STUDY OF INDUCTION TECHNOLOGY BASED NEXT GENERATION INDUSTRIAL LIGHTING SYSTEM

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ABSTRACT

The Indian industry is one of the largest consumers of electricity than the other sectors and these industries are having a considerable consumption in the lighting elements. A number of studies have introduced energy efficient lighting as a key short-term action to reduce energy consumption and addressing the climate change issues. To make the lighting system more energy efficient without degrading the quality and the other features of the light, induction lamp is being recognized as one of the latest energy efficient lighting technologies for industries developed in recent years. This paper highlights the concept of induction lighting system and their features with an example of the return on investment analysis. It also includes the benefits of the induction lighting system as compared to other lighting sources for the industries.

***Keywords*: Technology, Lighting, Industry, Efficiency, Climate**

I. INTRODUCTION

Energy optimization, better productivity and safety are the major objectives to keep in mind when evaluating any lighting system for the industry purpose. A plant's illumination system should meet the certain minimum requirements in order to be cost-effective as well as from the feasibility point of view. Now a day it is a need in the industry to provide adequate illumination at the lowest possible cost. The industries are also making their best efforts to achieve such objective for the benefit of the self as well as to fulfil the different government norms.

With the interest of energy efficiency and the legal requirement of the government norms for reducing specific energy consumption of the different industrial sectors, numbers of industries are interested in engaging in transformation activities that results a considerable amount of energy saving and the extensive CO2 emission reductions. Lighting is one of the important areas for the industries from the view point of energy efficiency and energy conservation as it also consumes a substantial amount of energy. For transformation in the lighting system induction lighting is now being recognized as a truly long life lamp with real world energy saving potential in this area.

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II. INDUCTION TECHNOLOGY OUTLINE

Induction lighting is based on a technology that is fundamentally different from that of traditional lighting products where fluorescent or high-intensity discharge bulbs are used. It is a revolutionary technology of light generation that combines the basic principle of induction and the gas discharge. The Induction lamp contains no filaments and electrodes to burn out. It allows these unique lamps to last up to around 100,000 hours and makes them virtually maintenance-free. The system is comprised of three components; the generator (electronic HF ballast), the power coupler and lamp.

Induction lamps basically employ electromagnets wrapped around a part of the tube. In these lamps, high frequency energy, from the electronic ballast, is sent through wires, which are wrapped in a coil around a ferrite inductor on the outside of the glass tube.

The power coupler transfers energy from the HF generator to the discharge inside the glass bulb using an antenna that contains the primary induction coil and its ferrite core. The power coupler also has a heat conducting rod with mounting flange. The mounting flange allows the Induction lamp system to be mechanically attached to the luminaries.

The induction coil produces a very strong magnetic field which travels through the glass and excites the mercury atoms in the interior which are provided by a pellet of amalgam (a solid form of mercury). The mercury atom emit UV light and, just as in a fluorescent tube, the UV light is up-converted to visible light by the phosphor coating on the inside of the tube.

Fluorescent lamps, however, use electrodes inside the bulb to strike the arc and initiate the flow of current – each the arc is struck, the electrodes degrade a little, eventually causing the lamp to flicker and then fail.

III. IMPORTANT TERMINOLOGIES

3.1 S/P Ratio: It is an indication and a measure of the visual effective light from the lighting source. The S/P ratio determines the apparent visual brightness of a light source and determines how much light a lamp produces which is useful to the human eye (i.e. Visually Effective Lumens/Lux).
The S/P ratio of a light source is determined by measuring the output in Lumens or Lux using a light meter or spectrometer calibrated first to the Photopic vision sensitivity curve, and then measuring the same light with instruments calibrated to the Scotopic vision sensitivity curve. The resulting numbers form a ratio that is expressed as a single number.

3.2 Photopic Lumens: Photopic lighting is light measurement based upon the response of the human eye under daytime conditions. Published lumen ratings reflect photopic lumens.

3.3 Scotopic Lumens: Scotopic lighting is the light measurement based upon the response of the human eye under nighttime conditions. Scotopic lumens are higher for high CCT light sources.

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Table1: S/P ratio

	S/P Ratio
Sun + Sky	2.47
6500k RealTime Induction Lamp	2.25
5000k RealTime Induction Lamp	1.96
4100k RealTime Induction Lamp	1.62
Metal Halide (Na/Sc)	1.49
High Pressure Sodium(50w)	1.14
Incandescent (2850k)	1.41
Warm White Fluorescent	1.00

(Source: Francis Rubenstein of Berkley Labs)

3.4 Lumen Maintenance: "Lumen Maintenance" is a measure of how well a lamp maintains its light output over a period of time. All lamps produce less light output as they age which is known as "Lumen depreciation". The information for Lumen depreciation is usually published as "Lumen maintenance" curves. The lumen depreciation of a lamp type will determine how often it must be replaced.

