

Research on the Photometric Performance of Modified HID Headlamps

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Abstract—In order to obtain brighter light beam, consumers would like to replace the halogen bulb in the headlamp of their car with HID conversion kit. In the vehicle market of China, relevant laws or regulations on modified headlamps are rarely found for now. This study investigated the photometric performance of modified HID headlamps. Using the performance assessment method for headlighting systems described in CIE 188 Technical Report, this study compared the shape of cut-off line, road scene illumination and glare of headlamps installed in cars of same type but with different light sources (including halogen bulb, HID light source and HID conversion kit). The results indicated that the photometric performance of modified HID headlamps depended heavily on the optical system (reflector or projector) of headlamps. For consumers, it is hard to tell the quality of modified HID headlamps. We suggest that it requires regulations for the modified HID headlamps, in order to improve traffic security.

Keywords—HID conversion kit; photometric performance; CIE 188 Technical Report; Modified Headlamps

I. INTRODUCTION

For the sake of pursuit of brighter light beam, the phenomena that consumers themselves replace the halogen bulb in the headlamp of their car with HID conversion kit have been prevalent in China for a long time. Using the same socket as headlamp with halogen light source, HID conversion kit can easily generate more than two times the light volume on the road as the standard halogen light source, meanwhile, has lower price compared with purchasing a high level car with original HID headlamps[1].

However, such headlamps may cause big safety problems because that the photometric performance of such headlamps may not meet the basic photometric requirements. Using the same optical system while changing the light source, the photometric performance is very likely to change dramatically[2]. Subsequently, glare is the main bad consequence[3]. Additionally, though most of the HID conversion kit can produce high illuminance, such headlamps tend to be installed in a car without the headlamp cleaning device. However, many researches have proved that it was necessary to equip with cleaner for the headlamps of which the luminous flux is high. Otherwise, glare intensities would be much higher because of dirt[4, 5]. For the same reason, ECE R 48 also dictates that headlamps with a total luminous flux exceeds 2000 lm have to be installed in conjunction with

headlamp cleaning device[6]. There's no doubt that glare has negative effect on driving performance[7].

Moreover, such headlamps pose big problems to the testing originations because that none of the relevant national standards (such as GB4599-2007, GB21259-2007, etc.) can be used as the suitable one in the testing process[8, 9]. In other words, none of the current standards or regulations cover the requirements for modified HID headlamps. Consequently, the quality of such headlamps in market varies greatly from one to another.

Unfortunately, there is rare research focusing on the photometric performance of modified HID headlamp so far. This leads to the ambiguity whether the modified HID headlamps have security problems during nighttime drive and how the photometric performance of such headlamps is.

Therefore, this study focuses on the photometric performance of modified HID headlamps. The main evaluation methods is the performance assessment method for headlighting systems described in CIE 188 Technical Report titled "Vehicle Headlighting Systems Photometric Performance-Method of Assessment"[10]. Since the methods in this report have nothing to do with the light source in the headlamp, the comparison of the performance of headlamps with different light sources was made feasible. It is hoped that the results could be a reference advice for developing the relevant regulations about modified headlamps in China.

II. METHODS

The study was carried out in the laboratory. Since most of the modified headlamps were aimed at passing beam, in this paper, the research was only confined to passing beam, too. The study fall into two parts.

A. Part I: The influence of optical system on modified headlamps

In this part, the issue was to find out the relationship between optical system and photometric performance of modified headlamps. Two kinds of halogen headlamps (one was with reflector and the other was with projector) were modified by replacing the light source from halogen bulb with HID conversion kit (as listed in Table 1). All the headlamps were fixed on the specialized fixture. They illuminated a screen in 25m distance. An illuminance sensor and the mechanical multi-dimensions rotating platform have been

used to measure the illuminance of B 50 L (the point describes the location of the opposing driver's eyes) and visibility test points (50 V, 50 R). The comparisons between the illuminance and the shapes of the cut-off lines of the headlamps were carried out. In order to make the comparison of the illuminance of headlamps with different light source feasible, the test voltage for the measurement was 13.2V.

TABLE I. HEADLAMPS IN PART I OF THE STUDY

	Optical System		Bulb	
	Reflector	Projector	H7	HID Conversion kit
1#	×		×	
				×
2#		×	×	
				×
3#	×		×	
				×
4#		×	×	
				×

B. Part II: The comparison of photometric performance

In this part, we compared the photometric performance of three kinds of headlamps installed in cars of same type but with different light sources: halogen bulb, HID light source and HID conversion kit. The information of headlamps were listed in Table 2.

