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Simulation of Energy Efficient Lighting System For Energy Optimization: A Case Study of A Dairy Farm

Aylin Duman Altan
Namık Kemal University Agricultural Faculty Biosystems Engineering Dept./Turkey
Corresponding Author: Aylin Duman Altan

ABSTRACT:- The aim of this study is to design and develop lighting system with the help of lighting programmes for energy optimization at Namık Kemal University (NKU) dairy farm. The lighting systems are studied experimentally with different armatures (lamps). The current lighting system is simulated with the Dialux program. As a conclusion, it is determined that the brightness level is insufficient and energy efficient lighting system design is proposed with the Dialux.

Keywords:- Efficient Lighting, Dairy Farm, Energy Optimization, Dialux, Simulation

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I. INTRODUCTION

Modern agriculture facilities need a high quality work environment to optimize plant, animal and worker efficiency, and comfort [1]. It has been proven that cows are performing better, when there is natural light cycle ensured in the barn (day and night rhythm). This is due to fact that light activates certain hormones in cow's brain which makes cow more active and therefore she produces more milk. Milking cows exposed to 16 to 18 hours of light with a brightness of 15 to 20 foot candles followed by 6 to 8 hours of uninterrupted darkness per day had milk production increases ranging from 5 to 16% compared to cows exposed to 13.5 hours or less of light per day [2]. Darkness is also an important role in lighting manipulation; there was no difference on milk production between cows exposed to continuous lighting (24 h of light) and cows exposed to natural photoperiod (8-12 h of light/d) [3]. Natural lighting is generally not enough for this process and artificial lighting is used in dairy farms. Energy consumption of lighting is represented an average of 17 % of total dairy farm electrical energy use is reported [4]. The result of these developments in lighting has requires of energy efficient lighting system design for artificial lighting in dairy farms.

Energy efficiency is a generic term which refers to using less energy to produce the same amount of services or useful output [5]. Lighting system performance factors seen in Table I [1]., which are defined as follows, should be considered when selecting light sources to obtain quality lighting, energy efficiency and optimum energy consumption.

Table I: General Characteristics of Light Sources

Lamp Type	Lamp Power (W)	CRI	Efficacy (lm/W)	Typical Lamp Life (hrs)
Incandescent	34-200	100	11-20	750-2000
Halogen	50-150	100	18-25	2,000-3,000
Fluorescent	32-100	75-95	75-98	15,000-20,000
Compact Fluorescent	5-50	80-90	50-80	10,000
Metal Halide	70-1,000	60-80	60-94	7,500-20,000
High-Pressure Sodium	35-1,000	20-80	63-125	15,000-24,000

Performance factors are defined like that, color rendition index (CRI) is a measure of the quality of light or the lamp's ability to render the true color of an object as compared to natural light. [6]. The life value assigned to a particular type of lamp, in hours, at which half of a large group of lamps have failed [7]. Illuminance (unit=lux) is the quantity of light energy falling on a surface. The efficiency of that process is the luminous efficiency/efficacy, measured in lumens per watt. Higher the number is, more efficient the light fixture

is (Hiscocks, 2008). On the other hand, using an efficient light source in a poor design does not provide energy optimization. For this, optimum design of the systems is required. The current system is simulated and optimum design of energy efficient lighting system is proposed with the Dialux.

II. EXPERİMENTAL SETUP

The dimensions of the area examined are as Fig.1, which is obtained from the dairy farm of the NKU. A total of 35 armatures is symmetrically (7x5) placed on the metal frame as shown Table II.

Fig.1: The dairy farm' lighting

Table II: The measurement data

Length	37.8m
Width	22.8m
Height	10m
Suspended height	3.23m

The acceptance values of the parameters used in the simulation with Dialux program are as in the Table III.

Table III: The acceptance values of parameters

Floor Reflection	%16
Ceiling Reflection	%70
Wall Reflection	%43
Maintenance factors	0.5

In the simulation of current system, Philips TMX204 2XTL D36WHFP + GMX465 M-NB model is used.

III. RESULTS & DISCUSSION

a) Simulation of Current System

The simulation image of symmetrically placed armatures is Fig. 2. According to the standards [1], it is required that the level of illumination is 200 lux for dairy farm and it is clearly that the standard required for dairy farms is not provided according to the simulation output (Fig.3).

