Asesorías y Tutorías para la Investigación Científica en la Educación Puig-Salabarría S.C.
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RFC: ATI120618V12

Revista Dilemas Contemporáneos: Educación, Política y Valores.
http://www.dilemascontemporaneoseducacionpoliticayvalores.com/
Año: VI Número: Edición Especial Artículo no.:58 Período: marzo, 2019.

TÍTULO: Cálculo y construcción de elementos ópticos de dispositivos de luz.

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RESUMEN. En la elección o cálculo del módulo LED, deben considerarse muchos factores, incluidos los requisitos para la iluminación y la ejecución de la óptica. Teniendo en cuenta un diseño de módulos LED se lleva a cabo el modelado de la distribución luminosa de los dispositivos de iluminación. Para crear el gráfico de iluminación requerido, en muchos casos se utiliza la óptica secundaria especializada para diodos emisores de luz. El cálculo de los elementos ópticos consiste en etapas del modelado del módulo LED y su optimización. El programa de modelado óptico TracePro cuya funcionalidad se considera en un artículo se aplica al modelado y al diseño por computadora. También se da el ejemplo de modelado y optimización del módulo LED con un reflector de espejo.

PALABRAS CLAVES: dispositivo de luz, diodo emisor de luz, lente, reflector, sistema óptico.

TITLE: Calculation and construction of optical elements of light devices.

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ABSTRACT: At the LED module choice or calculation many factors, including requirements for illumination and execution of optics, have to be considered. Taking into account a design of LED modules, modeling light distribution of light devices is carried out. In order to create the required chart of illumination in many cases, the specialized secondary optics for light-emitting diodes is used. Calculation of optical elements consists of stages of the LED module modeling and its optimization. The program of optical modeling TracePro which functionality is considered in article is applied to modeling and computer design. The example of modeling and optimization of the LED module with a mirror reflector is also given.

KEY WORDS: light device, light-emitting diode, lens, reflector, optical system.

INTRODUCTION.

Lighting devices are an important element of a large number of the technical systems including road, inhabited, industrial lighting, lighting systems of vehicles, etc.

Now evolution of lighting devices is directed to transition from lamps to light-emitting diodes. It is connected with adoption of arrangements in the European Union countries, the USA, Canada on the legislative ban of use of inefficient glow lamps.

The LED industry around the world became one of the most quickly developing sectors of economy in recent years. Each half a year parameters of light-emitting diodes (LED) and lighting devices on their basis become on new quantitative level on light return, power of radiation and a light stream, color characteristics. According to the Borovkov company decrease in prime cost of LED is expected and it is predicted that by 2020 LED light sources and light devices on their basis will occupy 75% of the lighting market (Borovkov, 2011).

Features and problems of led light devices optical systems design.

The LED light device (lamp) is the complex technical device in which the light source - the LED module (LEDM) - cannot be separated from a lamp design. In it the set of components has to be calculated and mutually coordinated:

- Requirements for illumination and optics.
- Light-emitting diodes and power supplies for them.
- Operating modes of light-emitting diodes and condition of their cooling.
- The cooling radiators and the case of the lamp.

Design of LED light devices (LD) includes processes (Bayneva, 2016):

- Choice of components for the lamp (light-emitting diodes (LED), optics, power supplies, drivers, special optical materials, etc.).
- Modeling the light distribution taking into account the planned lamp design.
- Thermal calculation of the lamp depending on the chosen electric operating mode of light-emitting diodes, their arrangement scheme, the chosen design components.
- Electric calculation.
- Development of circuitry decisions (payments, drivers, etc.).
- Lamp design assessment (cases, radiator, the used optics) and issue of recommendations about its improvement on the basis of lighting, thermal and electric calculations.
- Performance of the model.
- Measurement of the declared parameters.
- Search of the optimal solution on cost and service life.

