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LIGHTING IN TEXTILE INDUSTRY

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Abstract: *Mostly all tasks or activities of human being depend upon the light. Good lighting is essential to perform visual tasks efficiently. Each activity in the textile industry requires some lighting level on the work table. Adequate lighting is an important factor in ensuring product quality, enhanced productivity, proper and safe working. For a textile project manager, the knowledge of lighting is very essential to sound mill planning and management. In this paper various aspects of industrial lighting have been discussed.*

Key Words: *Artificial lighting, Industrial lighting, Illumination, Room index*

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1 INTRODUCTION

Lighting is an essential requirement in textile industries as well as all other industries. Light is a radiant energy from a hot body which produces the visual sensation upon the human eye. It is required for practical purposes as well as aesthetic purposes. Illumination differ from light very much, through generally, these terms are used more or less synonymously. Light is the cause and illumination is the result of that light on surfaces on which it falls. The power consumption by the industrial lighting varies between 2 to 10% of the total power depending on the type of industry. Proper and adequate lighting in the textile industry improves the visibility of an object, enhances work performance, improve the job satisfaction and reduce loss and compensation payment due to accidents in the industry [1,2].

Light is just one portion of the various electromagnetic waves travels through space. These waves have both a length and a frequency, the values of which distinguish light from other forms of energy on the electromagnetic spectrum. Visible light represents a narrow band (380 to780 nm wavelength) between ultraviolet light (UV) and infrared energy (heat). The light waves are capable of exciting the eye's retina, which results in a visual sensation called sight. Therefore, seeing requires a functioning eye and visible light [3,4].

Lighting can be classified in following three categories [1]:

i. ***Accent lighting***: This lighting is mainly decorative and used for interior design, landscaping or highlighting pictures or plants.

ii. ***Task Lighting***: This type of lighting is required for performing various activities such as: reading, writing, production process or inspection.

iii. ***General lighting***: General lighting or ambient light is fall in between above mentioned two lighting and is used for general illumination of an area.

2. CHARACTERISTICS AND BENEFITS OF GOOD LIGHTING

In textile industry, poor lighting at work place can cause of eye strain, fatigue, stress, headaches and accidents. On the other hand, too much light 'glare' can also cause health and safety problems. Both can lead to mistakes at work, poor quality and low productivity [5]. Characteristics of good lighting are as under:

- Light should be of adequate intensity for the particular job,
- It should be equally bright throughout the workshop.

- Light should not allow marked shadows.
- It should be diffused and not glare (excessive luminance).
- It should not be dazzle (bright confusing light)

Good illumination (Aadequate and balanced levels) in textile industry have following benefits:

i. Increase production
ii. Enhance quality of product
iii. Protecting health, eyes and nervous system of workers
iv. Improved safety and security
v. Reduce workers fatigue
vi. Reduce accidents
vii. Improve satisfaction and morale of employees.

3. IMPORTANT TERMS

The following are some important terms used in industrial lighting [3,6-8]:

3.1. Illumination

When the light falls upon any surface, the phenomenon is called 'illumination'. It is defined as the number of lumens, falling on the surface, per unit area. It is measured in lumens/m^2 (or meter-candle or lux) or lumen/ ft^2 (or foot-candle). The meter-candle (or lux) is the unit of illumination and is defined as the luminous flux falling per square meter on the surface which is everywhere perpendicular to the rays of light from a source of one candle power and one meter away from it. Foot-candle is defined as the luminous flux falling per square foot on the surface which is everywhere perpendicular to the rays of light from a source of one candle power and one foot away from it.

$$1 \text{ foot candle} = 1 \text{ lumen/ ft}^2 = 10.76 \text{ lux or meter-candle}$$

3.2. Utilization Factor

Utilization factor (or coefficient of utilization) is a measure of the effectiveness of the lighting scheme. Utilization factor is defined as the ratio of total lumens reaching the working plane to total lumens given out by the lamp.

$$\text{Utilization Factor} = \frac{\text{Total lumen reaching the working plane}}{\text{Total lumen given out by the lamp}}$$

3.3 Maintenance factor

Due to accumulation of dust dirt and smoke on the lamps, they emit less light than that they emit when they are new once and similarly the wall and ceilings etc. after being covered with dust, dirt and smoke do not reflect the same output of light, which is reflected when they are new. Maintenance factor can be calculated as under:

$$\text{Maintenance factor} = \frac{\text{Illumination under normal working conditions}}{\text{The illumination, when the things are perfectly clean}}$$

3.4. Room Index

The room index is a dimension less number that is indicative of the size and shape of the room. In other words, it is a number that describes the ratios of room length, width and height. Based on the room index, the minimum number of illuminance measurement points is decided.

$$Room\ Index\ (K) = \frac{(Length\ x\ Width)}{height\ x\ (Length + Width)}$$

Where, height = ceiling height –working plane height

The room index (K) is valid when the room length is less than the 4 times the width or when the value of K is greater than 0.75. Usually, the value of K lies between 0.75-5.

