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Experiment on Heat Transfer from Plate Fin

Mohd Rosdzimin Abdul Rahman, Mohd Faiz Mohd Zahar, Mohd Rashdan Saad, Azam Che Idris, Norwazan Abdul Rahim

Abstract: This work is to study mesoscale plate fins under natural and forced convection. Five different designs of plate fins are used to investigate the efficiency of thermal performance under natural and forced convection. The heating plate power is 350 watt. Various air velocities are used for the forced convection study. Size of the testing enclosure is 0.4 m (W) × 1.0 m (L) × 0.09 m (H). Two axial fans are fitted at one end of the testing enclosure. It is found that the Nusselt number increases as increase in Reynolds number for all plate fin design. In the natural convection case, it is found that there is an optimum value of the Rayleigh number where the Nusselt number is at the peak. In overall, result shows that the design 4 gives the best thermal performance for both natural convection and forced convection cases.

Index Terms: Forced convection, mesoscale plate fin, natural convection, thermal management.

I. INTRODUCTION

The plate fins generally use as gadget to accomplish the cooling warm for electronic devices. There are a couple sorts of cooling procedures that have been utilized as a part of the plate fins in this period. Several researchers have conducted study on plate fin heat exchanger [1]-[4]. In [5] designed many types of plate to investigate the experimental of heat convection. Experimental investigation was conducted to measure the convective heat transfer coefficient and thermal performance of plate fins and plate cubic pin-fins heat sinks, under natural convection regime.

In [6] developed a correlation for plate fin heat sinks. They found that increasing fin numbers does not helped to a better heat transfer. In [7] propose a new cross fin heat sink. They claimed that this new cross fin heat sink could overcome an internal thermal fluid flow defect that generally occurs in conventional heat sink. In [8] investigated the straight heat sink at various mounting angle under natural convection. Mounting angle at 90 degree gives a best heat transfer performance and 15 degree mounting angle is the poorest heat transfer performance. Following the previous study on plate fin heat exchanger, this study is to investigate performance of several design plate fin heat exchanger at mesoscale size. This is interesting since a current electronics device is made at mesoscale size.

II. METHODOLOGY

Five aluminum plate fins are being used in this study. Design for each plate fin is shown in Fig. 1. Rectangular test enclosure is used with the dimension 0.4 m (W) × 1.0 m (L) × 0.09 m (H) in Fig. 2. Two axial fans are fitted at the end of the testing enclosure. Temperature is measured at five locations using *K*-type thermocouple. The hot wire anemometer is used to measure airflow rate. Qualitative measurement of the temperature distribution along the plate fin surfaces is recorded using thermal imaging camera (Fluke TiS65). The set up consists of a plate fin placed inside an open enclosure as shown in Fig. 2.

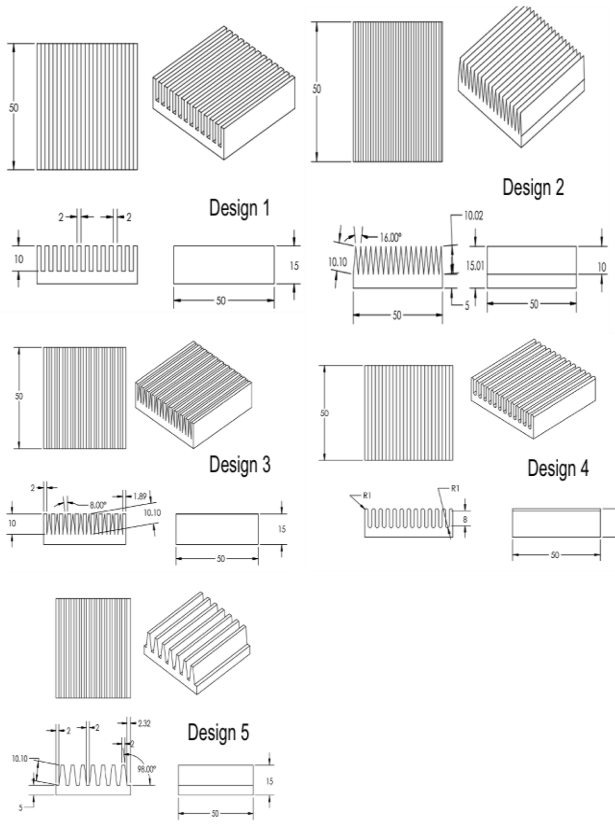

Fig. 1: Various plate fin design

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Mohd Rosdzimin Abdul Rahman, Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia.

