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ANALYSIS OF CHARACTERISTICS OF HALOGEN AND LED AUTOMOBILE LAMPS

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ABSTRACT

This work contains analysis of characteristics of automobile lamps by Philips, KOITO, ETI flip chip LEDs, Osram, General Electric (GE), Gtinthebox, OSLAMPledbulbs with H1, H4, H7, H11 caps: luminous flux, luminous efficacy, correlated colour temperature. Characteristics of the studied samples are analysed before the operation of the lamps. The analysis of the calculation results allows us to make a conclusion that the values of correlated colour temperature of halogen lamps are close to the parameters declared by manufacturers. The analysis of the study results has shown that, based on actual values of correlated colour temperature, it is not advisable to use LED lamps in unfavourable weather conditions (such as rain, fog, snow). The results of the study demonstrate that there is a slight dispersion of actual values of luminous flux of halogen lamps by different manufacturers. Maximum variation between values of luminous flux of different lamps does not exceed 14 %. The analysis of the measurement results has shown that actual values of luminous flux of all halogen lamps comply with the mandatory rules specified in the UN/ECE Regulation No. 37 and luminous flux of LED lamps exceeds maximum allowable value by more than 8 %. Luminous efficacy of LED lamps is higher than that of halogen lamps: more than 82 lm/W and lower power consumption. The results of the measurements have shown that power consumption of a LED automobile lamp is lower than that of similar halogen lamps by 3 times and their luminous efficacy is higher by 5 times.

Keywords: light emitting diode (LED) lamp, halogen lamp, automobile lamp, luminous flux, colour temperature, luminous efficacy, cap, photometric measuring unit, spectral distribution

1. INTRODUCTION

Contemporary automobiles use different types of lamps for illumination of road, signalling and output of information on automobile parameters. Types of these lamps depend on their use and manufacturer. Most of modern automobiles are equipped with headlights with halogen lamps. Light emitting diode (LED) sources of light have become successfully applied in transport industry, namely in traffic lights, road signs, interior indication, brake lights. Drivers and manufacturers have been constantly looking for ways of enhancing headlight because it affects the level of detail of a driver's view during night time and in case of poor visibility and, thus, increasing traffic safety. Nowadays, the Russian market of vehicle lamps is full of a large number of different automobile lamps, from conventional halogen sources of light to relatively new sources of light: LED automobile lamps. A number of studies of characteristics of LED sources of light have revealed problems related to lighting conditions which affect visual performance, efficiency of application of sources of light in agriculture and in other industries [6, 7]. Application of LED sources of light, as automobile headlights, remains a relatively

Table 1. Technical Parameters of the Halogen Lamps

Manufacturer, lamp type	Power consumption, W	Luminous flux, lm	Correlated colour temperature, K
GE, halogen	55	1550	3000
Osram, halogen	55	1550 ±10 %	3000
KOITO, halogen	60	–	4500
Philips, halogen	55	1550 ±10 %	3700

new area hence, it is necessary to study characteristics of LED automobile lamps.

2. THE STUDY OF AUTOMOBILE LAMP CHARACTERISTICS

To evaluate light engineering parameters of lamps for road lighting, in particular luminous flux and correlated colour temperature, halogen and LED lamps produced by different manufacturers were studied: Philips, MTF Titanium, KOITO, ETI flip-chip, Osram, General Electric (GE), Gtinthebox, 1 or 2 samples of each.

The parameters of the studied lamps were measured in the Light Engineering Metrology core facility centre of the Institute for Electronics and Lighting Engineering in accordance with GOST R8.749–2011 [4]. To measure parameters of automobile lamps the Gooch&Housego photo-colorimetric measuring unit was used. It is designed for measuring luminous flux and radiant flux; spectral distribution of radiant flux; correlated colour temperature; general colour rendering index and special colour rendering index; tristimulus values and chromaticity coordinates in *XYZ* (1931), *u v* (1960), *u' v'* (1976) systems [10]. The operation principle of the unit is based on determination of radiant power by measuring spectral distribution of radiation and its integrating. The measuring unit consists of the OL IS7600 photometer sphere with diameter of 2 m, OL 770 VIS/NIR multi-channel spectroradiometer, 770–7G-3.0 fibre-optic cable, OL410–200 PRECISION LAMP SOURCE DC power supply for the AUX LAMP A180 auxiliary lamp, fasteners for fixation of lamps and the computer [9].

