Thermal Analysis of Automotive Headlamp

Ms. Susmita Kamat[1], Mr. Swapnil Shinde[2], Prof.N.V.Sali[3]

[1,2] Student (Government College of eng.Karad)
[3]Professor, Dept. of Mechanical Engineering, Govt. College of eng. Karad, Maharashtra, India

---

Abstract – *The use of plastics have increased due to its lower weight hence it is necessary to examine its ability towards the sustainability over temperature. This study focuses on finding the main hotspot regions over the headlamp by using Thermocouples and Thermal Imaging Camera. Thermocouples help us to find the temperature but they do not always have exactly the same characteristics, even if they meet fairly strict standards and tolerances. Thermal imaging camera helps us to find the hotspot zones whereas thermocouples help to find the exact temperature at that point.*

Key Words: Automotive headlamp, Thermocouples, Thermal Imaging Camera, hotspot, thermal degradation

1. INTRODUCTION

Modern automobile lamps have a complex body design and contain powerful built-in sources of light. This can create problems for the materials used for their construction. The complex geometry and the combination of radiation, thermal conduction and free convection make difficult to find areas of critical temperature distribution inside the headlamp. Thus headlights need to be extensively tested to avoid damage caused by high temperatures. Experimentation under the same conditions determines the accuracy of the results or detects possible errors.

1.1 Structure of Headlamp

The headlamp studied in this paper is sample type of headlamp which can be observed in Figure 1. The H4 type bulb has two filaments named high beam and low beam which are the main heat source inside the headlamp.

Fig-1: Front View of Headlamp

The main parts of the headlamp are lens, reflector, bulb and coating, out of which the coating is made from polycarbonate material. This sample headlamp has 3 vents for proper air distribution. Two of the vents are located at bottom and one at top, assuring the heated air to escape.

1.2 Heat sources inside the headlamp

The main heat source inside is the filament of bulb which gives heat in all three forms i.e. conduction, convection and radiation. Other sources like radiation from sun, atmosphere also contributes as heat source.

1.3 Thermal Imaging Camera

IR radiations are emitted by all the objects which are captured by the IR sensor of the camera. It is mostly used to find the surface temperature of a object. The thermal camera used here is of FLIR make E85 model which captures 76,600 pixels of thermal data. The accuracy of measurement is ±2°C.

2. MECHANISM INSIDE THE HEADLAMP:

The flow of air inside the headlamp depends mainly on natural convection which is forced by the heat from the light bulb. The light bulb will heat the surrounding air and force the hot air to rise as new colder air enters from below. Radiation from the sun and the light source will be reflected by the reflector and energy will be absorbed by the nearby surfaces and cause the adjacent air to be heated. The heat absorbed by the surfaces will be transported through the materials by heat conduction. The headlamp casing is equipped with three ventilation holes that allow the headlamp to breathe.

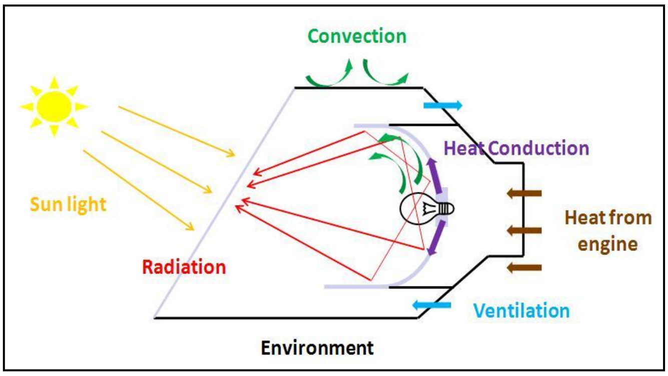

Fig-2: Mechanism **inside the headlamp**

The flow inside the headlamp is mainly depends on the natural convection phenomena. The tungsten filament emitting the heat that will heat the surrounding air inside the headlamp enclosure. Due to the phenomena of natural convection process the colder air enters from the bottom ventilation hole that will force the hot air rise to pass through the top ventilation hole [1]. Buoyancy force mechanism is the principle that has been done the above process. Both the natural convection and buoyancy force mechanism together to work with the inside the headlamp.

