INDUSTRY LIGHTING LUMINAIRES TYPES AND THEIR IMPACT ON THE ELECTRICAL GRID

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Abstract: The paper deals with the potential energy saving in industry using efficient lighting sources. Industry lighting with three types of light sources are considered in this paper: metal halide lamps, fluorescent lamps and light emitting diodes. First two types are those lamps in which the light is created by an electric discharge within a gas or a vapour, while third one is semiconductor device coated with different phosphor materials. Beside comparison of energy consumption, for the same light levels on the working place, measurements and comparison of harmonic current distortion of considered light sources were also performed.

Keywords: energy efficiency, harmonic distortion, power quality.

INTRODUCTION

Lighting participates about 15% in total electricity consumed in Industry. Implementing new lighting technologies in combination with lighting control, a significant cost savings could be reached. Metal halide lamps in High bay luminaires have been widely used for industrial lighting, and still are presented in new installations. But there are a lot of examples of using fluorescent lamps in industrial applications. Fluorescents systems have been proven as a method that will save energy and improve quality of light. The T5 high output fluorescent lamps have good quality of light, high efficacy and long life. On other side light emitting diodes (LED) are more energy efficient and do not contain toxic materials. Discharge lamps have some amount of mercury (Hg) which is environmentally hazardous material. Since LED is semiconductor device it uses driver with constant current. LED drivers were considered as devices which produce higher harmonics. Beside that LED is still more expensive than discharge lamps. Considering all advantages and disadvantages of all light sources, pay-back periods of using LED instead of metal halide or fluorescent lamps are between 1 and 5 years.

LIGHTS SYSTEM SOLUTIONS

The lighting installation of the furniture factory are designed based on different production technologies and requested light levels. Required light levels of each part of the production hall are shown in Fig.1.

Requested light levels can be reached using three different solutions. First solution is a combination of High bay luminaires with metal halide lamps and fluorescent lamps. Second solution is based on fluorescent lamps only, and third solution is realised using LED. Since all three types of light sources request nonlinear driver, which are source of higher harmonics, laboratory measurement of electric characteristics are performed.

As a measure of a effective value of harmonic distortion is common to use the total harmonic distortion (THD),

$$I_{THD} = \sqrt{\frac{I_{rms}}{I_1} - 1} \cdot 100 \qquad (1)$$

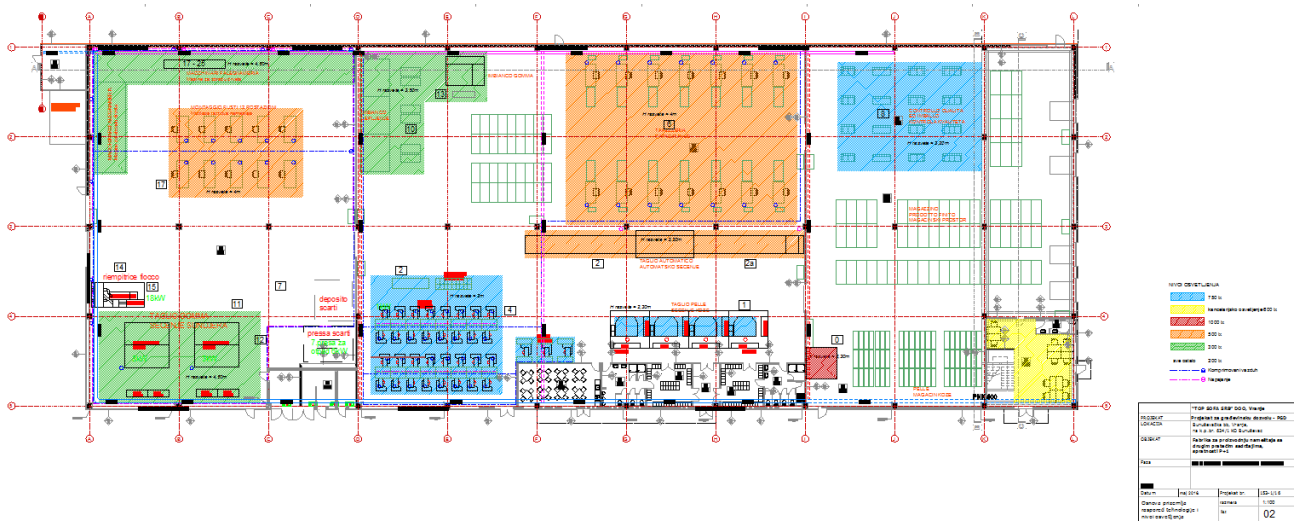


Fig.1 – *Requested light levels based on technology.*

Table I

Electrical characteristics of different light sources.

Type of light source	I_{rms} [A]	I_{THD} [%]	U_{rms} [V]	U_{THD} [%]	P [W]	Q [var]	PF
MH High Bay 250W	1.61	18.81	222.61	1.77	206.30	291.87	0.577
Fluo 4x14w 840	0.29	7.09	223.57	1.73	63.52	11.13	0.985
Fluo 2x58w 840	0.49	6.81	222.97	1.69	107.40	17.71	0.987
LED HighBay	0.42	8.53	223.82	1.73	92.27	15.76	0.986
LED WT120C	0.17	11.96	224.19	1.79	36.41	12.27	0.948
LED Panel 60x60	0.21	13.79	224.79	1.76	45.11	11.50	0.969

