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Heat Dissipation Design of High Power LED Headlamp

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Abstract. High brightness white light emitting diodes(LEDs) are very promising in many new illumination applications. This paper is to investigate the cooling solutions of a LED heallamp. Air cooling with heat sink were proved to be unsuitable. A cooling method based on heat pipe is adopted which is proved to be effective. Simulations were performed with Flotherm software to investigate the thermal permance.A sample of LED headlamp is fabricated based on the structure of a certain sedan combined headlamp. The testing results are in accordance with the simulation results.

Introduction

LED light source has a long service life and fast response speed. The colour temperature of white LED ranges from 5500K to 6000K, which is closer to natural light(4800-600K) than xenon light source(4000K). Besides, it is energy-saving and environment-protecting that it does not contain mercury. Multiple modules can be used so as to give more freedom to optical design. It is and ideal choice for the new generation of headlamp light source[1]. With the rapid development of automobile industry and the continuous improvement of LED light efficiency, LED is increasingly used in automobile, including interior light, brake lamp, steering lamp and taillight, which are all equipped with LED light source. Because headlamp has higher requirement for brightness, only a few concept vehicles are equipped with LED headlamps. However, being a new energy-saving light source with high efficiency, LED will inevitably replace other light sources and become the new generation of headlamp light source. There will be many problems to be solved, in which heat dissipation of high-power LED is a highlighted problem.

Heat dissipation design of LED headlamp

LED light source. The light source of headlamp must have adequate luminous output and is for optical design. To meet the requirement of optical distribution of headlamp ,three linearly packaged LED with multiple chips are used as the light source of the low beam of headlamps. LED light source is packaged in linear arrangement on a baseplate with five chips. The spread length of chips ranges from 4.5 to 5.5mm.LED working current is 700 mA, total power is 12 W, total light flux is above 1 000 lm, and the maximum junction temperature that is allowed is 150 degrees. The light type is 120 ° Lambert light. The light color is white, the thermal resistance of LED is 10K / W, the thermal resistance of PCB layer is 4.2k / w[2]. Fig. 1 shows the LED module.

Heat dissipation methods of high-power LED . Heat dissipation methods of high-power LED mainly include natural cooling, forced cooling and heat conduction of heat pipe. Natural cooling requires a large cooling area providing a large enough space for heat sink.

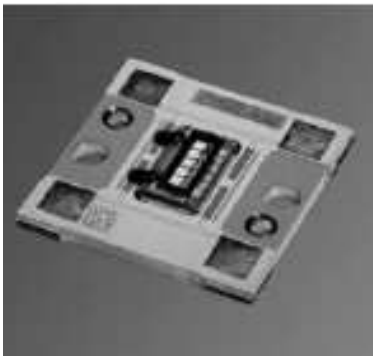

Fig. 1 The LED module

As is shown in Fig. 2, the cooling fin is 20cm in length and width, 10cm in height, and 5mm in thickness, and there are 10 cooling fins. The thermal performance of this method was simulated with Flotherm software[3]. As the temperature of engine compartment is relatively high while driving, the ambient temperature is assumed to be 50 degrees, it can be seen from the simulation results that the temperature of LED chip is 108 degrees while the ambient temperature is 50 degrees, and it has met the work requirements of LED, but the cooling fin with larger volume and heavier weight is required, which will affect the economy and reliability of vehicle fuel. Therefore, this heat dissipation mode is not suitable for automotive Lamps.

In addition, heat sink has a large mass that is inappropriate for the complex work environment of vehicle. Forced cooling requires fan on lamps, which has an influence on stability of lamps. This scheme is also inadvisable.

