ENERGY MANAGEMENT STUDIES IN AN ENGINEERING INDUSTRY

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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December 2016

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr.Amar Preet Singh S/o Sh.Rishpal Singh, M.Tech(Energy Technology & Management) of Thapar University, Patiala has successfully completed his In-plant Training of one year in our organization during the period from 15-6-2015 to 14-6-2016. He worked on the following projects:-

- Data Collection of Motors
- Evaluate Motor Efficiency
- Recheck recommended projects by Energy Auditors
- Prepare the energy flow chart and energy cost on monthly basis
- Reintroduce VFD
- Introduce the concept of Heating FO by fuel gases in Dip Brazing Furnace
- Installation of Solar PV(Photovoltaic) Power System
- Monitoring the Project LPG to Propane Gas

We wish him all the best in his forthcoming career plans.

For HERO CYCLES LIMITED

J.C.VERMA
ASSTT.GENERAL MANAGER-HR

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SR.VICE PRESIDENT(OPERATIONS)

DECLARATION

I hereby declare that the project work entitled "Energy Management Studies In an Engineering Industry" is an authentic record of my own work carried out at Hero 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. Vipin Garg and Dr. A.S. Reddy, during June 2015 to June 2016.

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

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ACKNOWLEDGEMENT

Whenever in my life , when I do have to give credit for my works, my achievements or success it directly or indirectly goes to the fountainhead of my life ; or what I prefer to call them, trinity of my life (My Parents, Brothers and sisters). My internship in Hero Cycles Ltd., Ludhiana became possible due to the following people: **Dr. A. S. Reddy (HOD, SEE), Mr. A. K. Singh (President, Hero Cycles Ltd.)**, Thapar University and many more people, without them I would have not been able to manage the things by myself.

I specially thank Dr. Anoop Verma, Dr. Venkat for his support and guidance throughout the project duration.

It is with immense gratitude that I acknowledge the support and help of my Internship coordinator at Hero Cycles Ltd. **Mr. Vipin Garg (Senior Vice President).**

It gives me great pleasure in acknowledging the support and help of Mr. J.C. Verma, Mr. Surinder dhar (Assistant manager-Operation), Mr. Manmeet Pal Singh (Senior Enigeer), Mr. Rohit raina (Engineer), Mr. Gaganpreet Singh and the Technical Team, operation department for providing me excellent guidance, material and motivation.

I thank my friends Mr. Basu Jain and Mr. Ajay Pratap Singh for the interest and inspiring views they provided, along with many hours of their valuable time to clarify my doubts and help me with my projects.

I would like to express my sincere thanks towards Dr. A. S. Reddy (HOD, SEE) sir as well to encourage me and to explain me the need of good industrial internship for career prospect.

-Amar Preet Singh

ABSTRACT

As an M.Tech student of Energy Technology and Management course, engineering industry is joined where manufacturing process and surface platting occur. For doing these things, many energy resources are consumed. In order to save and use these energy resources, appropriate steps are suggested. Electrical, thermal and renewable energy sources are considered in this engineering industry. I had a chance of being an intern at Hero Cycles Ltd. Ludhiana during this training. After being a part of 10 days induction of the entire industry, many innovative ideas and suggestions were presented. These ideas and suggestions were necessary for energy saving projects and saving the wasted energy of the industry. Thereafter, many energy saving projects, which would be beneficial for the industry were proposed and implemented. Daily energy consumption data was prepared in a suitable format. Doing this, the energy consumption (before and after implementation of saving projects) was clearly understood.

I had done many valuable and innovative energy saving projects (Electrical, thermal and renewable energy) in engineering industry. Main energy consuming device are motors in this industry. As behalf of this concept, specification of all motors is collected. After this, the present efficiency of motors are evaluated and compared with mentioned efficiency on name plate of motors, the convectional motors/ low efficiency motors were replaced with energy efficient motors. Some of the heavy motors, where damping valves are being used (like ASU, ID & FD fans of Boiler and Blowers), are connected with VFD (Variable Frequency Device) controller. Dip brazing is the process for robust and smooth joint of works. Lots of thermal energy is wasted. For reusing of this energy, an energy efficient design is architected. By this design, fuel is heated with this wasted energy rather than electrical heater. I had an attention on changing the fuel, LPG to Propane. This project was also completed in my supervision. For learning of boiler and its functions, I had formulated boiler's efficiency. As well as electrical and thermal energy projects, Renewable energy projects are implemented. A small solar PV (photovoltaic) power system was established in industry in my supervision. Energy saving reading, calculating, energy flow diagram, energy cost is evaluated at daily basis.

These above projects are useful and valuable for enhancing my knowledge and supervision. The theoretical and practical knowledge should be balanced.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Energy management and conservation

The population of India is 17% of the world's population therefore the energy resources consumption is quite higher than other countries. The Indian government policies and interested citizens of India have aimed to reduce the uses of Energy resources and improve the energy efficiency. Government introduces many energy saving programs and attracts people for saving energy.

For covering the requirement for procurement, preservation, allotment and use of energy is complement of forecasting, methodical coordination. Energy management system is a system in which we can study about energy saving ideas and its implementation.

There are many new and innovation ideas are formulated. We can do energy conservation in all directions like switch off the unnecessary bulbs in home; reduce convectional bulbs with new LED bulbs. Many of energy conservation techniques are implemented in surrounded areas. Wasting of unnecessary energy will effect on environments directly or indirectly. Now these days, people are focusing on renewable energy, it is also a best technique of energy conservation.

Energy management is complement of energy conservation. In energy management, we can manage the energy. The energy could be either thermal or electrical. Saving the both energy will help us for saving, preserving the human being and nature.

1.2 Energy overviews of engineering industry

Engineering industries are those industries in which designing, manufacturing, platting and panting are occurred. For manufacturing, many heavy motors are used in industry. These motors may be Induction motor, synchronous motors and DC motors. Many numbers of motors are played role in industry. In other hand, we can say the motors are the heart of the industry. There are lots of industries in India. Therefore the wasting of energy is also a great problem. If the efficiency of these motor are increased with 1 % then lots of electrical energy can be saved and the reduction of greenhouse gases will be decreased. As well as, thermal energy should also be conserved because the thermal energy is produced by burning of fuel, and many hazardous gases are produced while

burning of fuel. So if we save the thermal e energy then the less amount of fuel will be burnt and lots of hazardous gases will not be produced. As well as saving the environment, the money will also be saved.

1.3 Introduction of industry

The engineering industry where I have done my one year industrial internship is a cycle manufacturing industry. There have many new and innovative machines for production. Much individual machinery is used under this industry for better performance. Mainly five types of energy resources are being used in industry Like Electricity, Pet coke, High speed Diesel, Briquettes and Propane gas. The uses of these resources are following:

- Electricity: Electricity is being used for driving the electrical machine and many conformable equipment like Fans, light, Air conditional and etc.
- Pet coke: Pet coke is being used in boiler for production of steam.
- High Speed Diesel: HSD is being used in DG set for generating Electricity against power cut. As well as is also being used for heating purposes in burners and ovens
- Briquettes: It is being used in thermopac boiler as fuel
- Propane gas: it is being used for production in ranger as Brazing and heating purpose in burners and ovens.

1.4 Objective of Thesis

The main objective of the thesis is the examination of the energy conservation opportunities in engineering industry. The induction of industry has played a fabulous role to find the opportunities.

- To determine the potential of energy consumption in engineering industries
- To determine the energy saving projects which can be implemented in industry after auditing
- Data analysis and determine the saving of project after implementation.
- Establishing economic evaluation and analysis for those energy conservation opportunities.
- To identify specific areas where to minimize energy costs/waste without affecting production. The energy survey was analyzed respective of energy demand of each unit process with the above objectives in mind.

1.5 Organization of thesis

According to the different strategies of work, this thesis is divided into five chapters. The first chapter contains the induction of energy management and conservation, energy overviews of engineering industry, introduction of industry, objective of thesis and last is Organization of thesis with brief details.

In Second chapter, literature reviews are discussed which are very useful for enhancing my knowledge and supervision. During studying or reading of literature many new innovative ideas are inserted in my mind. Many helpful literatures are described in this second chapter.

In third chapter, methodologies are discussed which have been done during implementation of projects. The step by step processes are mentioned in this chapter. Which kind of equipment are used in the projects and its working principle are also mentioned briefly.

In Fourth chapter, results and discussions are mentioned. Many projects which have been implemented are discussed in this chapter. Results and discussions are further divided into three parts like Describe industrial unit, energy analysis and details & energy conservation projects and their implementation. In Describe industrial unit, entire departments of the industry is described with their workings. In energy analysis and details, the whole projects which are implemented or not, are described. In energy conservation projects and their implementation, those projects which are implemented are discussed.

In fifth and last chapter, conclusion is described. What kind of energy have been saved and conserved and its benefits are discussed. This is substance of all researches and projects.