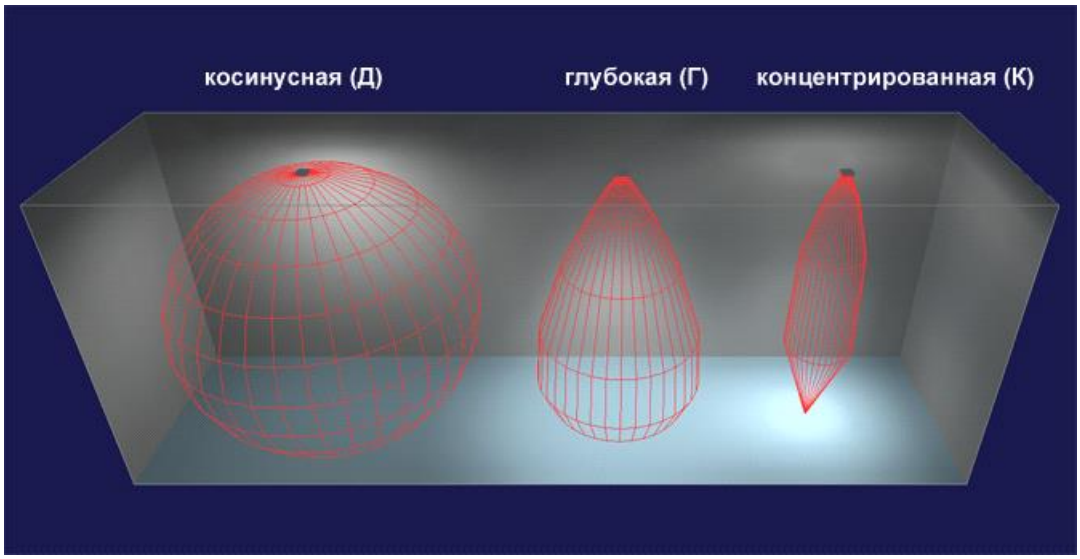
The first design stage of the LED lamp is lighting calculation of LD. During this stage, the LED type is selected and if it is necessary, the optics, the most suitable under a problem of lighting, is defined a necessary light stream of LD (Bayneva, 2016).

Secondary led optics and its calculation.

The light-emitting diode possesses light distribution, but for many purposes of lighting, for example, in rooms with high flights or streets, such light distribution is not appropriate.

Creating the a necessary light distribution (fig. 1) in the form of the luminous intensity curves (LIC) (for example, deep, concentrated, etc.) requires specialized optics (fig. 2). It is a lens or a mirror reflector which in total with a light-emitting diode (light-emitting diodes) form the LED module (LEDM). Use of secondary optics allows receiving demanded light distribution LED (Bayneva, 2015; Bayneva & Baynev, 2016).

Fig. 1. Curve light distribution of light devices.



Конусная (Д). Глубокая (Г). Концентрированная (К).	Cone (D). Deep (G). Concentrated (C).

The secondary optics forms the required distribution (chart) of illumination, and the most widespread charts: narrow - a corner of effective radiation 5-20 °; average - a corner of effective radiation 20-50 °; wide - a corner of effective radiation more than 50 °.

Fig. 2. Options of secondary optics execution.

The greatest distribution was gained by the lenses using the principle of full internal reflection, as well as reflectors. Calculation of lenses of full internal reflection and reflectors demands the accounting of the features of a specific light-emitting diode demanded optical parameters, dimensions and the price (Bayneva & Baynev, 2016).

Calculation of optical elements - lenses and reflectors generally consists of several stages. At the first stage the light source model is created, the light distribution is set, the choice or development of a form and design of an optical element is carried out. The second stage - modeling and optimization of the received system. It is carried out by the analysis of characteristics, control of optimization parameters and directly the optimization with obtaining final result (Gadzaov & Dzerzhinskaya, 2018).

Creating the mathematical and geometrical models of optical system is a basis for modeling the passing of a light beam. The optical analysis is used for calculation of their trajectory of the movement. Optimization of such models is also very useful.

Automation of optical systems design.

Process of design and designing, as a rule, iterative also assumes search of several options therefore simplification and automation of model creation for the future product are one of the most important problems of computer-aided engineering systems (CAES) (Baynev, 2017a; Baynev, 2017b; Baynev, 2017c).

In the field of optics and optical instrument making specialized SEA-systems (systems of the engineering analysis, each of which allows to solve a certain settlement problem), from which it is possible to distinguish the program for modeling and computer design of the optical TracePro (Lambda Research Corporation; Starostina et al, 2016), systems are used.

TracePro is applied to the solution of a wide range of engineering tasks in various areas connected with optics including in lighting engineering. It allows creating virtual prototypes of optical systems, to model various factors of the optical environment, to create geometry of objects and to investigate parameters of sources and receivers of radiation. The program is compatible to the majority of modern CAES (Autocad, the COMPASS, SolidWorks, the CATIA, etc.) and allows carrying out data exchange through various formats. Also TracePro models KSS, a light stream, brightness/illumination on the separate considered surfaces trace of beams by Monte Carlo method.

