ENERGY AUDITING OF BICYCLE MANUFACTURING INDUSTRY UNDER 5S PROGRAM

A Dissertation

submitted in partial fulfilment of the requirement

for the award of degree of

Masters in Technology

In

Energy Technology and Management

Submitted by

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SCHOOL OF ENERGY AND ENVIRONMENT
THAPAR UNIVERSITY, PATIALA
(Declared as Deemed-to-be-University u/s 3 of the UGC Act, 1956)
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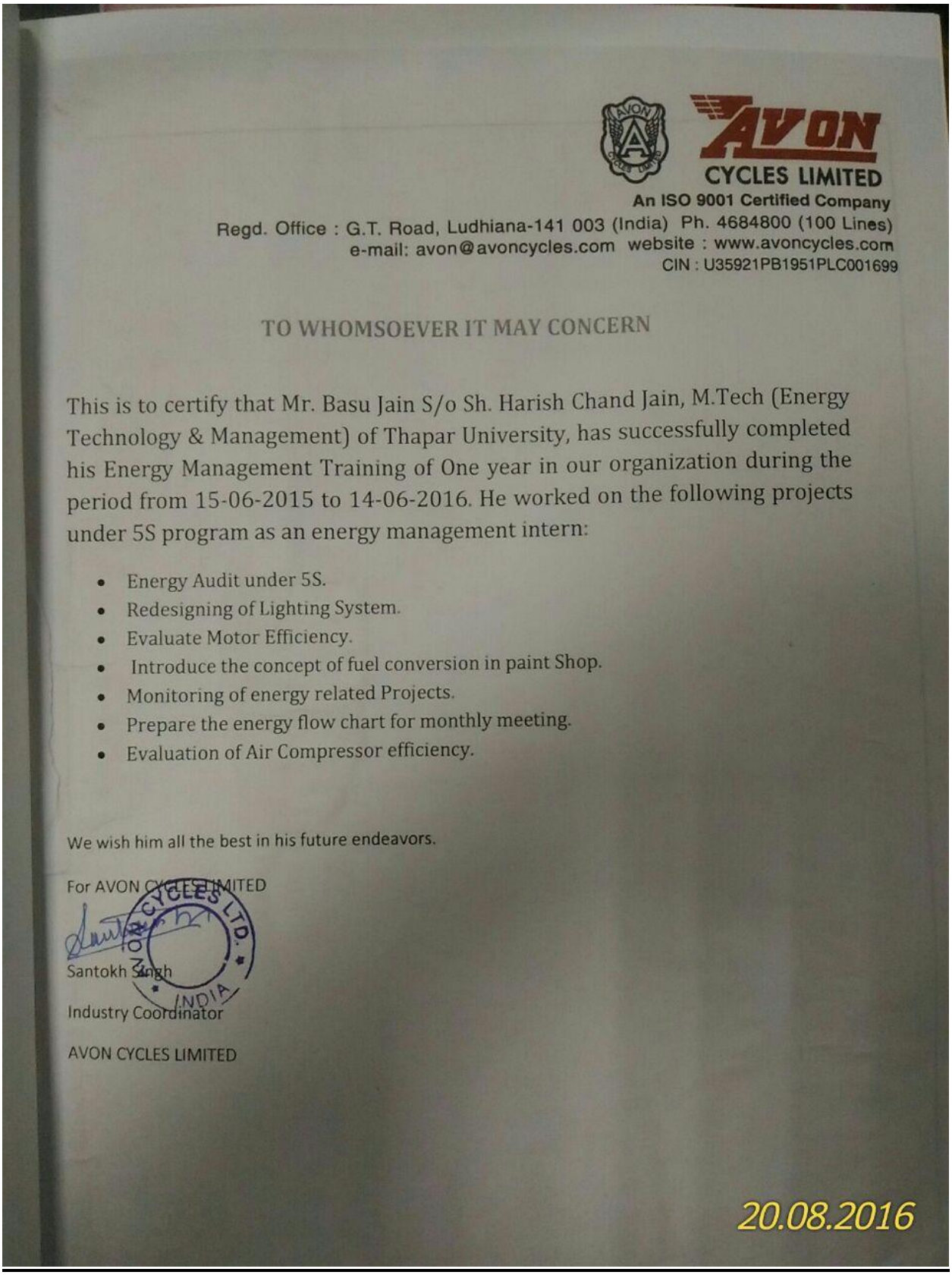

AVON CYCLES LIMITED

An ISO 9001 Certified Company

Regd. Office : G.T. Road, Ludhiana-141 003 (India) Ph. 4684800 (100 Lines)
e-mail: avon@avoncycles.com website : www.avoncycles.com
CIN : U35921PB1951PLC001699

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr. Basu Jain S/o Sh. Harish Chand Jain, M.Tech (Energy Technology & Management) of Thapar University, has successfully completed his Energy Management Training of One year in our organization during the period from 15-06-2015 to 14-06-2016. He worked on the following projects under 5S program as an energy management intern:

- Energy Audit under 5S.
- Redesigning of Lighting System.
- Evaluate Motor Efficiency.
- Introduce the concept of fuel conversion in paint Shop.
- Monitoring of energy related Projects.
- Prepare the energy flow chart for monthly meeting.
- Evaluation of Air Compressor efficiency.

We wish him all the best in his future endeavors.

For AVON CYCLES LIMITED

Santokh Singh

Industry Coordinator

AVON CYCLES LIMITED

20.08.2016

DECLARATION

I hereby declare that the project work entitled "Energy Auditing of Bicycle Manufacturing Industry under 5S Program" is an authentic record of my own work carried out at Avon Cycles Ltd. Ludhiana as requirements of one year project internship for the award of degree of M.Tech Energy Technology and Management, Thapar University, Patiala, under the guidance of Mr Santokh Singh and Dr Venkatsubramanian, during June 2015 to June 2016.

Basu Jain
Reg. No: 601405002

Date: 15 July 2016

Certified that the above statement made by the student is correct to the best of our knowledge and belief.

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My internship in Avon Cycles Ltd. became possible due to the following people: Dr. A. S. Reddy, Mr. Onkar Singh Pahwa (MD, Avon Cycles), Mr B. S. Dhiman (Executive President, Avon Cycles), Thapar University and many more people, without them I would have not been able to manage the things by myself.

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Most importantly, none of this could have happened without my family. My Parents, Brothers – Bhabhi, nephews who offered their encouragement through phone calls every day – despite my own limited devotion to correspondence. Every time I was ready to quit, you guys did not let me and I am forever grateful. This dissertation stands as a testament to your unconditional love and encouragement.

- **Basu Jain**

ABSTRACT

5S-operation model is one tool of the Lean-philosophy. It stands for improving the order and cleanliness, and creating comfort and a safe working environment. The aim is to increase the productivity of labour. At the same time all the non-value adding actions, such as the time used for searching, should be cut out. The aim of this master´s thesis was to introduce Energy Conservation under the 5S-Program in Avon Cycles. In addition a plan to expand this operation model to other facilities in the company was created.

5S is a systematic technique used by organizations comes from five Japanese words; Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardize), and Shitsuke (sustain). This system helps to organize a workplace for efficiency and decrease wasting and optimize quality and productivity via monitoring an organized environment. It also provides useful visual evidences to obtain more firm results. There is a real need for empirical studies in field of new management systems and their impact on company's performance.

This report shows the effect of 5S program on Energy Management Initiative taken by the team, how it has reduced energy use and enables optimization of energy resources. I have been involved with energy projects; this initiative offered the opportunity to challenge the assumption that grows due to lack of awareness in working parameter and lack of working standards

By better overseeing vitality, this activity makes our industry a living research facility and a model for a more maintainable future. Responsibilities to lessen GHG (greenhouse gases) place energy management at the bleeding edge of our supportability endeavours. The main focus of many of these efforts has been to reduce energy use in Head Office buildings, beginning with lighting activities.

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CHAPTER 1
INTRODUCTION

1.1 COMPANY PROFILE

ESTABLISHED	**1952**
LOCATION	**G.T. ROAD, DHANDARI KALAN, LUDHIANA- 141003**
EMAIL	**avon@avoncycles.com**
WEBSITE	**Avoncycles.com**

Figure 1.1: Plant Zonal Layout

Avon Cycles Limited is Avon groups lead the organization which was fused in 1951 in Ludhiana. Figure 1.1 shows the zonal layout of organization. Avon is a genuine brand and is one of the biggest exporters of bicycles in India. The saying of the organization is to convey quality at

moderate costs. They have additionally wandered in the corner section of e-bikes and fitness tools as AVON E-SCOOT & AVON FITNESS. They are currently producing 10000 bicycles/day.

Present Organization

Mr. Onkar Singh Pahwa leads the team as Managing Director. His sons are the joint director of companies. He is one of the early pioneer in bicycle industry took Avon cycle to new heights.

Location

The company's manufacturing units are located at Ludhiana popularly known as Manchester of India. Additional information about layout can be analyzed through figure 1.1. The National Capital Delhi is only 300 km away.

Brand Equity

Years of trust building has made AVON CYCLE the synonym of quality and cost effective bicycle. 'AB-310', 'MOLTEN' & 'CRONUS' etc. are some of its brand.

1.2 Overview of 5S Program

In September 2015, Avon Cycles Ltd. with Indian Council of Manufacturing Excellence started 5S program under which Energy Management and optimization of resources (EMOR) was launched to provide a better functionality for efficiency measures to reduce & optimize the amount of energy usage in the plant. In the first month of the operation, we have formed a team of experts towards setting up vitality productivity as a mandatory standard and a portion of the daily activity in the plant. We envision and improve through the four Energy related projects that are making a difference in AVON. Further established ourselves as an ecologically concerned, financially mindful pioneer in bicycle manufacturing industry.

Manufacturing costs have been ascending at a rate of about 2-4% every year - and almost 24% since 1990. Indeed as costs expand, industries have in the past had no genuine learning of how and where is the actual rise.

Since the initiation of 5S program in September 2015, the undertaking has accomplished the saving of more than 30 lakhs surpassing our arranging gauges - and have done as such while staying under spending plan. Staff, workforce, and senior management have been included in EMOR program endeavors.

5S have its five main pillars of working:

1. **Seiri: Sort**

Figure 1.2 and 1.3 (a), (b) shows the feature of Seiri and its implementation in industry.