CHAPTER 2

LITERATURE REVIEW

Induction motor is the heart of the engineering industry because every machine in industry is connected with induction motor. Therefore, the main focus of energy auditor is upon motors, if the efficiency of motors is improved then automatically the major part of electrical energy will be saved. The efficiency of induction motors are also depended upon the internal designing of motor. Like taping of coil, this is also a major problem occurs in motor. Sometime, the coils of motor are not tightly wrapped by tape. Then the vibrations are occurred in coil during operation. This vibration takes more energy or wastes the electrical energy. Many other parameters play important role in efficiency of motors. Resistance of the coil also the major factor because the heat loss is related to resistance. In other hand, the heat loss of induction motor is the function of the resistance [1]

To increase the efficiency of the induction motor is not only save electrical energy, it can save the money and reduce the global warming. The metric tons of fuel are burnt to generate electricity and many greenhouse gases are produced during this generation. The motor efficiency is in good condition then the electricity will be less consumed and the generation will also be reduced. Then the production of greenhouse gases will also be reduced. 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. Copper loss, eddy current loss and hysteresis loss depend on the material of the motor. The uses of artificial intelligence techniques are also useful for enhancing motor efficiency. This technique can be fuzzy logic, evolutionary programming and genetic algorithm [2]

The efficiency of three phase induction motor also depends on the low load and high load condition. If the induction motor is operated in low load condition then the life of the induction motor will decrease. So we should also make a focus on loading of motor. The loading of induction motor is evaluated with slip method, is used in calculation. When the induction motor is operated form no load to full load, then much energy consuming parameter are generated within motor. Like copper losses, core losses, eddy current losses, hysteresis losses, friction and Windage losses and rotor losses. The efficiency of motor is also evaluated by many various parameters like resistance, torque, speed of rotor in RPM, pole of the motor, frequency of the motor etc. A core loss is constant loss which depends on the supply voltage. Copper loss is variable loss which

depends on the resistance of the coil. Friction and Windage losses are mechanical loss which depends on the smoothness of the bearing and attached components. [3]

Generally, the most common method for evaluating efficiency of three phase induction motor is field evaluation method. Every year many new methods are evaluated. There are some following method for evaluating efficiency as per engineer can select it:

1. Nameplate method
2. Slip method
3. Current method
4. Statistical method
5. Equivalent circuit method
6. Segregated loss method
7. Airgap torque method
8. Shaft torque method

We can use these methods according to the parameters we have. The combination of the equivalent circuit with empirical parameters is the most accurate and reliable method. But this is very complex method. For selecting of method, the cost and accuracy is very big deal. Cost or intrusive and accuracy are inversely proportional. The least cost and least accurate method is nameplate method and most costly and accurate method is shaft torque method because of its costly equipment. After researching on loading the average load factor is approximate 75%. It is best for motors' life. [4]

We know 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 [5]

Motor Rated Power	Stray load losses relative to the output power
0.75 – 90 kW	1.8 %
91 – 375 kW	1.5 %
376 – 1800 kW	1.2 %
1801 kW and higher	0.9 %

Table 2.1: Relation between motor rated power and stray load losses

Improving the torque of the induction motor is as important as improving efficiency. The torque controlling is quite different from the field oriented control because instantaneous slip frequency is depended. In the transient state, produce maximum slip frequency and obtaining highest torque response, fastest accelerating voltage vector is selected. In steady state, in this state the accelerating vector and zero voltage vectors are selected. The hysteresis comparator of torque is used to maintain the constant torque with small switching frequency. [6]

We know that the induction motors are being used in industry. The whole plant is depended upon the motor. If the motor suddenly get failure then the plant may be closed. So regular maintenance are also occurred in industry for motor. Planned maintenance strategies are beneficial in power station. By this the failure of motor are controlled. Exiting monitoring techniques control the failure in plant. Like, sometime the gap between the stator and rotor is done low because of good efficiency. But the rubbing factor is occurred, in this the stator and rotor rubs each other and will be damaged.so there need some monitoring techniques to prevent rub, misalignment, coupling problem, blocked rotor and stator bar [7]

There are many industries in the world and each industry has many induction motors if the low part of efficiency of induction motors are increased then the huge percentage of electricity can save. Loading factor also effect the consuming energy factor. If the motor run under load condition then the life of the motor decreases as well as the power factor in the industry also decrease. The huge electricity will be consumed by decreasing power factor. Some other methods for increasing

efficiency of induction motor; using of VFD in induction motor, replacing the standard motors with energy efficient motors. [8]

The efficiency of induction motors can also be improved by the efficiency optimization controller and drives. The controllers 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. [9]

Stator losses are depended on the current and stator resistance. When the motor runs then the motor become hot because of this stator loss or heat loss and we know that the resistance is any materials increases with the increasing of temperature. It means continuously the stator loss increases. The mostly induction motors are air cooled. There is a fan for cooling the motor but after using of this cooling system the motor remains hot. So now WCCA method is applicable for cooling. It is simple technique to cool the motor with water except air. The meaning of this WCCA method is water cooling capillaries action method. The efficiency of motor are increased approximate 4.30 %. [10]

Variable frequency Drive is known as VFD which is useful to control the RPM of induction motor according to the changing of connected load. The basis study of VFD is based on the PLC and SCADA. There is a Cyclo-convertor in VFD for controlling the frequency. VFD is installed before the induction motor. Basically three components are connected in VFD; Like Rectifier, DC bus and Inverter. There are following advantages of using VFD.

1. The process control is improved by it.
2. The induction motor will take less electricity.
3. The acceleration will be soft, smooth and stable.
4. The motor heating and stress are reduced. [11]

The improvement in VFD is being done day by day. A new hybrid model is taken placed with the help of Programmable Logic Controller based by ladder logic diagram and Pulse Width Modulation. This PLC based software is applicable up to 96% of the synchronous motor and the efficiency of the motor could be increased till 10 – 12 %. [12]

The new revolution in automation is taken placed by VFD and using of PLC and SCADA in VFD. The automatic machines and model machine are easy to handle by VFD and its components. VFD

is used to control the speed of motor according to work. PLC is a device in which the programming is feed and the machine will work according to programming. SCADA is an Output device, a monitor is placed with SCADA and whole system and working of the machine can be seen in monitor. [13]

The main focus of variable frequency drive is on controlling of voltage amplitude. The load of motor is changed according to time. So the speed of the motor should also be changed according to load. When the voltage of the drive is decreased then then the torque of the motor also decreases because the torque of the motor is directly proportional to supplied voltage. For maintaining the torque the slip of the motor will decrease therefore the speed of the motor also decrease. So the supplied V/F ratio should be varied accordingly. The reduction in 20 % of speed can save 50 % of electricity. [14]

Total Harmonics Distortion also involves in the VFD. The voltage decreases then the THD of voltage also decrease but the current THD increase so it is necessary to maintain equal level of the voltage and current THD. With the help of pulse width modulation, the frequency cans continuously change with speed. The filtration procedure of harmonics is also taken place; this device should be small and reliable. [15]

Generally, welding and brazing is used for joining the two similar or dissimilar materials. For tubular structures brazing is more efficient and reliable. Brazing is achieved by induction, gas flame heating and general heating (by fuel). The equipment using in gas flame suffer from non-uniform in expected heat zone. While we can be achieve uniform zone heating by induction which is the latest technique. The coolant fluid is used through coil which is in induction furnace .Before brazing pipe fitting is necessary. Without this the brazing joint doesn't strong, reliable. In pipe fitting the tubular pipes are be joint with threading. The seat, head and BB shell joints are done by this method for making strong rigid joint. And the press machines are also used to press the pipes in each other's. The brazing method consumes money as well as the cleaning of the brazing consumes more money. The cleaning is necessary process. But before brazing no need for cleaning, rubbing and labor work after brazing the whole process should be proceed. The beginning manufacturing the entire head, seat and BB shell clusters are maintained for better production [16, 17, and 18].

Hydrocarbon of high heating value usually has been burned for heating purpose. We used atmospheric oxygen for complete burning. That oxygen reacts with carbon form carbon dioxide and water. In other a side gas of low heating value is mixture of combustion and inert gases these gases are caused of environment pollution. To decrease the rate of atmosphere pollution the excess air/ oxygen are used to convert carbon mono oxide to carbon dioxide and water. The large amount of low heating value gases have large amount of energy that energy can be recovered by boiler / turbine. [19]

We generally know that the fuel gases are flameless combustion. Because that fuel gases have energy but haven't flame. Absence of flame we can use it as radiant heat source and by this we can increase the temperature of any materials. Preheating of fuel achieve flameless combustion. The tank of heat exchanger which has two tubes (one inlet and second outlet) is situated into ground and the tank is filled with fuel. When the flue gases pass through the pipes, then it transfers its heat energy to fuel. [20]

In glass meting furnace, generally we can use fuel and air mixture. So if we enter the ambient temperature air into the furnace then it will take more energy to heat. So we can use a heat exchanger to pre heat the air. That is known as Granular heat exchanger. That has two functions: first, we can remove the heavy particulars from the exhaust gases and second, to pre heat the inlet air. In first bed the exhaust gases are passed to remove the heavy particulars and second bed is used as a heat exchanger vice versa. [21]

One more invention is preheating hydrocarbon feedstock to thermal cracking of the hydrocarbon in radiant zone by using burner in cracking furnace. We can use heat exchanger for extracting heat energy of gases to cracking the hydrocarbon to diluent stage. Hydrocarbon can be preheated by heat exchanger arrange in convection zone of furnace and its venting stack is divided in bundles of tubes which can be used as fire tube heat exchanger for preheating. And remaining stacks are used according to feedstocks. [22]

We generally know that oil is a most important fuel in industry world. But it's a convection source of energy. So increased its demand and decreasing its supply, we have to choose its alternative such as heavy crude and bitumen etc. We have many methods to recover unconventional oil are Steam Assisted Gravity Drain (SAGD) process and VAPEX process which uses steam and diluent as fluid respectively. In both methods we use two well. In first well, we can use steam/diluent as

feeder, doing this the heavy oil is heated up and reduce viscosity. And the heated oil is collected by the second well. Then we can collect the useful oil from the second well. [23]