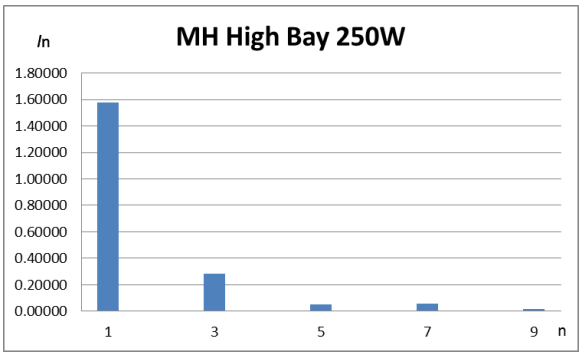
where: I_{THD} - total harmonic distortion of current wave shape (%), I_{rms} - root mean square value of current, and I_1 - magnitude of fundamental component of the current wave shape

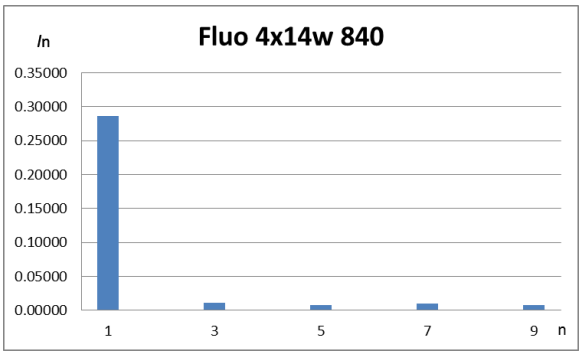
The magnitude of an individual harmonic component as a percentage of the fundamental one is also used as a measure of the harmonic contribution to the total harmonic distortion. The formula used for this calculation is as follows:

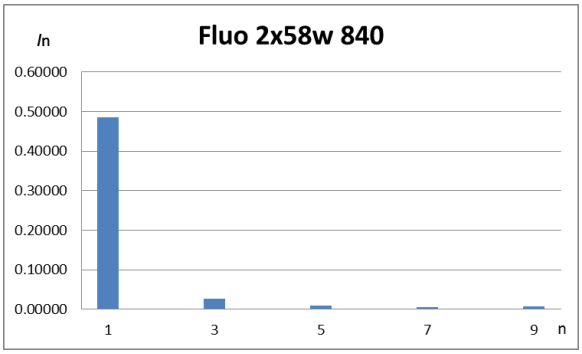
$$I_{hd(n)} = \frac{I_n}{I_1} \cdot 100 \qquad (2)$$

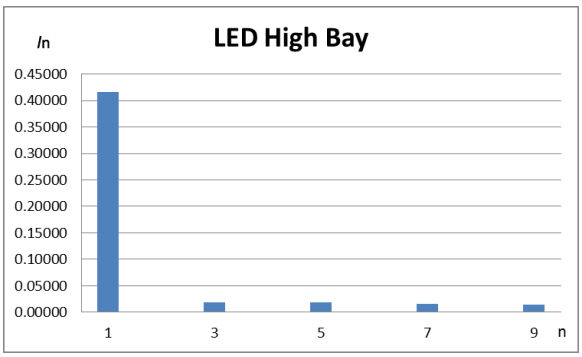
where: $I_{hd(n)}$ - harmonic distortion due to n-th current harmonic (%), I_n - magnitude of n-th current harmonic The total Power Factor (PF) is also given as a result of measurement.

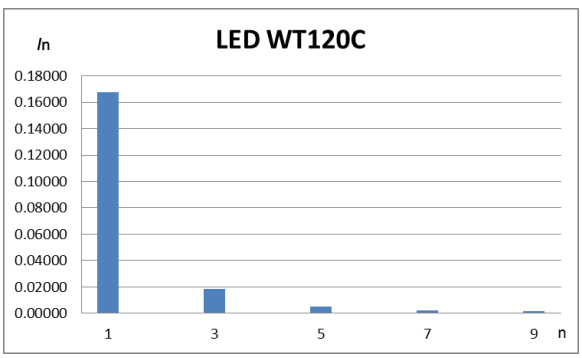
Measured results of all light sources used in all three light designs are shown in Table I, while detailed reviw of higher harmonics are shown in Fig. 2.











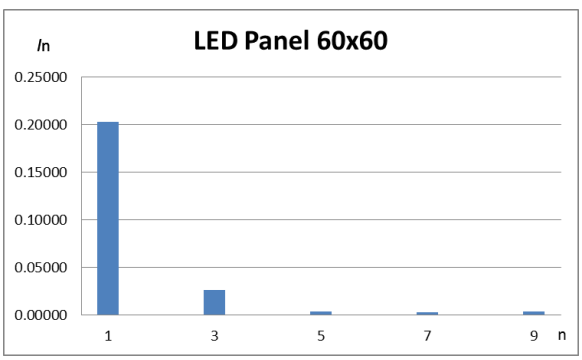


Fig.2 – *Higher harmonics of light sources.*

Considering measured electrical characteristics of different light sources it is obvious that luminaire with metal halide 250W lamp has the worst parameters. The measured PF is only 0.577. All other luminaires have PF above required 0.95, while total harmonic distortion of current is different. The cheap LED luminaires have higher I_{THD} than more expensive one.

Comparing all three lighting solutions based on installed power the figure is as follows. The total installed power for first solution is 43.148 W, and investment is 19,740 €. Installed power for second solution is 40,802 W, and investment is 16,399 €. Third solution, with all LED lamps, has installed power of 17,971 W and cost 43,117€. The harmonic distortion for all three systems are similar. Considering price of electrical energy in Serbia (0.04€/KWh), 300 working days and two shifts working time payback period is about 3.2 years.

CONCLUSION

All requirements for light levels and light control in industrial environment could be achieved by new light sources technology - LED. Efficacy of LED is much higher than efficacy of metal halide and fluorescent light systems. The harmonic distortion of LED drivers is not high as it was in the past since a lot producers of LED drivers implement filters within devices. The difference in efficacy could compensate initial higher investment in LED, and pay-back period is less than 5 years.

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