- Remove pointless things and discard them legitimately.
- Segregate undesirable material from the work environment.
- Don't put pointless things at the working environment
- Characterize a red-tagged territory to keep those unnecessary items.
- Need a well-trained & efficient manager for keeping an eye on standard premise.

Figure 1.2 Centralized Red Tag Area

(a) Before (b) After

Figure 1.3 (a) (b): Removed Unnecessary Fittings from M/C

2. **Seiton: Straighten**

Figure 1.4 shows the feature of Seiton and its implementation in industry.

- It can be interpreted as "set all together" or "streamline".
- Arrange every single fundamental thing so they can be effectively chosen for use.
- Make it simple to discover and get necessary things.
- Ensure first-start things (FCFS) i.e. first come first serve.
- Make work process smooth and simple.
- All above points should be formulated in practice on a daily basis.

Figure 1.4: Systematic Work Flow

After the implementation of Seiton in Avon cycles, figure 1.4 shows the easy work flow of things. It makes work easy and set them in right direction, reduced the time and enhance the productivity.

3. **Seiso: Shine**
    - It can be interpreted as "sanitize" or "clean".
    - Clean your work environment totally on a daily basis.
    - Use cleaning as standard.
    - Keep work environment sheltered and simple to work.
    - Keep work environment spotless and satisfying to work in.
    - Must have the capacity to recognize issues in 5 seconds inside of 50 feet.

Figure 1.5: Shining Example

Figure 1.5 shows the feature of Seiso and its implementation in industry. Cleaning improves the work environment and hence, improve the productivity.

4. **Seiketsu: standardize**
    - Institutionalize the best practices in the work region.
    - Maintain exclusive expectations of housekeeping and working environment association at all times.
    - Maintain deliberateness. Keep up everything all together also, as per its standard.
    - Everything in its perfect spot.

(a) Before

(b) After

Figure 1.6.1 (a), (b): Automation of white tail painting. © Avon Cycles Ltd.

(a) Before

(b) After

Figure 1.6.2 (a), (b): Automation of fork Brazing. © Avon Cycles Ltd.

Figure 1.6.1 (a), (b) and 1.6.3 (a), (b) shows the feature of Seiketsu and its implementation in industry. It can be easily analyzed from the above figures that it increases the efficiency and improves the productivity.

5. **Shitsuke: Sustain**

- To keep things manageable in a settled order.
- Also deciphers as "manage without being told".
- Regular audits and inspection should be performed.

- Training is objective arranged procedure. Its subsequent input is important and must be done on a monthly basis.

BENEFITS:

- Less breakdown, hence productivity is increased
- Due to Shute's material handling is minimized.
- Space recovered by removing unnecessary items.
- Easy to clean & lubricate.

1.3 Bicycle Manufacturing Process

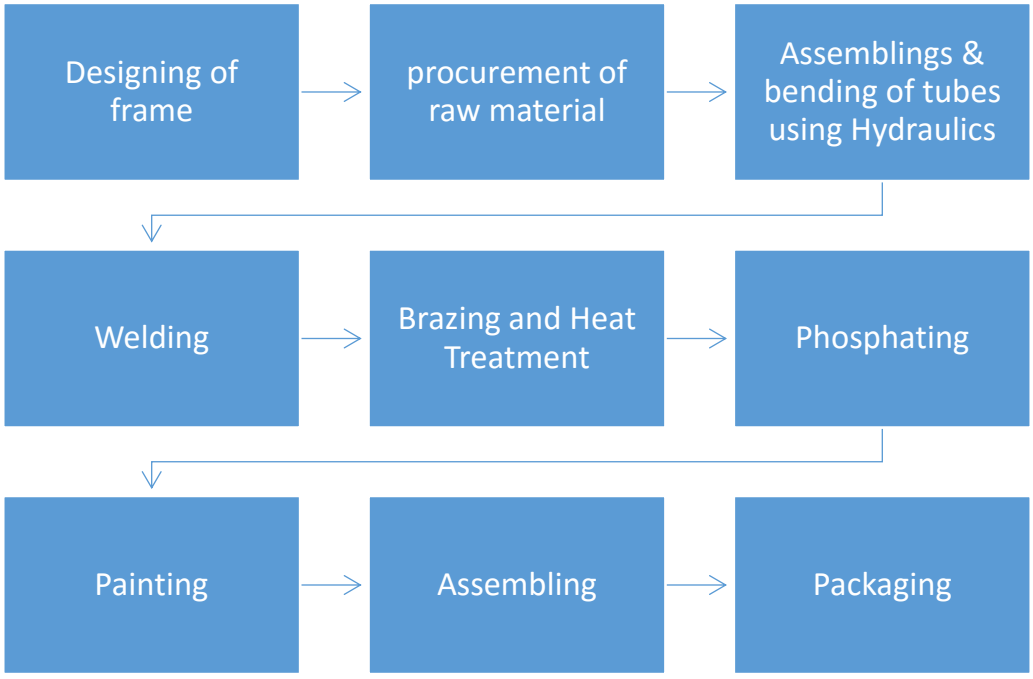


Figure 1.7: Flowchart for the Bicycle Manufacturing Process

Bicycles are one of the world's most prominent methods of Transportation. They are likewise the most Energy-Efficient vehicle. Bikes are utilized for transportation, as well as for wellness and sports. They come in styles, including hustling bicycles, off-road bicycles, and stationary bikes, and additionally unicycles, tricycles, and tandems.

Figure 1.7 shows the operation involved in making of full-fledged bicycle. As you can see the first step is the designing of frames and after the designing is the procurement of raw material likes tubes etc. In frame assembly firstly the tailoring of the tube is done by the both manual and machines. The metal is strengthened, or diminished by warming, and burrowed out to shape "hollows". To remove the scale, they are heated again. The tubes then are drawn into the variety of shapes and lengths. Then the drawn tube structure sent to next operation i.e. brazing. It is a dip welding at very high temperature 871°C or higher. Brazing provides the strength to the frame. The brazing filler is mostly the brass (copper – zinc) alloy. The filler is connected and as it melts, it streams around the joint, fixing it.

After brazing cycle frame and mudguard are sent for cleaning by phosphating process. After the phosphating process, they get ready for paint and through goods lift took to paint shop. After painting, they get inspected and after inspection, they went for finishing. After all these processes mentions above in flow chart, this is how you roll on your new Avon bicycle.

1.4 Energy Audit

Energy Audit is the tool can be used by any individual, industry for analysis of its system to check its energy consumption. It is a study through which we can identify energy consumption in various sections. It provides the opportunity for energy conservation. It is the major step an individual or an organization can take towards Energy Management System.

Energy management set the standards in an organization for any energy consumption whether it is electrical or thermal. Its main emphasis is on the electrical usage of the premise. It is a remedy to reduce the energy wastage.

1.4.1 Principle

At the point when the organization of study is a possessed building then reduction in its energy usage, while keeping up or enhancing human comfort, wellbeing and security, are essential worry.

1.4.2 Type of Energy Audit

Energy audit technique is divided in a fashion that ensures simple procedure for energy conservation scheme.

For example, in the case of energy auditing in industry, we have to silently do the audit without disturbing their working and main emphasis that it shouldn't affect their productivity. We have to propose the cost savvy proposal which can be done in a way that it always maintain their performance and productivity while securing the energy conservation.

- Phase – 1 Survey: In this phase the auditor act as an observer. Each and every section is visited by the auditor. Preliminary analysis is created to assess building energy efficiency to spot straightforward and low-priced enhancements. This review relies on visual verifications, the study of installed instrumentality, operative knowledge and careful analysis of recorded energy consumption collected throughout the survey part. It the method that offers the thought of potential and not possible amendment in the system.

- Phase – 2 General Audit: It is based on the outcome of previous audit i.e. survey. It needs a little time, with sole analysis of premise in person and read of bills and different information analysis. It additionally familiarizes with the building functions, the area of energy waste. This audit analysis helps the higher understanding of the billing pattern of the premise or the organization. It provides the final image of the building energy audit i.e. its use, operation Associate in wherever an energy loss is going down. This phase analysis involves actual ground measurements and computer based simulation tools like Matlab or energy plus for the better analysis.

  Outcome of this audit:

  1. Knowledge of the overall energy consumption of the premise.
  2. Identification for the area of energy saving.
  3. It helps in obtaining the data present with organization.

- Phase – 3 Detailed Audit/Investment Grade Audit: It is the most important audit that can be done in an organization. It is also the most time consuming one. It is focused on the

costly energy saving and efficiency improvement projects with keeping in mind the payback period or Return on Investment (ROI).

1.5 Identification of major energy consumer (Avon cycles, Dhandari Kalan Plant)

1. Light Load
2. Air Compressor
3. Effluent Treatment Plant
4. Brazing
5. Debrassing
6. Degreasing
7. Drier
8. ESP New Hall
9. ESP Main Hall
10. Generator
11. Paint Shop
12. Phosphating

1.6 Organization of Thesis

- Chapter 1 is the introduction which gives the basic idea of organization, manufacturing of bicycle, details of 5S program and the idea about Energy Auditing.

- Chapter 2 is the literature review in which the literature used for our work and reference is detailed.

- Chapter 3 is the methodology which explains the method we employs for our project in industry and the tools used with their specification.

- Chapter 4 is the result & discussion which describes the analysis of projects and their results.

- Chapter 5 is the conclusion and future scope describes the overall result of our internship and about the studies that can be implemented in future.

2.1 5S

Shraddha P. *et al* showed the effect of implementation of 5S technique in a manufacturing industry. By applying the philosophy industries increases its productivity and profit [1]. Vipul Kumar C. Patel *et al* showed the after effect of implementation of 5S program in various organization. It improves the working culture and reduces the wastage at every section [2]. 5S is a tool for implementing simple and effective work culture, reduction of wastages, enhance motivation of employees and ultimately profitable to industries [3].

2.2 LED Lighting System

L. H. Koh *et al* showed in study that houses and industries we are utilizing Alternating Currents for the electrical or electronic appliances including lighting. Now days, we have an efficient lighting source that is light emitting diode (LED), surpassing the incandescent and fluorescent light. Initially LED designed for Direct Current (DC) instead normally using AC [4]. Sung hoi Park *et al* showed in experiment that if we modify the electrical lighting system by installing high power switch mode multiple supplies, then we are able to use it as DC source lighting [5]. The researches result in saving of more than 15% by introducing IOT (internet of things) and power line communication technology, able to manage our electrical over the internet [6].