3. EXPERIMENTAL SETUP

The setup contains Headlamp, SMPS, Thermocouples, Thermal imaging camera, Wattmeter and Data Acquisition System.

The SMPS used in desktop CPU is modified by adding a capacitor to obtain the required power for the bulb to operate. This is done as the headlamp requires DC current. K-type thermocouples are used for measuring the surface temperatures. The thermocouples are pasted by using an adhesive tape. Thermocouple calibration is done to check the effect of adhesive on the temperature reading. The difference found is of 1% maximum. These K-type thermocouples are connected to the data acquisition system which records the temperature data for every one second. The wattmeter is connected so as to get the power consumed by the headlamp.

Initially, the headlamp is kept in working conditions (Status ON) for about two hours. Considering the average speed of the vehicle as 40 km/hr, air is forced on the headlamp to get the actual real life conditions, where the air is forced on the headlamp due to the travel of the vehicle.

The thermal camera is used for getting an overview of hotspot regions. Correspondingly, the thermocouples are pasted on the hotspot location.
Grid formation is done on the cover as shown in fig 3

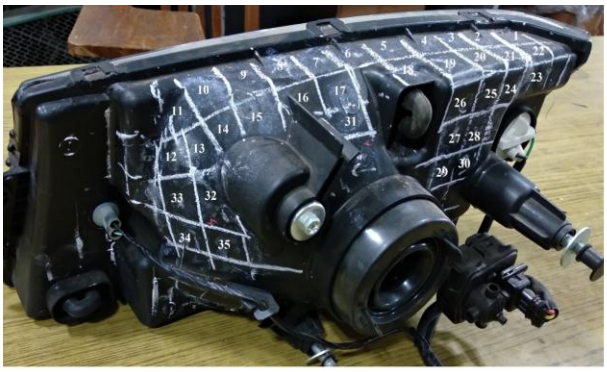

Fig-3: Grid formation on the back cover of headlamp

Then the data acquisition records the data for about 5 minutes i.e. 300s. About 300 values of temperature are obtained for a single point, average of which is taken as final temperature at that point.

The experiments are run for two different powers of 55 W and 100 W and the hotspot regions are found out.
Sets are created according to locations shown in the fig 3. Set A contains 8 locations marked from 1-8. Similarly other sets are created.

4. RESULTS AND DISCUSSION

The results here are for both the cases. The first case has the bulb of 55 Watts and second is of 100 Watts. The images obtained from the thermal imaging camera and temperatures from thermocouples are also discussed.

