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Experimental Approach for Split Triangular Finned Heat Sink

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***Abstract*— Modern day product development processes are highly depended up on the experimental methods for estimating the component's performance. The high cost involved in setting up the actual operating conditions during experimental setup is always a deterrent. Hence, a standard approach for conducting the experimental studies must be developed. In this research work, standard methodologies for conducting the experimental studies for the natural convection mechanisms in the heat sink. The experimental procedure had been listed. As a validation, the results obtained from the experimental work was compared against the CFD simulations results. Heat transfer rate predictions between the CFD simulations and experimental studies were in the range of 10%.**

Keywords*— *Heat Sinks, Fin Design, Experimental Natural Convection

I. INTRODUCTION

Experimental studies have been part of the product development cycle in all major engineering domain such as automobile, aerospace, turbo-machinery etc. In case of experimental studies, the operating conditions that exist in the component working conditions need to be established to evaluate the performance of the respective components. This provide the opportunity for the comprehensive performance study under the expected operating conditions.

However, the cost associated with setting up of the experimental setup for the actual working conditions could prove to be prohibitively high. Also, the data obtaining during the experimental study should follow the established standards. This require expertise knowledge in conducting experimental studies.

There have been many industries that apply numerical simulations for product development studies recently. Numerical simulations are based on computer oriented solvers such as CFD, FEA. The results obtained from these simulations are reliable and have been proven their accuracy for wide range of conditions. However, a validation of results obtained from these methodologies are usually obtained by comparing the results with the experimental data from the identical configuration.

The project work is based on optimizing a heat sink with triangular fins. The heat sink dimensions were obtained from **Aishwarya Patil** [1]. In their research work, the author had conducted the experimental and numerical studies to estimate the heat transfer rate from the split pin-fins. Due to the sharp corners on the triangular fins, the flow separation would occur in those regions. This was expected to enhance the mixing between the cold air and hot air. As a result heat transfer rate from the heat sink surface will be higher.

The present work had investigated various triangular fin configurations such as the triangular fin orientation, split triangular fins and vertical offset triangular fins. These studies were conducted with the help of CFD simulations as well as the experimental procedure. The details and the results shall be found in Rahul Gundla [2]. Also, a comprehensive literature survey on the natural convection mechanism from the heat sinks were published [3] and are not repeated here.

II. EXPERIMENTAL SETUP FOR THE TRIANGULAR FIN HEAT SINK

Individual triangular fins were manufactured and were assembled on the heat sink plate that was made of Aluminum as shown below.

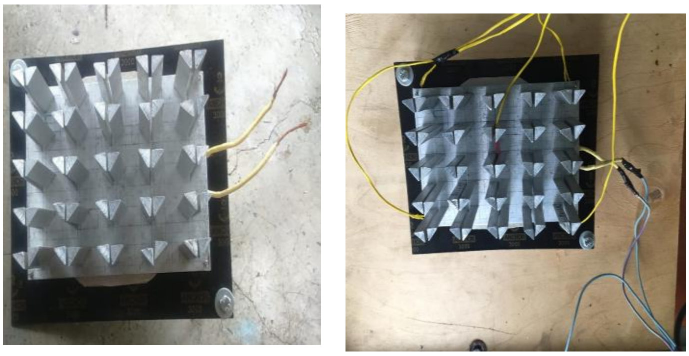

Fig. 1 Assembled heat sink configuration

The heat sink configuration has to be connected with the heat source for maintain at the constant temperature. Also, the thermocouples to be placed at the rear-side of the plate for

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temperature measurement. In the following figure, heat sink configuration with these requirements had been shown.

A. Heat Sink Details

The heat sink dimensions were obtained from Aishwarya Patil [1]. Heat sink base dimensions were considered identical to their model [120 mm in width and 180 mm in height while the thickness of the heat sink was 10 mm]. The dimensions of the triangular fins were calculated by maintaining identical surface area of the pin-fins. However, the number of fins as per this calculation were quite high, hence only 33% of the available area was considered for the heat sink design calculations.