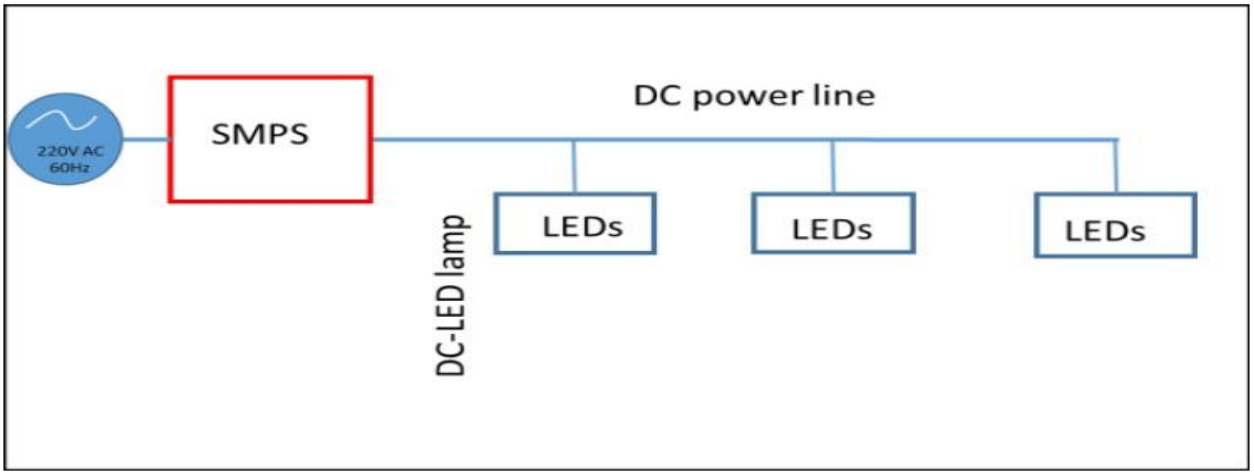


Figure 2.1: DC LED lighting system [4]

Sheng Zong *et al* researches it is seen that new systems being designed based on the user movement. It is the plethora of advancement. The internet is now became the core of the researches [7]. The recent advancement in the field of building lighting due to the involvement of information technology. BEMS (building energy management system) program uses variety of sensors to controls the luminous flux at a particular place as per the user movements [8]. By using motion sensors and photocells light will automatically switch on and off. The Light Control Gateway (LCG) and Light control Module (LCM) are the techniques used for sending the data packets and to calculate the user movement using various sensors and reduce the luminous flux and do the energy saving. These techniques are in their development phase and definitely are the technology of future [9]. **U**se of puff sheets for the better utilization of natural lighting in buildings and industries [10].

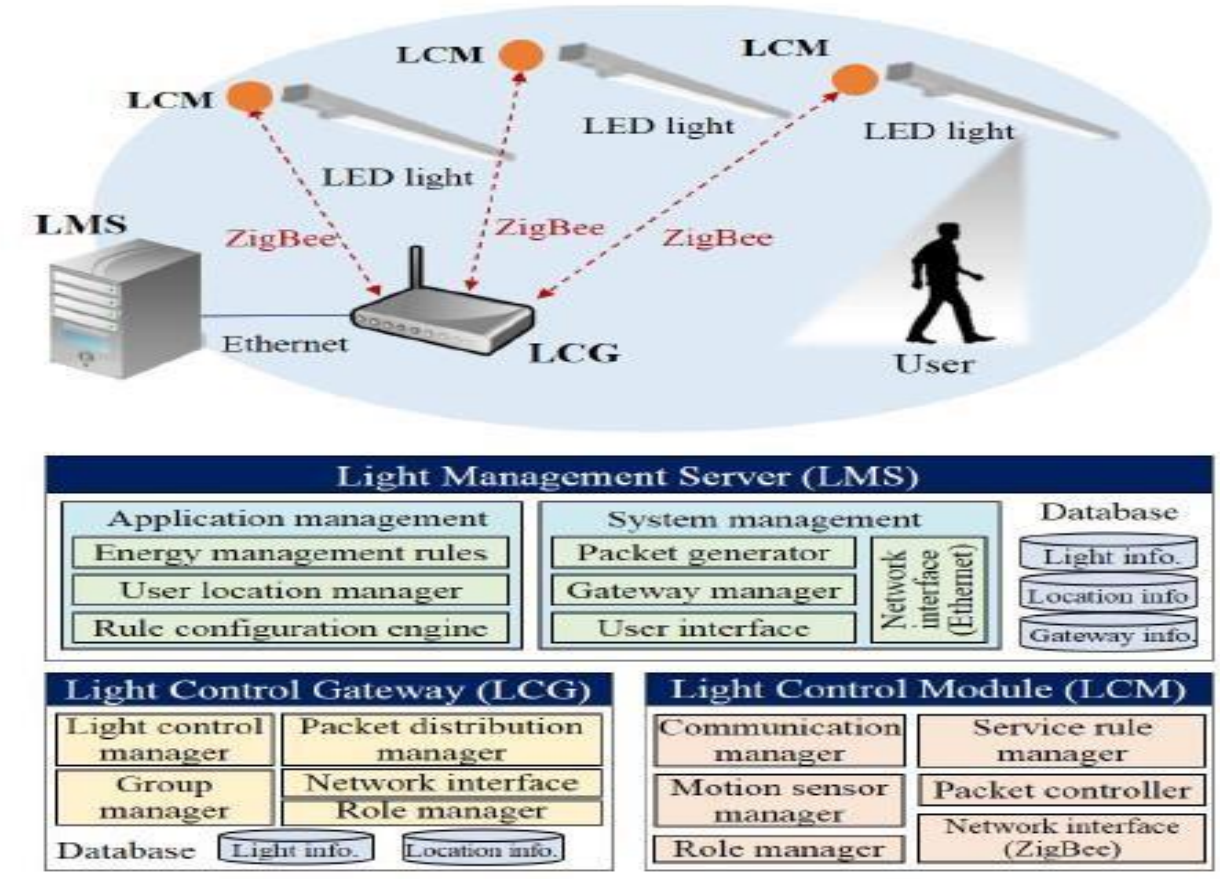


Figure 2.2: LMS system [5]

Light Emitting Diodes LEDs and induction Lamps LVD are more efficient and effective compare to compact florescent lamps (CFLs) and florescent tube light. It was more effective that if current lights source like CFL and TFT are replaced by new electrical energy efficient lights such as LEDs or LVD lamps, the overall lighting load on transformer/ generators will decrease on average by 50% or more without any compromising in light quality in building. **[11]**

Aries M. *et al* showed in industry Productivity as well as safety is one of the primary concern of the management, even engineers, Management peoples also acknowledge the benefits of proper lighting.

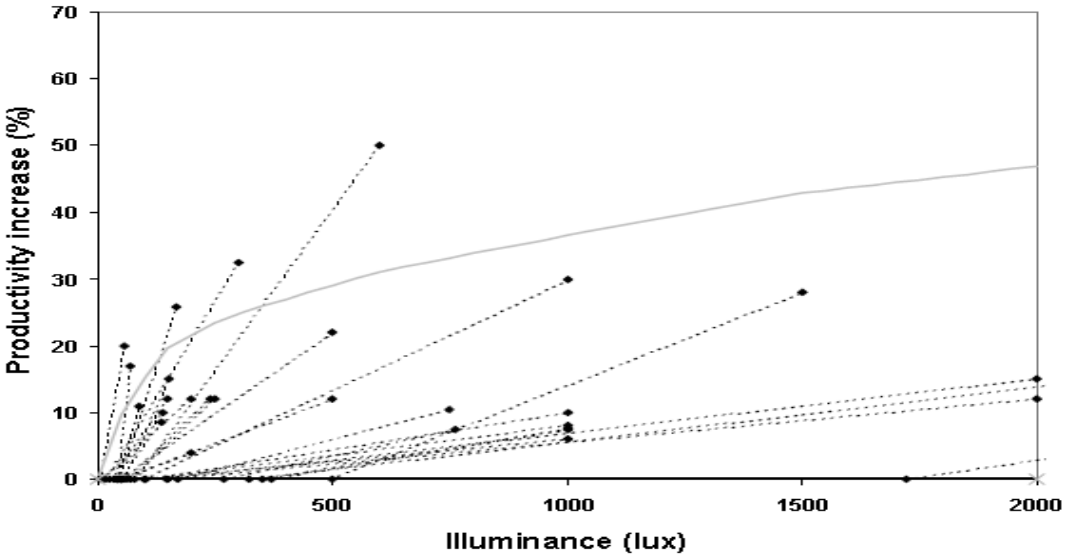


Figure 2.3: Graph shows the effect of illumination on workers productivity [12].

Is also an important factor in maintaining high productivity from workers [12], [13]. Sarun Sumriddetchkajorn *et al* the measure of light is an imperative issue in a few situations going from picturesque outline, light contamination study, enlightenment designing, and farming. It is regularly controlled by utilizing a lux meter. By understanding that the expansion of mobile phones is as of now enormous, this paper proposes interestingly an ease cell phone based lux meter [14].

2.3 Induction Motor

C. Thanga Raj *et al* showed the effect of low efficiency motors on the industry and environment. Increased the efficiency of the induction motor is not only save electrical energy, but it can also save the money and reduce the global warming. The metric tons of fuel are burnt to generate electricity, and many greenhouse gasses are produced during this generation. The efficiency of three phase induction motor is enhanced by two methods; optimal control and design technique. In design technique, the material and the construction of the motor can be changed because the qualities of material also play a great role in efficiency [15].

Hussein Sarhan *et al* showed that the efficiency of induction motors can also be improved by the effectiveness optimization controller and drives. The drivers can control voltage of motor to operate at operating point. For reducing the slip, a slip compensator is installed in the drive because the rotor losses are depended on the slip. The frequency and speed controlling drives can also be installed in system, but these optimization controllers are applicable or satisfactory at low frequency and light loads [16].

B. Renier *et al showed* that there are many losses in induction motor, but stray loss couldn't understand yet. Basically, stray loss is the remaining part after all/entire losses. The stray losses are produced by the harmonics of stator and rotor, and the flux leakage in the winding ends. There are table of stray losses in motor according to rating [18].

