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Led light computer simulation and design on solar battery

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Abstract. The article considered the features of architectural lighting and lighting devices. They analyzed the requirements for architectural luminaires and their features, solar elements, their operation principle and design. They described the developed luminaire, its design and light sources and the device electronic elements. The modeling of lamp light distribution and illumination is carried out.

Key words. Architectural lighting, lamp, LED, light source, optical system, simulation, de-sign, visualization.

1. Introduction

Architectural lighting is one of the main trends in light design. Architectural and landscape lighting is an indispensable detail for modern cities. One of the advantages of architectural lighting is the use of special LED lamps and search-lights, by which you can change the color range of an illuminated building completely or partially. Speaking about architectural lighting, one cannot ignore its cost and energy costs. These costs represent capital investments, consisting of light source and luminaire cost, installation works, and are relatively static ones. The operational costs associated with energy consumption and lighting system maintenance, grow throughout the lifetime of a building and the surrounding area. The traditional architectural lighting of buildings and territories consumes more than 20 % of the total electricity. And in connection with the constant development of urban infrastructure, the energy costs for various types of lighting grow only. The state of the modern world economy and ecological situation leads to the need of renewable energy source use. That is why energy-efficient street lighting is being introduced so actively now, in its various versions [1–3].

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2. LED lamp design and operation principle on solar batteries for architectur-al lighting

The principle of a LED lamp operation is based on the conversion of sunlight into electrical energy using a solar panel [4]. It works autonomously and does not require the connection to a power source. During a day it can work up to 12 hours after charging. LEDs are used as lighting elements. A lamp has a waterproof and heat-resistant housing in order to ensure a reliable operation under adverse climatic conditions. It is also equipped with a motion sensor, which is triggered automatically at any actions within the radius of 2 meters from a luminaire. The developed ID has a third class of protection against electric shock, since it is fed by safe extra-low voltage. In this regard, it can be in-stalled on conducting surface directly or near swimming pools and fountains. A projected luminaire has a diffuser made of polymethylmethacrylate that is capable to keep up burning, so this ID should not be used in fire-hazardous areas and shouldn't be installed on combustible surfaces. Also, a luminaire has no protection against explosion, it is intended for operation under normal conditions and has the protection degree against impacts IK06.

Structurally a luminaire consists of two parts: a support and a lighting part. The main feature of this ID is the availability of a rotary module with a solar battery and a rotary light module, which will allow to change the direction of a luminaire luminous flux. Besides, a motion sensor is installed in order to control the device inclusion in the light module housing.

One can distinguish the following elements in the luminary on solar panels: an accumulator; the LED that emits visible light when an electrical current passes through it; an electric accumulator; light sensor; a microcircuit that controls the illumination of the LED depending on the voltage and turns it off when the battery is discharged to a certain level; a photocell turns on the lamp and converts the energy of light into electrical energy. All these components are integrated into a single scheme. Table 1 presents the characteristics of ID.

Table 1. Characteristics of the projected illumination device

Parameter	Value
Lamp power (W)	12
Luminaire rated voltage (V)	3.6
Luminous flux (lm)	800
ID type	SD
Protection class against electric shock	III
Luminaire protection degree	IP44
Climatic execution and placement category	UHL1
LFC type	Cosine (D)
Light efficiency (lm/W)	67
Installation method	Ground

Six LEDs OLP-5065F6L-06A-80-D07N0 with a service life of more than 50 000 hours are used in the developed luminaire as a light source. The solar panel STAR SOLAR CNC85x115-18, made of poly-crystalline silicon, is used in the projected ID, the elements are protected by a strong outer shell. The solar panel is made of 36 cells with the total power of 1.5 W, the rated current of the panel is 100 mA, the nominal voltage makes 12 V. Figure 1 shows the general connection scheme of all components of ID solar system. The principle of the scheme operation is the following one: the solar battery GB2 charges the battery GB1, when the voltage level of the solar battery drops to night one YX8018 converter turns on the VD1 LED, which is connected via a motion sensor. The motion sensor responds to the presence in the sensor coverage area (2–3 meters) and turns on the lamp, after 20 seconds the lamp will shut off automatically. The motion sensor has 12 meter range, the detection angle makes 120 °.