Mohd Faiz Mohd Zahar, Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia.

Mohd Rashdan Saad, Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia.

Azam Che Idris, Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia.

Norwazan Abdul Rahim, Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Sg. Besi Camp, 57000 Kuala Lumpur, Malaysia.

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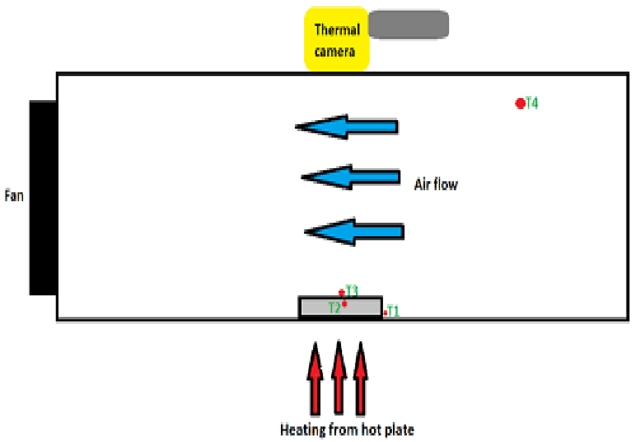

Fig. 2: Experimental test rig

III. RESULTS AND DISCUSSION

Initially, natural convection study has been conducted for all plate fins. The Rayleigh number is depends on the temperature difference between plate's fin and surrounding. Fig. 3 shows the Nusselt number for the plate fin at various Rayleigh number.

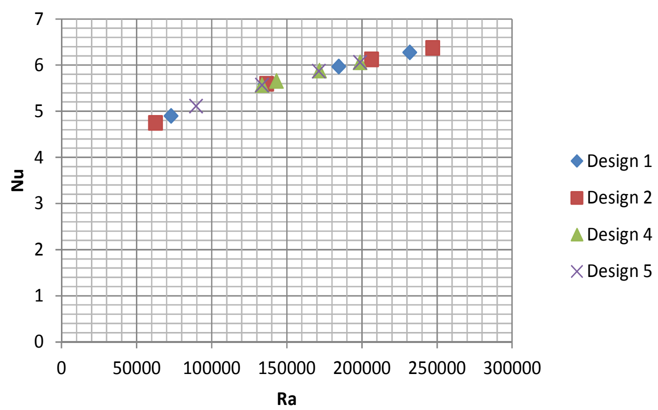

Fig. 3: Plate fin Nusselt number at various Rayleigh number

In Fig. 3, it is seen that increase in Rayleigh number bring the Nusselt number increases for all plate fin design. Thus, for the natural convection case design of the plate fin is not significantly influence the Nusselt number. Fig. 4 shows the efficiency of the all plate fin at various Rayleigh number.