CHAPTER 3

METHODOLOGIES

3.1 To determine the Lux level and efficiency of lighting system

To determine the energy efficiency of lighting systems, LUX measurements and strategies appropriate for field conditions has been done. Confirm the energy potency of lighting with reference to the brightness level out there at task areas and non-task areas. To advocate brightness levels appropriate for varied activities to supply pointers for distinctive energy saving choices in lighting. Industrial surroundings will be improved with the hope of providing higher operating conditions and improved satisfaction and productivity for the employee.

This report defines and describes the ways for evaluating energy conservation of lighting systems in the following end user categories.

In Avon Cycle major areas were:

- Manufacturing plant
- Offices
- Packing and dispatch
- Parking
- Mess
- Others

3.1.1 Lightning basics

An understanding of a number of the elemental terms in lighting technology is necessary. Important terms and concepts are reviewed here for this purpose.

- **Lumen (lm):** The lumen is the SI derived unit of radiant flux, a quantity of the whole "amount" of light emitted by a supply. Scientifically it can be defined as
  "1 lumen = 1.46 * 10^-3 watt at 555 nm wavelength".

- **Luminous flux:** Luminous flux shows us the measurement of total lamp output. It is a rate of flow of white light.
- **Luminous intensity (I):** The SI unit of luminous intensity is candela; it is "luminous power/single fixed angle". It is also known as candlepower and narrates the white light measurement in lumen (lm) for particular angle. This unit of angle is named the Steradian.

- **Luminous Efficacy (lm/W):** It shows how much amount of light on a surface is coming for every watt of power consumption. This is the magnitude relation of radiant flux emitted by a lamp to the facility consumed by the lamp.

- **Illuminance (E):** Illuminance is the amount of luminous reaching a unit space of surface and is quantized in foot-candles or lux.

3.1.2 Procedure

- Measurement of illuminance in an electrical lighting framework ought to be done after dull. With impedance of sunshine, double estimations with lights ON and lights OFF can be taken after gave the study time should not be long.

- In numerous circumstances, the measuring plane may not be determined or even non-existent. Thus it is important to characterize estimation stature, ordinarily 0.8 to 1 meter from the beginning floor level.

- Stray light from encompassing rooms, spaces and through outside windows ought to be minimized by utilization of blinds, shades, and so on.

- Any programmed lighting control or sunlight connected controls ought to be set such that the lights' yield is at full power and won't shift amid the tests. All lighting in the range that would ordinarily enlighten the territory ought to be working.

- It is advantageous to have a second individual recording the readings got out by the individual moving the lux meter.

- Care must be taken not to shadow the lux meter when making estimations.

- In single-stage supply of force for lighting in a territory, when measuring light circuit force utilizing a cinch on sort meter, measure the force ideally on the stage condition.

- Define workspace where assessment is to be done, say an office room, eatery and so forth.

- Measurement of room length 'L', width "W" and mounting stature 'Hm'.
  Estimation of Room Index:

$$RI = \frac{L \times W}{H_m \times (L + W)}$$

- Based on Room Index, focus the base number of illuminance estimation focuses required and circulate these focuses equitably in the room.
- Measure illuminance utilizing an aligned lux meter at every point. Ascertain the normal estimation of measured illuminance at all focuses. In the event that E1, E2… En are illuminance estimations at focuses 1, 2, up to n points.

$$\text{Average illuminance, } E_{av} = \frac{E1 + E2 + E3 + \ldots\ldots\ldots + En}{N} \times \text{correction factor}$$

Correction Factors for Lux Meters

Light Source	Correction Factor
Mercury Lamp	1.05
Fluorescent Lamp	0.99
Sodium Lamp	1.11
Daylight	0.95

Table 3.1.1: Correction Factors for Lux Meters

Minimum Number of Points for Illuminance Measurements		
Room Index	**For +/- 5% accuracy**	**For +/- 10% accuracy**
RI < 1	8	4
1 < RI < 2	18	9
2 < RI <3	32	16
RI > 3	50	25

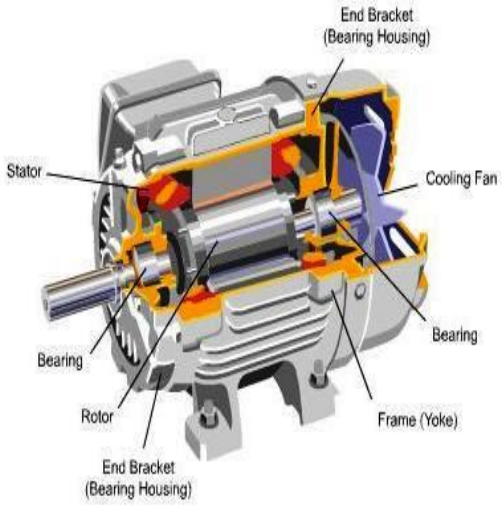
Table 3.1.2: Minimum Numbers of Points for Illuminance Measurements

Increase normal illuminance with the region to get all out glowing flux (lumens) episode on the estimation plane. All out accessible "*lumens on the estimation plane = Average illuminance X (L X W)"*

Installed Load Efficacy, ILE

$$= \frac{\text{Average luminous flux on the surface}}{\text{Circuit watts}} \quad (\text{lm/W})$$

3.2 Calculation of Motor Efficiency



Cutaway View of Motor

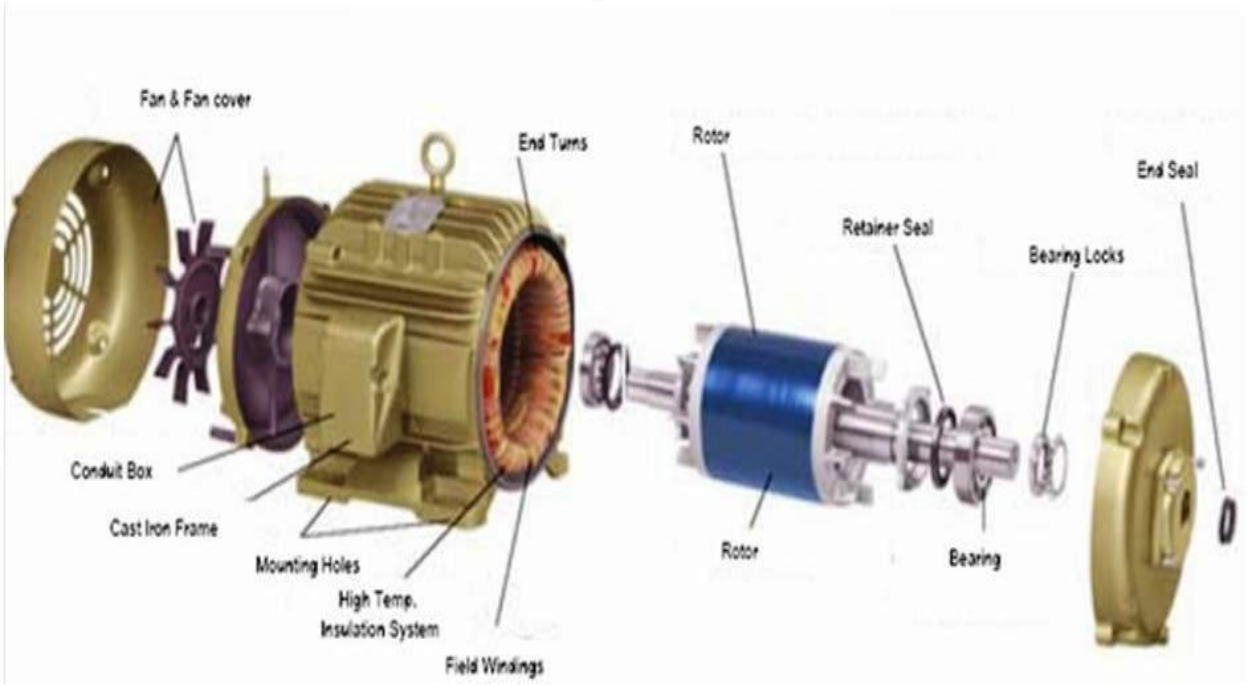


Figure 3.2.1: Induction Motor and its parts

For evaluating the efficiency of motors, study of many factors and important fundamentals has been done. We know that efficiency of any system is the ratio of output and input. On another hand, we can say remaining output energy is input power after all losses in the system. 3-phase induction motors are the majorly used motor in industry. There are several losses in stator and

rotor of induction motors. In the below figure, we can understand step by step process of energy flow in motors.

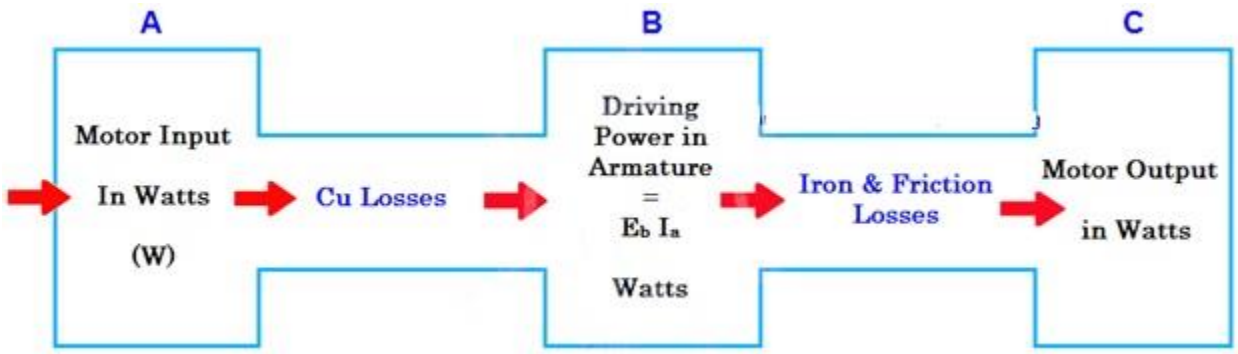


Figure 3.2.2: Energy Flow diagram of Induction Motor

Losses in Induction Motors:

1. Stator and Rotor I^2R losses
2. Core losses
3. Hysteresis losses
4. Friction and Windage losses
5. Stray Load-losses

It is said that that three phase induction motors are self-started, but due to some limitation, it needs starter. The starter for induction motor doesn't mean to start the motor; it is to prevent it from high starting current, overloaded and under loaded conditions. The induction motors take highest current when it starts because motor have to work against friction, and it's self-weight. Therefore it needs high torque at starting.

