UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Mechanical Engineering

GEOMETRIC OPTIMIZATION OF LED HEAT SINK FOR COOLING OF LED LIGHTING

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GEOMETRIC OPTIMIZATION OF LED HEAT SINK

FOR COOLING OF LED LIGHTING

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A thesis submitted

in fulfillment of the requirements for the Bachelor of Mechanical Engineering with Honours

Faculty of Mechanical Engineering

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DECLARATION

I declare that this project report entitled "Geometric optimization of the led heat sink for cooling of led lighting" is the result of my own work except cited in the references.

Signature : …………………………

Name : HOR WOEI TSONG

Date : …………………………

SUPERVISOR'S APPROVAL

I hereby declare that I have read this project report and in my opinion, this report is sufficient in terms of scope and quality for the award of the Bachelor of Mechanical Engineering with Honours.

Signature : ……………………………………………………………………

Name : DR. CHENG SEE YUAN

Date : ……………………………………………………………………

ABSTRACT

Light Emitting Diode(LED) lighting is one of the well-known energy efficient and rapidly developing technologies. LED lighting has a longer lifespan, higher durability and better light quality if have a good cooling performance of heat sink. The purpose of this research is to optimize the geometry of heat sink without increasing production cost to achieve high performance of heat sink without using excessive materials. The experimental work of the study will be expensive. Therefore, software simulation Ansys version 16 was used to simulate the case study. In order to validate the simulation were correct, comparison of the experimental and numerical result was done. Once the difference between them was not huge, case study proceeded. After several case studies were done, it found out that reduce in fin thickness of heat sink and increased in height of fin of heat sink had the highest cooling performance of heat sink compared to the others. This is because reduce in fin thickness resulted the thermal boundary layer did not fully develop at an early stage. While increase in fin height resulted in a huge increase in surface area, therefore, heat transfer surface area greatly increased. This study will be used for geometry optimization of the heat sink with another shape.

ABSTRAK

Pencahayaan Diod Pemancar Cahaya (LED) merupakan salah satu teknologi yang cekap tenaga dan teknologi yang berkembang pesat. Pencahayaan LED mempunyai jangka hayat yang lebih panjang, ketahanan yang lebih tinggi dan kualiti cahaya yang lebih baik jika adanya penyejuk haba yang prestasi baik. Tujuan penyelidikan ini adalah untuk mengoptimumkan geometri sinki haba tanpa meningkatkan kos pengeluaran supaya mencapai prestasi sinki haba yang baik tanpa menggunakan bahan berlebihan. Oleh sebab kerja eksperimen kajian mahal. Oleh itu, simulasi perisian Ansys versi 16 digunakan untuk mensimulasikan kes kajian. Supaya pengesahan simulasi adalah betul, perbandingan keputusan eksperimen dan simulasi dilakukan. Sebaik sahaja perbezaan antara mereka tidak besar, kajian kes terus dijalankan. Selepas beberapa kajian kes dilakukan, ia mendapati bahawa mengurangkan ketebalan sirip sink haba dan peningkatan ketinggian sirip haba mencapai prestasi penyejukan yang paling tinggi daripada sinki haba yang lain. Ini disebabkan dengan mengurangkan ketebalan sirip sinki haba menyebabkan lapisan sempadan termal tidak sepenuhnya berkembang pada peringkat awal. Walaupun peningkatan ketinggian sirip menyebabkan peningkatan yang besar di kawasan permukaan. Oleh itu, kawasan permukaan pemindahan haba bertambah tinggi. Kajian ini akan berguna untuk mengoptimumkan geometri sinki haba yang berbentuk lain.