A flat type heat pipe is made by thin elements with high accuracy for heat transfer. In it two layers of thin flat aluminum plate are connected parallel with each other and brazed it to form heat transfer path. The operating liquid is filled in the gaps of both plates. That heat transfer path is formed by pressing, punching etc. That flat pipe type pipes are made thin for the variety of uses. Grooves and wicks are used for improving the heat conductivity. Because of flat surface the fin ca be easily attached, doing this we can obtain the satisfactory radiation effects. That flat type heat pipes have small size. And it can be used to cool heat generating elements like IGBT (insulated gate bipolar transistor), IPM (intelligent power module), thyristors etc. That flat type heat pipes have many uses and embodiments. The flat type heat pipes have aluminum plate interposed in the corrugated manners. The penetrating holes are used on side walls of aluminum plates for working in corrugated manners. [24]

In an automobile air conditioning system, a brazed heat exchanger unit is used. A flux is made of aluminum-silicon powder, zinc and a binder. That called flux is coated in the internal and external surface of the heat exchanger. Flux is also used in the internal surface which is of aluminum alloy header and external surface which is of tubes / pipes to form uniformly and smooth join in both surface. This heat exchanger also has many uses and objects. This can be used like a heat exchanger in the condenser of an automotive air conditioning system. A brazing alloy clad the assembly of component of heat exchanger is a composition of flux brazing. This heat exchanger has good and rigid joint in pipes and surfaces. For the better responses and better quality of joint, we can use potassium tetra fluoro aluminate particles flux in place of aluminum silicon powder. That can be used in that alloy which have electrode potential less than aluminum alloy which is used in the tubes and header.[25]

The other process of brazing is done by convection brazing known as aluminum header condenser. That process done two step; first to dry the flux and the second is to braze the goods. The oven of blazing is divided into two zones. In one zone we take the goods near the furnace where it is heated with low temperature to dry the flux. In other zone, the goods are blazed with high temperature. The system has also two parts core and tanks. Both are heated hotter, if we want to dry the flux although the core is heated slightly more. For cooling of flux we transport the flux through ambient

air which temperature less then tanks. Now we can do brazing because those tanks are not cooler than normal temperature. Doing this, braze achieve sooner than normal. [26]

Now days the solar energy is very hot topic. The people are paying attention on solar energy. The most famous topic is solar photovoltaic system. In this the solar panels are used as energy system. It converts solar energy to DC voltage which is an electrical energy. Firstly, solar energy is used directly. But now these days the advance technology is faced grid system. In it we can use solar energy with domestic electrical energy. Some part of desired power is consumed by solar energy and remaining is consumed by domestic electrical energy. One more other method is to store the electrical energy in the battery system. In it when our load is zero or less than solar output then that time the battery is charged by the solar energy. At higher load, the produced solar electrical energy and the batteries charged energy cover said higher load limitation. [27]

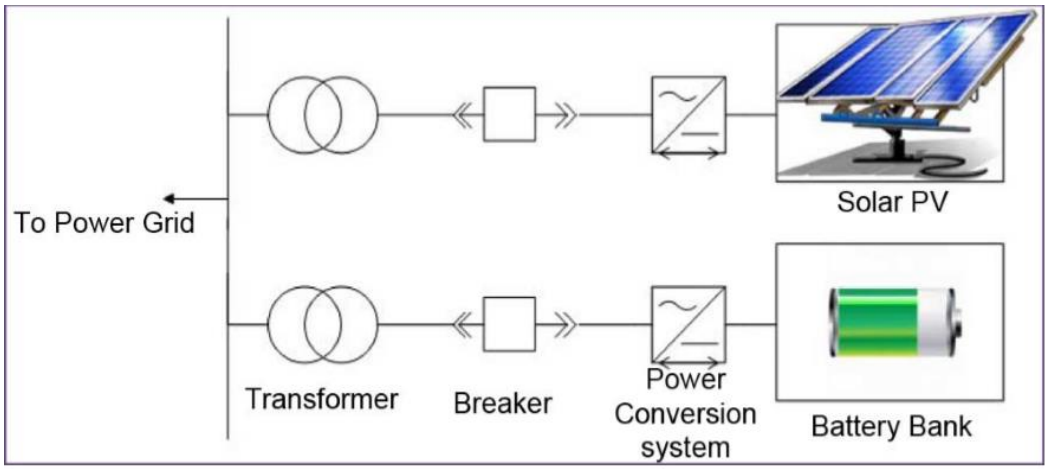

Figure 2.1: Energy flow chart for Solar PV grid system

We generally know that the people are growing towards renewable energy source. From few years people are installing the renewable plants to produce energy from renewable sources likes wind, tidal, solar. Solar and wind are most adorable topic. Before the more research on these topics the efficiency of these systems was low. But the efficiency of these systems is increased. Now we can use power electronics in this system to get high efficiency. Now we can use variable speed devices in the wind mill. By using this annual production increases by 5%. In it the active and reactive power can be controlled. Also it reduces losses in generators. No flicker problems are generated. The disadvantage of this power electronics device is the cost factor. This device is connected with individual system that's why it becomes costly. One more device is known as variable speed

concept utilizing doubly fed induction generator. Using this device the rotor frequency and the stator frequency will be matched. It's also beneficial device. [28]

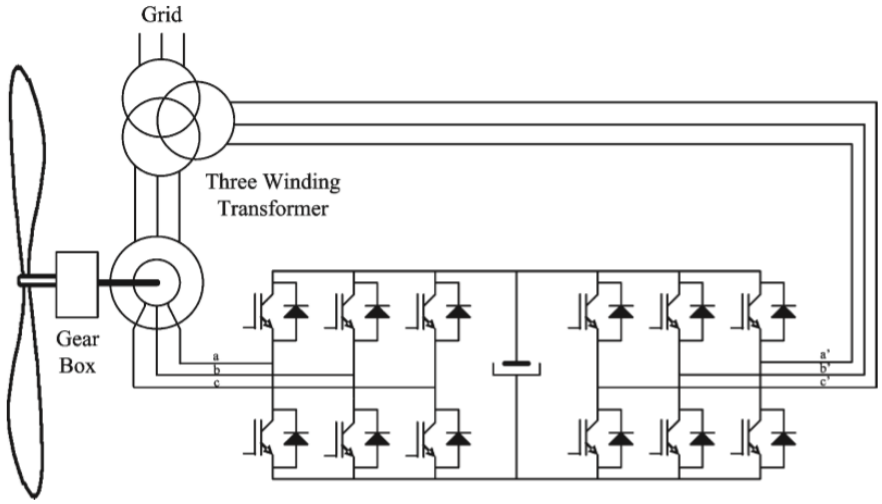

Figure 2.2: Cyclo - converter For Wind generation

Now the solar inverters are useful device for solar system. This is applicable for online grid system; in this system the batteries and other energy storage devices are not used. When the sun is there the energy is generated. In absence of sun, no energy is generated. That type of system is installed in Hero cycle ltd, Ludhiana. In this the solar panels are connected via string to the combiner box further that combiner box is connected with the inverter. Inverter is used to convert DC voltage to AC voltage. For one phase we can use one inverter and for three phase supply we use three inverters for individual phases. That is very useful and model technique. [29]

As well as the installation of solar panels is increased day by day, the researches have also increased. We generally know that the solar panels are worked in the solar radiation. So more solar radiation, more energy. So keep this though in mind, we should concentrate on the arrangement of solar panels because if the solar radiation is not proper at that place how can say energy will be sufficient. So we can arrange the solar panels as that arrangement, doing this the maximum radiation should be put on said solar panels. And one's shadow will not put on other's panels. The arrangement you can see in following diagram. [30]

Figure 2.3: Solar panels and modules

One more method to increase the efficiency of solar panels is maximum power point tracker for PV array. In this experiment they connect a servo motor with the fuzzy controller. Fuzzy controller has microcontroller. That microcontroller is very adorable and important device. The servo motor is used to rotate the solar panel in the direction of sun at which the maximum radiation will be occurred. For this the tracking program is installed in microcontroller. There is no sensor in this technique. The solar panel is rotate according with time. For this process, we actually have to audit the place, at which angle the maximum radiation occurs. After it install program in the microcontroller. And the system is ready. That project is very useful and efficient project. [31]

The main advantages of Solar PV module are counted how much the CO2 emission is reduced and how much the energy payback period. The solar panels which are made by the crystalline silicon and thin film technology, was produced energy. The payback periods of the roof-top systems were 2-3 years and the almost 4 years for megawatts production. But now the technology is increasing day by day. So the improvement in solar panels is also increasing. The payback period is now 1.5 years of roof-top system and 2 years for megawatts production if the radiation is 1700 kWh/m^2. And CO_2 emission is also decreased. The CO_2 emission is calculated by 50-60 g/kWh. Its means if we produce one kWh electricity then we can save 50 grams CO_2 gas emission. The CO_2 emission during manufacturing the solar PV module is less than other fossil fuel power plant. And in wind and biomass energy it is quite greater. [32]

