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Modernity and trends of development of automobile engineering

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Abstract. Advantages of light-optical devices (LEDs) were investigated in the article. Based on the research, special attention is paid to the prospects of development of led headlights. Complicacy of car electrical equipment leads to increase of indicated efficiency and energy storage capacity and electric generators, yield increase, decrease of labor intensity maintenance operation and reconstruction. On the other hand, innovations in scientific-technological progress in electronic engineering sphere lead to rise in reluctances, so more than 30% of these reluctances account for electrical equipment. Analysis of current requirements to automobile components of lighting devices has been carried out. LEDs as automobile light sources are gaining rapid popularity. Currently, LEDs are widely used as internal light sources (instrument illumination, indicator lamps) and external ones (tail lights, additional brake lights, daytime running lights). Since 2007, white LEDs have been used as dipped- and main-beam sources. Light sources are characterized by such parameters as voltage, light power and luminous power. Derivative of these parameters is the luminous efficiency (luminous power per unit of light power), that acts as a kind of lamp′s performance and economy indicator. This article has been made in relation to the study of auto technical expertise in Moscow and Moscow Region.

1 Introduction

Modern life is characterized by rapid economic and social development. However, not all spheres of life have developed in a sustainable way, for example, some elements of anthropotechnical systems are still far from steadiness. This leads to a low level of safety of these systems, which brings on a high risk of injury or death as a result of road accidents [1]. Lighting system is used for safe and comfortable handling a vehicle during periods of reduced visibility. Lighting system includes head and back lights, license plate number lamps, saloon and luggage boot lamps, engine and glove compartment lights. White light is used for main-beam and dipped-beam headlamps, while white and yellow ones are for head and fog-lights. Setting main-beam and dipped-beam headlamps is obligatory. In addition,

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fog-lights also can be used. Application of any recapitulated lights on drawbar trailers is prohibited. Two or four main-beam and dipped-beam headlamps must be set at a vehicle. Two fog-lights are also allowed to be installed. Mentioned above lights are assembled on the forecarriage. However, emitted light, reflected by driving mirrors and/or other light-reflecting surfaces of the vehicle, shouldn't bother a driver. Extra pair of main-beam headlamps is allowed to be installed for category of vehicle N3 on the stipulation that burning two pairs at the same time and dipping of headlamps leads to simultaneous switch off all the main-beam ones [2-4]. Security issues remain the most important when a car is designed and created [5-7]. Today, the perception of visible light of headlight beams allows to determine a vehicle speed [8], to solve problems of controlling high-speed traffic. Automobile communication and sensor technologies are mainly based on radio frequency (RF) or laser technologies. These systems suffer from several problems, such as radio frequency interference and poor efficiency in cases, when the angle of incidence between the speed sensor and the vehicle changes rapidly. The system "Finding and determination of visible light range" (ViLDAR) is void of these disadvantages. ViLDAR uses visible light perception technology to determine changes in the intensity of a car's headlights and assess the speed of the car [8]. The use of led headlights works towards the introduction of new sensing technology, adds variety to existing systems and increases the reliability of real-time data. This study is relevant in connection with the rapid development of technologies that bring autonomous cars closer to reality. The use of autonomous cars causes changes in road capacity, gas emissions, public opinion, and other areas. There is a large amount of works on creating models to predict future road capacity with different penetration speeds of autonomous cars. It is worth to remark that they get completely different interesting results. More stochastic models should be offered to make a correct prediction of future state [9]. Questions of lighting devices of autonomous cars are considered in the work [10].

2 Materials and methods

Authors of the article analyzed current status of the issue of the effectiveness of the applied headlights in relation to the study of auto technical expertise in Moscow and Moscow Region. http://avtoekspertiza.msk.ru.

Current types of main-beam and dipped-beam headlamps are shown in the Table 1 below.

Table 1. Types and markings of main-beam and dipped-beam headlamps.

Types of headlights for the purpose intended	Marking of the headlights depending on the type and applied light source		
	Incandescent lamp	Halogen lamp	Gas-discharge lamp
Dipped-beam headlamps	C	HC	DC
Main-beam headlamps	R	HR	DR
Double-dipping headlight	CR	HCR	DCR

Types of headlights and lighting devices, as well as other designations, are indicated on their bodies or lenses in an indelible way.

Nowadays it is not uncommon to set additional main-beam and fog lamps on vehicles, that is why it makes sense to focus on the requirements for their installation.

There are no separate requirements for the installation of main-beam lamps in United Nations Economic Commission for Europe (UNECE) Regulation No.48.

Headlight beam must be directed forward, but there are special requirements for dipped-beam lamps concerning vertical direction of the beam and position of cutoff line of its spot.

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The design of the headlamp or light source emitting low beam must provide a special form of light spot on a white matte screen located in a vertical plane square to the fore-and-aft axis of the vehicle. The characteristic shape of this spot for European type C, HC, CR, HCR headlamps is shown in Fig. 1. For DC or DCR type headlamps, it can also have the shape shown in figure b. Special requirements are also applied to the light spot of fog lamps, whose shape is given in figure c [11-12].