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LIST OF ABBREVATIONS

LED	Light Emitting Diode
L	Long
LM	Long Middle
LMS	Long Middle Small
CFD	Computational Fluid Dynamics

LIST OF SYMBOL

R_{th}	=	Thermal Resistance (°C/W)
h	=	Heat Transfer Coefficient
H	=	Height Of Fins (mm)
θ	=	Degree
A	=	Surface Area (mm^2)
$\dot{m}$	=	mass flow rate (kg/s)
λ	=	Thermal Conductivity (W/m.K)
E	=	Young's Modulus
α	=	Electrical Resistivity, (μΩ.Cm)
Cp	=	Specific Heat Capacity (H/g.°C)
ρ	=	Density
t	=	Thickness (mm)
$\dot{q}$	=	Heat Flux (W/m^2)
P	=	Pressure (Pa)
r	=	Radius (mm)
T	=	Temperature (°C)
M	=	Mass (kg)
L	=	Length (mm)
u	=	x-component of velocity (m/s)
v	=	y-component of velocity (m/s)
w	=	z-component of velocity (m/s)
g	=	Gravity (m/s^2)
μ	=	Dynamic viscosity (N/m^2s)
ref	=	reference
ave	=	average
o	=	outer
i	=	inner
l	=	long
m	=	middle

∞	=	ambient
f	=	fins

CHAPTER 1

INTRODUCTION

1.1 Background

Light- Emitting Diode (LED) is one of the well-known energy-efficient and rapidly- developing technologies. LED lighting has a longer lifespan, higher durability and better light quality compared to incandescent lighting and other types of lighting. Although LED lightings do have a lot of advantages, it still faces the issue of heat. Heat produced by the led lighting will cause failure toward LED lighting.

Heat is the greatest enemy of LED technology (Victor, 2015). Heat brings failure or drop of performance for LED. While the failure included light output decreased permanently due to the damage was done by the heat toward LED, the color temperature of the white LED changed and etc. This failure because of materials used in the LED unable to withstand high temperature. To prevent LED lighting from overheating, a heat sink for led lighting must be applied.

Without a good heat sink, the internal temperature of LED lighting increases causing to failure. With the increase of internal temperature of a LED, voltage and lumen output of the LED decreases. With the characteristic changed, brightness and efficiency as well as an overall lifetime of LED decreased. Internal temperature of LED high lead to faster LED deterioration. This is why it is important to make sure internal temperature of LED remains low. (Taylor Scully, 2015)

There were several challenges in heat dissipation of LED lighting using a heat sink. The heat sink is a cylinder with longitudinal fins that usually applied in LED light bulbs. With a suitable design of heat sink, it will bring out the most effective on heat dissipation of LED lighting. Which will greatly reduce the overheated of LED lighting that will cause a reduction in the performance of lighting?

Due to competitive of LED lighting in the market, LED lighting industry required to develop innovative, low-cost conductive and convection heat sink to make sure LED lighting performance last longer.

1.2 Problem Statement

With the incandescent light is fading away, LED light is taking the sports light of the current market. However, LED light bulb is facing a problem when dealing with heat dissipation due to its limitation of internal temperature that causes a drop in performance. In order to reduce the internal temperature of LED light, heatsink was applied. Although heat sink will reduce the internal temperature of LED light, heat sinks are expensive in the market. In order for the manufacturer to provide an efficient heat sink with same price. Without excessive usage of materials, optimization of the design of heat sink should be done without increasing the cost of production.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To analyze the differences in geometry of heat sink like height of fin, length of fin and thickness of fin of the heat sink effect on its conjugate heat transfer by performing simulation under natural convection.
2. To provide an improved heat sink performance after optimization of geometry without an increase in mass.

1.4 Scope of Project

The scopes of this project are:

1. Geometry optimization of LED heat sink only focuses on the radial heat sink.
2. Simulation geometry changes of the LED heat sink without an increase in mass
3. Radiative heat transfer at the heat sink is negligible.

CHAPTER 2

LITERATURE REVIEW

2.1 LED Heat Sink

Light Emitting Diode (LED) lightings replaced by conventional lighting devices which provide higher efficiency, longer life and small in size. A lifetime of LED will be reduced if did not apply heat sinks with the main purpose of cooling LEDs (Kwak et. al. 2017). Similar to (Park et. al. 2016), stated thermal dissipation structure needed to assure long life and efficiency of LED lamp.