TABLE II. HEADLAMPS IN PART II OF THE STUDY

Sample NO.	Optical System		Light Source		
	Reflector	Projector	Halogen (H7)	HID	HID Conversion kit
5#	×		×	×	×
6#		×	×		×

The CIE 188 Technical Report illustrates an objective calculation method to assess the photometric performance of vehicle headlighting systems. In simplicity, the method in this report is to calculate the performance scores of a headlighting system at a number of critical areas of the road scene taking account of the actual installation parameters. For passing beam, aspects for evaluating include range for lane guidance (both on straight road and on curved road), range for pedestrian detection, width for lane guidance and visibility on curves, width for pedestrian detection at intersections, total luminous flux and opposing glare.

The procedure of this part were as follows:

- Data relating to the lighting installation were recorded (mounting height, separation, beam aim and supply voltage).

- Fixed the left part of the halogen headlamp on the specialized fixture. Turned on the headlight and preheated for a while. Aimed the cut-off line. Then the photometric laboratory produced a matrix of data using a defined angular field and test point resolution according to CIE 188 Technical Report.
- Replace the halogen bulb with HID conversion kit. Turned on the headlight and aim the cut-off line again if necessary. Carried out the same photometric measurements.
- Repeated the above steps for the right part of the headlamp.
- Repeated the above steps for the HID headlamp.
- Used a self-exploitation software to calculate the scores of range, width and glare for all the headlamps.

III. RESULTS

A. Results of Part I

Fig .1 illustrated the cut-off line of the four headlamps listed in Table 1. All the pictures were taken by the same camera placed at a fixed point and with same exposure time and aperture size. It can be seen that for the headlamps with reflector optical system (1# and 3#), after modifying the light source from halogen bulb to HID conversion kit, the cut-off line turned out blurred, or in other words, not as sharp as before. As to the headlamps with projector optical system (2# and 4#), the influence of modifying light source on cut-off line was not as obvious as the ones with reflector optical system . However, the procedure lasted for about 20s for the luminance of the modified HID light source to reach a steady state.

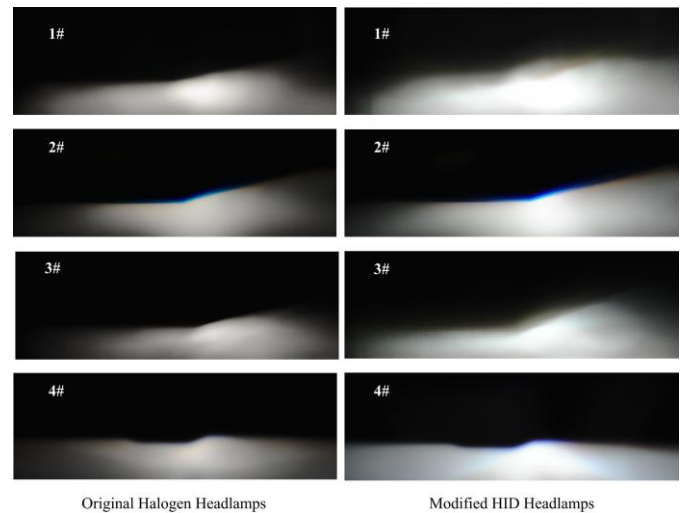


Figure 1. Comparison of the cut-off line of halogen headlamps and modified HID headlamps

Then the illuminance of B50L, 50V and 50R were recorded in the study. The results were listed in Table 3. It is obvious that the illuminance becomes larger when the light source was changed to HID. However, as a result, the illuminance of B50L of three quarters of the modified HID

headlamps was far greater than the requirements in the relevant ECE regulations, which means that the modified HID headlamps may cause severe glare for the opposing driver.

TABLE III. RESULTS OF ILLUMINANCE

Sample NO.	Light Source	Illuminance (lx)		
		B50L	50V	50R
1#	Halogen	0.649*	20.159	38.946
	HID Conversion Kit	4.262*	70.226	78.002
2#	Halogen	0.078	23.945	31.255
	HID Conversion Kit	0.22	43.904	64.125
3#	Halogen	0.185	17.022	32.302
	HID Conversion Kit	4.811*	58.678	59.177
4#	Halogen	0.329	14.575	27.593
	HID Conversion Kit	0.758*	18.291	64.844

Notes: the illuminance with (*) means it does not meet the requirements in the relevant ECE regulations

B. Results of Part II

Table 4 listed the results of the headlamps calculated according to the methods described in the CIE 188 Technical Report with the help of the self-exploitation software. It can be seen that the influence of simply changing the light source on photometric performance depends heavily on the optical system of the headlamp.

