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ScienceDirect

Procedia Engineering 157 (2016) 89 – 97

Procedia Engineering

www.elsevier.com/locate/procedia

IX International Conference on Computational Heat and Mass Transfer, ICCHMT2016

# On Numerical Investigation of Heat Transfer Augmentation through Pin fin Heat sink by laterally impinging Air Jet

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**Abstract**

Computational study of heat transfer augmentation using air jet impingement is the most contemporary provocation in the micro scale and electronic packaging systems. Since the cooling of heat sink becomes the most prior and conspicuous issue, as far as the efficiency and life of the system is concerned. Hence enhancement in local heat transfer coefficient becomes a most primitive parameter in the looming world of electronic packaging system. Extensive research is carried out in the area of steady air jet impinging over the flat plate by varying geometric as well as the injection parameters. Not only that, plenty amount of research works is also available with pin fin array as the target surface. But the numerical analysis of the current problem in commercial simulating software seems to be done very less. This work is beneficial as far as the visualization of various contours; physical time and effort required in performing experiments are concerned. The present research tries to propose a valid and optimum grid size required by the current computational domain in order to obtain the results which are independent of grid size. Also an appropriate turbulence model capable of accurately predicting the realizable flow regime is being proposed. Since the heat interaction data needs to be well predicted in near wall and jet system; region simultaneously, shear stress transport model is recommended for the present computational study.


Peer-review under responsibility of the organizing committee of ICCHMT2016

*Keywords:* Heat transfer; electronic packaging; computation; heat sink

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Peer-review under responsibility of the organizing committee of ICCHMT2016
doi:10.1016/j.proeng.2016.08.342

## 1. Introduction

Heat transfer in MEMS, electronic packaging system and robotics applications are the upcoming challenges of this looming world. The enhancement in convective heat transfer rate by impinging air in the form of jets to increase the efficiency of these appliances is one of the important calling tasks. Use of steady air jet in cooling the blades of gas turbine is still insistence. But as far as cooling of heat sink in electronic systems is considered, it is provided with some extended surfaces attached to the target surface. This is done in order to enhance the heat transfer rate of system and provide better performance. The impingement of air jet over such target surfaces not only enhances the heat transfer but also disturbs the turbulence flow regime. This disturbance reflects in enhancing the heat transfer rate.

**Nomenclature**

| | |
|---|---|
| Re | Reynolds number. |
| Pr | Prandtl number. |
| Nu | Nusselt number. |
| A | Area of base plate ($m^2$). |
| d | Diameter of nozzle (m). |
| h | Heat transfer coefficient ($W/m^2$-K). |
| k | Thermal conductivity (W/m-K). |
| Q | Heat input (Watts). |
| r | Radial distance over the base plate (m). |
| SST | Shear stress transport. |
| T | Temperature (K). |
| Z,H | Jet to the target spacing (m). |
| S | Spacing between pin fins (m). |

**Subscripts**

| | |
|---|---|
| a | Ambient condition. |
| b | Base plate. |
| s | Steady state. |
| z | Jet to the target spacing. |

### *1.1. Literature Overview*

Hung et al. [1] experimentally determined the thermal resistance of pin fin heat sink using infrared thermograph technique. Experiments were carried out at different Reynolds numbers, jet to the target spacing and width of pin the fins. Different plots of Nusselt distribution curve concludes the tangible effect of geometric dimensions of target surface on heat transfer rate at low Reynolds number. Hani and Suresh [2] compared the heat transfer coefficient for unpinned and pinned surface in presence of single and multiple jets by varying Reynolds number, jet to the target spacing and diameter of the nozzle. The resulting Nusselt distribution curve showed a strong dependency of heat transfer coefficient on air flow rate of impinging jet. On an average 60% increment in heat transfer rate was reported for pinned surface in presences of multi jet with that compared to unpinned ones. On behalf of this sets of parameters, regression analysis was carried out and an empirical correlation for area average Nusselt number was proposed as $Nu = 3.361\, Re^{0.724}\, Pr^{0.4}\, (D_e/d)^{-0.689}\, (S/d)^{-0.10}$. Suresh and Vincent [3] further took an effort in determining the local heat transfer coefficient at different radial distances of pin fin surface by varying H/d and impinging Reynolds number. As far as the comparison between the multi jets impinging arrays of 9×1.59mm and 4×3.18mm with single jet is concerned, 20% increment in heat transfer coefficient for 4 × 3.18 mm over 9 × 1.59 mm is being observed. The dominancy of multi jet in promoting the heat transfer rate is due to the presences of secondary peaks. These peaks are the local rise in the Nusselt distribution curve. Also these secondary peaks are observed to shifts toward the center as a result of which the Nusselt distribution curve becomes flattened and smooth. This happens