2.1.1 Shape of Heat Sink

According (Yu et. al. 2010) stated that majority of studies related to rectangular bases of heatsinks did not produce a significant result for cooling circular LED lights. Therefore, a radial heat sink with circular base and rectangular fins were studied. There was three types model of heat sink (Yu et. al. 2011) studied which were L type model, LM type model and LMS type model. LM type model showed the most efficient in heat dissipation in the result. Figures below show L type model and LM type model of heat sink.

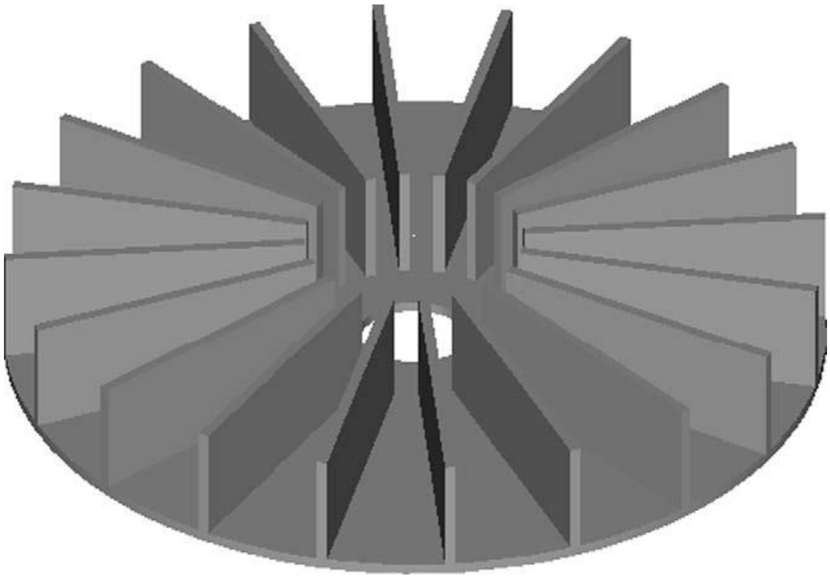

Figure 2.1 : L type model (Yu et. al, 2011).

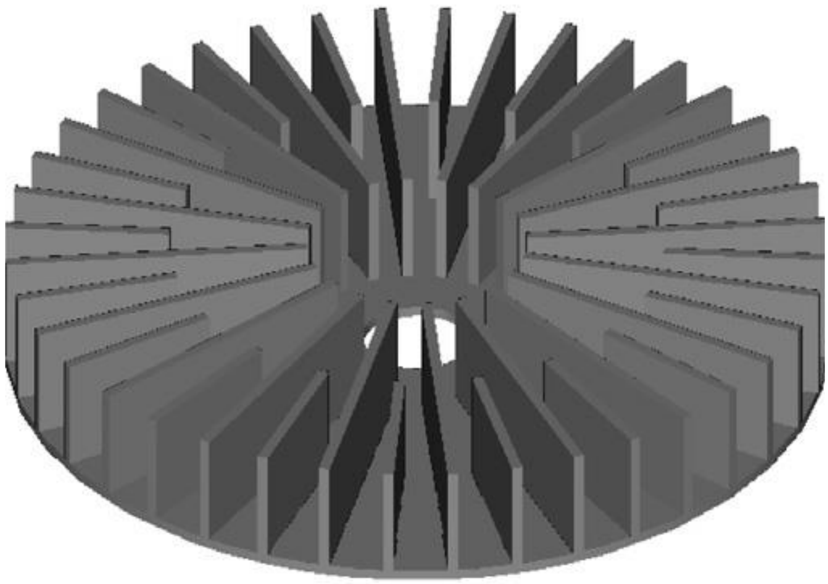

Figure 2.2 : LM type model (Yu et. al, 2011).

2.1.2 Material of Heat Sink

According to J.Padmaja & A. Ravindra (2015), selection of material heat sink is important in the conduction of heat from the heatsink. According to G. Prashant Reddy & Navneet Guptal, (2010) studies, the high thermal conductivity of the material used for heat sink, the faster the heat dissipation to the surrounding. There was three cases study specified by them.