Types of starter:

1. DOL starter (Direct on line starter)
2. Star-Delta starter
3. Autotransformer starter

Effects of Load on induction Motor:

Determine motor working load is the main part of the energy efficiency calculation of induction motor because the life of the motors depends on the loading. If it is working under load condition then it will damage it winding. In case of overload condition, it will consume more current. It will also damage the motors gradually. So we need to maintain the loading factor. The most common method for finding loading is slip method. In this the RPM of the running motor will be found with the help of tachometer and its loading can be find in percentage.

$$\text{Motor Load (in percentage)} = \frac{(\text{Slip})}{(\text{Ss} - \text{Sr}) \times (\frac{\text{Vr}}{\text{V}})\text{^}2} \times 100$$

Where; Slip = Synchronous speed – measured speed,

S_r = Rated RPM on nameplate of induction motor

S_s = Synchronous speed of induction motor

V_r = Rated voltage on nameplate of induction motor

V = Measured voltage of induction motor

Calculation for Evaluating Efficiency of Motors:

Electrical multi-meter: for finding voltage and current, I took a multimeter and adjusted it on AC voltage and AC current mode. I took three voltages of V_{RY}, V_{YB}, V_{BR} and IR, IY, IB. After doing it, I took an average of these three voltages and current (according to formula).

$$\text{Input power in } 3-\Phi \text{ induction motor (Pt)} = (\sqrt{3} \times \text{V} \times \text{I} \times \cos\emptyset)/1000 \text{ Watts}$$

$$\text{Losses in Stator (Psl)} = 3 \times \text{I} \times \text{I} \times \text{R}$$

$$\text{Total Power after Stator (Ps)} = (\text{Pt} - \text{Psl}) = \text{Rotor input}$$

$$\text{Slip} = \frac{(\text{synchronous speed} - \text{measured speed})}{(\text{synchronous speed})}$$

$$\text{Rotor losses (Prl)} = \text{Slip} \times \text{Rotor Input}$$

$$\text{Total power Delivered to Rotor (Pr.)} = (\text{Ps} - \text{Prl})$$

$$\text{Suppose that Frictional losses in motor} = 0.04 \times \text{Rated KW}$$

$$\text{Total Mechanical output power (Pl)} = \text{Pr} - \text{frictional losses}$$

$$\boxed{\text{Efficiency of } 3-\Phi \text{ induction motor} = \frac{\text{Pl}}{\text{Pt}} \times 100}$$

3.3Tools Used: For the analysis purposes there are numbers of tools utilize:

- **LUX METER:** It is a device used for measuring the intensity of light or in simple word illumination from the light source at the task area. It consist of a photo sensor,

Sensor type	Silicone photodiode
Measuring range	0 to 99999 Lux
Accuracy ±1 digit	±3 Lux or ±3 % of mv (compared to reference Class B, DIN 5032 Part 7)
Resolution	1 Lux (0 to 19999 Lux) 10 Lux (remaining range)

General technical data

Measurement rate	0.5 s
Storage temperature	-40 to +70 °C
Protection class	IP40
Operating temperature	0 to +50 °C
Battery type	2 AAA micro batteries
Battery life	200 h (average, without display illumination)
Dimensions	133 x 46 x 25 mm
Weight	95 g (incl. batteries and protective cap)
Warranty	2 years

Figure 3.3.1: Testo Lux meter with its specification

When light strike on the sensor it calculate its intensity. But when checking the intensity from an artificial light source; one must take precaution that natural light doesn't mix with the artificial one. Otherwise it provide the mix intensity of both natural light and the artificial one.

- **Infrared Thermometer:** It is a non-contact thermometer which can measured infrared rays between 4 and 14 microns.

Specifications

Thermal	
IR Temperature Range	-30 °C to 900 °C (-22 °F to 1652 °F)
IR Accuracy (Calibration geometry with ambient temperature 23 °C±2 °C)	≥0 °C: ± 1 °C or ± 1 % of reading, whichever is greater (≥32 °F: ± 2 °F or ± 1 % of reading, whichever is greater) ≥-10 °C to <0 °C: ±2 °C(≥14 °F to <32 °F: ±4 °F) <-10°C: ±3 °C (<14 °F: ±6 °F)
IR Repeatability	±0.5 % of reading or ±0.5 °C (±1 °F), whichever is greater.
Display Resolution	0.1 °C / 0.1 °F
Spectral Response	8 µm to 14 µm
Response Time (95 %)	<500 ms
K-Type Thermocouple Input Temperature Range	-270 °C to 1372 °C (-454 °F to 2501 °F)
K-Type Thermocouple Input Accuracy (with ambient temperature 23 °C±2 °C)	<-40 °C: ±(1 °C + 0.2 °/1 °C) ≥-40 °C: ±1 % or 1 °C, whichever is greater <-40 °F: ±(2 °F + 0.2 °/1 °F) ≥-40 °F: ±1 % or 2 °F, whichever is greater
K-Type Thermocouple Repeatability	±0.5 % of reading or ±0.5 °C (±1 °F), whichever is greater
K-Type Thermocouple Resolution	0.1 °C/0.1 °F

Figure 3.3.2: Fluke f-572 infrared thermometer with specification

It measure the temperature of surface which emit the infrared rays, but it cannot measure its core temperature. Basically it is used for measuring the temperature at a particular point.

- **Tachometer:** It is a device used for calculating the rotating speed of any disk or shaft of the induction motors. With the help of this, one can find the RPM of

CONTACT TYPE
DIGITAL TACHOMETER
MODEL : KM- 2235B

TECHNICAL SPECIFICATIONS:

Model	Model KM 2234 BL (Non Contact Type)	Model KM 2235 B (Contact Type)
Display	5 digits, 10mm (0.4") LCD Display with function annunciation.	
Sampling Time	1 sec. (Over 60 RPM)	
Test Range	Autoranging.	
Range I	5-999.9 RPM	5-999.9 RPM
Range II	1000-99,9999RPM	1000-19,999 RPM
Accuracy	±(0.05% + 1 dgt)	
Resolution	0.1RPM (5-999.9 RPM)	
	1 RPM (above 1000 RPM)	
Memory	Last value, Max Value, Min value.	
Detecting Distance	50 to 500mm	
Operating Temp	0-50°C	
Operating Humidity	Less than 80% RH	
Power Consumption	DC 153 mA	
Battery	4 x 1.5V AA Battery	
Size	190 x 72 x37 mm	
Weight	235 gms including batteries	
Accessories	Carrying case, Instruction Manual & 2 pcs of Reflecting Tape (350 mm)	Carrying case, Instruction Manual, surface speed Test Wheel, RPM adapter (cone),RPM adapter (funel)

motor and then can

Figure 3.3.3: Meco Contact type Tachometer with specification

calculate the slip of the induction motor.

- **Vaporizer:** LPG is stored at pressure in a liquid form, but it need to be converted into vapour for its utilization. Vaporizer is an electrical vaporizer uses water as a heat transferring medium. It is fully automatic system with various safety interlocks, it seamlessly vaporize the LPG to satisfy the demand at other end.

TECHNICAL DETAILS:

Make	:	**Enggmech Engineers (Primer and Regular)**
Type	:	Electrically Heated, Hot Water Bath Type Vaporizer.
Controls	:	Solenoid Valve, Pressure Switch, Thermostat, Heaters.
Special Feature	:	**Water Level, Switch, Liquid Level Switch.**
Coil	:	SA 312 Types S.S. 304.
Water bath Tank	:	MS Duly Insulated with 50 mm thick glass wool with Aluminum Cladding as per IS 2062.

Figure 3.3.4: Vaporizer and its specification

CHAPTER 4
RESULT & DISCUSSION

4.1 Lighting System

In industry Productivity as well as safety is one of the primary concern of the management, even engineers, Management peoples also acknowledge the benefits of proper lighting. It is also an important factor in maintaining high productivity from workers. Lighting incorporates the utilization of both simulated light sources like Incandescent bulb, FTL, lighting fixtures etcetera and in addition, it also utilize the natural illumination i.e. sunshine, or we say natural light. In industries lighting covers many numbers of tasks; from small shops to huge workshops etcetera. A plant's brightening framework ought to meet certain base necessities with a specific end goal to be financially savvy. Vitality was streamlining, better profitability and security are real objectives to remember while assessing any lighting framework. Critical expansions in profitability can be accomplished by lighting adjustments that diminish the yearly cost of electric brightening. A plant's brightening framework ought to meet certain base necessities with a specific end goal to be financially savvy.

Simulated lighting is a costly affair in any plant or industries. Improper illumination or no knowledge of lighting standards results in little or excess electricity consuming and that wastes energy. Light load constitutes of 20% of the electrical load of the industry, and if 50% can reduce it, we can save the huge amount of money.

Nowadays lighting trends are changing from general work application to various sensitive visual tasks. In this the first need that does we done by the person is to reduce the operating voltage; let say 200V AC. So that it will lower the electricity consumption by different lighting equipment’s mainly in the long burning hours. Besides the industries also can employ the servo stabilizers for maintaining the voltage hiccups or the inductor in parallel combination can be hooked on the lighting circuits and can be used as a controller.

