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Design And Thermal Analysis Of LED Lamp Cooling By Using Optimization Of Fins

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ABSTRACT

As energy resources being depleted from world day by day in enormous amount .With keeping it as root cause engineers and scientist continually focus over inventing something better than existing. In case of LED(Light Emitting Diode) lamps ,the LED life is the prime important which is achieved by removing large amount of heat from lamp, since near about 80% of energy is converted into heat. The phenomenon by which heat transfer takes place through LED lamp is nothing but fins which must frequently be improved. Fins are extended surface basically used to cool various structures via the process of natural convection. Heat transfer by fins is limited by the design of the system; still it may be modified by improving certain design parameters of the fins. Hence the aim of the paper is to present experimental as well as ANSYS analysis to compare the company's existing i.e. (conventional rectangular type of fins) with proposed new cross type of fins to optimize the overall thermal system of LED lamp by cost wise as well as performance wise.

***Keywords*— Natural convection, Rectangular fin, Cross fin, LED lamp**

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I. INTRODUCTION

The latest solid-state lightening through light-emitting diodes (LED's) has a inevitable trend to produce white light illumination. Now-a-days LED's are more popular for their higher luminous efficiency, energy serving and service life as compared to conventional lights, but has a limitation of higher heat generation due to which life of LED becomes decreases ([1], [2]). Hence it is necessary to modify or design an advance cooling system which can serve effective cooling so as to get better luminous efficiency for longer period. For that computational, analytical and experimental studies are carried out mainly for the fins geometry, its number and pitches.Fins are generally used to increase the heat transfer rate from the surface. According to Yunus A. Çengel [3] in analysis of fins we consider steady operation with no heat generation in the fin & assume thermal conductivity of material is not changed i.e. constant. The heat transfer coefficient (h) is assumed to be constant over the entire surface of the fin. The value of convective heat transfer coefficient (h) is much higher at the tip as compared to its base, since working fluid is majorly surrounded by the solid surface near its base. Hence adding so many fins on a working surface decreases the overall heat transfer coefficient.Up till now, a serious consideration of advanced thermal management techniques for high power LEDs has been already tried in many literatures. To investigate package and system level temperature distribution of high power LED array, Christensen et al. [5] combined a 3-Dimensional Finite element model and thermal resistor network model to calculate the impact of a compact high power LED array density, and active versus passive cooling methods on device operation. It was suggested that active cooling such as, forced air convection, flat heat pipe and liquid cooling would be better to maintain high power LEDs under the maximum temperature limit. But practically the above methods are not possible to incorporate, it would be better to innovate conventional fin design.Muhammed Nasir Inan and Mehmet Arik [6] developed the figure of merits (FOM) which are important for the designers and researchers to find the most optical solution for accounting for important facts such as weight, size, cost and performance. They studied the thermal and optical experimental results of various commercial A-line LED lamps and investigated a various FOMs based on size, weight and performance. They

concluded that thermal performance is crucial for LED lamp, large heat sinks or other cooling components with large weights reduce consumer acceptance hence developing a novel heat sink with the lowest thermal resistance and with an optimized mass is the key for improving LED thermal system. Cheng et al. [7] carried out study of substrate materials with different thermal conductivity and thicknesses using finite element method (FEM). These simulations results were demonstrated and concluded that increasing thermal conductivity of chip substrate material could improve overall thermal resistance, but there may be no need to pursue a material having much better thermal conductivity which had higher thermal conductivity than SiC (490 W/m K). To improve convective heat transfer coefficient, also to remove heat in the board quickly, and thus decrease in thermal resistance from board to ambience, many advanced cooling designs were reported. For e.g., piezoelectric fan is a viable cooling technology for the thermal management of electronic devices since its low power consumption, small and configurable dimensions, as well as minimum noise emission.
Acikalin et al. [8] investigated these piezoelectric fans for cooling of LEDs. They observed that convective heat transfer coefficient was drastically exceeding relative to natural convection, resulting in a temperature drop at the heat source of more than 36.4 ^{0}C,but again drawbacks are one more drive is required to run the fan means again the LED is getting costlier and also the maintenance of that fan was not so easy . Ma et al. [9] proposed vibrating fin for thermal management of an LED device. These vibrating fins, which are coated with thin copper and composed of piezoelectric material, can vibrate and conduct heat from the finned base using piezoelectric effect, but the cost of these types of LEDs, are so high and hence not easily accepted by the customer. so not suitable for commercial purpose. Chau et al. [10] investigated and proposed the cooling enhancement design of LED heat sources through an electro-hydrodynamic (EHD) approach, in which the forced convection of air is achieved by the ion wind due to gas discharge phenomenon. With this type of design, the sink temperature can be maintained in the range of 20-30^{0}C from the peak value of 650C without using any external cooling.Many Researchers has proposed and demonstrated the different types of fins over a conventional rectangular type of fins such as Shivdas S. Kharche and Hemant S. Farkade [11] have studied and proposed rectangular finned array by providing notch in natural convection, and used the material as copper .From the experimental study they found that the heat transfer rate in notched fin is greater than un-notched fin, and convective heat transfer rate is increased by overall 20%.,also as the notch area increases the heat transfer rate increases. Abdul Aziz and F. Khani [12] used the homotopy analysis method (HAM) to develop an analytical solution for the thermal performance of rectangular and various types of convex parabolic fins. They concluded that results produced by HAM i.e. convex parabolic fins have the better heat dissipation than rectangular type fin are more accurate than direct numerical solutions. E.M.Sparrow and L.F.A.Azevedo [13] carried out experimental and computational study on the heat transfer characteristics of natural convection in an open end vertical channel which is surrounded by isothermally heated wall and also by an unheated wall. These experiments were performed by using water as a fluid for the parametric variations in spacing and for order of magnitude range of wall to atmospheric temperature difference. The numerical analysis is conducted on both natural convection and wall conduction and correlation for Nusselt number was presented by author.