Development of optical system models in TracePro.

The reflector is the most widespread LD optical system. During creating a reflector, the surfaces of rotation or cylindrical surfaces having as forming a circle, an ellipse, a circle, a parabola can be inserted. The generated objects can be displaced and turned concerning axes of global system of coordinates. The system does not give to any surfaces of optical properties therefore it is necessary to appoint them independently. At the same time such options as spherical, parabolic, elliptic surfaces are possible. For them it is possible to set thickness, opening radius, length, focal length, as well as optical properties of objects and light sources. Trace of the beams going from a source as

which it is accepted one or several surfaces and display of distribution of luminous intensity is carried out by means of the corresponding teams. The algorithm given above allows modeling any light devices and optics (reflectors, Fresnel's lenses, light-emitting diodes, etc.).

One of the directions of use of the program TracePro complex is modeling the optical systems of light devices. Process of creating the model of the lamp and its elements and the analysis of the received results can consist of the following stages: creating the model of the LED module (fig. 3), purpose of properties to model surfaces; task of parameters to light-emitting diode surfaces; trace of beams from the module (fig. 4); creating the KSS of the LED module (fig. 5).

Fig. 3. Creating the model of the LED module.

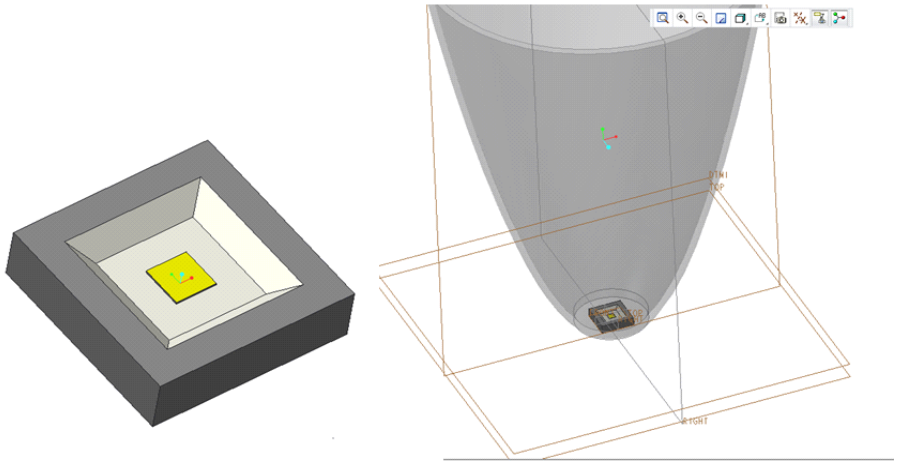
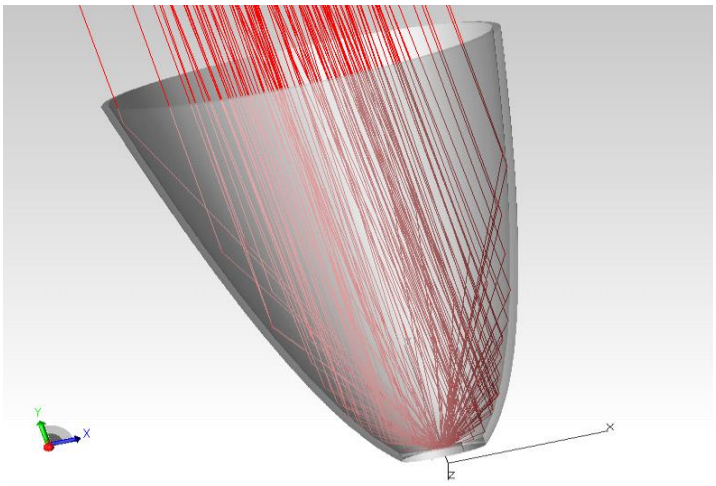


Fig. 4. Trace of beams from LEDM.



For convenience of development of models for the products, TracePro allows to import a mechanical component from popular CAES. Modeling is carried out with initial geometry of the imported object. Thus, having created model of LED LD in CAD system and having imported it to TracePro, the developer considerably will simplify and will accelerate process of design of a product.

If the received KSS does not suit the developer, i.e. does not meet the requirements of specifications of the lamp, then model is possible to optimize by means of the optimizer of the program (fig. 6). In this case, optimization consists in change of a form of a regulated reflector under the required KSS. Upon termination of process of optimization charts of light distribution in 2D and 3D types (fig. 7) will be received.