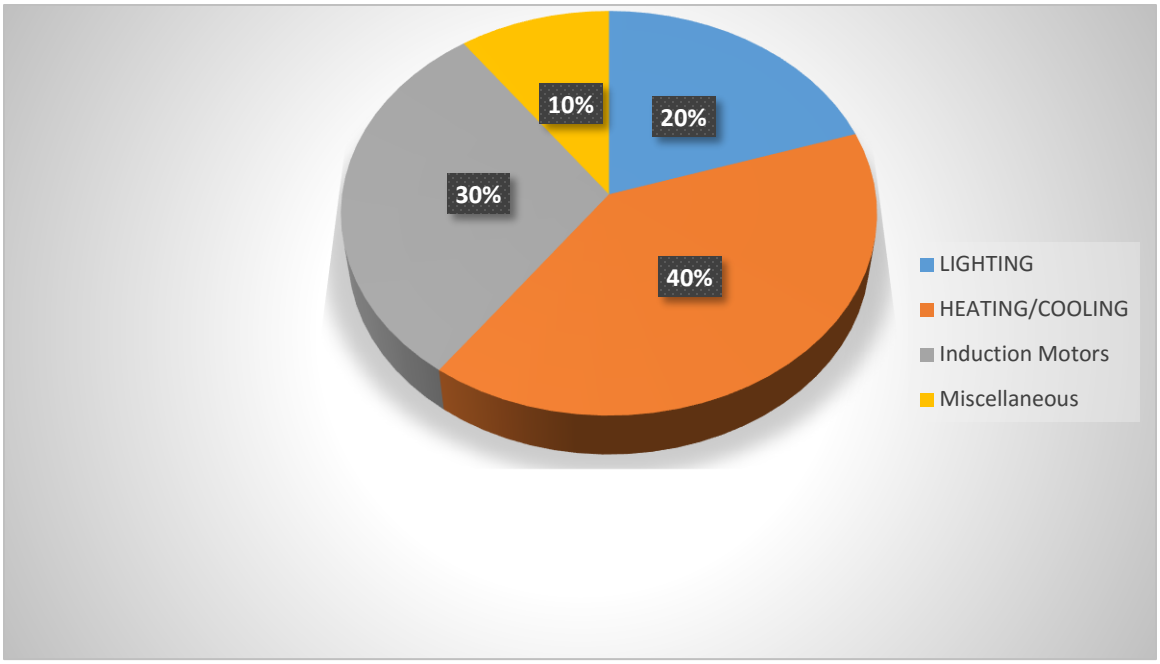


Figure 4.1.1: Breakdown of typical electricity usage in Avon cycle limited.

There is excellent savings potential in most plants from converting present lighting systems to more efficient light sources.

In preliminary energy audit, I checked the light load of industry section wise in different phases. During the audit, I have found that the lighting fixtures are not evenly distributed results in excess light at some places and very low light at some places.

For example, in Mechanical Lab the FTL are distributed in a very uneven fashion. 52 FTL are placed using 32 fixtures. The FTL were placed in the corner reduces the output flux which causes very low illumination instead of having this much FTL employed. With the help of Lux meter, I checked the luminous flux output of light in the lab, and it is very low as compared to BEE standard. It has been seen during the study that by redesign the lighting layout the number of lighting is reduced by 40 %. Only 30 lighting used in the new layout. In the place of FTL new LED T8 were used results in illumination level increased by 1.8 times when the bay height is reduced by seven inches.

Figure 4.1.2: FTL installation in the corner result in illumination loss

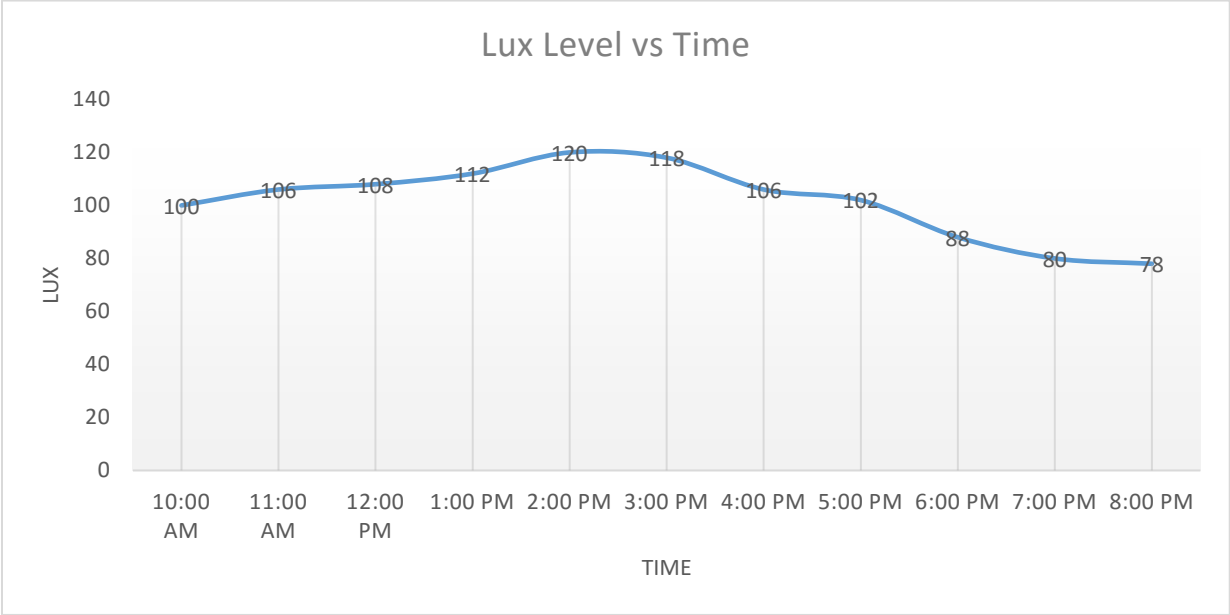


Figure 4.1.3: Change in Lux Level with time in Mechanical Lab when T8 40W FTL installed.

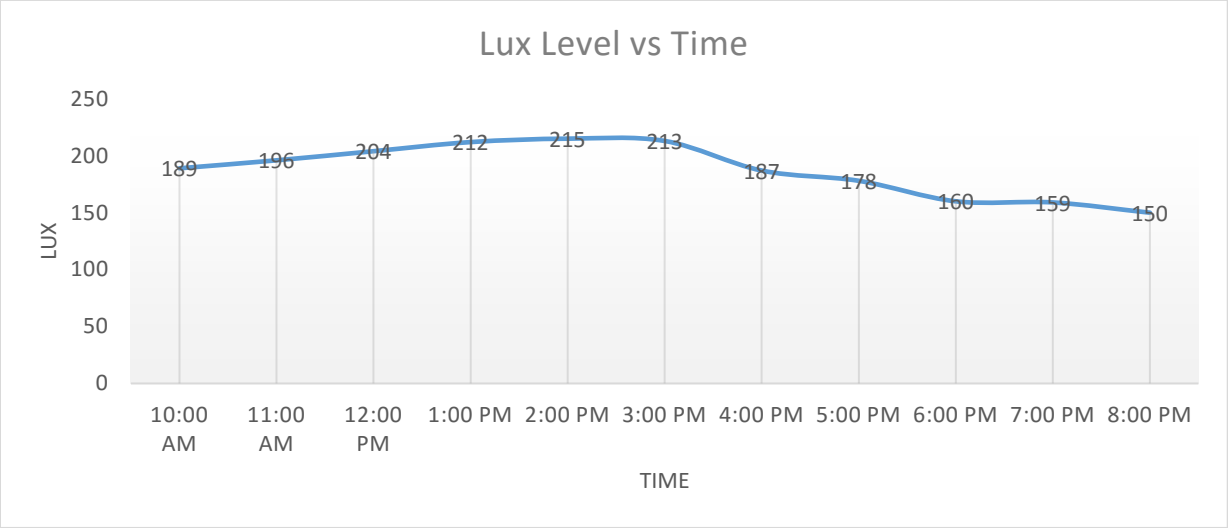


Figure: 4.1.4: Change in Lux Level with time in Mechanical Lab when T8 18W LED install with new layout.

Figure 4.1.5: LED installation with proper Layout

By seeing this we can understand the elevation in LUX level after installing the LED with proper layout. Below you can see the calculation for the payback period is briefly described using the necessary parameter.

❖ Replacement of FTL (T8 40W) by LED (T8 18W) in Mechanical Lab.

ANALYSIS:

- No of FTL in Mechanical Lab: 52 (approx.)
- Power rating of FTL: 40W + 10W choke losses = 50W (2000 lumen)
- Operation hour: 20H (09:30 am to 05:30 am)
- Working days in a year: 300
- Power consumption of 1 FTL/year : 50W * 20H * 300 days = 300 kWh / year
- Power consumption of 52 FTL: 52 * 300 kWh = 15600 kWh / year
- LIFE: up to 5000 Hour
- Decrease in lumen with usage. Detrition in lux level is high.
- No replacement and high power consuming.
- Very cheap to buy.

PROPOSED:

- No of LED tube required in Mechanical Lab: 30
- Power rating of LED: 18W (1800 lumen)
- Operation hour: 20H
- Power consumption of 1 LED/year : 18W * 20H * 300 days = 108 kWh / year
- Power consumption by 30 LED: 30 * 108 kWh = 3240 kWh / year
- LIFE: 30000 - 40000 Hour

TOTAL SAVING in a YEAR: 15600 kWh – 3240 kWh = 12360 kWh. (approx.)

INITIAL INVESTMENT: INR 741 * 30 = INR 22230/- including 14% vat. (approx.)

Saving in terms of Money/year: 12360 kWh * INR 7.5 = INR 92700/year

Payback Period: 4 month (approx.)

In the same way I have calculated for the overall industry premise. In a month audit calculation of number of light, running hour, including lux calculation on periodic basis.