B. Experimental Procedure

- The heat sink model was placed vertically in room that had a static conditions – no movement of air – as well in isothermal condition.
  - Under the natural convection heat transfer mechanism, temperature rise of the air from the high temperature solid surfaces results in reduced air density.
  - This forces the lighter air to move upwards while the heavier air moves downwards, commonly known as natural convection currents.
  - As the natural convection heat transfer had been studied in this project work, it must be ensured that the any fluid motion occurs only due to the natural convection currents.
- Heat supply was achieved with the help of dimmer stat. The voltage and current were monitored by the Voltmeter and Ammeter.
  - In the project work, the thermal operating conditions were defined as the difference in temperature between the heat sink bottom surface and the ambient conditions.
  - Hence, it was mandatory to maintain the specified heat sink bottom surface temperature.
  - This was achieved by controlling the electrical supply when the heat sink bottom surface temperature either below or above the required operating temperature.
- The diagonally placed thermocouples on the back of the heat sink were monitored.
  - Five thermocouples were placed at the rear-side of the heat sink for ensuring the required thermal operating conditions.
  - Of these five thermocouples, four of them were positioned at the corner of the heat sink plate while one of them was positioned at the heat sink center.
- The electrical energy was adjusted to maintain the respective thermal operating condition.
  - At various time intervals – for every minute – the readings from thermocouples, Voltmeter and Ammeter were noted.
- When the variation in the readings for these between successive time intervals were negligible, it was concluded that the steady state conditions had been obtained for that thermal operating condition.
  - This condition was mandatory to identify the steady-state / thermal equilibrium conditions.
  - Experiment was continued until this condition was obtained for all the heat sink configuration that was studied as well as for each thermal operating conditions for those heat sink configurations.
- This experimental methodology was repeated for all configurations.

C. Experimental Data

In the following table, the experimental readings after achieving the steady-state conditions during experiments had been listed. The total time to reach this state varied for each of these conditions. Only the final state values had been shown.

TABLE I. EXPERIMENTAL READINGS FOR THE HEAT SINK CONFIGURATION

ΔT, °C	**Thermocouple Readings**					**T_{avg}, °C**	**$T_{ambient}$, °C**	**ΔT Achieved, °C**
	T1, °C	***T2, °C***	***T3, °C***	***T4, °C***	***T5° C***			
40	65	66	65	66	65	65.4	25	40.4
60	86	85	85	85	85	85.2	25	60.2
80	105	105	105	106	105	105.2	25	80.2
100	126	125	125	126	125	125.4	25	100.4

As could be observed from the table, minor variations in temperature between the required conditions to the achieved temperature was observed. Since obtaining the exact operating conditions, may take longer time. The variations were 0.4° C and this was considered acceptable.

In the experiments, heat was supplied in the form of electrical energy. From this, heat transfer rate was calculated as the product of Voltage and Current. In the following table, heat transfer rate from the heat sink configuration for each operating conditions. Also, a graphical plot of the heat transfer rate had been provided in Fig. No. 2. The heat transfer rate was found to be increasing with the increase in the ΔT, following the expected thermal behavior of the heat sink.

III. RESULTS COMPARISONS- EXPERIMENTS AND CFD SIMULATIONS

The heat transfer rate had been found to be increasing with the increase in ΔT in both experiments and CFD simulations. This was expected as heat transfer potential increases with the increase in ΔT.