Fig. 5. Curve of luminous intensity of LEDM.

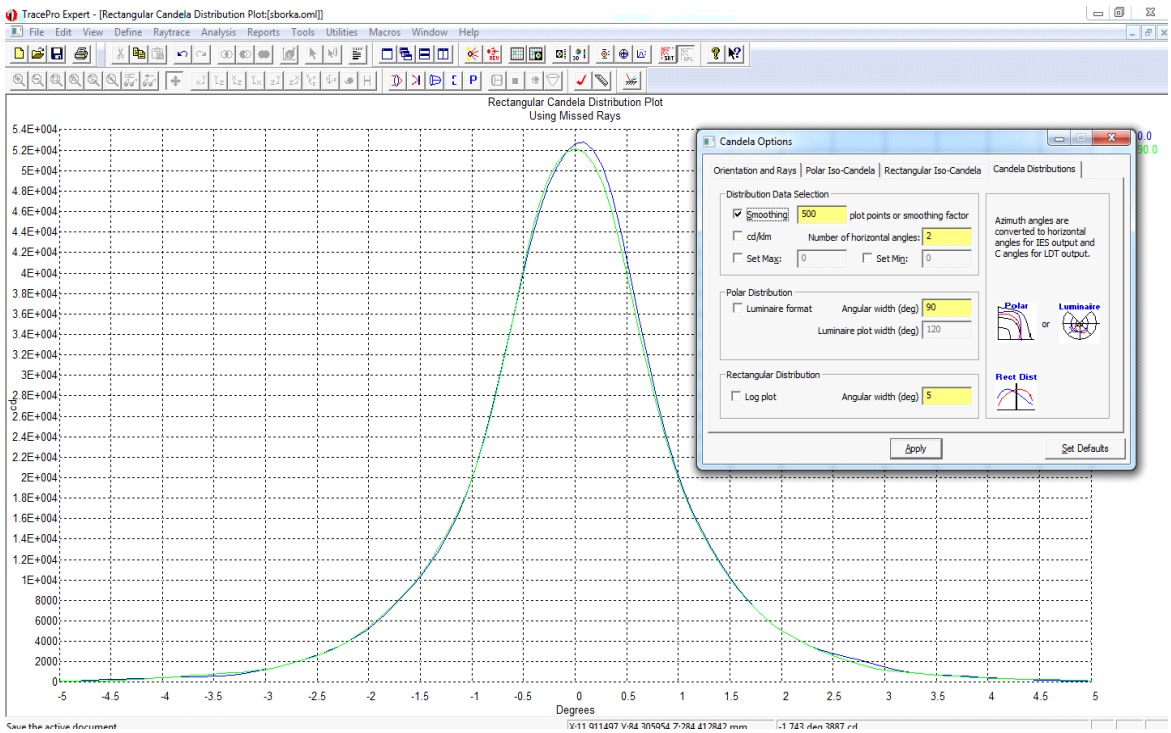


Fig. 6. Process of a LEDM reflector optimization.