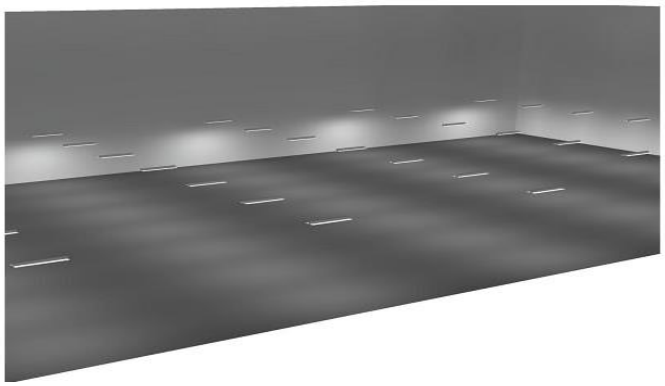

Fig.2: The simulation view of current system

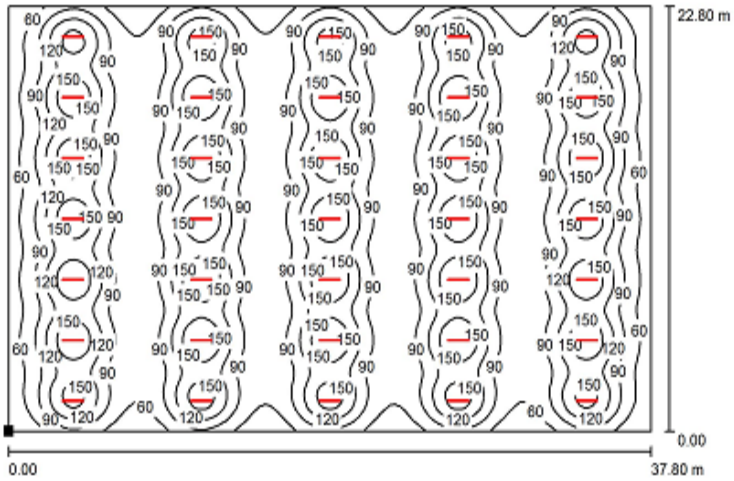

Fig.3: The simulation output of current system's illuminance distribution

a) Simulation of First Alternative System

The first simulation is carried out to show the optimum design dimensions of lighting system based on current armature model. This simulation shows that the wrong system has been designed for the using of this armature. In order to provide sufficient lighting with current model armature , 72 armatures are needed, which are placed symmetrically.

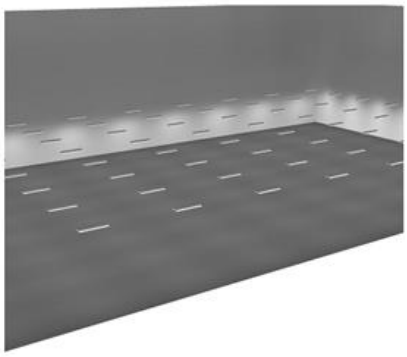

Fig.4: The simulation view of. System

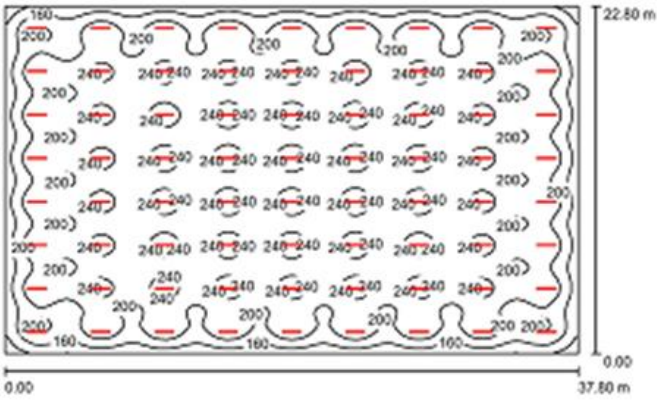

Fig.5: The simulation output of illuminance distribution

b) Simulation of Second Alternative System

The second simulation is carried out to show the optimum design dimensions of lighting system based on a more efficient armature model, which is called Philips TMX400 2XTL5- 80WHFP+GMX555 MB+GGX555 C6T. It has been determined that 42 (6x7) armatures are required according to the simulation result.

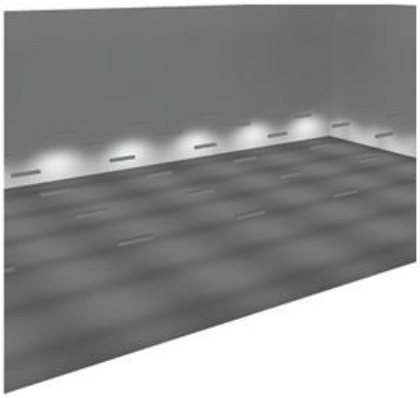

Fig.6: The simulation view of system 2

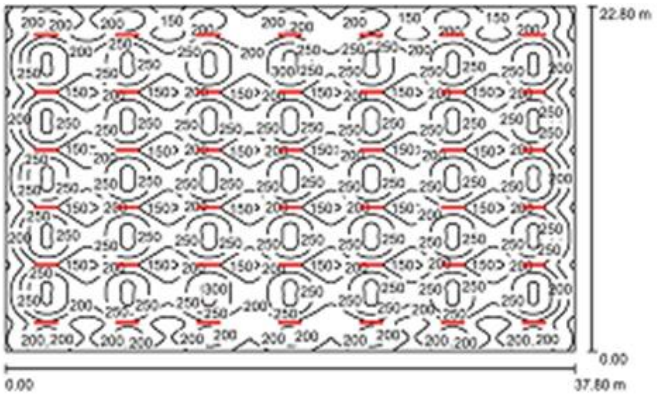

Fig.7: The simulation output of.illuminance distribution 2

IV. CONCLUSIONS

In this study, it is clearly that the simulations of lighting systems must be done before the installation of the systems and an important contribution has been made to the end-user in designing energy efficient lighting systems. As another result, not only the correct selection of the armature for efficient lighting is not enough, but also the system simulation is require for energy optimization in lighting systems. Otherwise, either an insufficient level of illumination is provided or energy consumption can be increased by incorrect system setup.

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