S. No.	Lamp Type	Power Rating + Losses	Quantity installed	Yearly Consumption (kWh) (12H/day)	Replaced By LED	Yearly Consumption (kWh) (12H/day)	Saving/ year (kWh)	Payback
1.	FTL	50 W	800	1,44,000	650 (18 W)	42,120	1,01,880	8 months
2.	Metal halide	250 W	40	43,800	60 (70 W)	15,768	28,000	3 years
3.	Metal halide	100 W	20	8,800	30 (25 W)	3,300	5,500	4 year
4.	CFL	23 W	180	14,900	150 (15 W)	6,750	8,150	1 year

Table 4.1.1: Payback calculation Table of lighting equipment

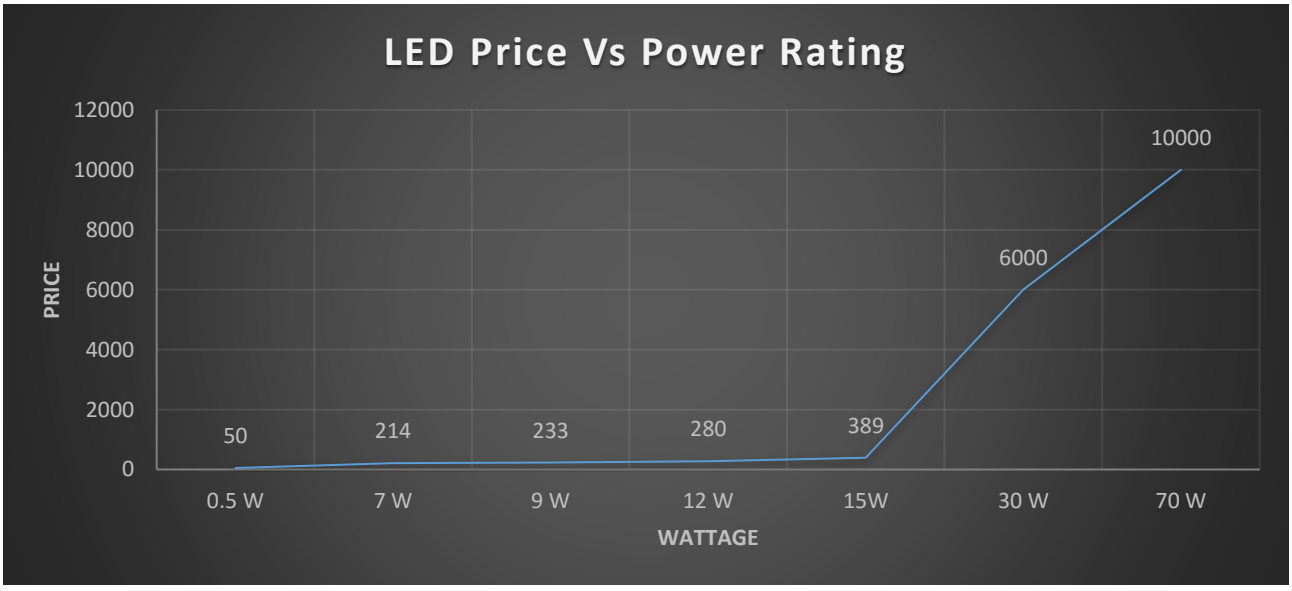


Figure 4.1.6: Change in LED price with the Power rating.

As it can be clearly read from the graph that prices are high in the low Wage group i.e. 0.5 W to 7 W. In the same way the bracket above the 15W see the exponential rise in price band. But, if we check the price band between 7W to 15W they are very much related to each other. Reason behind that is they were the most used, and there application are also very high in domestic as well as industrial. But on the other hand the lower Wage LED are not very popular, and the higher Wage LED more than 15W are majorly used in industry as a high bay light or the security lights. Another reason behind that is the material used in the manufacturing is of very high quality in high bay lights. As they have to serve far superior purpose than the domestic LED lamps.

4.2 Fuel Conversion of Paint Shop

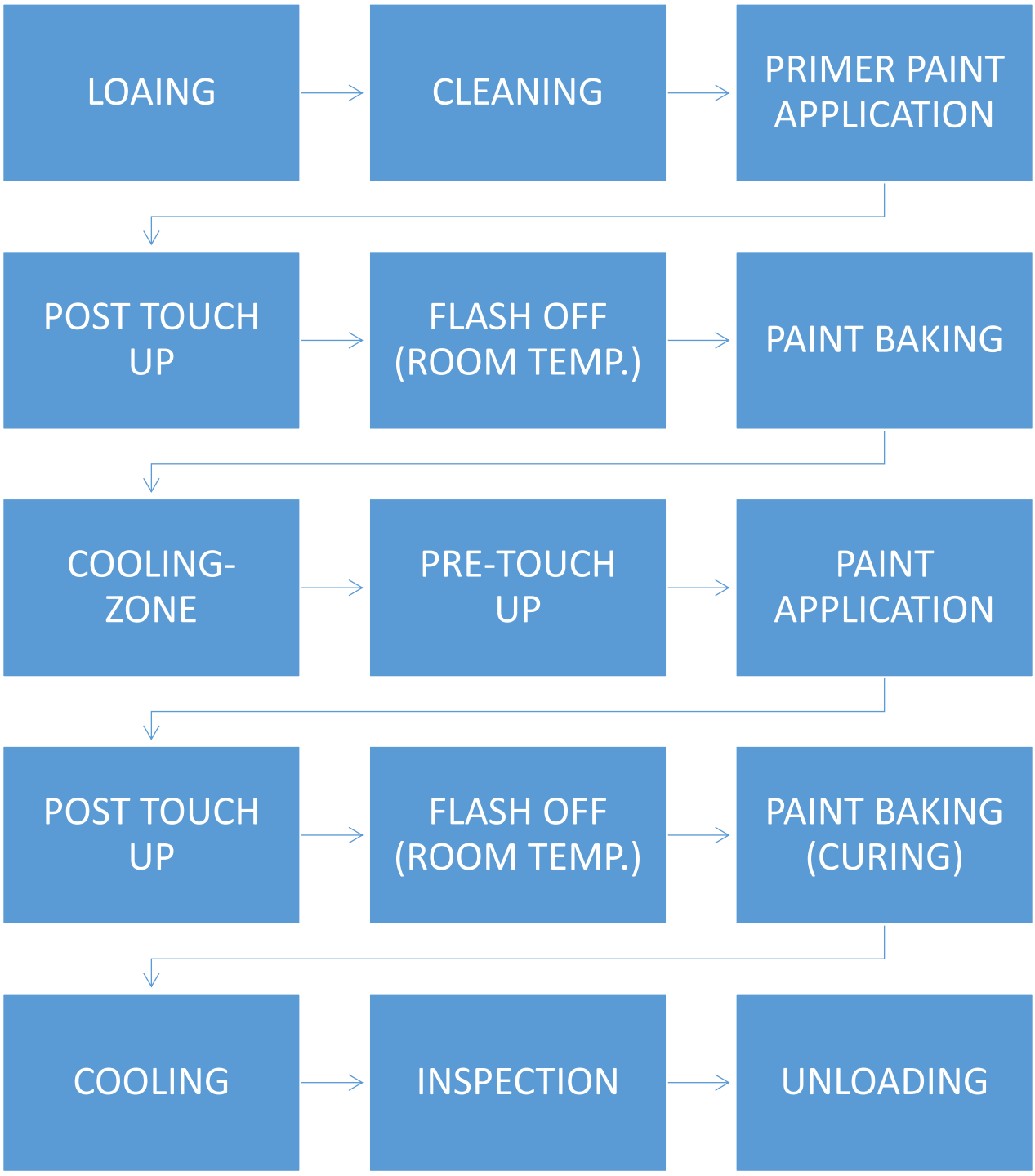


Figure 4.2.1: Flow chart of ESD plant process

Figure 4.2.2: Electrostatic Disk type Paint Shop

Working: The paint shop is a plant which used for painting the cycle parts. It is a big closed chamber employs a burner, heat exchanger, Electrostatic disk, manual electrostatic paint gun, hangers and conveyor through which the cycle parts travel in the chamber. In this, the electrostatic disk uses the paint which is highly charged and pressurized. It is a procedure that utilizes charged particles to paint a workpiece more productively. Paint, as either powdered particles or atomized fluid, is at first anticipated towards a metal cycle parts through the electrostatic disc nozzle and is then quickened toward the workpiece by an excessive Electrostatic charge.

The present conductor charges paint in the nozzle. Electrical current is generated from the have packed nozzle, through it the negatively charged paint is getting positively charged by coming through the conductor. This positively charged paint act on the metal workpiece through spraying. It achieves the highest quality finish and utilization of more than 90% of paint sprayed. It reduces

the effort and wastages. Bicycle parts are easily coated using this technology. Due to the full automation of the plant, it is very fewer chances of the uneven coating of paint.

Figure 4.2.3: Electrostatic disk

Process: The workpiece goes down through a conveyor line towards a paint stall, or paint tank, where it is splashed with, or dunked into, electrostatically charged paint particles. Coordinated into a powder paint stall is a powder recuperation unit, which recoups somewhere around 95% and 100% of the paint over-splash coatings. After the workpiece is covered, it proceeds on the transport line to a stove, where the paint is cured. The advantages to the procedure of electrostatic covering are the capacity to recoup the minimal over-shower and having the procedure mechanized which will cut expenses. The purpose behind the minimal over splash is the paint particles that don't hit the piece will turn noticeable all around and backpedal to the piece. All holders, transports, and so on must frequently be cleaned to guarantee a decent ground and keep anybody in the region from getting a serious stun. In an airborne framework, any breaks on the piece that are being covered can be missed in light of the fact that the electrostatic paint is more pulled into corners and sharp edges; this implies another procedure for covering can be a superior choice if the piece has breaks.

Paint is statically attracted just to the metal from all bearings, so there is no overspray, splashes or chaos.

Working of Burner: After the paint process, the bicycle parts went for drying using conveyor. In this process, the conveyor goes into the chamber where a burner is installed and it heat is spread all over the chamber using the heat exchanger. In the paint shop diesel was used previously as a burner fuel. Drying of paint is called as hot air curing process. Curing process consist of drying and hardening of paint on metal component. Hot air curing comprise to apply certain temperature to the painted surface.