I. OBJECTIVE OF WORK

From literature survey, it is observed that many researcher uses the different techniques to minimize the overall temperature of fins, but the methods are not commercially accepted, very complicate and not reliable. Hence the best solution over this problem is to design the effective geometry of fin over the conventional fin of LED lamp. So we planned to design cross shape of fin to provide optimised solution to the company in cost wise as well as performance wise.We analyse many types of fins over the conventional rectangular fins & finally we obtained overall best result in cross type of fin. Hence we used this cross type of fin for comparing the temperature & convective heat transfer coefficient with existing one to optimize overall LED efficiency.

II. 3-DIMENSIONAL MODELS

Fig. 1 Shows the 3-dimensional model of company's original rectangular type of finned pate of LED lamp and fig.2 shows the 3-dimensional model of proposed cross type of finned pate of LED lamp.

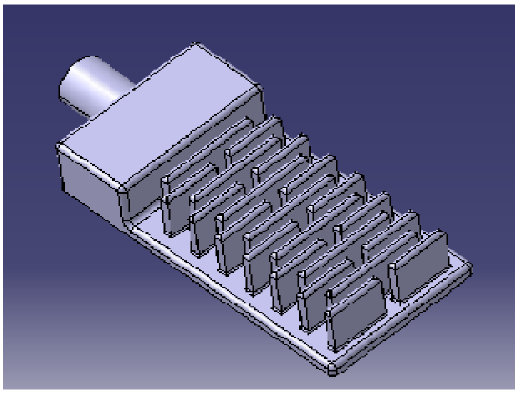

Fig.1 3-D model of existing rectangular finned plate

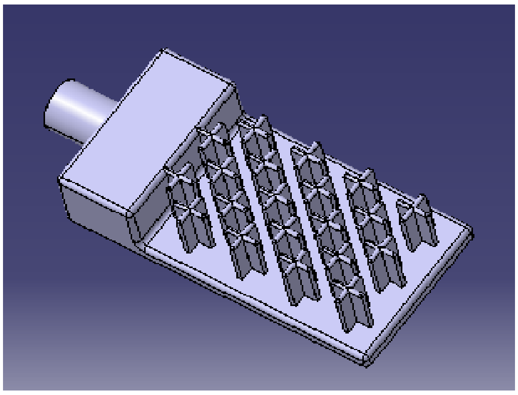

Fig. 2 3-D model of proposed cross finned plate

III. EXPERIMENTAL SET-UP

Main Components of experimental set up are square channel with 45^0 inclined handle, LED lamp, Battery, Laser gun, base plate, fin array. Laser gun is used to measure the temperature of the fin. The laser gun used in experiment is a non-contact type temperature measuring instrument which generally used in industries. The dimension of the LED lamp is 100*200 mm.

An aluminium finned base plate is used in the experimental set up. Fins are made up of aluminium because of its high thermal conductivity. We analyse different standard types of fins and proposed new cross type of fin which gives a much better result than the conventional fins.