LPG (Liquid Petroleum Gas) is the mixture of propane and butane and its hydrocarbon. It is used as a fuel for heating, cooking and vehicles. After refining the petroleum, LPG is extracted. LPG has a small amount of propylene and butylene. By normally, generally experiments, power output

form LPG was found decreasing, but by some new and innovative experiments, the power output from LPG is improved by decreasing its ignition time, the amount of the LPG injection in engine, adjusting the stoke length and compression ratio. But improving the ignition timing and compression ratio produce NOx. By increasing the LPG amount in engine, the brake thermal efficiency was found. If the certain amount of the LPG is being used the production of HC, CO and CO_2 would be decreased. [33]

Propane gas is extracted for natural gas. It is colorless and odorless gas at ambient temperature and Pressure. It can be stored in liquid state under a certain pressure and temperature. It is a clean fuel comparison with LPG. The ignition point of propane is lesser than LPG and the calorific value of propane is higher than LPG. The combustion of propane is better than LPG and if the propane is changed with LPG then the ratio of air: fuel is not required to change. [GAIL]

No need to change the air fuel ratio. Homogeneous composition has no residue on combustion. It can be used in manufacturing units of glass, tubes, automobile industry. Propane gas has clean burning property. No scaling losses are occurred like Sulphur, lead or carbon. The propane gas also is used in paint shop. In paint shop, the burner and oven is taken place. [35]

There are an experiment in which the influence of high temperature oxidizer is found with different oxygen concentration in fuel and the flame length and its concentration. There are three states in this experiments, flame length, flame volume and high temperature. Flame length can be increased with the help of decreasing oxygen/ increasing the oxidizer temperature or decreasing the fuel temperature. By this the result is found that flue flow rate and the diameter of the nozzle doesn't any effect upon flame length. The amount of oxygen can increase the flame volume. [36]

CHAPTER 3

METHODOLOGY

In one year industrial internship in an engineering industry, many of the energy saving projects were implemented and were played an important role in many innovative energy saving projects. After visiting and induction in industry, methodology is divided in these following steps:

1. Preliminary survey
2. Energy analysis of engineering industry

These steps are very beneficial for implementing the projects and make easy the working process.

3.1 Preliminary survey: in this step, the induction of entire industry has been done with the knowledgeable persons/employers. After visiting the industry, many of energy saving projects are analyzed. These projects are related with thermal energy and electrical energy because overall the main objective of the saving projects is to save money of industry, to reduce greenhouse gases emission and to save the environment. After brief studying of the machines and its process, the area of energy saving projects are found and implemented.

3.2 Energy analysis of engineering industry: keeping in mind the energy saving projects which are learnt in books /literatures is found in industry. These projects are very beneficial for industry and easy to implement because the basic rules and concepts are already known. After discussing the issues with HODs of the plants, these following projects are found:

- Data collection of motors (KW)
- Evaluate motor efficiency
- Recheck recommended projects by energy auditor
- Prepare the energy flow chart and energy cost monthly
- Reintroduce VFD
- Introduce the concept of heating FO by fuel gases in Dip Brazing furnace
- Installation of Solar PV (Photovoltaic) Power System
- Monitoring the project (LPG to Propane)

3.2.1 Data collection of motors (KW)

The data collection of induction motors are very useful and important concept for energy saving because the knowledge of the motors, using in the industry, is very important part of energy conservation. Therefore, these steps are followed:

- Due to lack of resources, the data collection of induction motors has done manually with the help of respective departments.
- The digital data has been prepared department wise.
- Now, the induction motors below 10 HP (horsepower) are eliminated.
- The evaluation of motor efficiency is done on induction motors above 10 HP rating.

3.2.2 Evaluate motor efficiency

The high KW rating induction motors are very important for evaluating efficiency because improvement in these high rating motors can save lots of electrical energy. Therefore, some instruments likes electrical multi-meter, tachometer and power analyzer are needed. The following steps have been done for evaluating motor efficiency:

- Meet the knowledgeable employee of electrical panel and assist him for evaluating the motors' present data.
- Note the voltage, current, resistance and RPM of each motor under no load and on load condition.
- After collecting this data, the efficiency of motors has been evaluated.
- As well as the actual loading of running motors has been evaluated by slip method.
- Prepare the list of loading below than 70 % and again note the voltage and current at starting of motor.
- If the starting current is found equal to rated current then recommendation of maintenance is suggested.
- Otherwise those motors should be replaced with small capacity motors.
- The efficiency of the motors is beneficial above 75 % according to motor rated capacity.
- If the motors' efficiency is lesser than 75% then these are recommended to change with high efficiency IE3 motors.

3.2.3 Recheck recommended projects by energy auditor

The rechecking of recommended projects is also very important part of energy saving because the energy auditors had to be charged for his innovative ideas. So the previous energy audit files used to be found and read these files for knowledge and implementation. These steps are following:

- The previous auditing reports used to be found.
- Carefully read these files.
- Make a list of recommended energy saving projects.
- After this, visit the departments and schedule the meeting with HOD and supervisor.
- Then check the projects' progress and prepare the project reports after inspection.

3.2.4 Prepare the energy flow chart and energy cost monthly

As the energy intern and energy saving consultant in engineering industry, the energy fuel consumption data should be known at daily basis and should prepare the fuel consumption data. Two charts or concepts are involved in this system.

1. Prepare the energy flow chart daily
2. Prepare consumption of fuel weekly.

In energy flow chart, the electricity or fuel consumption per component is studied like how much electricity and fuel are consumed for making one frame or how much cost of this frame. These following steps are followed:

- Make a list of the manufacturing departments and its manufactured components.
- The consumption data of electricity and fuel are collected.
- Then make a sheet of this data in respect to department.
- Evaluate the electricity and fuel consumption for making each component.
- Prepare the energy flow chart and discuss with HODs' of respective departments.

In energy cost, the entire energy resources, are being used in the industry, are listed or analyzed. How much energy is consumed and how much cost is of the resources. The following steps are:

- Collect the data of energy resource like electricity, high speed diesel, propane, briquettes and furnace oil at weekly basis from industry software.
- Find the cost of the resources
- Prepare the chart of this cost with consumed resources.

3.2.5 Reintroduce VFD

After visiting the entire industry, many of projects or drive may be not in use. So should collect data of these unused machines and drives, and could machine on the work. The steps are following:

- Visit the entire industry carefully.
- Collect the used machines and drives.
- Research on the machines and drives.
- Discuss with HODs' of individual departments, electrical and maintenance department.
- Suggest the suitable solution of their problems
- And restart the machines and drives.

3.2.6 Introduce the concept of heating FO by fuel gases in Dip Brazing furnace

After visiting the tubular department and brief studying of dip brazing furnace, the new energy saving project is analyzed. The viscosity of the furnace oil is too low, so it is not able to flow through the pipes. Keeping in mind this problem the pipes are heated by the electrical heater, therefore this heating process are suggested to replace with the intern heat energy of furnace. The implementation of this project is done by these following steps:

- Carefully visit the dip furnace
- Study about its working
- Study about the furnace oil and electricity consumption in furnaces.
- Analyze the inlet and outlet temperature of furnace oil through pipe line by infrared thermometer.
- Analyze the temperature of furnace, flow and temperature of hot air in furnace.
- Collect this all data and evaluate the length of pipes will be used in this projects and the outlet temperature of furnace oil from this project.

3.2.7 Installation of Solar PV (Photovoltaic) Power System

The new revolution for green energy and renewable energy the solar PV power system of capacity 48.8 KW is installed in engineering industry. The monitoring of the solar PV power system is done in this various following steps:

- Check the material specification and the quality which are using in this project.
- Check the all solar panels
- Check the voltage of each solar panels
- Prepare the data of solar panel's voltage
- Check specification of the using inverters and grid panel
- Prepare data of generating Kwh at daily basis

3.2.8 Monitoring the project (LPG to Propane)

This project is also very beneficial and useful for heating and production because the calorific value, pressure of propane gas is much higher than LPG and the cost of propane gas is lower than LPG. So the monitoring of this project is done in these following steps:

- Check the materials which are entered in this project.
- Check the all legal documents
- Check the bullets specification.
- Check all equipment and probes which are used in project
- Prepare the documents for applying license
- Approving all drawing from legal office.
- Apply for purchasing propane for the authorized dealer
- Testing of electrical panels, motors, compressor, light bulbs and operation of safety equipment
- Prepare the sheet of saving fuel after implementing the project.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Describe the industry unit

Engineering industries are those in which modification, designing and treatments occur. The engineering industry where I have completed my one year internship is a Cycle manufacturing industry. In this industry, Cycle's manufacturing, painting and assembly takes place. These processes majorly require five types of energy sources like electricity, furnace oil, high speed diesel, LPG (now Propane) and briquettes. Moreover, manufacturing of heavy and large number of cycles require induction motors from 0.25 KW to 160 KW. The process of steam generation takes place in two boilers, one of which operates with pet coke. The secondary boiler is Nestler Boiler which operates with furnace oil. In the instance of electricity cut-off, there are DG sets of different capacity. LPG is used for brazing and heating purposes and briquettes are used in thermopac boiler for heating thermopic oil. More details of working and uses of these energy sources are discussed in the remaining part of the chapter.

