Optimal indoor lighting system design by genetic algorithm

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Abstract

The paper deals with problems concerning indoor luminaire placement by genetic algorithm. In contrast to outdoor illuminance calculations multiple reflections from walls must be taken into account. Therefore a basic reflection calculation has been proposed and a genetic algorithm script tested in MATLAB (software) on a model room. It appeared that requirements laid out by the Czech National Standards do not restrict solutions of luminaire placement too much, hence several solutions met the requirements. The most suitable solution is always chosen by the designer’s preferences. Implementing these preferences into the algorithmic solution is quite a big deal, nonetheless some methods to achieve this are presented in the paper.

Keywords

Genetic algorithm, lighting, luminaire placement, illuminance

Introduction

While designing lighting systems for indoor working places the designer must take several requirements into account, of which the main would be to provide enough light for the given purpose of the interior space at a reasonable power consumption. These and more requirements are set by the Czech National Standards1 mandatory on the territory of the Czech Republic.

A test model room of dimensions 5 m × 10 m, 4 meters high with luminaires 4 meters above the floor has been chosen within the framework of this project. The model room’s chosen purpose has been to provide for handwriting, writing on typewriters, reading and processing data according to reference number 5.26.21. There are several conditions required by the standard that have to be met by the lighting system:

 Maintained Average Illuminance of 500 lux

 Unified Glare Rating 19

 Lighting Uniformity 0.6

 General Color Rendering Index 80

The model room will meet the stated requirements if the reference plane’s average illuminance will not drop below ** over the course of operation of the lighting system. Calculating the initially needed illuminance values can be achieved by using the Maintenance Factor 2. defines the depreciation of the reference plane’s illuminance at the end of the maintenance period. The has been chosen to be 0.75. For the model room’s purpose the reference plane1 represents desktops of writing desks and has therefore been placed horizontally 75 cm above the entire floor. To obtain the lighting system’s quality a grid of measurement points placed in the reference plane is used representing placements of the lux meter’s measuring head, for this instance in a horizontal position. According to3 the measurement grid should start 1 m away from walls with a spacing from 0.5 m to 2 m. For this project we chose a more detailed grid covering the whole reference plane. To calculate the task area and occupants’ view directions must be known, which is beyond the scope of this project. Furthermore a room of this size using ordinary office luminaires would most probably not yield values higher than the limiting top value. ** is a parameter of light sources and luminaires dependent on their light spectrum, is not dependent on the test room and will therefore not be included into calculations.

Lighting System Quality Evaluation

Evaluating the model room’s lighting system quality in terms of standard CSN EN 12464-11 requires the observation of four parameters. As mentioned in the previous section only average maintained illuminance  (Equation 1) and uniformity  (Equation 2) will be calculated in this project, both obtained from illuminances of the reference plane.