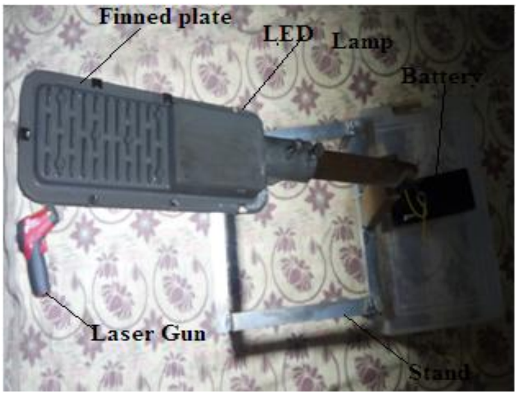

Fig. 3- Experimental Set-up

IV. RESULTS AND DISCUSSION

A. Variation of temperature with height with respect to time.

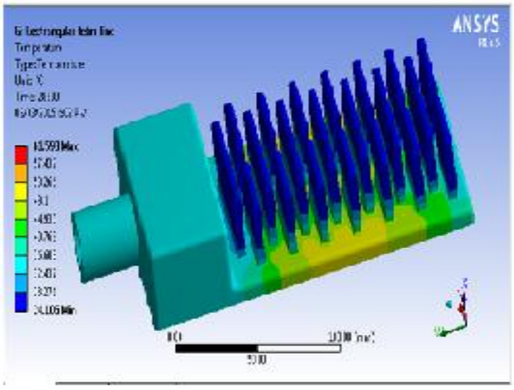

Fig. 4 Temperature contour for rectangular fin

Fig.4, shows the temperature distribution from the base to the tip of the fin with respect to the time, if we compare this distribution with the newly designed cross fin which is shown is fig.5,then we observed that for the same height cross fin gives a better heat dissipation as compared to rectangular fin.

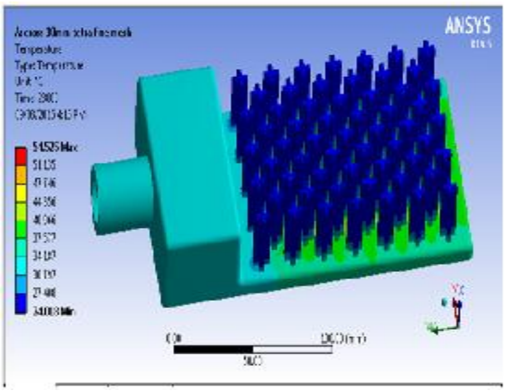

Fig. 5 Temperature contour for cross fin

B. Graph of Temperature verses time for rectangular and cross fin on the basis of analysis

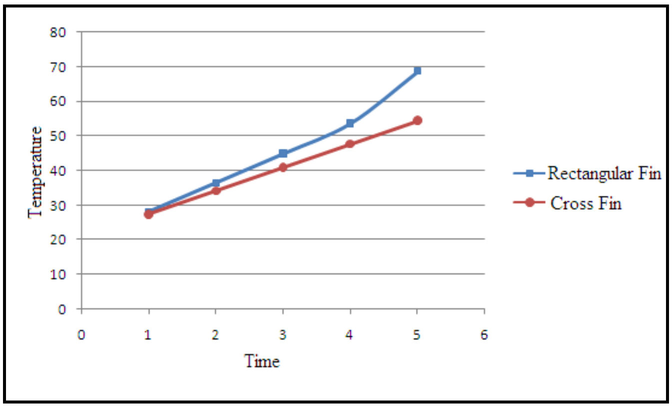

Fig. 6 Comparison of temperature for rectangular and cross fin

As shown in the fig. 6, the temperature reaches near about 70^0C after five hour of LED lamp running for rectangular fin and for cross fin it reaches near about 55^0C.These results are carried out on the basis of analysis.

C. Graph of Temperature verses time for rectangular and cross fin on the basis of Experimental results

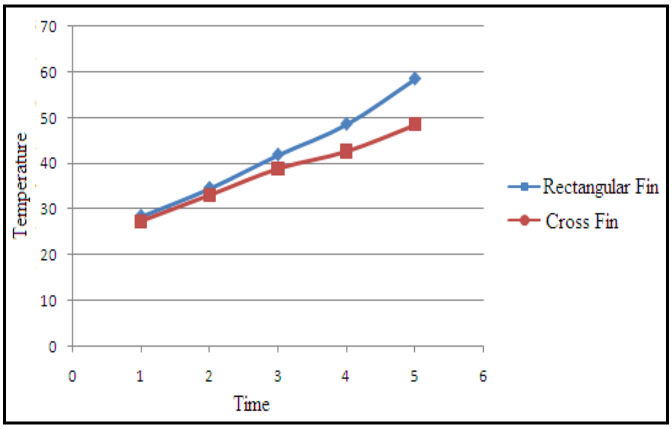

Fig. 7 Comparison for temperature for rectangular and cross fin

As shown in the fig. 7, the temperature reaches near about 60^0C after five hour of LED lamp running for rectangular fin and for cross fin it reaches near about 50^0C.These results are carried out on the basis of readings taken from experimental set up.

V. CONCLUSION

Experimental and ANSYS analysis is conducted over the company's existing conventional rectangular finned plate and proposed cross type finned plate in order to find out optimized solution for LED lamp in natural convection heat transfer. Steady state natural convection heat transfer for rectangular fin and cross fin is experimentally presented. ANSYS analysis is done on software ANSYS workbench version 14.5 Release. After analysing many types of defined fins we found that pin fin such as circular pin fin is also good for particular this case, but the weight of material is too high, hence it cannot be used commercially. It is found that by changing the geometry of conventional fin by proposed cross fin, convective heat transfer coefficient increases as well as the material required for fins is about 20% less over rectangular fin. On the basis of design calculations and experimental study the average convective heat transfer coefficient for rectangular fin is found to be 8.1W/m^{2}K and for cross type fin is 10.811W/m^{2}K.

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