There are many departments and units for manufacturing, painting and assembling, which are under regular 24 hours operation for optimal performance. These departments and units are as follows:

1. Tubular
2. Ranger
3. Rim
4. Paint shop
5. Saddle
6. Unit – 5
7. Unit – 6
8. General Electroplating
9. Powder Coating
10. Boiler house
11. ETP (Effluent Treatment Plant)
12. DG sets room

13. Thermopac Boiler
14. Incinerator

Tubular: Tubular is a unit in which standard cycles are manufactured by tubes. After shaping tubes to frames and forks, these items are carried for brazing. Main energy sources used in brazing are Furnace oil, LPG (and now electricity because induction technology is used for brazing). In this plant, most electricity consuming machines are induction brazing and ASU (Air supply unit). ASU is also known as FD fan (Forced draft fan) for cooling the plant. Some other fuel consuming devices for energy sources are dip brazing furnaces (approximate 14 furnaces for frames and 7 furnaces for fork brazing).

Two debrassing plants are placed in this tubular plant. The extra brass after dip brazing is washed in the debrassing plant. Many chemicals tanks are used in debrassing. These chemicals are in very active position. Cooling towers are used for cooling these tanks' temperature.

Ranger: Ranger is a unit in which Ranger Cycles and Fancy Cycles are manufactured. The raw materials for all cycles, either Tubular or Ranger are tubes. After shaping the tubes for better and strong joints, MIG and TIG welding is used. By using these types of welding, joints become smooth, robust and strong. The mixture of Argon and CO_2 gases are used for MIG welding with 5-10 LPM (Liters per minute) flow. Only Argon gas is used for TIG welding with 15-20 LPM flow. 20-25 % frames and forks are manufactured by SLR department in the Ranger plant. In SLR department, LPG gases are used for brazing. Full frames are manufactured by LPG brazing in SLR. The major energy sources (LPG) consuming machines are SLR Brazing machines.

RIM: RIM is one of the biggest and largest plants in the industry. In this plant, rims are manufactured, polished and electroplated. The whole process takes place in one plant. Bases of this area and machines of this plant are most efficient. Approximate 6 mills are established. In these mills, rims are manufactured from role of rectangular plates. Butt welding, punching and sizing machines are used in these mills. On the other hand, there is one punching and one sizing machine in each individual mill machine. After manufacturing, the rims are taken by bore machines. In bore machines, rims are polished in all directions.

After manufacturing and polishing departments, rims are taken for electroplating. There are approximate three electroplating plants, two for rim electroplating and one for hero motor's parts.

In electroplating, many chemical tanks are placed which are heated by steam (175°C @ 8.5kg/cm^2). After this electroplating process, our rims are ready to be dispatched.

In RIM plant, there are many ASU and Dust collectors. ASUs are used for cooling of men and plant. Dust collectors are used for sucking dust which is produced by polishing of rims. In the method of polishing, rims are rubbed by hard brushes. So the hard iron dust is circulated in air. These dusts are collected by dust collectors. After cooling of men and plants, we need to cool the mill machines also. Therefore, we use three chillers for this purpose. These are most electricity consuming machines in RIM plants, and most steam consuming plant is electroplating plant.

Paint shop: Due to heavy and large production of cycles, there are two paint shops. One is known as the main paint shop and the other is known as unit -5 paint shop. In paint shop, all parts of cycles are painted like frames, forks, mudguards, and chain covers. The components are carried by bonderising plants. There are two bonderising plants under the main paint shop. In these plants, derusting, passivation, activation, degreasing and phosphating methods are used. This helps in the painting being smooth, perfect and protected by physical distortion. Due to production and different varieties of cycles, the main shops have 5 main departments. The working of these departments is same. The primer coating and painting is done automatically and manually. With dual methods, the painting takes place in good quality. The working of Unit-5 paint shop is the same as main paint shop. Also, there are two bonderising plants under unit-5 paint shop.

Heavy motors are used in paint shops because of large number of production. Many ASUs and air blower is used for drying the painted components. Most heavy motors in the entire plant are placed in paint shops. Two chillers are located under the main paint shop. These chillers contain heavy motors.

Saddle: Saddle plant is the smallest plant in the entire industry. Saddle is a seat where we can sit during cycling. The entire manufacturing method takes place in saddle plant by using chemicals. There are no heavy electricity consuming machines in the saddle plant.

Unit – 5 & Unit – 6: Both units are used for assembly purposes. In these plants, the assembly and wrapping process occurs like entire cycles, mudguards, chain cover and forks. Unit – 5 is an individual unit for assembly but unit-6 is under main shed. Under the main shed, standard cycles are assembled and in unit-6, fancy and modern cycles are assembled. But in unit-5, only fancy,

modern and export cycles are assembled. There are no major electricity consuming machines except FD fans. Many FD fans are used for men's cooling and cooling of the plant.

General Electroplating: General Electroplating is also considered in the main shed. In General electroplating unit, three general electroplating are involved. One electroplating plant is used for small particulars like spoke, nipples etc. This plant is also known as 'Tin-Co plating plant'. Another plant is used for chain wheel and small sized rims etc. This plant is also known as 'Ni/Cr old plant'. In these plants, a thin layer of nickel and chromo chemicals are coated at micrometer thickness. Many chemicals solutions tanks are used in these plants for electroplating and these chemicals are heated by steam (175°C @8.5 Kg/cm^2). Major electricity consuming machines are exhaust fans and steam.

Powder Coating: Powder coating is the famous technique for painting. Some components are not needed for painting, so these components are coated in powder coating plant. In powder coating plant, dry paint is coated on the components by machines. After this dry coating, these components are moved for heating. By using heating process, these dry coated paints are adhered on the components. The most electricity consuming machine in this plant is Cyclone machine in which the remaining dry powder is collected for reuse. One of the energy sources consuming (LPG gas) device is oven, which is used for heating the dry powder on components to enhance its adhesive property.

Boiler house: For optimum performance and 24 hours of working, there are two boilers in the industry.

1. Water cum fire tube boiler
2. Nestler Boiler

Water cum fire tube boiler is operated with Pet coke. Pet coke is one type of petroleum waste product. The calorific value of this pet coke is 8000 Kcal/kg. The capacity of this boiler is 8 ton and DM water is used for making steam. In this boiler, firstly, water is heated in tubes and then that hot water is collected in another part of the boiler. In this part, the remaining fire is passed through that stored water. Due to high temperature, the steam is generated in the roof top of the stored water. The temperature of the generated steam is 175°C at 8.5 Kg/cm^2. The generated steam is used for heating the chemical solution tanks in electroplating, debrassing, etc. The major

electricity consuming machine or drive in this boiler is ID & FD fans (inducted draft fans, forced draft fans) and energy source fuel is pet coke.

Nestler Boiler is used for standby purpose. Nestler boiler which is a fire tube boiler operates with furnace oil. The calorific value of the Nestler boiler is 9000 kcal/kg. The capacity of both boilers is same.

DG set room: Diesel generators are known as DG set in industry language. This is the secondary option of generate electricity. There are almost 6 DG sets of different capacities from 2100 KVA to 1125 KVA I operation. All are ignited by battery's spark. 2100 KVA & 1125 KVA DG sets consume approximate 180 liters and 140 liters diesel per hour respectively and 3.64 KWH is generated by per liters. The maintenance is occurred weekly.

Thermopac Boiler: In Paint shop, blowers are using for drying the primer and paint. So in some places of paint shop, diesel operated blowers are using and in remaining places, drying of paint and primer are done by using of thermopac blower.

In Thermopac boiler, the thermopic oil is heated by boiler which is operated by Briquettes. It is made of rusk husk or bio fuel. It is eco-friendly because less hazardous gases are produced after burning it. But calorific value of these Briquettes is less approximate 4000 Kcal/kg. Firstly these briquettes are burnt in the boiler. These produced heat energy are used for increasing the temperature of thermopic oil @ 200°C. These heated thermopic oil are circulated in paint shop to boiler through insulated pipe lines. Heat energy of this thermopic oil is used for drying the painted components. After reducing heat energy of thermopic oil, it moves toward boiler for absorbing heat energy. This process repeats continuously. The major energy consuming machine is boiler (fuel: Briquettes) and electricity machines are ID and FD fans.

Incinerator: Incinerator is most important part of industry based environment because all the scrap and paint are burnt in incinerator. The wasted paints have many hazardous chemicals which can't throw in environment openly. So it need to burn for removing those hazardous chemical form paints in incinerator. Incinerator is operated by high speed diesel @ 1000°C and its fuel gases are washed by water through APCD (Air Pollution Control Device). The hazardous gases from incinerator are scattered down by water. The major energy fuel used in incinerator is Diesel.

4.2 Energy analysis and details

At induction period in engineering industry, I explored entire industry with working of each shops/plants and faced many energy saving opportunities. After this, I discussed with HODs about all opportunities. These opportunities are following:

4.2.1 Data collection of motors (KW)

We generally know that the motors are major electricity consuming device in industry. So I had main focus on motors using in shops/plants. I need to find efficiency of each motor but initially I had to collect the motors' specification like KWh, rpm, rated efficiency volts, ampere at full load and made a sheet of all motors' specification. The name plates on motors contain all data at full load.

4.3.2 **Evaluate Motor Efficiency**

After collecting data, I classified motors according to its KWh rating because removing heavy old motors with new energy efficient motors are more beneficial than low rating motors. So I prepared a new class of motors those KWh rating are greater than 10 Hp. After this process I moved the further process of evaluating efficiency of motors.

For evaluating efficiency of motors I studied many factors and important fundamentals. We generally know that efficiency of any system is the ratio of output and input. In other hand we can say remaining output energy is input energy after all losses in the system.

