APPLICATIONS OF CYLINDRICAL AND RADIAL HEAT SINKS FOR COOLING OF LED LIGHT BULBS: A REVIEW

N. L. Bhirud[1], P. H. Chaudhari[2], A.S.Dube[3] and Y.R.Falak[4]

[1,2]*Mechanical Engineering Department, Sandip Institute of Engineering & Management,*

[3,4] *Mechanical Engineering Department, Sandip institute of Technology and Research Centre*

ABSTRACT

Fin arrays on horizontal and vertical surfaces are used in variety of engineering applications to dissipate heat to the surroundings. Studies of heat transfer and fluid flow associated with such arrays are therefore of considerable engineering significance. The main controlling variables generally available are the orientation and the geometry of the fin arrays. The purpose of the present study is to study the recent literature available for the use of the heat sinks for the heat dissipation from LED light bulbs. The review of the latest research papers was carried out and reported here. It is found that more thrust is needed to be given on the reduction of the weight of these heat sinks. So it is proposed to carry out more research in this area. It is noticed that, the rectangular plate finned heat sinks are showing better performance with the area removed in the form of notches. So it is required to compare the performance of the finned arrays under notched and un-notched conditions.

Keywords: Fin Efficiency, Heat Transfer Coefficient, Notch & Un-Notch Fin, Nusselt Number, Thermal Resistance

I. INTRODUCTION

Fin arrays on horizontal and vertical surfaces are used in variety of engineering applications to dissipate heat to the surroundings. Studies of heat transfer and fluid flow associated with such arrays are therefore of considerable engineering significance. The main controlling variables generally available are the orientation and the geometry of the fin arrays. In case of short horizontal arrays, it is observed that the air entering symmetrically from both the ends gets heated as it moves towards the centre of the fin channel, as well as it rises due to decrease in density. So, the central portion of the fin becomes ineffective because hot air-stream passes over that part and therefore it does not bring about large heat transfer. This area is removed at the centre from fins and they became inverted notched fins.10%-40% area removal increases the heat transfer rate. This modified geometry increase in heat transfer rate, reduces material cost and material weight.

II. LITERATURE REVIEW

The aim of the survey is to study the ongoing work in the field of LED cooling using the heat sinks. Various fin geometries are studied and the brief is presented hereafter,

Kim et al, 2014 [1], compared the thermal performance of vertical cylindrical sink with Branched fins & conventional plate fins & Proposed correlation for estimating Nu. With increase in angle of inclination, the drag coefficient increased and the Nu decreased. The best thermal performance was obtained for vertical orientation. Orientation effect was intensified by increasing the number of fins or the fin length.

Kim et al, 2013 [2], investigated natural convection from horizontal cylinders with longitudinal plate fins. Numerical model considering for natural convection and radiation heat transfer was developed experimentally.

Kim et al, 2013 [3], investigated natural convection from vertical cylinders with longitudinal plate fins. Proposed correlation for estimating Nu.

Lee et al, 2014 [4], heat sink of LED lighting was optimized with respect to its fin-height profile. Optimization was conducted to simultaneously minimize the thermal resistance and Mass. The cooling performance of the optimized design (pin–fin array with the tallest fins in the outer region) showed an improvement of more than 45%.

Lee et al, 2012 a [5], radiation effect on total heat transfer for radial heat sink was studied by varying emissivity. Optimization was carried out for Rth with and without considering change in mass.

Lee et al, 2012 b [6], optimization of Mass and R_{th} for radial heat sink with pin fins was carried out. Compared to LM fin array mass reduction of 35% was obtained for fin array.

Lee et al, 2011 [7], three types of radial plate heat sink (L, LM and LMS) were compared to determine the optimum model. Multi-objective optimizations considering thermal performance and mass simultaneously were performed.

Lee, 2010 [8], experimental and numerical investigation of natural convection in a radial heat sink was studied. As the number of fins, fin length, and fin height increased, thermal resistance and heat transfer coefficient generally found to be decreasing.

Dixit et al, 2013 [9], horizontal rectangular fin array with notched fins were investigated. Different shapes of notches were numerically investigated. Heat transfer coefficient for fins with inverted notch is found to be more in comparison with plane fins & triangular notch gives better heat transfer. Triangular notch gives better heat transfer performance as compared to trapezoidal and rectangular notches.

Wange et al, 2013 [10], computational and Experimental analysis of Inverted notched fin arrays is carried out & Inverted notched fin arrays gives better performance compared to plane fins.

Shen et al, 2014 [11], orientation effects on the fluid flow and heat transfer of rectangular fin heat sinks were studied. The performances of four heat sinks were studied in 8 different orientations.

Sane et al, 2008 [12], computational and Experimental analysis of Natural convection heat transfer from rectangular notched fin array. Notches enhance the heat transfer rate.

Elshafei, 2010 [13], the heat transfer characteristics of round hollow/perforated pin fin heat sinks subject to the influence of its geometry, heat flux and orientation are investigated under natural convection. The heat transfer performance for heat sinks with hollow/perforated pin fins was better than that of solid pins.