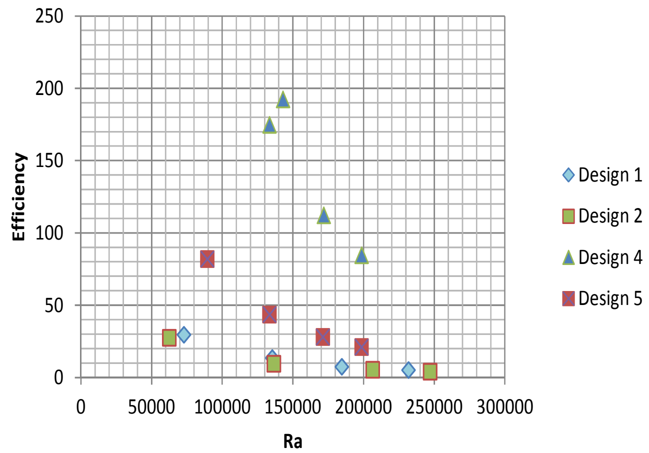

Fig. 4: Efficiency of plate fin at various Rayleigh number

Efficiency of the plate fin was plotted in Fig. 4. It is seen in Fig. 4 that efficiency of the plate fin increases as at low Rayleigh number and as increase in Rayleigh number the efficiency starts to decrease gradually. All plate fin reach zero efficiency at Ra = 250000. As demonstrated in Fig. 4, plate fin design 4 shows a high efficiency in comparison to other plate fin. Design 1 and 2 give the lowest efficiency for all Rayleigh number. Forced convection case is shown in Fig. 5.

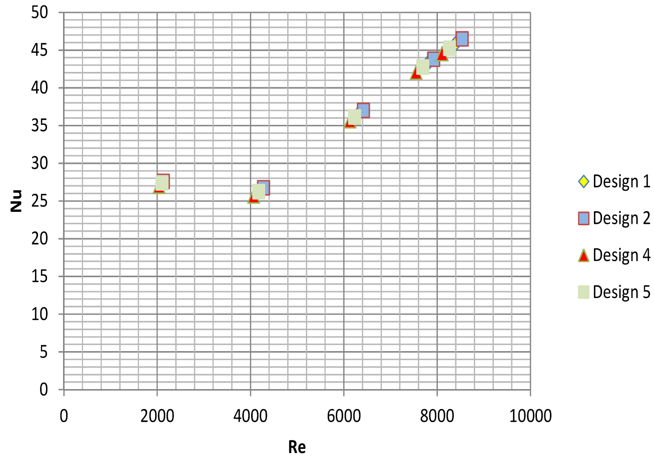

Fig. 5: Plate fin Nusselt number at various Reynolds number

As increase in the Reynolds number, the Nusselt number increases. It is seen in Fig. 5 that design of the plate fin is not significantly influence the Nusselt number.

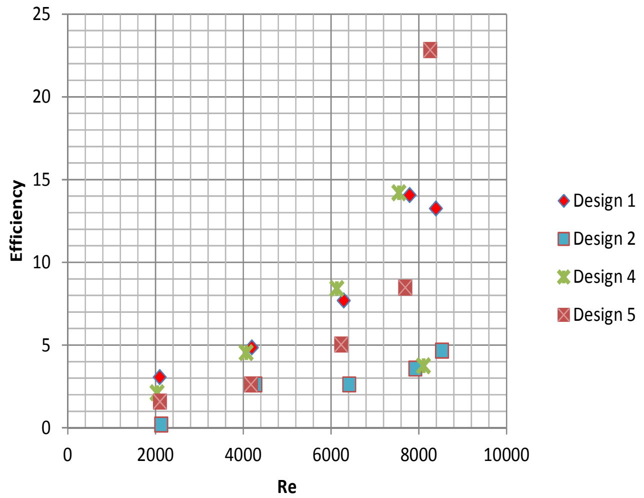

Fig. 6: Efficiency of plate fin at various Reynolds number

Efficiency of the plate fin for forced convection case was plotted in Fig. 6. The efficiency of the plate fin increases as increase in Reynolds number. As shown in Fig. 6, plate fin design 4 shows a high efficiency in comparison to other plate fin. Design 2 gives the lowest efficiency for all Reynolds number.