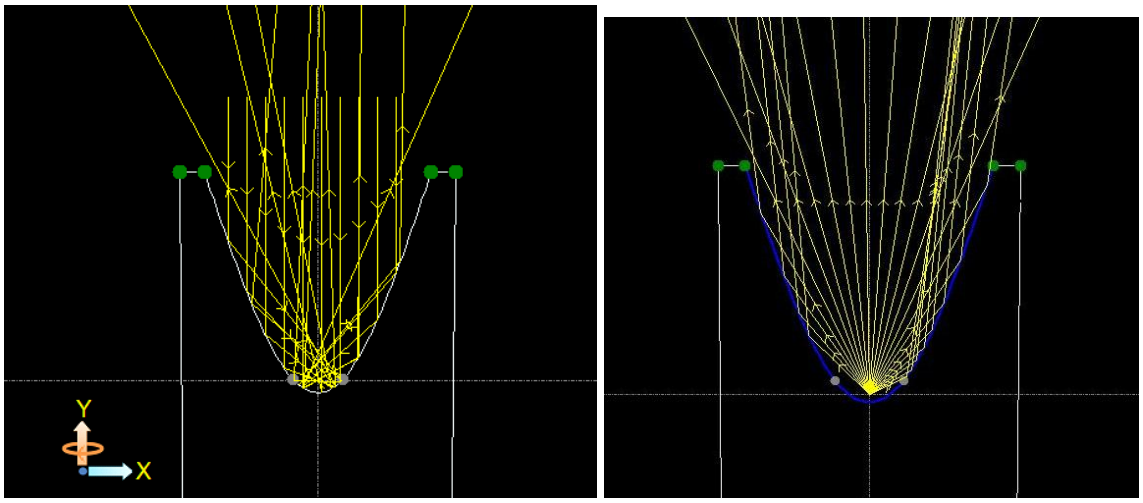
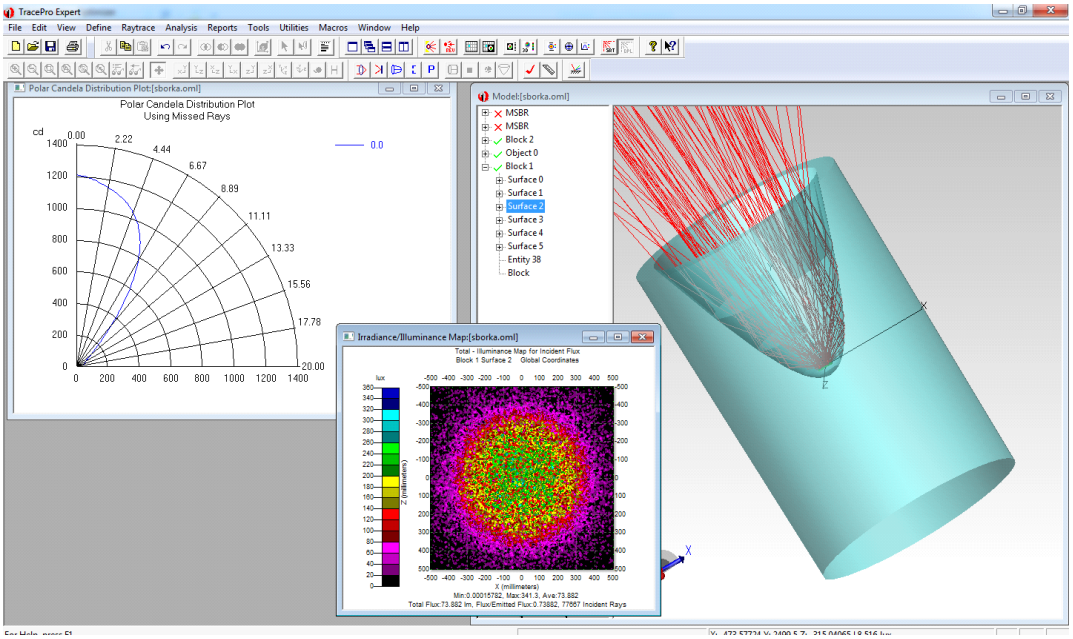


Fig. 7. Charts of LEDM light distribution.



CONCLUSIONS.

Low light source LEDs can easily obtain light distribution and secondary optical optimization, accurately control the direction of light, fully distribute the light to the required lighting paths, and Contaminated light and light reflection.

Secondary optics is an important bond that directly determines the output, distribution, uniformity and reflectivity of the LED lens lens. The green light of the green city requires LED street lights to produce rectangular patches that only cover the road and reduce light pollution to other off-road locations, such as residential buildings and buildings.

The highest point of the high-power LED is the circular market. LED Street Lights Without the lighting design of the secondary light, after turning on at the roadside, a cake will be rounded, about half the point will be scattered outside the road and will be wasted, and the spot in the middle will be relatively bright, Gradually darker away. When the lamp is mounted on the road, there is a clear distribution of light and dark bulbs, causing visual fatigue to the driver and the occurrence of accidents. In this case, LED street lights cannot be referred to as "energy saving" and "green lighting".

Glass lens in the street lamp, the use of light distribution technology, a reasonable control of light distribution such that the rectangular point is to ensure the ideal brightness and uniformity at a time, eliminating the reflection light of ordinary street lights Normal power and the use of street lights with high power street lights, without light pollution. The glass lens has a super high uniformity, if designed for a specific scene, it can achieve more than 85%. The light distribution curve is optimized according to the actual road conditions.

The perfect airfoil curve in the direction of C0-C180 and its angle of deviation in the direction of the C90-C270 can reach over 15 degrees. The ratio of the use of geometry (the ratio of the light level required to the actual lighting area) can be increased by more than 80% to some extent.

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RECIBIDO: 1 de febrero del 2019. **APROBADO**: 12 de febrero del 2019.