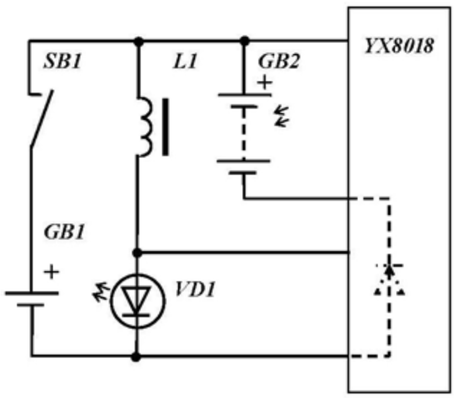

Fig. 1. ID electric circuit

The main role in the redistribution and the transformation of the luminaire light flux is played by ID optical system or by light-distributing devices [5]. The choice of an optical system depends on the complexity of the work per-formed and its specifics [5]. Since this id is intended for accenting and decorative landscape lighting, it must have a cosine light force curve (LFC), so the use of additional light-distributing devices is not required. In order to create more diffuse light and to protect the LEDs from external influences, a diffuser is used made of polymethylmethacrylate.

3. Luminaire computer modeling

The obligatory stage of works during the design of luminaires is the develop-ment of drawing and design documentation with the use of automated design systems [9–10]. Fig. 2 shows the 3D model of the luminaire, including a support based one. The optical properties of the materials - LED module reflector, the protective glass of polymethylmethacrylate and the illumination source - ID were set in the TracePro environment.

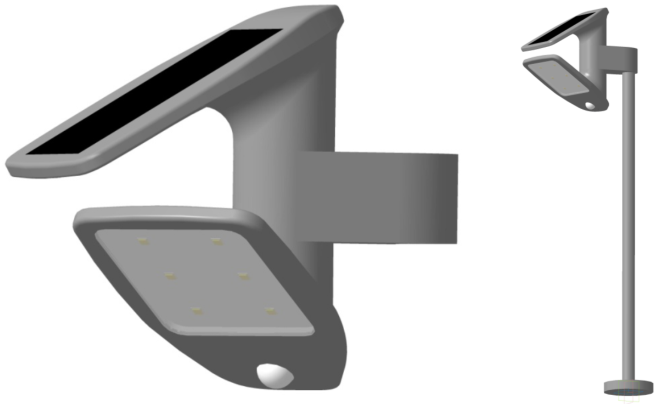

Fig. 2. Luminaire 3D-model

When the properties of materials and light sources were specified, ray tracing was performed (Fig. 3). The diagrams of light distribution and LFC are obtained (Fig, 4)—cosine, which corresponds to the specified lighting conditions.

Fig. 3. Graphic presentation of ray tracing process

Figure 5 presents 3D visualization of lighting. The display of the scene in fictitious colors is one of the effective methods to assess the quality of lighting, which allows you to determine under-illuminated or over-illuminated area accurately. Figure 5 shows the levels of illumination distribution in fictitious colors.

4. Conclusion

A solar-powered illumination device was designed for functional and decorative lighting. To this end, they used the tools of modern computer technology: computer-aided design KOMPAS-3D, optical modeling TracePro and illumination modeling