4.1 IR thermograph

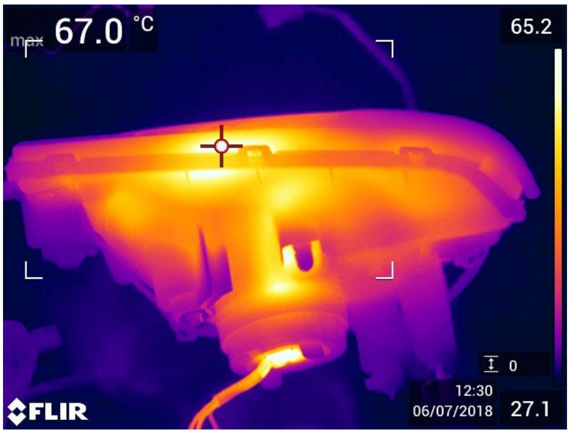

Fig-4: Top View-Thermal Image of Headlamp for 55W

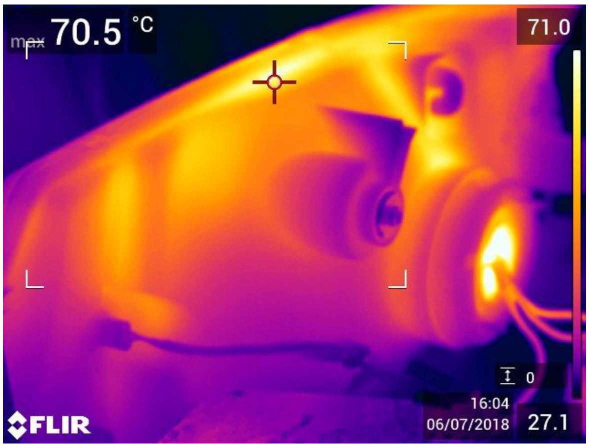

Fig-5: Side View-Thermal Image of Headlamp for 55W

Fig 4 and 5 shows the top and side view clearly indicating the hotspots and the maximum temperatures for bulb of 55W. The maximum temperature to which the headlamp is heated is 70.5 ˚C.

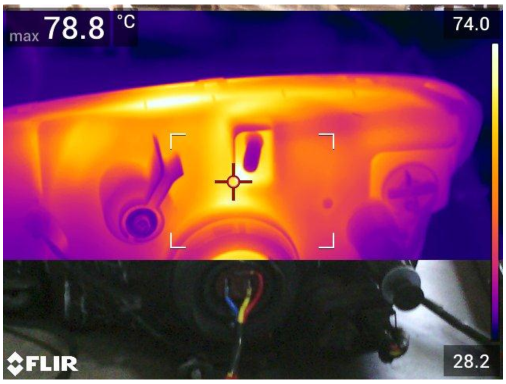

Fig-6: Front View Thermal Image of Headlamp for 100W

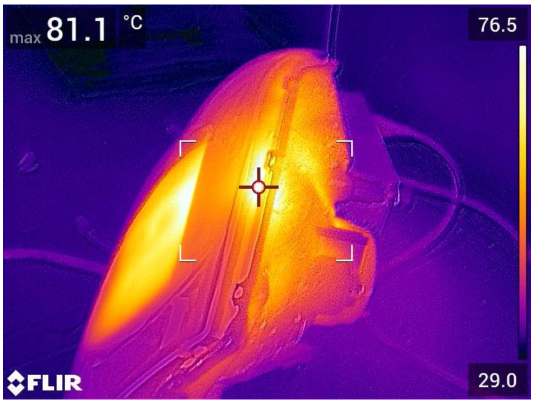

Fig-7: Top view - Thermal Image of Headlamp for 100W

Fig 6 and 7 shows the top and side view clearly indicating the hotspots and the maximum temperatures for bulb of 100W. The maximum temperature to which the headlamp is heated is 81.1 ˚C.

Also by analyzing the images in FLIR software we have hound the secondary hotspots,temperature for which are 79.7, 78.2, 72.6 for the case of 100 W bulb used. Whereas the temperature of secondary hotspots for 55W bulb are 57.8, 55.9, 53.7.

4.2 Using thermocouples

Among the five sets two sets are shown in gragh which states the temperatures at that location which have the maximum temperatures for bulb of 55 W

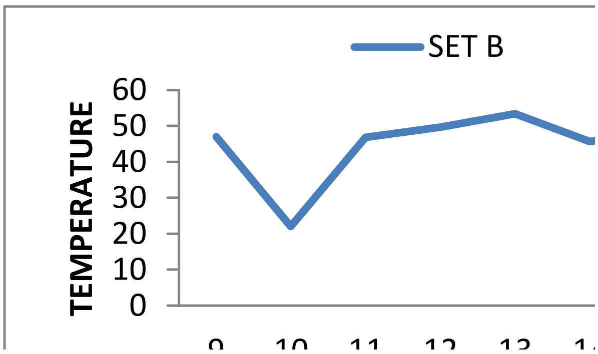

Chart -1: Temperature distribution along the location for 55W.