The vertical plane containing the original headlight axis divides the screen into two parts by the V-V line (see Fig. 1, a). The left part of the screen contains the horizontal part of the cutoff line parallel to the line H-H and the right part contains angled one that makes an angle of 15° to the horizontal.

A headlight of the European light distribution system, used for left-hand traffic, may have an UNECE type approval badge. However, usage of such headlamps on right-hand traffic creates a real danger of blinding drivers of oncoming vehicles and, as a result, a threat to road safety. A headlight for left-hand traffic is marked with the symbol -> applied together with the headlight type designation. Multi-purpose headlamps used for left-and-right-hand traffic are marked with the symbol "o". These lights must have a special change-over switch of light distribution.

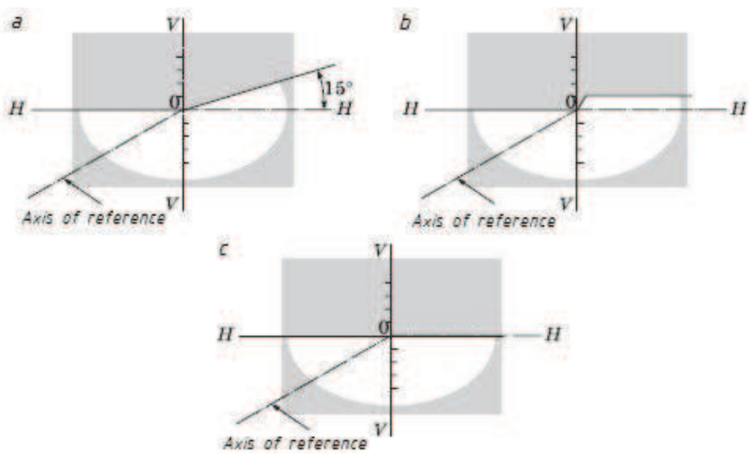

Fig. 1. Form of the light spot: *a* – dipped-beam headlamps with usual or halogen incandescent lamp; *b* - dipped-beam headlamps with gas-discharge lamp; *c* - fog lamps.

3 Results

The projection of the axis of reference on the screen can misalign vertically by means of headlight adjusting mechanisms or devices, thus creating a tilt of the headlight (a) about the axis of reference (see Fig.2). This tilt is characterized by the distance *e* (in millimeters) from the projection of the center of the headlight to the meeting point of the left part of the cutoff line of the light beam on the screen, that is 10 m distant from the head lamp lens. It can also be expressed as a percentage of this distance to the distance to the screen, herewith, 100 mm of absolute reduction corresponds to 1% of relative reduction [13].

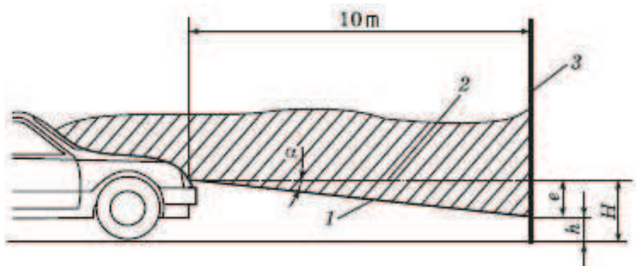

Fig. 2. Arrangement diagram of the vehicle's headlight relative to the measuring screen: 1 – cutoff line; 2 – axis of reference; 3 - matte screen.

Depending on the elevation (in meters) of the dipped-beam headlamps, the vertical tilt of its cutoff must remain within the limits indicated in the Table 2.

Table 2. Attitude of dipped beam cutoff line depending on the headlight set-up height.

Headlight set-up height	Range of initial tilt, %	Limits of cutoff line tilt, %
H<0.8	from -1.0 to -1.5	from -0.5 to -2.5
0.8<H<1.0	from -1.0 to -1.5	from -0.5 to -2.5
	from -1.5 to -2.0	from -1.0 to -3.0
H>1.0	from -1.5 to -2.0	from -1.0 to -3.0

Notice. Negative values correspond to downward angle.

Category of vehicles N3G (cross-country), where the height of the headlights′ setting is more than 1200 mm, should have the vertical tilt limits from -1.5 to -3.5 % with the initial orientation from -2 to -2.5 %.

The distance to dipped beam cutoff line must conform with the values listed in the Table 3.

Table 3. Location of the dipped beam cutoff line on a matte screen depending on the elevation of the headlamp.

Elevation of the headlamp (on center of lens), H, mm	Distance e from the projection of the center of the headlight to the cut-off line of the light beam on the screen, that is 10 m distant from the head lamp lens, mm
H<600	100
600<H<700	130
700<H<800	150
800<H<900	176
900<H<1000	200
1000<H<1200	220
1200<H<1600	290

4 Discussions

R-type (HR, DR) headlamps must be adjusted so that the discharge angle of the brightest (central) part of the light beam in vertical plane ranges from 0 to 34' down from the axis of reference H-H. In this case, the vertical symmetry plane of the brightest part of the light beam must pass through the axis of reference V-V.