IV. IMPORTANT FEATURES AND COMPARATIVE ANALYSIS

Induction lamps require much less resources, in terms of the raw materials for manufacturing, than the other lamp technologies. Considering the long lifespan of the lamps, number of replacement lamps for a particular span and the cost and ability to recycle the lamps, it is envisaged that the induction lighting will be the future generation lighting technology. The solid mercury amalgam which is used in the technology is easily removed and can be recycled with less chance of environmental contamination. The external or internal inductors can be removed (for metal recovery), leaving a glass envelope free of metal parts which takes less energy to recycle. Competing lamp technologies have a significant amount of metal embedded in the lamp envelopes, thus higher temperatures and more energy must be expended to recycle the components.

When compared to the two most commonly used lighting technologies in commercial and industrial applications (Metal Halide and High Pressure Sodium lamps), Induction lamps offer the following benefits:

- Significant reduction of electrical energy consumption.
- Significant reduction in CO_2 emissions from electrical power generation due to reduced energy consumption.
- Secondary energy consumption reduction through reduced thermal loads thereby saving HVAC costs and energy, and the ability to use on-demand technologies such as occupancy sensors due to the "instant on" feature of induction lamps.
- More light output when corrected for Visually Effective Lumens/Pupil Lumens.
- Extended lifespan which reduces the materials needed for replacement lamps compared to MH, HPS and SOX lighting technology.

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- Low mercury consumption over the induction lamp lifespan compared to competing lighting technologies.
- Induction lamps use a solid mercury amalgam which produces significantly less environmental contamination than other technologies, if accidentally broken. The sold mercury amalgam is also easy to recover and recycle at end of lamp life.
- End of life de-construction for recycling and materials recovery requires less energy.

Table2: Comparative Analysis for Different Lighting Technologies

Properties	**Induction**	**LED**	**Metal Halide**	**HPSV**
Lighting Efficiency	65-90	40-65	60-110	60-120
Colour Rendering Index	>80	>70	>70	>20
S/P Ratio	1.46-2.25	1.96	1.49	0.62
Colour Temperature	Full Range	Limited Range	Limited Range	Limited Range
Hot Restart	Instant	Instant	Delay	Delay
Mercury	Low	N/A	Low-High	Low-Medium

V. RETURN ON INVESTMENT ANALYSIS

A payback period calculation for replacing a 250W HPSV Industrial Highbay fixture with a 100W Circular Induction Lighting Highbay fixture has been taken with the following assumptions and results are shown in table no. 3.

- The prices for the fixtures suitable for 250W HPSV-T and the 100W Circular lamp induction lamp are net selling prices based on prices available of known brands in lighting.
- The 250W tubular lamp price is assumed to be Rs. 260/- plus CST
- The lumen package of 250W HPSV Tubular lamp is assumed to be 28000 lumens.
- 100W Circular Induction lamp is selected for comparison as its Visual Effective Lumen is close to that of 250W Sodium Vapour lamp.
- The electromagnetic ballast loss considered for 250W Sodium Vapor lamp is 32W.
- Visual effective lumen for the lamp is arrived by multiplying the rated lumen with its S/P ratio.
- Rate per unit of electricity is assumed to be Rs.6/-
- Calculations are for a period of one year (i.e. 305 Working days, excluding Sundays and public holidays).
- The lamp is assumed to be switched ON for 16 hours per day, considering a plant with two shifts operating.

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Table3: Calculation for the Approximation of Payback Period

Description	**250W HPSV**	**100W Induction lamp**	**Savings (Rs.)**
Wattage of Lamps (Watt)	250	100	
Luminous Efficacy (Lm/Watt)	94	85	
S/P Ratio	0.62	2.25	
VISUAL Lumens	17360	18000	
Cost of Lamp with Ballast (Approx) & Fixture* Rs.	3230	7843	-4612.6
Total Power Consumption with Ballast (Watts)	282	105	
No. of Hours of Operation per Day (Hrs.)	16	16	
Power consumed/Day in KWh for 16 hrs. for 305days in KW	1376.16	512.4	
Total Power Consumption per annum @ Rs.6/unit	8256.96	3074.4	5182.6
Cost of lamp replacement of MH@ (Rs.) in one year	0	0	0.00
Total Saving in a year (Rs.)			5183
Payback Period (in months)			11

VI. CONCLUSION

Magnetic Induction Lamps represent not only a breakthrough in energy efficient lighting, but also a sound environmental choice, when all aspects of a lamp technology are considered. When comparing various lighting technologies used in industrial applications, it becomes clear that induction lamp based lighting fixtures offer the best environmental characteristics and simultaneously providing a long term benefit for the consumers. It is highlighted that reducing the carbon footprint is a worthy goal and it really can make a difference in limiting global warming and climate change issues. As lighting consumes a significant fraction of energy production and leaving a huge amount of CO_2 emission to the atmosphere, installing this induction based energy efficient lighting systems will not only reduce energy costs and expenditures, but it will also address the environmental concerns.

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