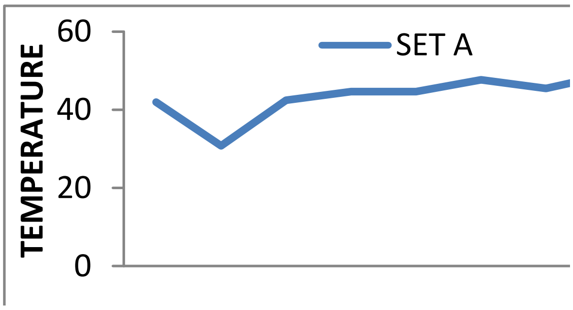

Chart -2: Temperature distribution along the location for 55W

From the physical grid generation figure 3 ,the SET B includes the location from 9-15 and the maximum temperature obtained from the set A is at point number 13. The highest temperature from set B is 53.42˚C which is shown in Chart -1. Similarly from Chart -2 the SET A ranges from point number 1-8 and the highest temperature is at point 8 which is 49.13˚C

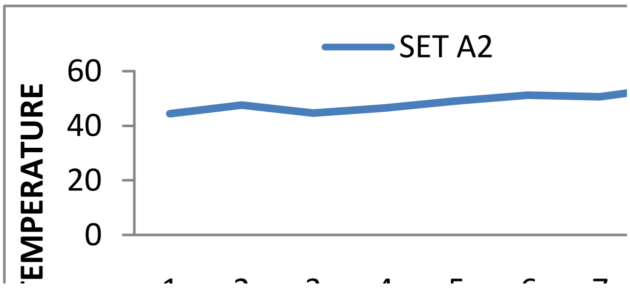

Chart -3: Temperature distribution along the location for 100W

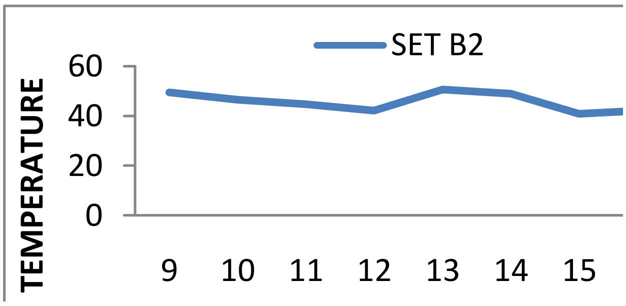

Chart -4: Temperature distribution along the location for 100W

From the physical grid generation figure 3 ,the SET A2 includes the location from 1-8 and the maximum temperature obtained from the set A is at point number 8. The highest temperature from set A2 is 54.72 C which is shown in Chart -3. Similarly from Chart -4 the SET B2 ranges from point number 9-16 and the highest temperature is at point 13 which is 50.12˚C.

5.CONCLUSION:

All the major hotspots occurred in both the cases of the headlamp are identified. It is seen that the major hotspot region is on the upper side of the bulb. The temperatures recorded by the thermocouple also show the same trend. But as clearly seen, the thermocouples are unable to detect the location where the maximum temperature occurs. Also in first case of 55W bulb used, the temperatures are in acceptable range, where as in second case of 100W bulb the temperatures are not acceptable. Hence it is advised not to use the locally available bulb of higher wattage as it can thermally degrade the headlamp, decreasing the life of the headlamp. Thus thermal imaging camera can be a convenient device when it comes to finding out the hotspots over a larger area.

REFERENCES

[1] Manoj Kumar S, N. Suresh Kumar R., ThundilKaruppa Raj,Heat transfer analysis of automotive headlamp using CFD methodology ,International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163 Issue 7, Volume 2 (July 2015)

[2] K.FurkanSokmen ErhanPulat Nurettin Yamankaradeniz SalihCoskun,Thermal computations of temperature distribution and bulb heattransfer in an automobile headlamp Heat Mass Transfer (2014) 50:199–210DOI 10.1007/s00231-013-1229-5.

[3] Michal Guzej, Jaroslav Horsky, Experimental verifications and numerical thermal simulations of automobile lamps ISSN 1580-2949 Original scientific article MTAEC9, 50(3)289(2016).

[4] Touichirou Shiozawa, Masatoshi Yoneyama, Koichi Sakakibara, Shuichi Goto, Norihisa Tsuda, Tetsuo Saga, Toshio Kobayashi, Thermal air flow analysis of an automotive headlamp:the PIV measurement and the CFD calculation fora mass production model,Elsevier JSAE Review 22 (2001) 245-252.