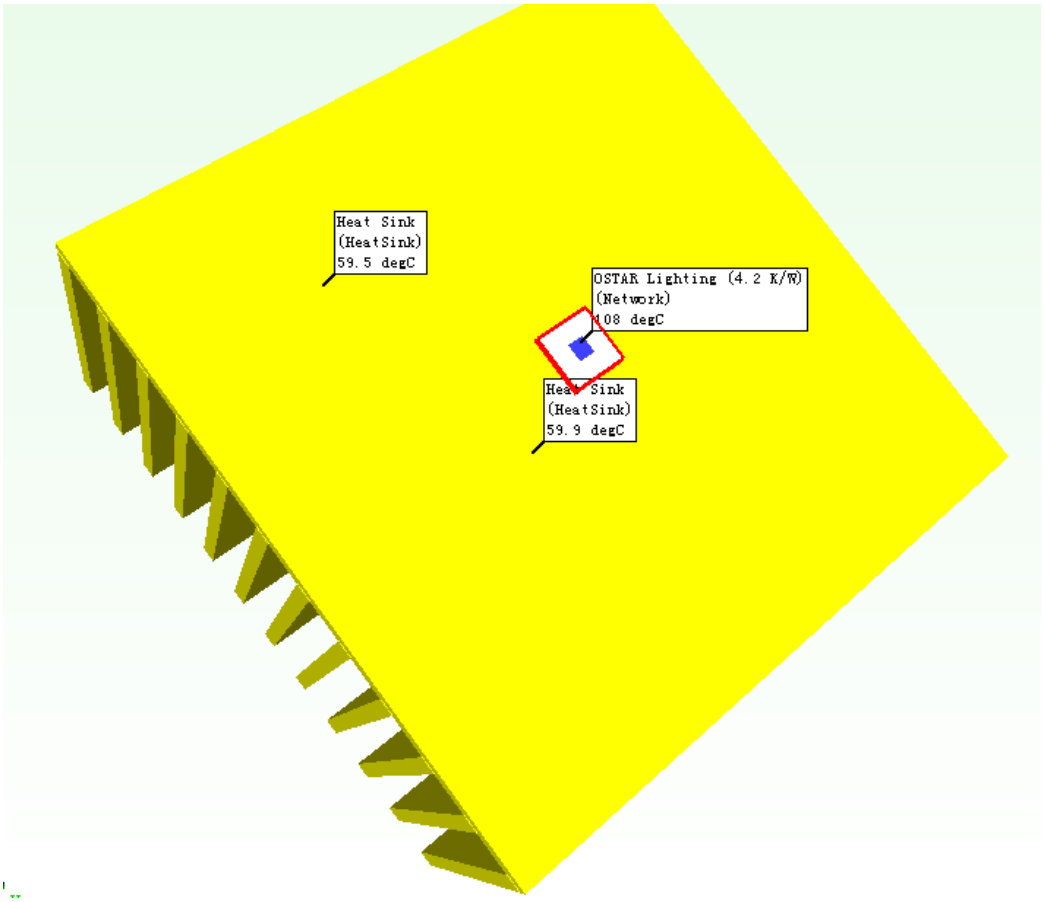

Fig. 2 LED with heat sink

Heat pipe (HP, also called heat conducting pipe or superconductive pipe) is a heat transfer element with extremely high thermal conductivity[4,5]. It transfers heat through evaporation and condensation of working medium in totally closed vacuum tube. Heat pipe cooling has a series of advantages, such as high thermal conductivity, good isothermal characteristic, arbitrarily changeable heat transfer area

of hot and cold sides, long-distance heat transfer and controllable temperatures. Heat exchanger formed by heat pipes has such advantages as high efficiency of heat transfer, compact conformation, small resistance loss of fluid, small thermal resistance, fast and large volume of heat transfer, average temperature, separated heat source and heat sink, unmixed hot and cold flow, simple structure, light weight, small volume and convenient maintenance. The main function of heat pipe is to conduct heat. If heat can not be dissipated after conduction, it will congregate on LED again. Therefore, heat pipe can not meet the design requirements. Heat should be dissipated by a perfectly configured cooling device such as heat sink. Fig.3 shows the simulation model of the thermal management with heat pipe. The effective heat resistance is set to 0.1K/W and the maximum heat flow is 12W. The heat sink is 8cm in width and 4cm in length, which is much smaller. The simulation results show that the junction temperature is 78 degree.