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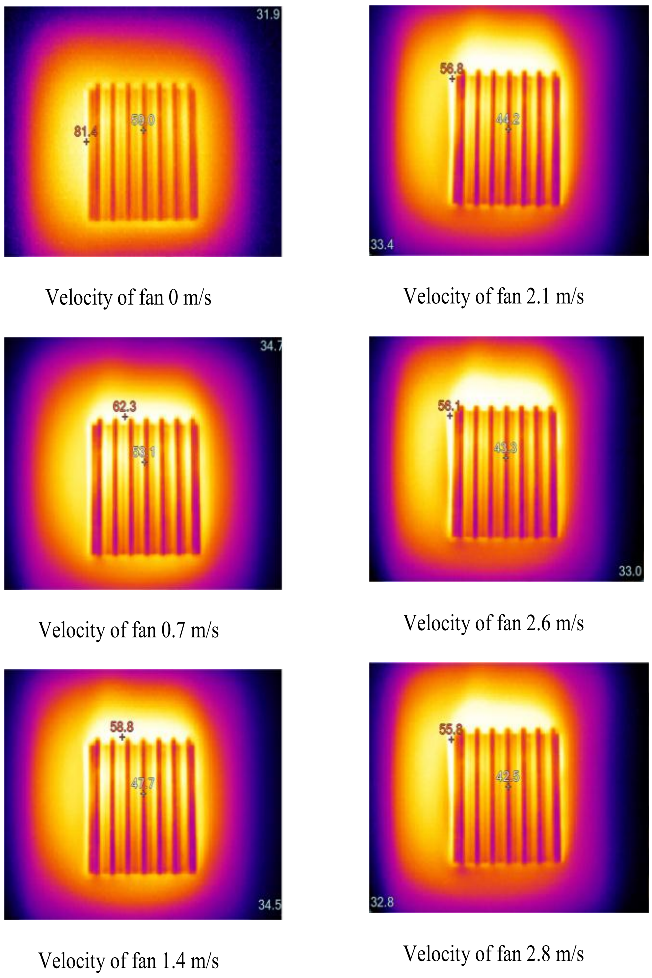

Fig. 7: Thermal image of the plate fin design 5

Fig. 7 shows thermal image of the plate fin design 5. These images were taken at various airflow velocities. It seen that temperature decreased as increase in airflow velocity.

IV. CONCLUSION

Studies on the thermal performance of plate fins have been done and objectives have been achieved. Some conclusions can be stated as:

a) The Nusselt increases as increase in Rayleigh number for natural convection case.
b) In forced convection case, the Nusselt increases as increase in Reynolds number.
c) In overall, design 4 is found to gives a higher performance for both natural and forced convection cases.

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REFERENCES

1. A. Akcayoglu, “Flow past confined delta-wing type vortex generators,” Experimental Thermal and Fluid Sciences, 35, 2011, pp. 112–120.
2. J. Ma, Y. P. Huang, J. Huang, Y. L. Wang, and Q. W. Wang, “Experimental investigations on single-phase heat transfer enhancement with longitudinal vortices in narrow rectangular channel,” Nuclear Engineering Design, 240, 2010, pp. 92–102.
3. J. M. Wu and W. Q. Tao, “Effect of longitudinal vortex generator on heat transfer in rectangular channels,” Applied Thermal Engineering, 37, 2012, pp. 67–72.
4. M. Khoshvaght-Aliabadi, M. Khoshvaght, and P. Rahnama, “Thermal-hydraulic characteristics of plate-fin heat exchangers with corrugated/vortex-generator plate-fin (CVGPF),” Applied Thermal Engineering, 98, 2016, pp. 690–701.
5. R. V. Rao and G. G. Waghmare, “Multi-objective design optimization of a plate-fin heat sink using a teaching-learning- based optimization algorithm,” Applied Thermal Engineering, 76, 2014, pp. 521-529.
6. S. S. Haghighi, H. R. Goshayeshi, and M. R. Safaei, “Natural convection heat transfer enhancement in new designs of plate-fin based heat sinks,” International Journal of Heat and Mass Transfer, 125, 2018, pp. 640-647.
7. S. Feng, M. Shi, H. Yan, S. Sun, F. Li, and T. J. Lu, “Natural convection in a cross-fin heat sink,” Applied Thermal Engineering, 132, 2018, pp. 30-37
8. X. Meng, J. Zhu, X. Wei, and Y. Yan, “Natural convection heat transfer of a straight-fin heat sink,” International Journal of Heat and Mass Transfer, 123, 2018, pp. 561-568.

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