Maaspuro, 2013 [14], thermal model for LED spot light device has been created and simulated using a FEM. Both external natural and forced convection conditions were simulated. Results indicated that LED junction temperature can be reduced up to few degrees if grease with poor thermal conduction is replaced with the best silicone materials.

Luo et al, 2007 [15], experimental research on an 80 W LED street lamp is described. Maximum surface temperature of the aluminum base of the lamp was found to be about 80 C. The junction temperature of the LED chips is nearly close to 120 C at an environment temperature of 45 C, which leads to poor reliability and lower life and optical efficiency.

III. CONCLUSIONS

Like other electronic devices, the maximum junction temperature of LED chips should be kept at a suitable temperature (normally below150 C). The traditional types of heat sinks to cool LEDs mainly include metallic fin heat sinks which have the highest reliability. Many metallic heat sink geometries are studied and reported. Cylindrical heat sinks with longitudinal plate fins, due to the geometry of LED lightings, take center stage for cooling LED lightings. The rectangular plate finned heat sinks are showing better performance with the area removed in the form of notches. So it is required to compare the performance of the finned arrays under notched and un-notched conditions.

REFERENCES

1) Kuen Tae Park, Hyun Jung Kim, Dong-Kwon Kim, "Experimental study of natural convection from vertical cylinders with branched fins", Experimental Thermal and Fluid Science, 54, (2014) 29–37.
2) Daeseok Jang, Seung-Jae Park, Se-Jin Yook, Kwan-Soo Lee. "The orientation effect for cylindrical heat sinks with application to LED light bulbs", International Journal of Heat and Mass Transfer, 71, (2014) 496–502.
3) Hyun Jung Kim, Byoung Hoon An, Jinil Park and Dong-Kwon Kim, " Experimental study on natural convection heat transfer from horizontal cylinders with longitudinal plate fins", Journal of Mechanical Science and Technology, 27 (2) (2013) 593 – 599.
4) Byoung Hoon An, Hyun Jung Kim, Dong-Kwon Kim, " Nusselt number correlation for natural convection from vertical cylinders with vertically oriented plate fins", Experimental Thermal and Fluid Science, 41, (2012) 59–66.
5) Daeseok Jang, Se-Jin Yook, Kwan-Soo Lee, " Optimum design of a radial heat sink with a fin-height profile for high-power LED lighting applications" Applied Energy, 116, (2014) 260–268
6) Seung-Hwan Yu, Daeseok Jang, Kwan-Soo Le, " Effect of radiation in a radial heat sink under natural convection", International Journal of Heat and Mass Transfer, 55, (2012) 505–509.
7) Daeseok Jang, Seung-Hwan Yu, Kwan-Soo Lee, "Multidisciplinary optimization of a pin-fin radial heat sink for LED lighting applications", International Journal of Heat and Mass Transfer, 55, (2012) 515–521.
8) Seung-Hwan Yu, Kwan-Soo Lee, Se-Jin Yook, "Optimum design of a radial heat sink under natural convection", International Journal of Heat and Mass Transfer, 54, (2011) 2499–2505.
9) Seung-Hwan Yu, Kwan-Soo Lee, Se-Jin Yook, 'Natural convection around a radial heat sink", International Journal of Heat and Mass Transfer 53 (2010) 2935–2938

10) S R Dixit, D P Mishra,T C Panda,."Experimental Analysis of Heat Tranfer & Average Heat Transfer Coefficient Through fin Array With or Without Notch Using Free Convection", International Journal of Advance Research, 1-2, (2012), 11-21.

11) S M.Wange, R.M.Metkar, " Computational Analysis of Inverted Notched Fin Arrays Dissipating Heat by Natural Convection", International Journal of Engineering and Innovative Technology, 2-11, (2013), 245-249.

12) S.S. Sane, N. K. Sane, G.V. Parishwad, "Computational Analysis Of Horizontal Rectangular Notched Fin Arrays Dissipating Heat By Natural Convection" 5th European Thermal-Sciences Conference, The Netherlands, 2008.

13) Qie Shen, Daming Sun, Ya Xu, Tao Jin, Xu Zhao, "Orientation effects on natural convection heat dissipation of rectangular fin heat sinks mounted on LEDs", International Journal of Heat and Mass Transfer, 75, (2014), 462–469.

14) E.A.M.Elshafei, "Natural convection heat transfer from a heat sink with Hollow/perforated circular pin fins", Energy, 35, (2010), 2870- 2877.

15) Mika Maaspuro, Aulis Tuominen, " Thermal analysis of LED spot lighting device operating in external natural or forced heat convection", Microelectronics Reliability, 53, (2013), 428–434.

16) X. Luo, T. Cheng, W. Xiong, Z. Gan and S. Liu, "Thermal analysis of an 80 W light-emitting diode street lamp", IET Optoelectron, (2007), 1(5), 191–196