Fig. 1. View of the Gtinthebox LED lamps with H1 cap type

Main technical specifications of the unit: spectral range: (380–1100) nm, scan step: 0.75 nm, reflectance of the sphere inner surface: at least 0.986, measurement range of correlated colour temperature: (1500–10,000) K, limits of allowable absolute error of correlated colour temperature: ±25 K, luminous flux indication range: 0.01 to 100,000 lm, measurement range of luminous flux: (5–2500) lm, limits of allowable relative measurement error of luminous flux are about ±9 %.

During measurements, power supply parameters of the lamps were set by means of DPS1060 AC power supply unit. The centre of the image receiving surface of the photometric head lay along the line crossing the photometric centre of the goniophotometer and its plane was perpendicular to this line. The measurements were conducted in a location with its walls, floor and ceiling covered with matt black coating. All calculations were conducted automatically, displayed on the controlling computer of the measuring unit and were presented in a convenient form [2].

To find the value of luminous flux using luminous intensity distribution, the formula 1 is used:

$$\Phi = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} I(\theta,\phi) \sin\theta d\theta d\phi, \qquad (1)$$

where $I(\theta,\phi)$ is the luminous intensity, θ is the angle characterising the position of the receiver between the poles, ϕ is the angle characterising the position of the receiver in relation to the equator [2].

Figs. 1–6 present view of the sources of light being studied.

The technical specifications of halogen lamps declared by manufacturers are listed in Table 1, their values comply with maximum and nominal

Fig. 2. View of the OSLAMPledbulbs lamp with H4 cap type

Fig. 3. View of the ETI flip-chip LEDs with H11 cap type

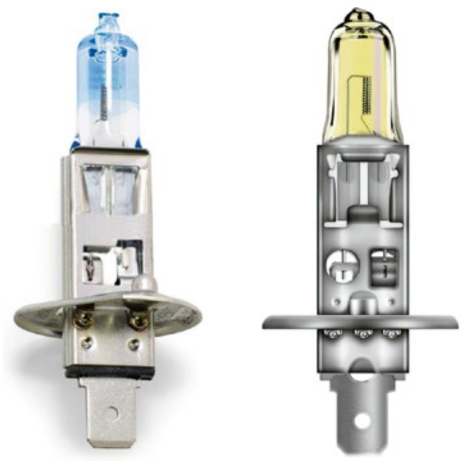

Fig. 4. View of General Electric (GE) and Osram lamps with H1 cap type

Fig. 5. View of KOITO White Beam III Premium halogen lamp with H4 cap type

Fig. 6. View of Philips White Vision H7 cap type halogen lamp

electric and luminous parameters of tungsten halogen lamps specified by [1]. No information on parameters of the LED lamps is specified on their packages. Current of the halogen lamps varied between 4.1 and 5.2 A, current of the LED lamps varied between 0.8 and 1.5 A. The measurement results obtained during the experiment are listed in Table 2.

The results of the study of spectral characteristics of OSLAMPledbulbs LED lamps measured in accordance with GOST are presented in Figs. 7, 8 [3].

The presented spectra demonstrate an intensive emission line in the blue region of the spectrum, which explains much higher values of colour temperature of OSLAMPledbulbs H4 LED lamps (6729 K and 6524 K for low beams and 6456 K and 6530 K for high beams) than the values of colour temperature of KOITO H4 halogen lamps (3548 K and 3562 K for low beams and 3822 K and 3815 K for high beams).

Fig. 9 presents the analysis of luminous efficacy of the lamps being studied.

