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Analysis of the Heat Radiation of LED Light Fixture using CF-design

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LED조명기구의 CF-Design 방열 해석

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Abstract This thesis is about the design of heat sink which is the obstacle in commercializing LED light fixture. It suggests a way of solving the problem by the analysis on heat radiation of LED light fixture using CF-design. As a result of the analysis, the difference of simulation value and the measured temperature of proto-type was derived as less than 6[℃]. Even the results approaching the target value of actual product could be obtained with the given factors well applied.

Key Words : LED, CF-Design, Heat sink, Heat Radiation, MCPCB.

요 약 본 논문은 LED조명기구의 상용화에 문제가 되고 있는 방열설계에 관한 논문으로서, CF-design을 이용한 방열해석을 통하여 문제해결의 방법을 제시한다. 해석 결과 시뮬레이션 값과 시작품 제작 후 측정 온도와의 차이가 6[℃]이하로 도출되었으며 주어진 제 요소들을 잘 활용하면 실제작품의 목표치에 근접하는 결과를 얻을 수 있다.

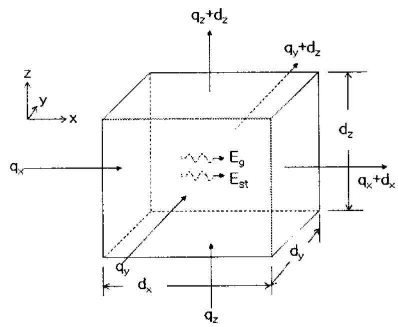
1. Introduction

As the efficiency increases and the price decreases, LED semiconductor is getting used more and more as a light fixture. LED light fixture developed for the purpose of improvement was commercialized by solving the heat radiation problem[1]. Due to the social needs of high capacity and the increasing unit capacity of semiconductor de-vice, however, the heat problem is getting serious and various kinds of methods suggested. The characteristics of LED being used as light fixture are that LED uses 15% of radiant energy as a visual ray while the incandescent light uses only 5% and that LED is eco-friendly without using mercury which is the problem of the fluorescent light[2]. LED also has long span of life. In this thesis, an analysis of heat sink using CF-d is sought as a way of solving heat problem.

2. Analysis of Heat Transfer

2.1 Basic Theory of Heat Conductivity and Thermal Diffusion

In the analysis of temperature distribution of heat transfer and diffusion, the heat conductivity in the normal state is ruled by the following conditions. By the principle of conservation of energy as shown in the [Fig 1], the heat conductivity to the directions of x, y and z respectively are expressed as follows according to the Taylor's grade unfolding[3][4].



[Fig 1] Concept Diagram of Heat Transfer and Diffusion

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$$q_{x+dx} = q_x + \frac{\partial q_x}{\partial_x} d_x \quad (1)$$

$$q_{y+dy} = q_y + \frac{\partial q_y}{\partial_y} d_y \quad (2)$$

$$q_{z+dz} = q_z + \frac{\partial q_z}{\partial_z} d_z \quad (3)$$

As energy source term related to heat energy generation can exist in the mediums, it can be express as below.

$$E_g = q\, d_x d_y d_z \quad (4)$$

Also as there can be changes of amount of internal heat energy stored by the materials in cubage, it can be expressed as below.

$$E_{st} = \rho\, c_p \frac{\partial T}{\partial_t}\, d_x\, d_y \quad (5)$$

Therefore, the general form of energy conservation demands is as follow.

$$E_{in} + E_g - E_{out} = E_{st} \quad (6)$$

According to the above theorems and the theorem of conductivity of transferred heat from the Fourier's law, the following general form of equation of thermal diffusion.

$$\frac{\partial}{\partial_x}(k\frac{\partial T}{\partial_x}) + \frac{\partial}{\partial_y}(k\frac{\partial T}{\partial_y}) + \frac{\partial}{\partial_z}(k\frac{\partial T}{\partial_z}) + q = \rho c_p \frac{\partial T}{\partial_t} \quad (7)$$

If the heat conductivity k is a constant and it is normal state condition, the above equation can be simplified to the below one.

$$\frac{\partial}{\partial_x}(k\frac{\partial T}{\partial_x}) + \frac{\partial}{\partial_y}(k\frac{\partial T}{\partial_y}) + \frac{\partial}{\partial_z}(k\frac{\partial T}{\partial_z}) + q = 0 \quad (8)$$

in which,

T: temperature

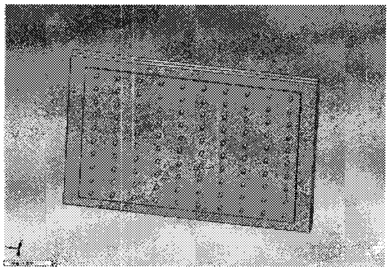
Cp: specific heat

k: heat transfer coefficient

2.2 Simulation and Analysis Model

2.2.1 Generation of Model

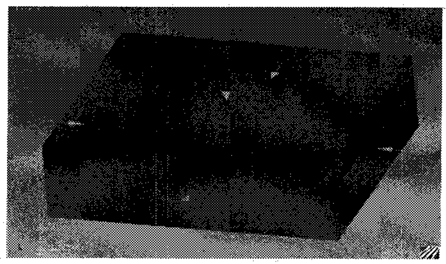
For the experiment, install 100[W] of LED with 10 in width and 10 in length and set MCPBC, copper plate and aluminum plate as heat sink over the LED. The space between LEDs is 10[mm] vertically and horizontally, and set them SMD of high brightness. For the whole cooling system, solid works are applied and the model is generated by direct launching function of CFd[Fig 2].