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TABLE II. HEAT TRANSFER RATE COMPARISONS FOR THE HEAT SINK CONFIGURATION

ΔT, C	Heat Transfer Rate, W		% Difference
	Experiments	*CFD Simulations*	
40	22.08	19.5	11.7%
60	36.27	32.9	9.3%
80	51.7	47.3	8.5%
100	69.6	62.5	10.2%

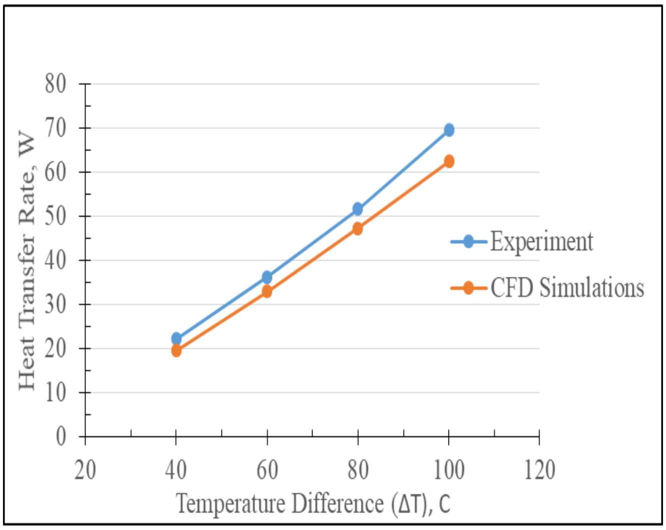

Fig. 2 Heat Transfer Rate Comparisons for the Heat Sink Configuration

The difference in heat transfer rate predictions between both these methods was consistently higher than 8%. CFD simulations had been under-predicting the heat transfer rate as compared to the experiment studies. One of the reasons for this was that the CFD simulations hadn't included the radiation effects.

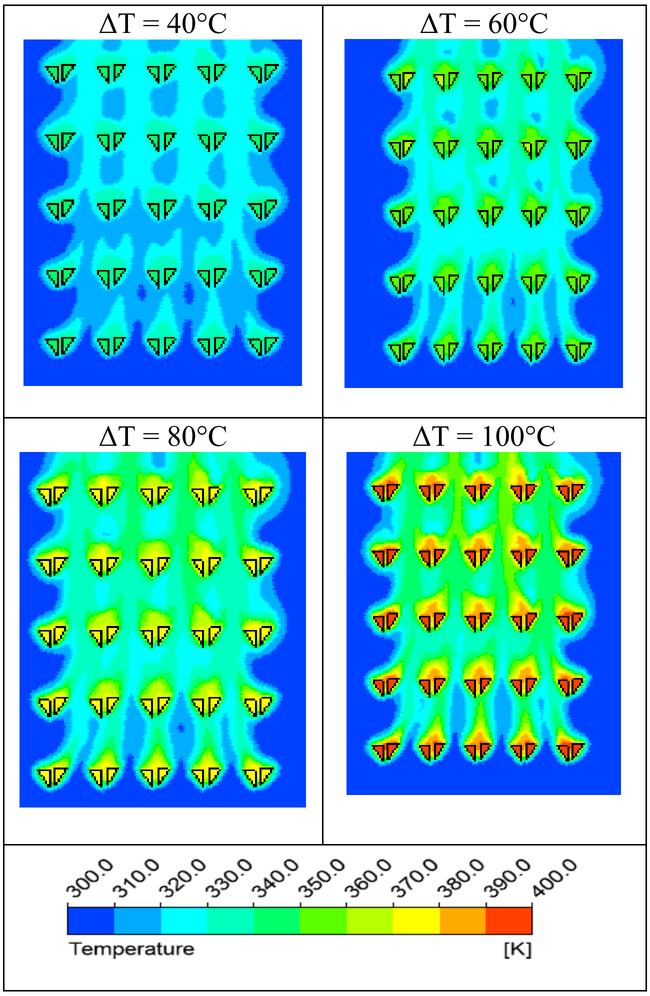

Fig. 3 Temperature Contours at the Heat Sink Mid- Plane from CFD Simulations

The temperature profile had near-identical pattern for all the operating conditions as could be observed from the above color plot, although the temperature magnitude changed from each operating conditions. The induced air velocity in the vicinity of the heat sink were observed to be 0.5 m/s. The maximum air velocity was observed near the top row fins on the heat sink. The sharp edges on the triangular fins enhanced the fluid mixing and subsequently high heat transfer rate from the heat sinks. High air velocity magnitude were observed for the high operating temperature due to the natural convection mechanism.