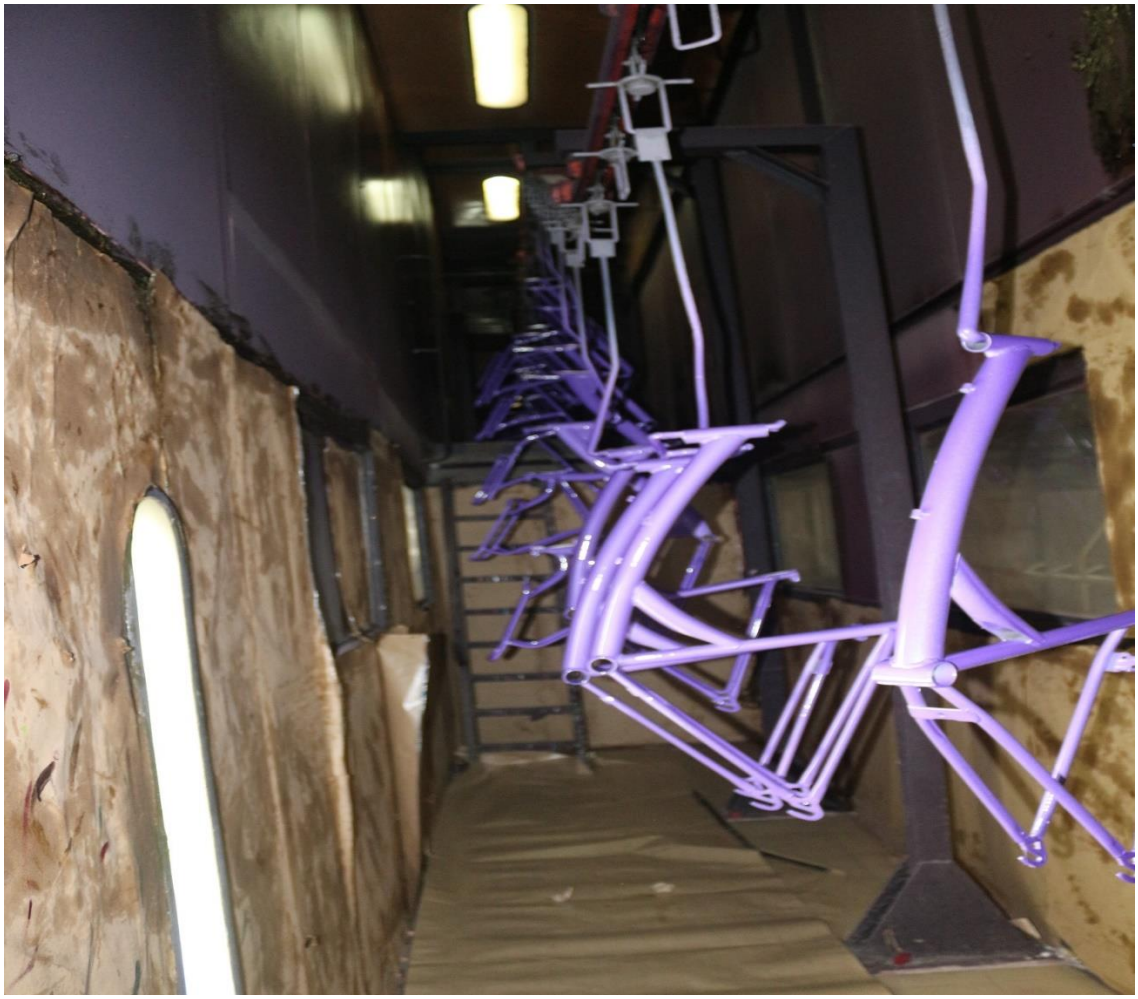


Figure 4.2.4: Bicycle parts going into the heat exchanger chamber through conveyor

Such that the expansion in temperature causes a quicker vanishing of the solvents and quickens the substance. Responses happen to make the principle polymer or pitch, i.e. the temperature goes about as an impetus which quickens the drying and solidifying process, accordingly quickening the curing procedure. It is the most utilized strategy because of the simplicity of curing of any

workpiece paying little mind to its geometry, because of the simplicity of hot air infiltration by an opening that has the workpiece. The temperature in the chamber is between 120 ˚C – 140 ˚C.

Problem with the System: Nowadays the price of Diesel is increasing quarterly on a periodic basis, so it became tough to manage the cost and productivity. Even the maintenance is also very high due to the carbon got accumulated over the burner with time and reduced the overall efficiency and results in the higher consumption of diesel. Maintenance is done monthly, and one-time maintenance cost is around twenty thousand including the price of the filter.

So for overcome this trouble management start studying and find that by some suitable changes and by replacing diesel by LPG will change the scenario. LPG is the cleaner fuel and better than diesel, having high calorific value. Agency has been hired after the one month of study of diesel consumption and by visiting other industrial premise and by seeing their LPG based paint shop management finally decide to replace the Diesel burner by LPG burner.

There is four paint booth, and two of them is converted to LPG, and two is still using diesel for the comparison.

GENERAL

Conforming to Indian Standard specifications		IS 4576
Vapor Pressure at 65 ℃	Kg/cm^2	16.87 (max)
Volatility. Evaporation temp. in for 95% volume at NTP	℃	2 (max)
Copper strip corrosion at 38 ℃		Not Worse than 1
Dryness		No free entrained water
Odour		Level2

CHEMICAL COMPOSITION

Ethane	%	1 max
Propane	%	38 max
Iso-Butane	%	19 max
Nor-Butane	%	41 min
Pentane and Olefins	%	1 max
Volatile sulfur	%	0.003 max

LIQUID

Density at 15 ℃	Kg/liter	0.558
Volume of liquid per kg at 15 ℃	Liters	1.85
Vapor pressure at 37.8 ℃	Bar	5.7
Gross Calorific Value	Kcal/kg	11840 +/- 1%
Net Calorific Value	Kcal/kg	10920 +/- 1%
Boiling Point at atmospheric pressure	℃	0

VAPOR

Density at 15 ℃	Kg/m^3	2.21
Volume of gas per kg at 15 ℃	m^3	0.48
Latent heat of vaporization at 15 ℃	Kcal/kg	86
Gross Calorific Value	$Kcal/Nm^3$	26170 +/- 1%
Net Calorific Value	$Kcal/Nm^3$	24130 +/- 1%
Air required for combustion	m^3/m^3	29

Figure 4.2.5: LPG specification *(Indian Standard Specifications IS 4576)*

Typical Density and Net Heating Value of Different Fuels

Fuel	Density, 15°C, g/cm^3	Net Heating Value			
		Btu/lb	Btu/gal	kJ/kg	kJ/L
Regular Gasoline	0.735	18,630	114,200	43,330	31,830
Premium Gasoline	0.755	18,440	116,200	42,890	32,390
Jet Fuel	0.795	18,420	122,200	42,850	34,060
Diesel Fuel	0.850	18,330	130,000	42,640	36,240

Table 4.2.1: Specification of Diesel and other different fuel (*chevron diesel fuels technical review*)

Comparative analysis of consumption of both LPG and Diesel in May 2016:

- Fuel – HSD (Price: 51.71/ liter)
- GCV – 10500 Kcal/kg 1Litre – 0.84kg (Specific Density – 0.84)
- Per Hour Consumption: 18 Liter/Hour
- Monthly Consumption: 560 Hours = 560x18 = 10,080 liter

- Fuel – LPG (Price: 38.44/KG)

- ESP No.-01 (Burner 1 & 2) Working on LPG
- Working Hour/Month = 560
- Per Hour Consumption = 16 Kg/Hour
- Monthly Consumption = 8960 KG

In case of HSD May-2016 Total Value of Diesel = 10080 x 51.71 = Rs. 5, 21,236/-

In Case of LPG May-2016 Total Value of LPG = 8960 x 38.44 = Rs. 3, 44,423/-

Monthly Saving in May-2016 from ESP No.: 01from LPG = Rs. 176800/- (approx.)

Yearly Saving = 176800/- x 12 = 2,121,600/-

4.3 Removal of old rewinded low efficiency motor

A list has been prepared during the phase – 2 audits of the industry. In the list, all the motors (AC or DC) of the industry were noted down. After studying the data, the project has been formulated for the removal of inefficient motors. But due to the delay in the decision-making of the organization, it got delayed for months.

S.NO	Machine Number	MAKE	HP	RPM	Rewinded
1	4	NGEF	3	2800	5
2	27	JYOTI	3	1400	5
3	28	NGEF	3	1400	5
				2800	
4	32	SIEMEN	20	1400	13
5	36	NGEF	3	1440	5
				2800	
6	41	NGEF	3	1400	5
				2800	
7	48	BROWN	3	2800	8
		BRAVRY			
8	65	KIRLOSKER	5	1400	6
9	69	BHARAT	5	1400	6
		BIZLEE			
10	81	SIEMEN	7.5	1400	5

11	86	SIEMEN	3	1400	5
12	95	SIEMEN			7
13	105	SIEMEN	1	1400	5
14	121	SIEMEN	7.5	1440	6
15	140	SIEMEN	5	2800	6
16	146	SIEMEN	5	2800	8
17	158	SIEMEN	5	2800	6
18	167	NGEF	5	2800	9
19	170	BHARAT	7.5	1400	6
		BIJLI			
20	174	NGEF	5	2800	8
					5
21	177	M.M.M.	3	1400	
22	180		0.5	1400	7
23	187	SIEMEN	5	2800	13

24	188	NGEF	5	2800	5
25	190	SIEMEN	5	2800	10
26	217	BHARAT BIJLI	7.5	1440	5
27	220		5	1440	6
28	232	NGEF	5	2800	7
29	257	KIRLOSKER	1/4	1400	6
30	262	NGEF	1	1400	6
31		KIRLOSKER	1/4	1440	8
32	329	NGEF	1/4		10
33	331	SIEMEN	5	2800	13
34	333	BHARAT BIJLI	5	2800	16
35	346		2	1440	7
36	366	BHART BIJLEE	5	2800	6

37	391	DO	15	1440	5
38	421	KIRLOSKER	3	1400	5
39	451	NGEF	1	2800	11
40	488	REMI	1/4	2760	7
41	544	KIRLOSKER	1	2700	7

Table 4.3.1: List of old and inefficient motor

Motors that are winded less than four times are excluded from its efficiency measurements. Induction motors, whose efficiency was less than 60%, were recommended to replace with Energy efficient motors. Out of fifty motors, forty-one have an efficiency less than 60%. In above table, you can see the list of motors having the efficiency less than 60 %. The purchase order issued so late in May end for replacing these motors by IE3 motors. Until the end of my internship around five motors were replaced, and the project is still in progress.

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

In this dissertation report, a unique approached to energy conservation with enhancing productivity is described. Before the commissioning of the project the approach towards energy management is very dull, but it is changing now, and one can see the difference in few upcoming months with the small electricity bill. After the implementation of program positive results are coming but due to the some problems not much as expected. It cannot be successful until the higher management in the organization doesn't take part seriously. Decision making is very slow and its hamper the growth of the company.

Organization is very positive towards the renewable energy, with more 0.5 MW plant of rooftop solar plant shows their determination towards the sustainable future.

5.2 FUTURE SCOPE

1. In upcoming year the paint shop can be switched from LPG to Propane with very less investment.
2. Switching from low-efficiency induction motors to high-efficiency IE3 motor will show the drastic change in electricity consumption.
3. By switching to Phosphorization process from the present phosphating process will the organization to show their commitment towards environment and it's economical too.
4. By digitalizing the Stores, handling of equipment will be easy, and it also reduces the RED Tag.

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