[Fig CAD Interface

2.2.2 Input Boundary Conditions

This analysis is to see the heat transfer tendency by LED's heat generation. LED body heating is the process of heating conditions using the generated LED parts; selection basis is set as Group-LED and type in the boundary condition is set as Total Heat Generation for which 0.8 is applied in consideration of the amount of heat generation of each LED. And for the room condition, the external 6 surfaces are selected and pressure is set as 0 after setting Surface in the Model Entity Selection of [Fig 3]. After inputting the atmospheric condition and then put the atmospheric state and temperature.



[Fig 3] Setting of Room Conditions

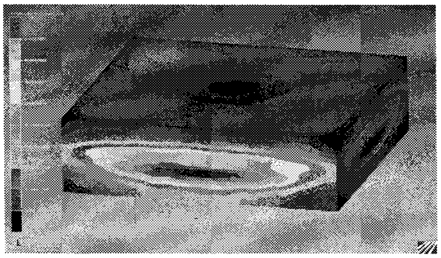
In the boundary condition, type is set the value of Film Coefficient at 5(and Ref. Temp term as 25[℃]). The unit is set as [W/m²/K]. By inputting the outside temperature and state of the object of analysis, the standard values are applied.

2.2.3 Analysis

Stable state analysis is to perform analysis at the pick point where there are no changes in temperature, velocity and pressure. Temporary state analysis is to perform analysis at a certain point to get values or to see the changes of temperature, velocity and pressure. For the analysis of LED heat transfer, stable state analysis is generally performed to check the astringency of each term (temperature, pressure, velocity, density, etc.). For this thesis, the values between 1,000 and 10,000 are set from the interim analysis to the Iteration to Run. However, attention should be paid as too small save-interval may make the storage space of computer overflowed[5].

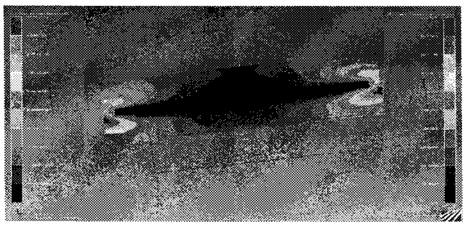
2.2.4 Results of Analysis

As a 3D analysis result of CF-d, scalar and vector can be seen at the Feature Tree. With selection of scalar, the image corresponding the term is obtained [Fig 4]. Also by getting the data by each steps stored after analysis, the heat distribution state can be checked.

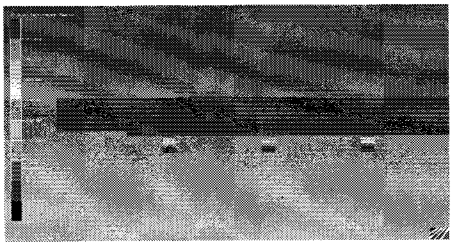


[Fig 4] Temperature Change Distribution (3D)

[Fig 6] is the analysis of heat transfer when the section is cut in 2D. In CF-d, scalar/vector results are supplied to see the results of cutting sectors. After setting the scalar/vector Results as wished values (velocity, temperature, pressure, etc.), check the values of each step.

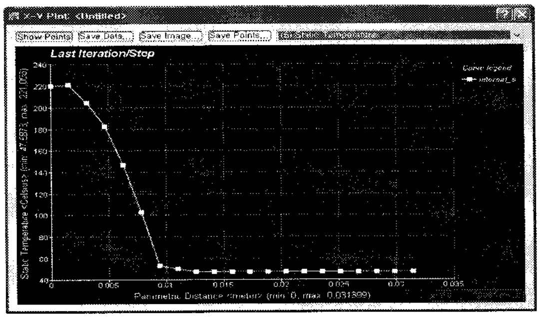


[Fig 5] Temperature Change Distribution (2D)



[Fig 6] Temperature Distribution by Each Step (2D)

These results can be obtained not only in qualitative values but also in quantitative values. [Fig 7] being XY Plot (Graph) shows that static temperature rises up to 220[℃] but it goes down to around 50[℃] as it approaches to 0.01 second. This result is satisfactory because LED works in normal.



[Fig 7] X-Y Plot(Graph)

3. Conclusion

By the analysis of LED heat transfer problem using CF-d, the temperature of LED comes close to 50[℃] for its satisfactory operation. But for the exact analysis and verification, various kinds of factors should be considered. The following procedures are necessary to be done simultaneously with the experiment.

1. For the general analysis, the manufacture's materials and experimental data of heat generation and temperature conditions are used. By performing heat experiments on the actual model, the amount of heat generation and loss values and the value of heat transfer to MCPCB can be obtained.
2. Make law data by setting data from the experiments and analysis conditions, and apply analysis

properties of matters to the various experimental variables to find optimized model.

3. Parallel performance of optimizing experiments and analysis can save time and reduce the number of Proto-types remarkably. It will create better results than optimizing by experiment in drawing better design and condition.

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<Research Area>

Electrical Facilities, Lighting and design, Heat-sink