For a space having length = 5m, width = 4 m and lamp mounting height of 2.4 m, room index (RI) = 0.93

4. LAWS OF ILLUMINATION

There are two laws of illumination:

i. Law of inverse square

It defines the relationship between the luminance from a point source and distance. It states that the intensity of light per unit area is inversely proportional to the square of the distance from the source (essentially the radius).

$$E = \frac{I}{d^2}$$

Where E = illuminance, I = luminous intensity and d = distance

ii. Lambert's Cosine Law

According to this law the illumination at any point on a surface is proportional to the cosine of the angle between the normal at that point and the direction of luminous flux.

$$E \propto cos\ \theta$$

5. SOURCE OF LIGHT

In the textile industries, basically two lighting sources are available [1,9]:

A. Natural light (such as day light) and

B. Artificial light (tube lights, lamps etc.).

[A]Natural light

Natural light is mostly used as the main source of light during daytime in various industrial buildings. It is best for working and reduces the energy consumption, but it varies from time to time within the day, within the year and in conditions of the weather (sunny or cloudy). It also varies with the size and positions of windows and moreover it is just not possible to regulate the intensity of natural light. Windows not only allow passage of light, but they form an easy path for noise and heat transmission which increase load for the air conditioning plant and the increase in noise radiation to the outside. This necessitates the use of artificial lighting.

[B] Artificial light

In olden days, artificial light was used in such a way that it should supplement natural lighting. Artificial lighting, during day time, serves only those areas which do not have enough light to work. In modern textile industries, artificial lighting is used to light mostly all workplaces. Artificial light sources are based on one of the following principles [7]:

a. *High Temperature type*: these are oil or gas lamps and incandescent filament type lamps emit light when heated to high temperature.

b. *Fluorescent type*: When certain materials exposed to ultraviolet rays, transform the absorbed energy into radiation of longer wavelength lying within the visible range. Fluorescent lamps and the mercury vapour lamps work on this principle.

c. *Gas discharge type:* It is possible to pass electric current through a gas or metal vapour, which is accompanied by visible radiation. This method is used in the sodium and mercury vapour lamps.

6. SOURCES OF ARTIFICIAL LIGHTING AND OTHER COMPONENT

The sources of artificial light are and components of lighting systems are as under [3,7]:

i. Incandescent lamps

The tungsten filament is heated to a temperature of about 2400°C, which then emit radiation in the visible range. The bulb contains a vacuum or gas filling. These are

inexpensive, easy to install and are available in different wattage range. But they have low rate of efficiency, need shielding to eliminate glare and therefore are used only for local lighting. The efficacy bout 12 lumens/watt and lamp life is upto 2,000 hours.

ii. Tungsten--halogen lamps

A halogen lamp is a type of incandescent lamp. It has a tungsten filament just like a regular incandescent that, however the bulb is filled with halogen gas. The efficacy of the lamp is about 18 lumens/watt and it's life upto 4,000 hours.

iii. Fluorescent lamps (tube)

They have best efficiency rate and are in very common use in factories. Their current consumption is less, they have a low brightness rating, longer life and are available in a number of colours. The two electrodes are made of coated tungsten wire filaments. The lamp is filled with low pressure argon gas and a drop of mercury. The radiation consists mostly of invisible ultra-violet rays. To convert these radiation in the visible range, the inside of the lamp is coated with a fluorescent powder which has the property of converting the UV radiation into visible radiation. The efficacy of the lamp is about 80 -90 lumens/watt and its life is upto15,000 hours.

iv. Compact fluorescents lamps (CFL)

Recently, compact fluorescents lamps are very popular and compete with incandescent and mercury vapour lamps. These lamps overcome the dis advantages of conventional fluorescent lamps such as size and wattage etc. These lamps design are compact provide high luminous efficacy and excellent colour radiation. These lamp's efficacy is about 60 lumens/watt and lamp life is upto 10,000 hours

v. Sodium vapor lamps

These are of two types: High pressure and Low pressure sodium lamps. The high pressure sodium (HPS) lamp is widely used for outdoor and industrial applications. Its higher efficacy makes it a better choice than metal halide. Although, low pressure sodium (LPS) lamps are similar to fluorescent systems; because, they are low pressure systems. LPS lamps are the most successful light sources, but they produce the poorest quality light of all the lamp types. Excellent lumen maintenance contains 1-6 mg sodium and 20 mg mercury. The lamp efficacy is about 50-90 lumens/watt and. lamp life is upto 24,000 hours.

vi. Mercury vapour lamps

These lamps have long life and low initial cost, they have poor efficacy and exude a pale green colour. However, mercury vapour lamps are still popular sources for landscape illumination because of their 24,000 hour lamp life and vivid portrayal of green landscapes. The efficacy of the lamp is in the range of 50-60 lumens/watt.