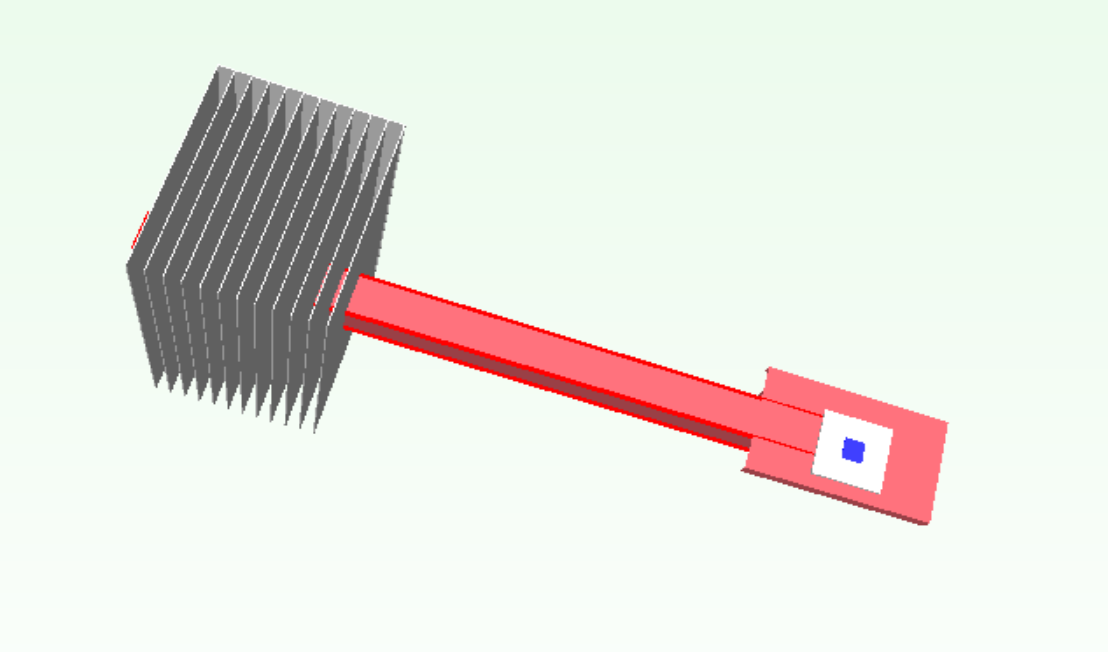

Fig.3 The simulation model of the thermal management with heat pipe

Heat dissipation design of LED headlamp. The Headlights have the heat dissipation method that combines heat pipe and heat sink, namely heat pipe radiator. This scheme skillfully agpplies heat pipe technology to radiating module of high-power LED. Weld the lamp panel of LED and heat conduction gasket, fix the foundation support of heat pipe with screw nail, and add a suite of circular radiating fins around the heat pipe so as to enhance the transfer of heat to the environment. This kind of heat pipe has 100 times higher thermal conductivity than the regular copper heat sink, which is commonly used in high-power LED. The heat dissipation structure of headlights on full beam is shown in Fig.4.

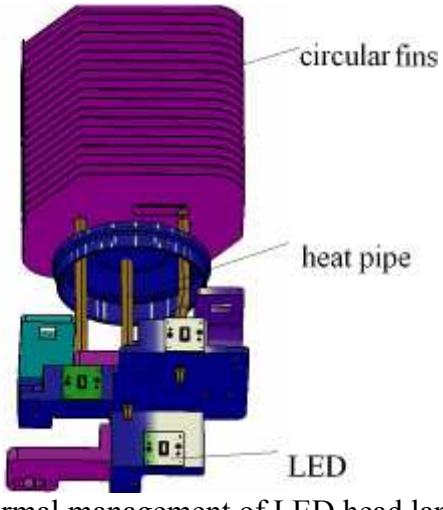

Fig .4 Thermal management of LED head lamp

Summary

By comparing software analysis and the production and test of sample lamp of certain automotive lamps, it is indicated that the results of software analysis and test data of sample lamp are basically the same, and the sample lamp is shown in the figure.

The design of heat conduction and heat dissipation through heat pipe proposed in this paper can solve the heat dissipation problem of high power LED automotive forward lighting, but there are still some limitations of heat pipe radiator, thus, the heat dissipation mode should be developed in the direction of intelligence

Acknowledgements

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