3. ANALYSIS OF THE STUDY OF AUTOMOBILE LAMP CHARACTERISTICS

The results of the study demonstrate that there is a slight dispersion of actual values of luminous flux

Table 2. Measurement Results of Automobile Lamps

Lamp No.	Manufacturer, lamp type	Supply voltage, V	Power consumption, W	Luminous flux, lm	Correlated colour temperature, K
1	Osram H1, halogen (sample 1)	13.2	67.6	1692	3280
2	Osram H1, halogen (sample 2)		62.0	1491	3150
3	GE H1, halogen		67.3	1671	3212
4	KOITO H4, (low beam, sample 1), halogen		63.8	710	3548
5	KOITO H4, (low beams, sample 2), halogen		63.8	696	3562
6	KOITO H4, (high beams, sample 1), halogen		68.1	1166	3822
7	KOITO H4, (high beams, sample 2), halogen		68.2	1162	3815
8	Philips, halogen, H7 (sample 1)		54.1	1029	3385
9	Philips, halogen, H7 (sample 2)		54.3	1043	3382
10	Gtinthebox H1, LED (sample 1)		23.4	1936	7616
11	Gtinthebox H1, LED (sample 2)		23.6	1940	7515
12	OSLAMPledbulbs H4, LED (low beams, sample 1)		19.5	1340	6524
13	OSLAMPledbulbs H4, LED (low beams, sample 2)		20.6	1705	6729
14	OSLAMPledbulbs H4, LED (high beams, sample 1)		19.1	1815	6530
15	OSLAMPledbulbs H4, LED (high beams, sample 2)		20.2	1929	6456
16	ETI flipchip LEDs H 11 (sample 1)		10.9	878	5306
17	ETI flipchip LEDs H 11 (sample 2)		9.7	789	5142
Requirements of the UN/ECE Regulation No. 37 [8]		13.2 V	no more than 68 W	1550 lm ±15 %	–

of halogen lamps by different manufacturers. Maximum variation between values of luminous flux of different lamps does not exceed 14 %.

The analysis of the results of measurements has shown that:

– Power consumption of halogen lamps exceeds the nominal value more than by 11 % but does not exceed the maximum allowable value, and it should also be noted that the tests were conducted at test voltage 13.2 V and nominal power is specified for supply voltage 12 V;

– Power consumption of LED lamps is less than power consumption of halogen lamps by at least 6;

– LED lamps have much higher luminous efficacy than that of halogen lamps and less energy consumption, wherein luminous efficacy of the sample No. 1 (lamp No. 12) is less than luminous efficacy of the studied sample No. 2 (lamp No. 13) due to less value of luminous flux;

– As seen from the results, colour temperature of tungsten halogen lamps is close to the parameters declared by all manufacturers; correlated colour temperature of LED lamps corresponds to cold light;

– Based on actual values of correlated colour temperature, it is not advisable to use LED lamps in unfavourable weather conditions (such as rain, fog, snow);

– Actual values of luminous flux for halogen lamps are comply with mandatory requirements of the UN/ECE Regulation No. 37, and average luminous flux of LED lamps is higher than the maximum allowable value specified in the UN/ECE Regulation No. 37 by 8 %, with the exception for

