doing so, it is important to make the correct choices based on reliable facts-even in the case of an abrupt shift by design constraints. The optimal performance is obtained when the heat sink fin geometry produces the best turbulent flow conditions that generate the largest heat transfer coefficient, and heat sink fins are large enough to provide minimum internal thermal resistance and maximum convective surface area. In this chapter optimum design of heat sink under multi-jet impingement condition is investigated using a novel technique Taguchi method [2-5].

II. TAGUCHI METHOD

The Taguchi approach requires reducing variance in a cycle by means of rigorous experiment design. The main goal of the approach is for the producer to deliver high-quality goods at low cost. The Taguchi system was developed by Japanese Dr. Genichi Taguchi who kept the variant. Taguchi has developed a framework for conducting tests to analyze how various parameters influence the mean and variance of a feature of process efficiency that determines how well the process is performing. Taguchi 's proposed experimental architecture involves using orthogonal arrays to coordinate process-influencing parameters and the rates at which they can be varied. Instead than trying to check all possible configurations, such as factorial configuration, the Taguchi system measures combination pairs. It allows the gathering of the data required to decide the variables that influence the consistency of the product with a minimal amount of testing, thus saving time and money [6]. The Taguchi method is better used where there is an intermediate number of variables (3 to 50), few interactions among variables, and where only a few variables make a major contribution. It is possible to construct the Taguchi arrays manually, and large arrays can be extracted from deterministic algorithms. The arrays are chosen by parameter number (variables) and level number (states). Variance analysis on the data obtained from the Taguchi experiment architecture will be used to pick new parameter values to improve the output characteristic [7-10].

III. EXPERIMENTATION

In this Experiment we are taking a micro fin heat sink on which the experimentation is carried out. It is very difficult to have direct reading of the specimen, so taguchi method is use to have the optimum result with a smaller number of experiment and it is also cost efficient. By using Taguchi Method, we are dealing with various parameters viz. Micro fin Diameter, Air Flow Ratio and Reynolds Number (Z/d ratio). The specimen taken for the experimentation is as shown in fig 3.1.

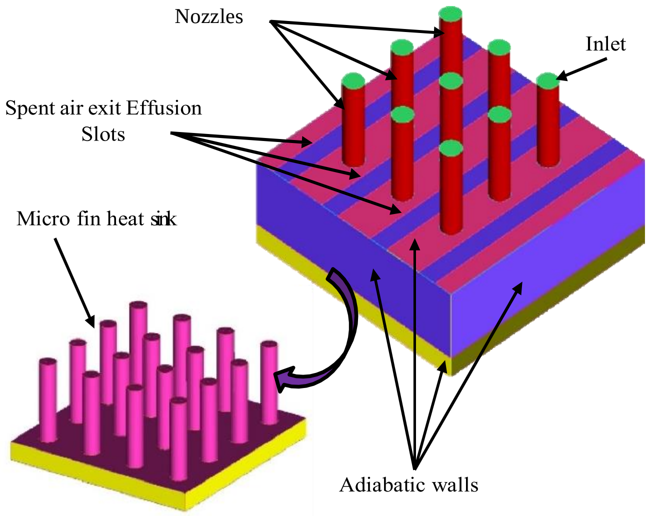

Fig. 1: Geometry of Computational Domain Considered for Optimization

IV. EXPERIMENTAL DETAILS

Table 1 shows the input parameter of the experimentation on which experiment is carried out, after performing the orthogonal array method we will get the optimum result.

TABLE 1

CONTROL PARAMETERS AND LEVELS

Control Parameters	Level 1	Level 2	Level 3
Pin Fin diameter, d (*mm*)	1.5 (11 × 11 fin array)	3 (6 × 6 fin array)	5 (4 × 4 fin array)
Z/d Ratio	6	8	10
Air flow rate (*m/s*)	26.59	39.88	53.17

V. RESULT AND DISCUSSION

Table 4.1 shows the S/N ratio for L9 orthogonal array. In the Taguchi method, all the observed values are calculated based on the concept that higher the better and smaller the better. In this analysis, the observed values of heat transfer coefficient will be set to the maximum.

TABLE 2

S/N RATIO FOR L9 ORTHOGONAL ARRAY

L9 Orthogonal Array	Pin Fin diameter, d (*mm*)	Z/d Ratio	Air flow rate (*m/s*)	Average heat transfer coefficient h, (W/m^2K)	S/N Ratio
1	1.5	6	26.59	245.674	47.80718
2	1.5	8	39.88	247.782	47.8814
3	1.5	10	53.17	242.181	47.6828
4	3	6	39.88	239.37	47.58139
5	3	8	53.17	250.84	47.98794
6	3	10	26.59	150.44	43.54727
7	5	6	53.17	283.19	49.04156
8	5	8	26.59	189.25	45.54072
9	5	10	39.88	216.43	46.70635
				CF	19954.06

TABLE 3

SIGMA S/N VALUES FOR HEAT TRANSFER COEFFICIENT

CF >>	19954.06		
	Diameter	*Z/d*	Air flow rate
Sigma S/N - I	143.3714	144.4301	136.8952
Sigma S/N - II	139.1166	141.4100	142.1691
Sigma S/N - III	141.2886	137.9364	144.7123

TABLE 4

ANALYSIS OF VARIANCE FOR HEAT TRANSFER COEFFICIENT (H)

	Diameter	*Z/d*	Air flow rate
1 Mean	47.80	48.15	45.64
2 Mean	46.38	47.136	47.39
3 Mean	47.10	45.98	48.24
SS	19958.59	19964.62	19969.96
% Contribution	33.33 %	33.34 %	33.34%

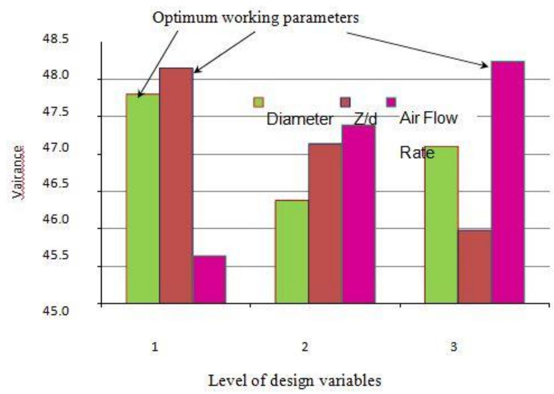

Fig. 2. Optimum working parameters

VI. CONCLUSION

By using Taguchi Method, with less number of trials we will get optimum solution. According to above calculations the maximum heat transfer coefficient will be obtained for micro-fin diameter 1.5mm, Reynolds Number (Z/d ratio) 6 and air flow ratio of 53.14m/s is 343.38W/m^{2}K. So, we conclude that, by using Orthogonal Array Method we will get the best result with less number of trials and it is also cost efficient.

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