Table 2.1 : Condition of material selection (G. Prashant Reddy & Navneet Gupta1, 2010)

Case 1 :

Function	Heat Sink
Constraints	(1) Material must have $\rho_e > 10^{19} \mu\Omega\ cm$ (2) All dimensions specified
Objective	Maximize thermal conductivity
Free Variables	Choice of material

Based on condition, a graph in figure 2.3 was formed. The graph showed that Aluminum Nitride (AIN) or Alumina (Al_2O_3) satisfied the condition.

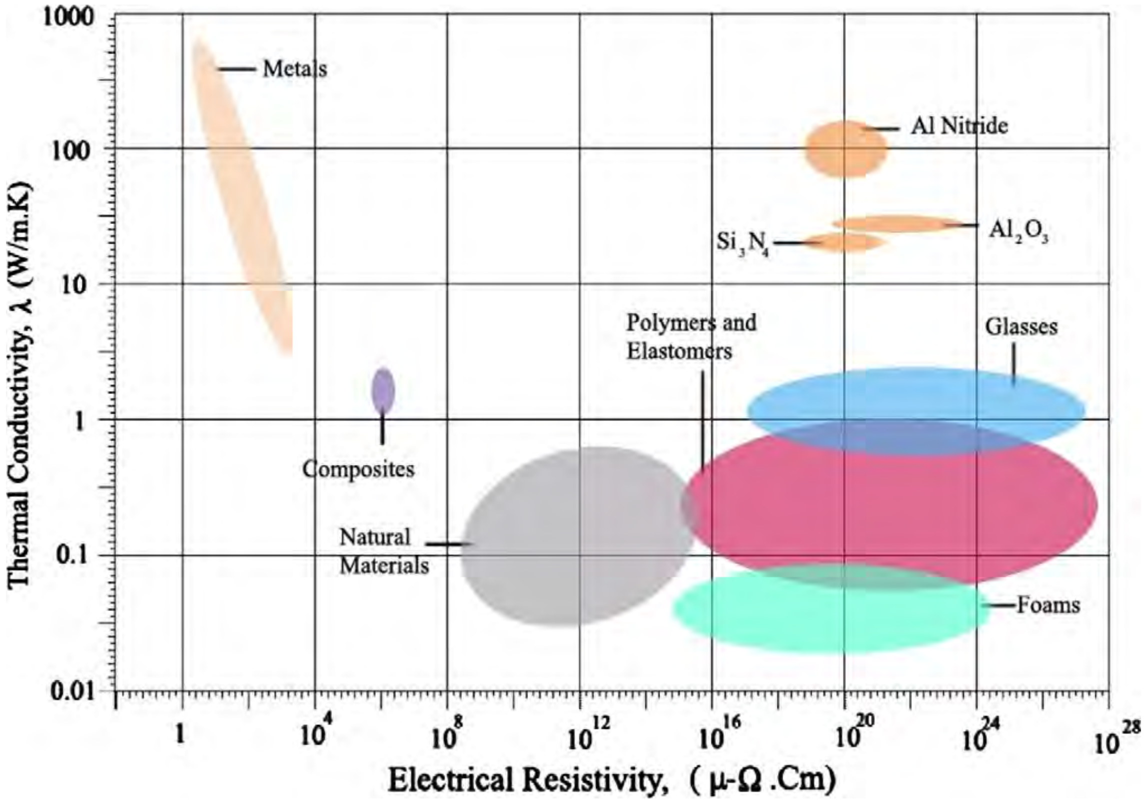

Figure 2.3 : thermal conductivity vs electrical resistivity for different class of materials (G. Prashant Reddy & Navneet Gupta1, 2010)

Table 2.2 : Second Condition of material selection (G. Prashant Reddy & Navneet Gupta1, 2010)

Case 2:

Function	Heat Sink
Constraints	(1) The temperature of material used in heat sink increase, thermal expansion decrease (2) High electrical resistivity (3) High value of Young's Modulus, thermal expansion must be significant
Objective	(1) Maximize Young's Modulus (2) Heat Transfer Coefficient increase, temperature increase