4.2.2.1 Losses in Induction motor

Mostly three phase induction motors are using in industry. There are various losses in stator and rotor of induction motors. These losses are occurred by current, fluctuation (voltage) and different reasons. For understanding the losses, we need to study about energy flow diagram in induction motor. In this diagram, we can understand step to step process of energy flow in motors. Energy flow diagram is following:

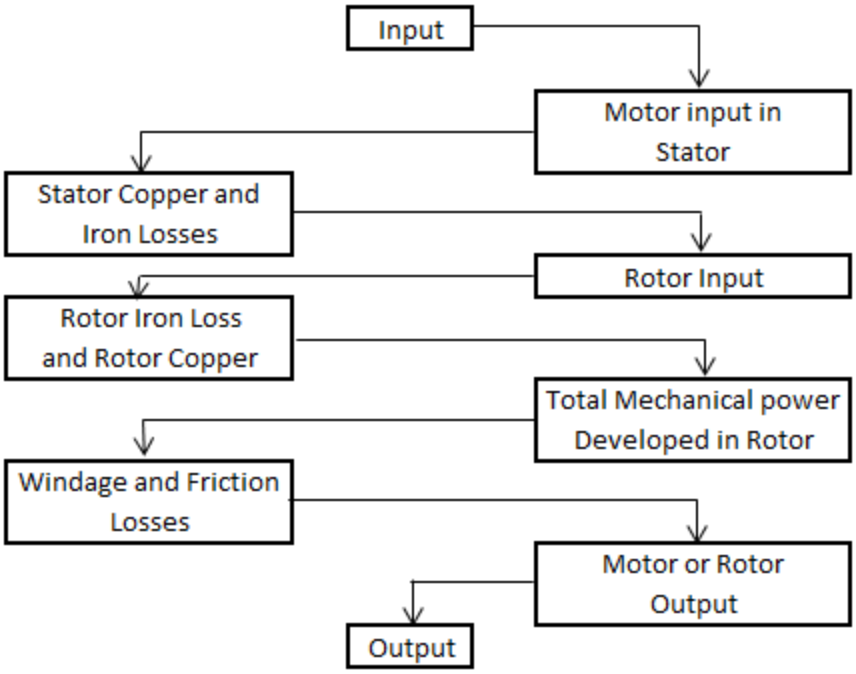

Figure 4.1: Flow diagram of losses in three phase induction motor

Stator and Rotor I^2R losses: These losses are major losses in induction motor like approximately 55-60% of total losses. I^2R losses are produced by current passing thought the conductors. I^2R losses are the function of the resistance and the square of the current flowing in the conductors. Resistance is depending upon conductor materials, length and cross sectional area. So the suitable and better selection of copper conductor will reduce the resistance and their losses. Further for reducing the motor current is most accomplished by decreasing the magnetizing component of current. It will occurred by reducing operating flux density and possible shortening of air gap. Rotor I^2R losses are the function of the rotor conductor and rotor slip.

Core losses: core losses are found in stator and rotor magnetic steel due to hysteresis losses and eddy current losses. These losses are independent of load and it is approximate 20-25% of the total losses. The hysteresis losses, which are the function of the flux density, are be reduced by utilizing low loss grade of silicon steel lamination. And eddy current losses are generated by circulating current within the core steel laminations. These losses are reduced by using thinner laminations.

Friction and Windage losses: Friction losses are occurred by the friction due to bearing and Windage losses are occurred by the circulating air though the cooling fan in the motors. These

losses are independent of load and approximate 8-12% of total losses. The heat generated by stator and rotor losses is reduced by the use of smaller fan. The Windage losses also reduce with the diameter of fan leading to reduction in Windage losses.

Stray Load-losses: These losses vary according to square of the load current and are caused by flux induced by leakage load currents in lamination and approximate 4-5 % of total losses. These losses are reduced by careful selection of slot number, tooth/slot geometry and air gap.

4.2.2.2 Starter for three phase induction motors

We generally know that three phase induction motors are self-started but we need some starter to start it. The starter for induction motor doesn't mean to start the motor; it means to prevent the motor 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. We studied that torque of induction motor is proportional to current then obviously motor take highest current. Three types of starter are used in industry:

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

The working principle and uses of these starters are different. Mainly, star-delta starters are used in engineering industry because it is cheaper, reliable and easy to maintain. In star delta starter, the motor runs with star connection at starting, after obtaining 80% of synchronous speed it is converted with delta connection. In star connection, there are three wires and one neutral wire. Therefore the phase voltage is $1/\sqrt{3}$ of line voltage. With the help of this function, the starting torque will be reduced because the starting torque is proportional to square of the starting voltage and this torque is also proportional to starting current. For overloaded and under loaded condition, the fuses are took placed.

$$\text{Starting torque with star-delta starting} = (V_L/\sqrt{3})^2$$

$$\text{Starting torque with direct switching in delta} = V_L{}^2$$

$$\frac{\text{Starting torque with star} - \text{delta starting}}{\text{Starting torque with direct switching in delta}} = \frac{\left(\frac{\text{VL}}{\sqrt{3}}\right)\text{ˆ2}}{\text{VLˆ2}}$$

$$\frac{\text{Starting torque with star} - \text{delta starting}}{\text{Starting torque with direct switching in delta}} = \frac{1}{3}$$

As per this method, the starting current with star-delta starting is one third of starting current with direct switching in delta connection because starting torque is directly proportional to starting current.

4.2.2.3 Determine Motor loading

Finding of motor working load is the main part of the energy efficiency calculation of induction motor because life of the motors depends on the loading. If the motor is working under load condition then it will damage the motors gradually. In case of overload condition, the motor will take 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 method, the RPM of the running motor will be found with the help of tachometer and found motor loading in percentage.

$$\text{Loading (in percentage)} = \frac{(\text{Slip})}{(\text{Ss} - \text{Sr})} \times 100$$

Where; Slip = Synchronous speed – measured speed,

S_r = Rated RPM on nameplate of induction motor

S_s = Synchronous speed of induction motor

Further researching on this concept, I found that this method is not accurate. For more accuracy, I should divide the square of the ratio of voltage. Now, the formula would be:

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

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

4.2.2.4 Determine the Resistance in induction motor

Finding resistance is also the main part for evaluating energy efficiency of motors because maximum losses in the induction motors are due to resistance. Core loss and heat loss is large amount of loss in induction motor. These losses are the function of resistance. But initially evaluation the losses, we should know that which type of connection are take placed in induction motor like star connection or delta connection. So recognizing of these connections is necessary.

In this diagram, the coils are connected with star connection. So evaluating of resistance I took use ohmmeter.

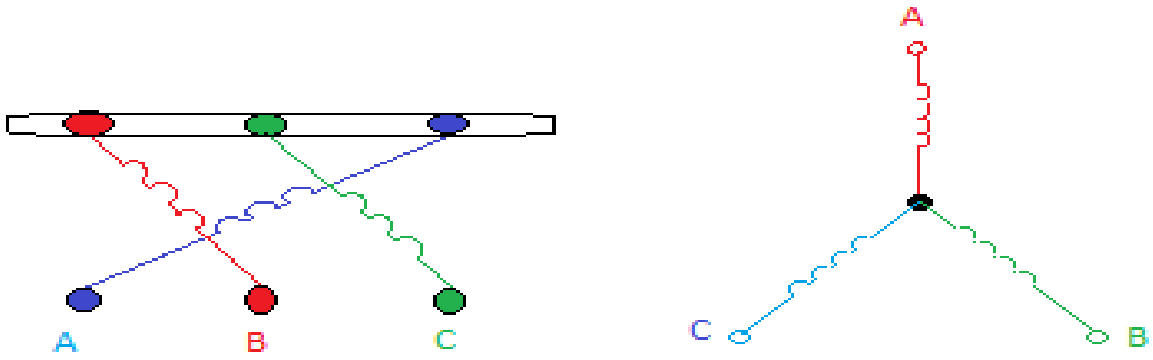

Figure 4.2: Star connection in induction motor

The ohmmeter has two probes. I connected one probe with A point and second probe with B point. According to diagram, the reading shown in ohmmeter was the total ohms of two coils. So for evaluating of resistance per phase, I divided by 2 in resistance shown in the ohmmeter.

If the coil is connected with delta connection then the entire physical process is same expect calculations.

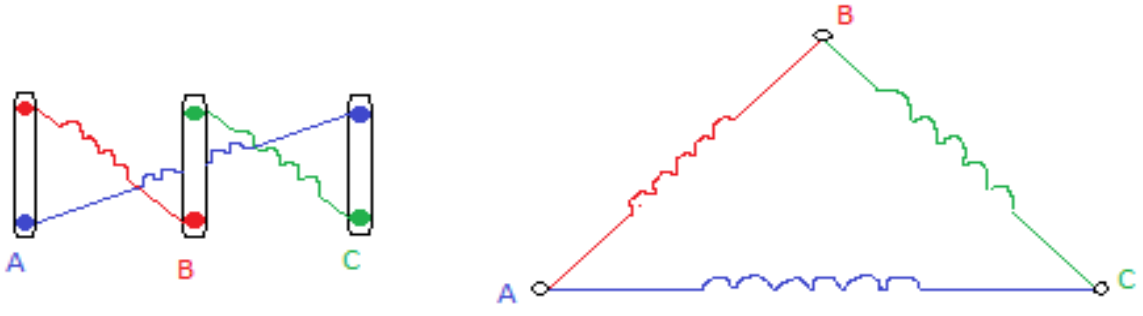

Figure 4.3: Delta connection in induction motor

According to this diagram, I connected one probe with a point and the second probe with B point. The reading was shown in the ohmmeter was different with the actual per phase resistance. The actual resistance was:

Suppose, the resistance between AB,BC and CA would be same 'R'. The resistance between A and B was,

$$\text{Resistance between A and B } (R') = \frac{R \times 2R}{(R + 2R)}$$

$$\text{Resistance between A and B } (R') = \frac{2}{3}R$$

The total resistance shown by ohmmeter was R'. If I multiplied by 3/2 in R', then I got the actual resistance per phase. This was simple and accurate method to find resistance per phase.