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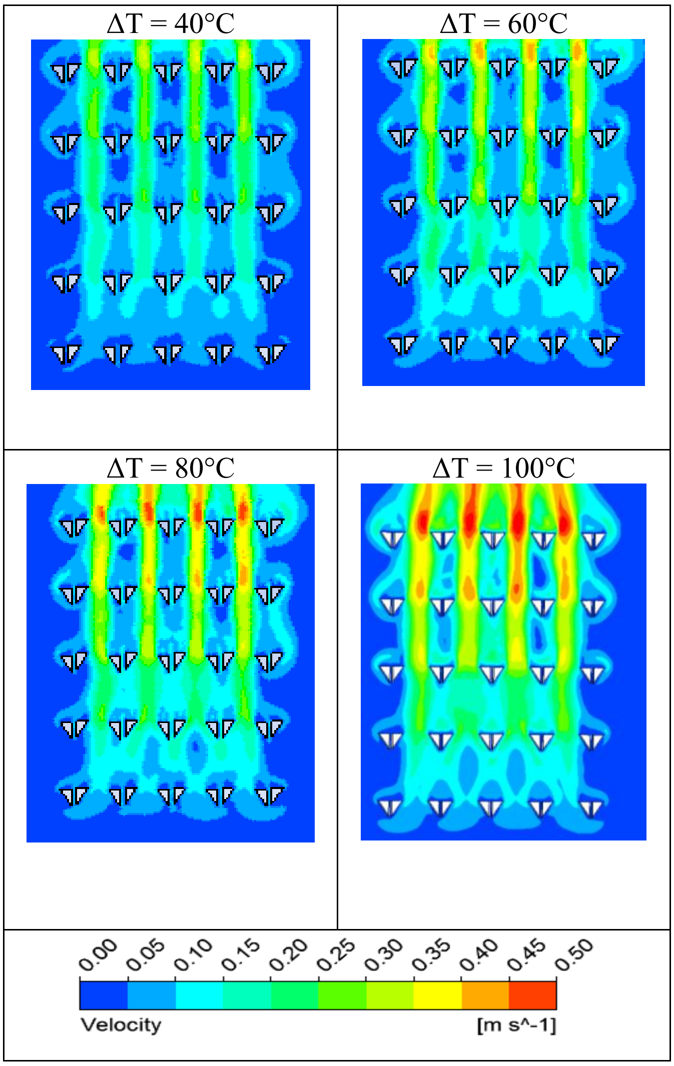

Fig. 4 Velocity Contours at the Heat Sink Mid- Plane from CFD Simulations

IV. OBSERVATIONS AND CONCLUSIONS

Experimental procedures were developed for predicting the heat transfer rate from the heat sinks under the natural convections operating conditions. The experimental data need to be obtained till the steady-state conditions was achieved. This has resulted in good agreement in heat transfer rate estimation between CFD simulations and experimental approach.

REFERENCES

[1] Aishwarya A Patil, S. G. Dambhare, “The Impact of Split-Distance on Pin-fins over Natural Convection Heat Transfer Enhancement” International Engineering Research Journal, Special Issue June 2016, pp 320-328;

[2] Rahul Gundla, Dr. Jitendra A Hole, “A Comprehensive Study of Split-Triangular Fins under Natural Convection Field: Experimental and Numerical Investigation” International Engineering Research Journal, Special Issue 16 June 2017.

[3] Rahul Gundla, Dr. Jitendra A Hole, “Literature Review on Heat Sinks Under Natural Convection Heat Transfer Mechanism” Journal of Emerging Technologies and Innovative Research, Volume 6, Issue 6, June 2019.