vii. Blended lamps

Blended lamps are often described as two-in-one lamps. This combines two sources of light enclosed in one gas filled bulb. One source is a quartz mercury discharge tube (like a mercury lamp) and the other is a tungsten filament connected in series to it. The efficacy of the lamp is 20 to 30 lumens/Watt. and it's life is upto 8000 hours.

viii. Metal halide lamps

The halides act in a similar manner to the tungsten halogen cycle. As the temperature increases there is disassociation of the halide compound releasing the metal into the arc. These have poor lumen maintenance. The efficacy of the lamp is about 80 lumens/Watt. and it's life is up to 20,000 hours.

ix. LED lamps

These are the newest addition to the list of energy efficient light sources. While LED lamps emit visible light in a very narrow spectral band, they can produce "white light". These lamps last from 40,000 to 100,000 hours depending on the colour. These have high luminous efficacy and good to excellent colour radiation.

Lighting Components

i. Reflectors

The most important element in a light fitting, apart from the lamps, is the reflector. Reflectors impact on how much of the lamp's light reaches the area to be lit as well as the lighting distribution pattern. Reflectors are generally either diffuse (painted or powder coated white finish) or specular(polished or mirror-like). The degree of reflectance of the reflector material and the reflector's shape directly influence the effectiveness and efficiency of the fitting. The most common materials used are anodized aluminium (85-90% reflectance) and silver film laminated to a metal substrate (91-95% reflectance).

ii. Gears

The gears used in the lighting equipment as under:

- ***Ballast:*** A current limiting device, to counter negative resistance characteristics of any discharge lamps. In case of fluorescent lamps, it aids the initial voltage build-up, required for starting.
- ***Ignitors:*** These are used for starting high intensity Metal Halide and Sodium vapour lamps.

7. COLOUR PROPERTIES

To define light source colour properties, the lighting industry predominantly relies on two metrics, correlated colour temperature (CCT), commonly used as an indication of the apparent "warmth" or "coolness" of the light emitted by a source, and colour rendering index (CRI), an indication of the light source's ability to make objects appear natural[3].The *CRI* of lamps makes them visually "warm," "neutral" or "cool" light sources. Mostly, the lower the temperature is, the warmer the source, and vice versa. CRI is the ability of a light source to render colours of surfaces accurately can be conveniently quantified by the colour rendering index. This index is based on the accuracy with which a set of test colours is reproduced by the lamp of interest relative to a test lamp, perfect agreement being given a score of 100. [1,3]

8. RECOMMENDATION ILLUMINATION LEVEL

The illuminance required for particular task depends on visual requirements of the job, satisfaction of the user, practical experience and cost effective use of energy**.** The table-1 gives the recommended luminance range for different areas, tasks and activities **[3,6,10,11]**.

Table1: Recommended Illuminance levels

Area/task/ process	Illuminance level (lux)
General Industries	
▪ Exterior circulating, walkways, stores, main entrances and exit roads, car parking, internal factory roads etc.	20-50
▪ Boiler house, transformer yards, furnace rooms, entrances, corridors, stairs etc.	70-100
▪ Circulation areas in industry, stores and stock rooms, canteen	100-150
▪ Coarse work	200-300
▪ Medium work	300-500
▪ Fine work	500-1500
▪ Very fine minute and precise work	1500-3000

Cotton Textile Mills	
▪ Bale breaking, washing , Stock dyeing, tinting, Mixing, Blowing	200-300
▪ Carding, drawing, roving	300-500
▪ Spinning, doubling, reeling, winding	300-750
▪ Warping	300-400
▪ Sizing	400-500
▪ Healding (drawing in)	750-1000
▪ Weaving (plain gray fabrics)	200-300
▪ Weaving (light coloured)	300-750
▪ Weaving (dark coloured)	500-1000
▪ Knitting	300-750
▪ Dyeing	200- 450
▪ Calendaring, chemical treatment	300-750
▪ Grey cloth inspection	700-1000
▪ Final inspection	1000-2000

9. OPTIMISATION INDUSTRIAL LIGHTING

To achieve the economy, efficient light source, good reflectors, and clean, well-maintained and appropriate visual backgrounds for walls, ceilings can be selected. For optimizing industrial lighting requires consideration of work tasks, environmental conditions and economic aspects . Innovation in the field of lighting, has given rise to tremendous energy saving opportunities. Lighting is an area, which provides a major scope to achieve energy efficiency at the design stage, by incorporation of modern energy efficient lamps, luminaries and gears and regular cleaning and maintenance [2,5].

10. CONCLUSION

Lighting is very essential requirement in textile industries. Inadequate lighting at place of work can create problem in human health and affect in production and product quality. Poor light can be cause of accidents. On the other hand, too much light 'glare' and dazzling light can also cause health and safety problems. Proper and adequate illuminations required for each task/ job/process to enhanced productivity and product quality, reduce accident and ensure the safety and security in the mill. In the market various types of lamps are available. According to specific requirement, proper lamps, other component and number of fittings can be selected. To achieve maximum efficiency of illumination, efficient light source, good reflector, clean well maintained walls and ceiling are required.

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