4.2.2.5 Calculation for evaluating Efficiency of motors

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

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

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

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

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

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

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

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

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

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

				Rated volts	415			Stator losses	0.04			Friction losses	0.02				
		Imp. DATA							Stator losses			Rotor					
S.No.	Particulars	Synchronous speed	Rated RPM	ON Load RPM	Rated KW	ON Load (Volts)	Stator input (KW) /Input power ON LOAD	LOADING (%)	Slip	Staor losses (KW)	Input powr to rotor	Rotor copper Losses	Total mech. Power delliverd by rotor	Friction losses	O/P of motor	Efficiency	Remarks
	Bonderising plant																
	Plant 1																
1	oven blower A	1500	1450	1480	7.5	407.33	3.2	39	0.01333	0.3	2.9	0.03867	2.86133	0.15	2.71133	**84.7**	**Oversized**
2	oven blower B	1500	1450	1480	7.5	403.33	3.8	38	0.01333	0.3	3.5	0.04667	3.45333	0.15	3.30333	**86.9**	**Oversized**
3	fume exhaust blower(phosphating)	1500	1450	1460	7.5	400	2.5	74	0.02667	0.3	2.2	0.05867	2.14133	0.15	1.99133	**79.7**	
4	fume exhaust blower(degrassing)	1500	1450	1440	7.5	400	1.8	111	0.04	0.3	1.5	0.06	1.44	0.15	1.29	**71.7**	

Figure 4.4: excel sheet of evaluating motor efficiency

Using this concept, I evaluated efficiency of many 3- phase induction motors. Induction motors, whose efficiency was less than 70%, were recommended to replace with Energy efficient motors. In loading table, I had to recheck its starting current, because these motors took very large current when it was started. So decreasing starting current, I recommended maintaining its gearbox and bearing regularly.

4.3.3 **Recheck recommended projects by energy auditor**

After collecting and finding more information, I used to work on the previous energy auditor recommended projects which were implemented in engineering industry. These are also an important part of my internship. Because all recommended energy saving projects should be completed/implemented in industry. After these projects, new projects could be implemented.

As per this system, I found the previous auditing reports and started rechecking of the recommended energy saving projects. After reading of their reports/projects, my knowledge and supervision for energy saving are enhanced. That was the best part of my internship. There were many energy saving projects in their reports. After reading these projects, I started to recheck their recommended projects. Day by day, I used to check and repaired it when there were any faults. Where the projects were not implemented, there I started projects with the electrical and mechanical departments.

4.3.4 **Prepare the energy flow chart and energy cost monthly**

As per doing internship in energy conservation in engineering industry, I should collect all energy consuming data and their consumptions in industry. Because for implementing of any energy saving projects, the previous fuel consuming data and after projects fuel consuming data are useful. By the help of this data we can calculate and know; how much projects are beneficial.

For this process, I prepared a list of all manufacturing departments in industry. Doing this, I identified the manufactured products under industry. In this process, I used to calculate that how much fuels and electricity are consumed for making one each product. For processing this project, I used to collect the productions, total fuel consumption and electricity consuming data of all shops/units on daily base. After collecting these data, I prepared energy consuming data on department vise.

Example for understanding, I would like to prepare the energy flow data of paint shop. So, there are two types of energy fuel are used in paint shop, like diesel and electricity. Diesel is used for drying the painted products and electricity are used for blower, light, fans, etc. So I collected the total production in day, after this I collected total fuel consumption and electricity used in this same shop in day. After collecting these data, I prepared a sheet. In this sheet there were five rows, like production, consuming fuel, electricity, fuel per production, electricity per production. After preparing the chart of this sheet, I used to present before responsible person.

These entire processes I did for all departments/shops on daily base. The main purpose of this process is to understand the variation of the consuming fuel and electricity per production & which departments are needed more energy saving and improving projects.

4.3.5 **Reintroduce VFD**

Variable frequency drives are known as VFD. Now these days, this device is very useful in energy saving projects because this device can decrease RPM (rotation per minute) of induction motor. VFD is useful where we need low RPM or where we need damping valve for increasing and decreasing the flow of air/water according to load.

Figure 4.5: picture of VFD

There are VFDs are stopped by some technical reason and carelessness. VFDs are an expensive device. So we should use it systematically.it are useless when it aren't used. After seeing the stopped VFD, I discussed with electrical department and higher authorities. After discussing, these problems are solved with the help of electrical department.as well as they provided an analogic controlling regulator for controlling RPM of motors as per uses.

4.3.6 **Introduce the concept of heating FO by fuel gases in Dip Brazing furnace**

There is main role of furnaces in engineering industry. Mainly, the combination of Fuels and air are used in furnaces. In this furnace we can burn the fuel and extract thermal energy. Using of this energy we can melt the materials and do brazing etc.

4.2.6.1 Furnaces in engineering industry

In engineering industry, the furnaces take placed in Tubular plant for brazing. There are 14 furnaces for frames brazing and 7 furnaces for forks brazing. Both furnaces rows have one- one APCD (Air Pollution control Devices). The fuel which are using in furnaces is FO (furnaces oil). Everyday 7 frame furnaces and 3 fork furnaces are burnt as per production.

Figure 4.6: Picture of Dip Brazing

In 14 Frame brazing furnaces, three main components of Cycles are brazed. These three components are BB joint, Head joint and seat joint. There are 7 head & seat joint furnaces and remaining 7 furnaces for BB joint.

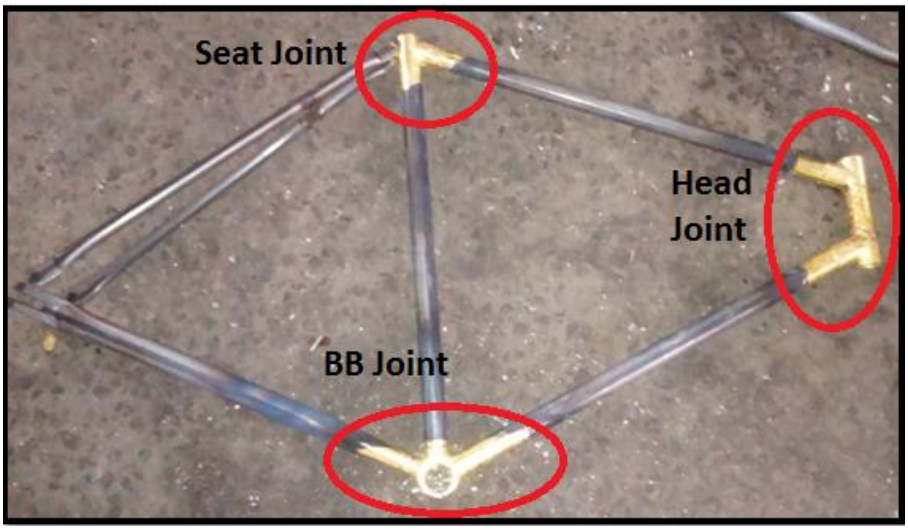

Figure 4.7: Joints in cycle frame

FO (Furnace Oil) is stored in large tanks of capacity 40kl at the back side of the industry. These tanks are heated by steam to maintain its viscosity. These tanks are insulated by fiber glass material.

Figure 4.8: picture of storage tank

Working

The area of furnace is 2×2 meter^2. These furnaces are insulated by the refectory bricks. In furnace FO is used. Borax & boric acid are also used as a flux. Brass and zinc are heated up till 1000°C temperature for brazing. Different parts of frames or forks are dipped in this solution. The

consumption of FO is 17 liters/furnace/day. The ratio of boric acid & borax which is using as flux in furnace is 2:1. The fuel is ejected in furnace with the help of air which are produced by air blower.

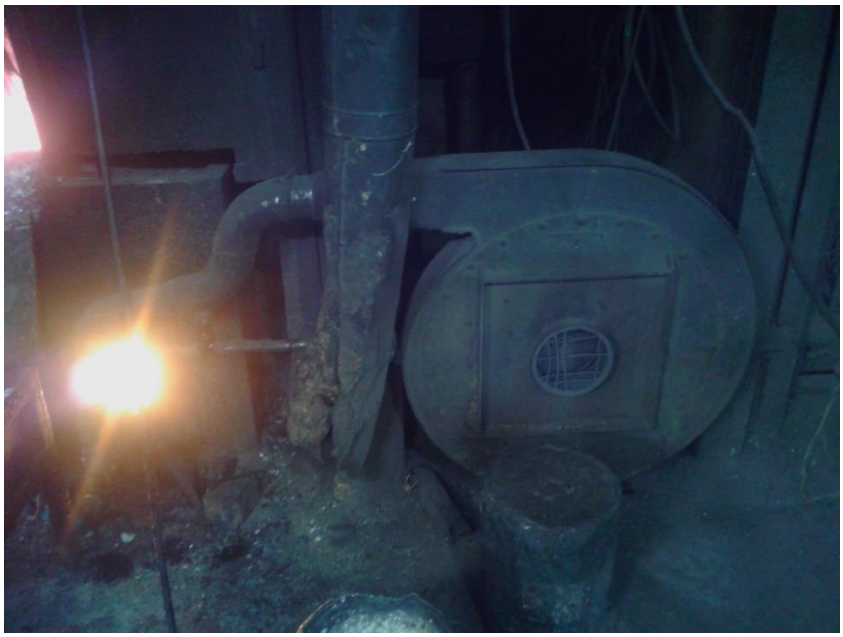

Figure 4.9: picture of air blower

4.2.6.2 Energy Consumption Units in furnace

The fuel which is used in furnace is the mixture of FO and air. In these furnaces, there have electric blower for air flow. These blowers were being operated for 20 hours daily. The furnaces were shut down then these blowers were being operated for cooling the furnaces.