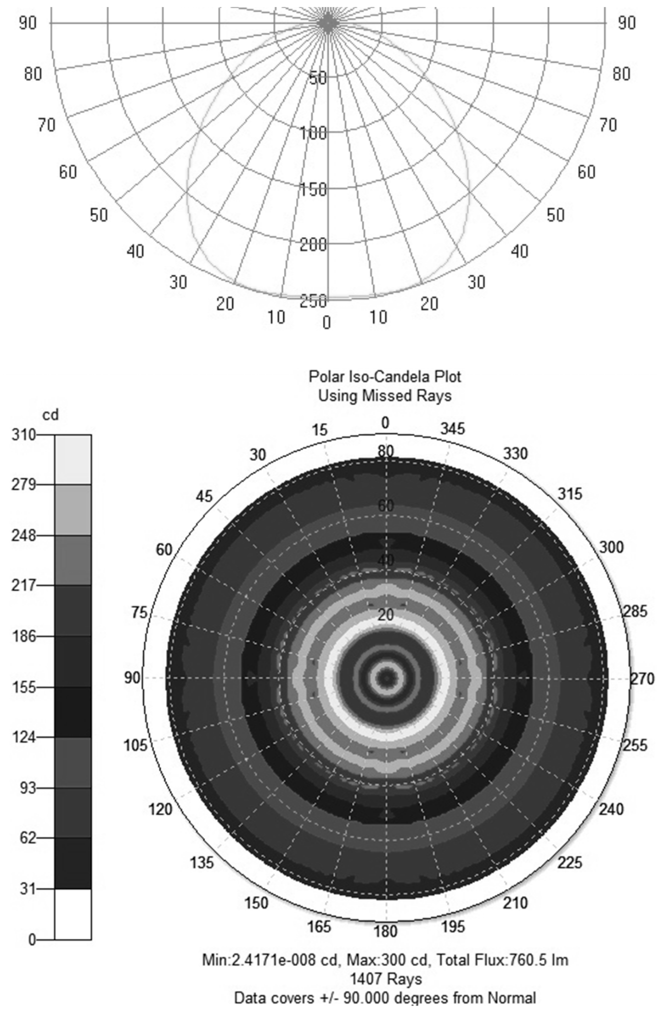

Fig. 4. LFC and luminaire light distribution diagram

DIALux. The developed luminaire with energy-efficient LEDs can serve as an alternative more economic and environmentally friendly substitution of an ID with traditional light sources.

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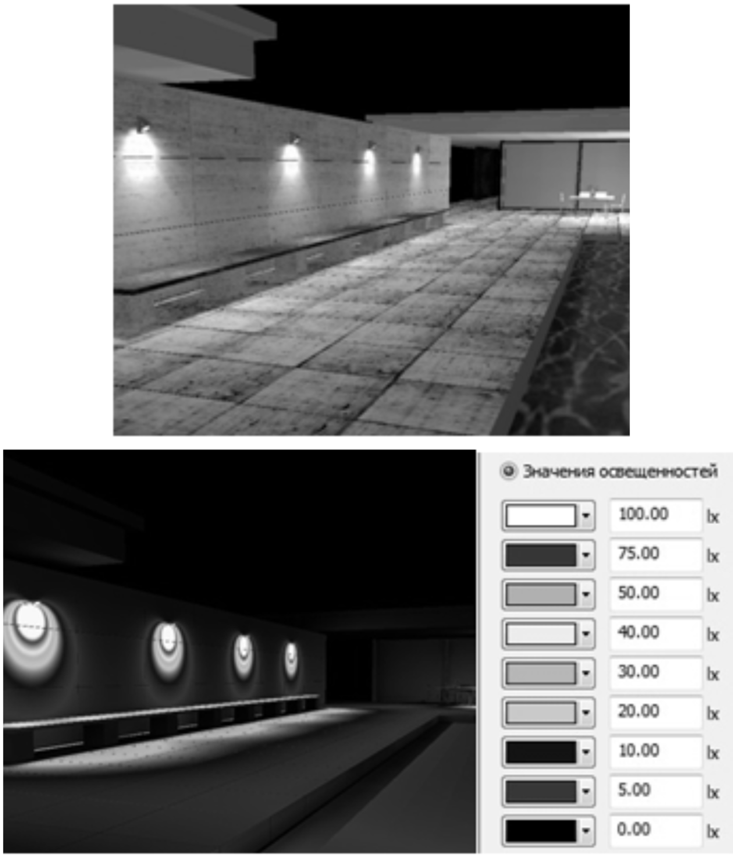

Fig. 5. 3D visualization of functional illumination and Illumination distribution levels in fictitious colors

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