For NO.5 headlamp with a reflector optical system, after replacing the H7 bulb with HID conversion kit, the range for lane guidance and pedestrian detection increased dramatically,

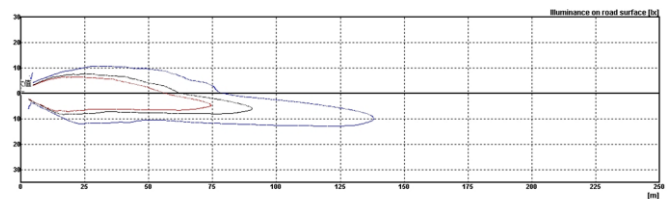
TABLE IV. RESULTS OF PHOTOMETRIC PERFORMANCE CALCULATED ACCORDING TO CIE 188 TECHNIAL REPORT

Parameters		Headlighting Systems				
		5#			6#	
		Halogen (H7)	HID	HID Conversion kit	Halogen (H7)	HID Conversion kit
Range (m)	Straight road	77.00	102.80	160.30	75.80	78.80
	Curved road	88.10	88.90	175.80	68.00	97.10
	Pedestrian visibility	53.90	62.00	141.30	51.50	53.20
Width (m)	Visibility at intersections	11.25	16.80	13.40	13.15	16.95
	Visibility on curves	13.33	24.27	21.60	13.03	18.78
Opposing glare (lm)		0.80	0.30	15.1	0.20	0.50
Total Luminous Flux (lm)		905.10	989.00	2160.50	674.40	1752.20

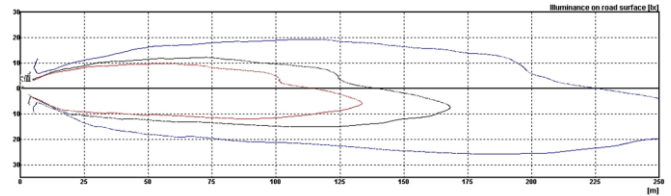
IV. DISCUSSION AND CONCLUSION

In this paper, the key issue was to research the photometric performance of modified HID headlamps. Therefore, the other performance of the headlamps, e.g., the stability of photometric performance, electrical safety, vibration resistance or other robust estimation, were not incorporated in this study. Thus, even though the photometric performance of

even much longer than that of the HID headlamp. The illuminous curves on road surface also demonstrated it, as shown in Fig. 2. However, the luminous flux value which indicated the opposing glare performance increased from the value less than "1" to an unmoral value "15.1". Such a result means the headlamp will cause very severe opposing glare.



(a) Halogen Headlamp



(b) Modified HID Headlamp

Figure 2. The illuminous curves on road surface

To our surprise, the range and width of NO.6 headlamp (the optical of which was projector optical system) both increased slightly when the light source changing to HID bulb. Though the opposing glare luminous also increased, but it was still an acceptable value.

modified HID headlamps is good enough, it still needs further study focusing on the other factors of modified headlamps.

In respect of the photometric performance of modified HID headlamps, there is no doubt that the road sense illuminance will increase if compared with that of halogen headlamps. However, the most important factor of modified HID headlamps we should focus on is the glare they may cause to the oncoming driver. The photometric performance of modified HID headlamps depends largely on the optical

system of the headlamps. For headlamps with reflector optical system, the results of this study showed that replacing the light source in the headlamp would bring big impact on the shape of the cut-off line and bring subsequent severe glare. For headlamps with projector optical system, as the increase of the luminous of the light source, results of modified HID headlamp showed an improvement of the range and width when compared with that of the halogen headlamp, while the luminous flux standing for glare changes slightly.

However, though the photometric performance of some modified HID headlamps were somehow good, there are two aspects need our attention. First, whether the time for the modified HID light source to be stable was short enough. Second, periodical cleaning of the modified HID headlamp was of big importance if there was no cleaning system of the car itself. Not only just because of the requirements in the ECE R 48 regulation, but also the influence of dirt on glare intensities.

All in all, it is not suggested for consumers to casually change the light source in the headlamps in their car. That is because that for consumers, it is hard to tell the quality of modified HID headlamps. We suggest that it requires regulations for the modified HID headlamps, in order to improve traffic security.

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