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THE METHOD OF CAR HEADLIGHTS LUMINOUS INTENSITY MEASURING FOR NON-POINT SOURCES OF LIGHT

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Abstract. *It is shown that the measurements of luminous intensity of car headlights luminous intensity for non-point sources have pecularities. A simplified method for correction the luminous intensity at various distances is developed. The applicability of the given method with possible measurement errors is studied. The results were obtained, using a stand of the National Scientific Center "Institute of Metroligy".*

Key words: *luminous intensity measurement, car headlights.*

МЕТОД ВИМІРЮВАННЯ СИЛИ СВІТЛА АВТОМОБІЛЬНИХ ФАР ДЛЯ НЕТОЧКОВИХ ДЖЕРЕЛ СВІТЛА

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Анотація. *Розроблено спрощений метод корекції сили світла автомобільних фар із неточковими джерелами, що дозволяє врахувати відмінності сили світла на різних відстанях з урахуванням похибок вимірювання. На основі експериментальних досліджень визначений діапазон значень поправок, що вводяться. Визначено межі застосовності методу.*

Ключові слова: *вимірювання сили світла, автомобільні фари.*

МЕТОД ИЗМЕРЕНИЯ СИЛЫ СВЕТА АВТОМОБИЛЬНЫХ ФАР ДЛЯ НЕТОЧЕЧНЫХ ИСТОЧНИКОВ СВЕТА

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Аннотация. *Разработан упрощённый метод коррекции силы света автомобильных фар с неточечными источниками, позволяющий учесть отличия силы света на разных расстояниях с учётом погрешностей измерения. На основе экспериментальных измерений определён диапазон значений вводимых поправок. Определены границы применимости метода.*

Ключевые слова: *измерение силы света, автомобильные фары.*

Introduction

In measuring of luminous intensity (LI) usually the optical radiation source is considered to be a point one [1]. Measurements can be made at different distances from the source. For non-point sources with increasing distance values of LI will be changed significantly. The well-known method of corrections introducing to the distance [2] allows to minimize the errors values. Its disadvantage is necessity of multiple measurements over a large range of distances which often is impossible in real conditions.

The analysis of publications

In accordance with the current standard of Ukraine [2], which describes general requirements to the state of the vehicle and its systems, the measuring of automobile headlights characteristics should be carried out at a distance of 5 m. Due to the fact that in real conditions the distance illuminated by a vehicle greatly exceeds 5 m, it is logical to enable measurements at a remote distance. [2–3]. This would allow to estimate the behavior of the LI and develop a method of correction. In accordance with the requirements of the asymmetrical motor vehicle headlights that are described in [3], the measurements should be carried out at a distance of 25 m. At such distances the point source model works reasonably well but often the dimensions of the room do not allow to do so. It is necessary to carry out the experimental research and on the basis of analysis of LI distribution at different distances to create a simple model which can correct the measurements at small distances (for example, 3 and 5 m) for receiving the results that would correspond to the results obtained in the stand at a distance of 25 m or more.

The aim and problem statement

The aim of the article is development of the method of correction of the results of luminous intensity measurement at short distances from the source and research of its applicability in various conditions.

The method of correction

As the base for the measurement the stand of National Science Center «Institute of Metrology» and the standard telecentric illuminator ETO-2 were used. Experimental studies were carried out using three car headlights and illuminator with three different diameters of the aperture at the distances of 3–23 m. The typical results of measurements for one of the sources (curve 1) are shown in Fig. 1.

It was found experimentally that with distance increasing of the luminous intensity values determined by an inverse square law are changed more than 50 %. Such errors are unacceptable. The result of the correction carried out by [1] is shown in Fig. 1 (curve 2).

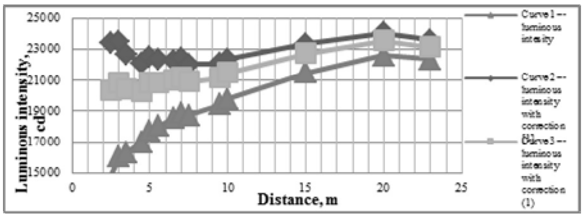

Fig. 1. Luminous intensity distribution at different distances

The using model assumes that the luminous intensity becomes almost constant one if you add the value Δ to the experimentally measured distance when the LI is calculated. For investigated sources of radiation the value Δ does not exceed 0,6 m. Due to space constraints the use of the method presented in [1] is not always possible. Consequently, it is proposed to introduce a correction into results of measurements at two distances (3 and 5 meters) and with its help to estimate the results that would be obtained in measurements at very long range. In order to determine a correction to the distance an analytical formula should be obtained. By equating the LI at 3 and 5 m it is easy to calculate the correction to the measured distance which minimizes the differences in luminous intensity at these distances

$$\Delta = \frac{L_5 - L_3 \sqrt{\frac{E_3}{E_5}}}{\sqrt{\frac{E_3}{E_5}} - 1}, \qquad (1)$$

where E_3 и E_5 – illumination at a distance of 3 m and 5 m; L_3 и L_5 – distances that are equal to 3 m and 5 m respectively.

The results of LI analyses are presented in Fig. 1 (curve 3). It can be seen that the result obtained by using of the formula (1) provides less high luminous intensity than by using of the method [1] (curve 2), but a greater than without correction (curve 1). The curve 3 is obtained under the assumption that the errors of LI measurement are equal zero.

The real measurements have some error. In this article we have investigated the applicability of the described method in the presence of measurement errors, i. e. results (illuminance E at different distances L) used for the processing are obtained by the formula (2) but not experimentally.

$$E = I \times (L + \Delta)^2. \quad (2)$$

In the formula (2) I is a luminous intensity.

According to the investigated model (when Δ varies in the range from 0 to 0,6 m), even at a relatively large distance of 10 m error in determining of the LI is about 5%. In accordance with formula (2) for each correction the luminous intensity was computed by introducing distortions that simulate the measurement errors.

For measurements with negligible errors the introduction of corrections to the distance in accordance with (1) leads to the right results, i. e. the LI becomes equal to unity at all distances. It should be determined such a measurement error in which the use of this approach application is justified. For this purpose in the measurement results the coefficient that simulates error was introduced. The critical value is considered as the result which goes beyond the uncorrected values of LI, i. e., the measurement error for which the introduction of the proposed method of LI correction becomes reasonless is determined. After analyzing of the calculations results one can find a linear relationship between the permissible error δ (%) and the value of Δ (m) ($\delta = 11 \cdot \Delta + 0,4$) that allows for the particular case to determine the validity of the proposed method application.

The conclusions

As a result of this work the method of luminous intensity measurement for non-point sources of optical radiation at short distances is proposed. The simple analytical formula for an correction to the distance between the optical radiation source (headlight) and a receiver (illuminance meter) has been obtained. This correction essentially (by tens of percent) increases the accuracy of luminous intensity measurement. The experimental measurements of luminous intensity of car headlights allowed to define the range of corrections values which is typical for the investigated sources. The analysis of method allowed us to determine the accuracy of the measurements for which the use of this approach application is justified. Processing of measurement results with using of this method does not require large stands, improves their accuracy and allows us to link the requirements of documents [2]. After the certification of a specific measuring stand, namely after finding the total error of the measurements, the proposed method allows us to enter the corrections that significantly increase the accuracy of luminous intensity measurement.

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