In "dipped beam" mode luminous intensity of C- and CR-type headlamps (HC, DC, HCR, DCR), measured in the V-V projection of the vertical plane on the measuring screen passing through the axis of reference, must be as follows: no more than 750 CD in the direction 34' up from the position of the left part of the cutoff line and no less than 1600 CD in the direction 52' down from the position of the left part of the cutoff line.

In "main beam" mode luminous intensity of CR-type headlamps (HCR, DCR) must be measured in the direction 34' up from the position of the left part of the cutoff line of the "dipped beam" mode in the vertical plane passing through the axis of reference.

Luminous intensity of R-type headlamps (HR, DR) must be measured in the center of the brightest part of the light beam.

Luminous intensity of all R- and CR-type headlamps (HR, DR, HCR, DCR) located on the same side of the vehicle must not be less than 10,000 CD in "main beam" mode. The maximum luminous intensity of all main-beam headlamps which can be switched on simultaneously must not exceed 225 000 CD, that corresponds to a reference value of 75. This value is the sum of individual reference values shown on the lens of each main-beam lamp next to the type approval icon.

The cutoff line of the light beam B (HB)-type fog lamp must be parallel to the plane of the work platform whereon vehicle is installed. Location of this cutoff line must conform with the one shown in the Table 4.

Table 4. Geometric values of location of the upper cutoff line of the fog light beam on the screen.

Elevation of the headlamp, H, mm	**Distance e from the projection of the center of the headlight to the upper cutoff line of the light beam on the screen, that is 10 m distant from the head lamp lens, mm**
250<H<500	100
500<H<750	200
750<H<1000	400

The main-beam headlamps can be switched on simultaneously or in pairs. Dipping of headlamps leads to simultaneous switch off all the main-beam ones. The dipped-beam headlamps can stay on at the same time as the main-beam ones. In the presence of dipped-beam headlamps with gas-discharge light sources, they must remain switched on when the main-beam lights are also switched on.

All external lighting devices must have designations with the information about the type approval of these devices, their classes and certain characteristics. In addition to the type approval mark and its number, they must have the corresponding alphanumeric code printed on the lenses or case-shaped parts of lighting devices in easily accessible places.

Headlights with LEDs as a light source on production vehicles are gaining popularity among automakers. A big advantage of LEDs is ultra-low power consumption and a very long operational life, ranging from 30000 to 100000 hours. For example, an ordinary car halogen lamp life cycle is 2000 hours (see Table 5).

Table 5. Main characteristics of light sources for the 12V electric system.

Light source	**Light power, W**	**Luminous power, lm**	**Luminous efficiency, lm/W**
Incandescent lamp	3-27	22-500	10-18
Halogen lamp	55-65	1450-2100	22-32
High-intensity discharge lamp	35	2800-3200	80-90
LEDs	up to 20	500-1000	30-50

5 Conclusion

A reflector, depending on the type of headlight, provides the reflection of light from the source directly on the road or optical lens. The reflector is made of plastic or metal. The ones that allow to create sone geometric shape are commonly used. A thin layer of aluminum is spread on the surface of the reflector.

The basic types of reflectors are parabolic, free-form and ellipsoidal. A parabolic reflector is used in classic headlamps where the light level is proportional to the size of the reflector (the larger the reflector, the more light). A free-form reflector (Homogenous Numerically Calculated Surface, HNS) is divided into separate sections (vertical, radial), which are set on a specific type of light reflection and have their own focal length. The HNS-type reflector provides high uniformity of lighting. The reflector′s geometric surface is developed by the means of computer modeling. A parabolic reflector and an HNS one form the basis of reflective (reflex) headlights. An ellipsoid reflector is part of the Poly Ellipsoid System (PES). The ellipsoid reflector in cooperation with the optical lens allow to reduce the size of the headlight significantly at the current level of illumination and the direction of the light beam. Ellipsoid reflectors have projecting (driving) lights. In daily use they are called lensed lights. Lens in modern headlamps make a little figure as light distribution is mainly carried out by the reflector. Since 1992 plastic lenses have been widely used.

Led headlights for the head light came into operation not so long ago. Not many models use them, for example, Audi, Cadillac, Lexus. As for Audi R8, a led headlight consists of three multi-crystal LEDs. Each multi-crystal LED includes two simple LEDs, each of which has its own reflector. The luminous power from all LEDs is converted into a common projecting lens. A light screen is used in the led headlight to create a cutoff line. Despite the significant advantages, LED headlamps are still rarely used.

A number of manufacturers offer LED lamps with a base for installation halogen lamps in proper locations. Despite the fact that these lamps shine very bright, they do not provide the required level of illumination.

Depending on the driving conditions, the control electronics lights a certain number of LEDs, the light from which, refracted through the lens, illuminates only the area that is needed at the moment of movement [14-16].

The last development level of LED optics is matrix headlights. Principle of their operation is the same as usual, corrected to the fact that the LEDs are combined in cells, and there may be several dozens of them in one headlight. Moreover, each of the diodes can be turned on and off, and its brightness can be changed. It is possible to create almost any pattern of illumination with the help of these headlights.

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