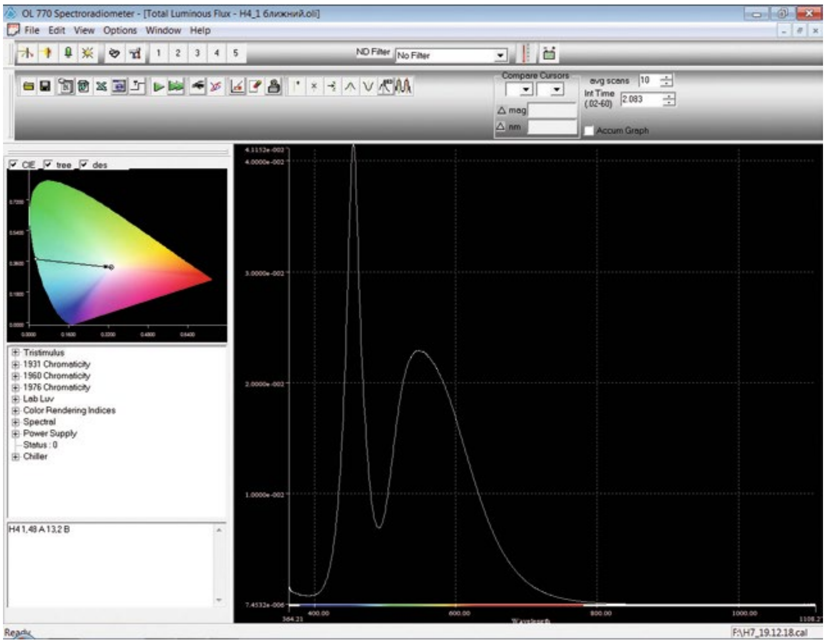

Fig. 7. Results of measurement of OSLAMPledbulbs lamp in low beam mode

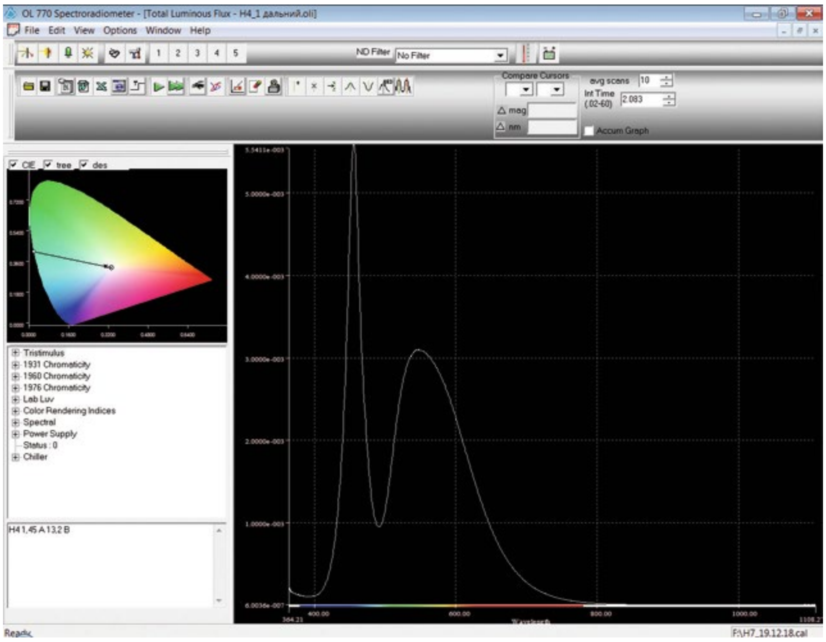

Fig. 8. Results of measurement of OSLAMPledbulbs lamp in high beam mode

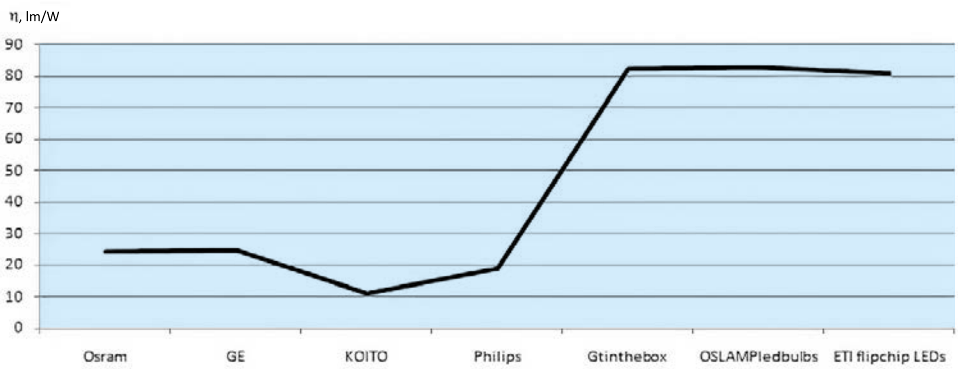

Fig. 9. Luminous efficacy of the studied lamps

the studied OSLAMPledbulbs H4 LED lamp (low beams, sample 1) with its measured value of luminous flux equal to 1340 lm;

– Power consumption of a LED automobile lamp is lower than that of similar halogen lamps by 3 times and their luminous efficacy is higher by 5 times.

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