There had electrical heaters for each furnace. These heaters were used to heat FO oil in pipes. The power consumption of each electric heater was 2 KW. These heaters were being operated for 20 hours to maintain the viscosity of FO oil.

Figure 4.10: picture of electrical heater

Therefore, after auditing the whole furnaces I found solution in the electric heaters which consume electrical energy. The amount of electrical energy which was consumed by heaters is quite large.

Total Electrical heaters working/ day = 7 frame furnace + 3 fork furnace = 10 furnaces

Electric heater energy consumption = 2 KWH

Working hours = 20 hours/day

Units consumed per day = 10 furnaces × 2 KWh × 20 hours = 400 units/day

Electricity cost = 7.3 rupees/ KWH

Money consumed per day = 400 units/day × 7.3 rupees/KWH = 2920 rupees

Money consumed per year = 2920 × 300 rupees = 8,76,000 rupees

If we remove these heaters then we can save approximate 8 lakhs in one year. So for doing this, we can heat FO pipes with internal thermal energy of furnace.

How to save energy

We can save this electrical energy by using internal thermal energy of furnace. Lots of thermal energy was wasted, which was not useable. So we could use it to heat the FO pipes. The temperature in furnaces' free space was approximate above 500°C and the walls' temperature was approximate 250°C. That temperature had lots of energy to heat the FO. The internal picture of the furnace is below:

Figure 4.11: inner picture of Dip brazing

You can assume the thermal energy in furnace. We can fit the FO pipes in the wall of furnace. And the thermal heat is consumed by these pipes and transfers the energy to FO. The gaps between the pipes and the length of pipes are calculated by calculation. The temperature of FO which we need for burning is 60°C. And the incoming FO's temperature is 48°C in summer season.

4.2.6.3 Calculation for new designing

For new design of FO pipes in furnaces, we use to study about heat and mass transfer. This concept is based upon that theory. How much air flow, its temperature etc. fluid mechanics play beautiful role in this calculation. The concepts which are useful for this calculation are:

- Heat & mass transfer
    - Conduction, convection & radiation theory

    - Kinematic viscosity
    - Reynolds number
    - Prandtl Number
    - Nusselt Number
    - Heat transfer coefficient
- Fluid Mechanics
    - Laminar and turbulent flow
    - Affinity Laws
    - Head loss

These topics are useful for this project. Absence of these knowledges we don't suppose to solve or understand these solutions. Then let's start these topics.

Heat and Mass transfer

In heat and mass transfer, we use to study about flow of heat .How can heat flow, how much heat can flow. Heat always flow from high to low .Heat transfer is always a non – equilibrium process. By heat transfer we can predict the distribution of temperature which is the function of time and spatial co-ordinates. Also by heat transfer we can determine the rate of flow of energy that energy is transferred between the different surfaces' temperature. The Heat transfer is done by three methods:

- Conduction
- Convection
- Radiation

Conduction: Thermal conduction is a mechanism of heat transfer from higher energetic body to low energetic body within the medium (solid, liquid and gaseous state). But heat can be transfer in same medium. The heat is transferred by free electrons present in the body, and vibration of the electrons.

Suppose, if the rod is heated up by a candle. One end of the rod is heated then the temperature of that end should be increased. Suddenly if we touch the other end of the rod then we feel, the temperature of this end also increase. That phenomenon is known as conduction.

The rate equation for one dimensional steady flow of heat;

$$Q = -kA \frac{dt}{dx}$$

Where, Q= the heat transfer rate

A = area of heat transfer surface

dt/dx = the temperature difference by changing the distance dx.

Convection: Thermal convection is a mechanics of heat transfer affected by the circulation from one substance to other substance by the fluid medium. This is considered by only the fluid medium like gas, liquid or powdery.

Suppose, if a hot air flow in a room and a material sheet is placed in a room. Then after some times that material is got warm by the air flow. This method is known as convection. The formula is;

$$Q = hA\,(ts - tf)$$

Where; Q = the convective heat flow rate

A= the area exposed to heat transfer

$(ts - tf)$= difference between the surface and fluid temperature

Radiation: Thermal radiation is the transmission of heat in form of radiant or wave energy form one body to another body. As conduction, convection the medium is not considered in thermal radiation. As like the Sun can also transfer heat by radiation. Thermal radiation is transferred by electromagnetic waves, transformation of waves and passage of wave through intervening space.

Kinematic Viscosity: to understand the meaning of kinematic viscosity, we have to know about the absolute/ dynamic viscosity. Dynamic viscosity is " the measure of the viscosity of a fluid, equal to the force per unit area required to maintain a difference of velocity of one unit distance per unit time between two parallel planes in the fluid that lie in the direction of flow and are separated by one distance: usually expressed in poise or centipoise.''

$$F = \mu A \frac{\partial u}{\partial y}$$

Where: F = Force acing on the surface

A= area of the surface

$\frac{\partial u}{\partial y}$ = local shear velocity.

μ = dynamic viscosity.

Kinematic viscosity is the ratio of the dynamic viscosity μ to the density of the fluid ρ. It is denoted by ν.

$$\nu = \frac{\mu}{\rho}$$

Reynolds number: Reynolds number is the ratio of inertia force to the viscous force, as well as indication of the relative importance of inertial and viscous effects in a fluid motion. If the Reynolds number is low then the flow motion is laminar, and if the Reynolds number is high then the flow motion is turbulent flow.

$$\mathrm{Re} = \frac{\text{Diameter of the pipes } \times \text{velocity of air}}{\text{Kinematic velocity}}$$

Prandlt Number: Prandlt number indicates the relative ability of the fluid to diffuse momentum and internal energy by molecular mechanisms.

$$\mathrm{Pr} = \frac{\mu\, \mathrm{Cp}}{\mathrm{k}} = \frac{\rho \nu \mathrm{Cp}}{\mathrm{k}} = \frac{\nu}{\left(\frac{\mathrm{k}}{\rho \mathrm{Cp}}\right)}$$

The parameter $\left(\frac{k}{\rho Cp}\right)$ is called thermal diffusivity α of the fluid.

$$\mathrm{Pr} = \frac{\nu}{\alpha} = \frac{\text{kinematic viscosity}}{\text{thermal diffusivity}}$$

Kinematic viscosity indicates the momentum transport by molecular friction,

Thermal diffusivity indicate the heat energy transport through conduction,

Prandtl Number provides a measure of the relative effectiveness of momentum and energy transport by diffusion.

For highly viscous materials, Pr is quite large. Then its means rapid diffusion of momentum by viscous action compared to the diffusion of energy.

For gases, Pr is near unity; its means the momentum and energy transfer by diffusion are comparable.

For liquid metals, Pr (0.003 to 0.01), its means more rapid diffusion of energy compared to the momentum diffusion rate.

Nusselt Number: Nusselt Number is the relation between convective film coefficients *h*, thermal conductivity of the fluid *k* and a significant length parameter *l* of the physical system;

$$\mathrm{Nu} = (\frac{\mathrm{hl}}{\mathrm{k}})$$

Heat Transfer Coefficient: convective coefficient *h* depends upon the thermodynamic and various parameters like density, specific heat, thermal conductivity and viscosity. These parameters are discussed in above section.

$$\mathrm{h} = \frac{(\text{Nusselt number } \times \text{thermal conductivity})}{\text{Diameter of pipes}}$$

After extracting *h* from the above equation, we can determine the total rate of convective heat transfer between the body and the fluid;

$$\mathrm{Q} = \mathrm{hA}(\mathrm{ts} - \mathrm{tf})$$

Where ; Tf = temperature of the fluid,

Ts = temperature of the wall surface,

A = area of the surface,

H = heat transfer coefficient.

Fluid Mechanics

In fluid mechanics, we can study about the motion, behavior and physical properties of fluid. And if we are studying about heat and mass transfer and thermal dynamic then we have to study about fluid mechanics. Some parameters which are using in this project are following:

Laminar flow: In laminar flow, the path of the fluid's flow is uniform, flat and well-define. The fluid particles obtain the uniform position at cross sections of the flow passage. The particles are always parallel to the successive below layers.

Turbulent flow: In Turbulent flow, the path of turbulent flow is irregular, unpredictable. The flow of the fluid always suddenly changes. The fluctuating transverse velocity components are superimposed on the main flow. The direction of flow and perpendicular to it are fluctuated by the velocity of individual fluid.

Affinity laws: Affinity laws are applicable for when we discuss about head loss, efficiency and energy consumption. In this project we have to know the fuel's flow rate after implementation. So Affinity laws have three equations;

$$Q \propto N$$

$$H \propto N^2$$

$$P \propto N^3$$

Where: Q = Flow rate

H = Head

P = Power absorbed

N = Rotating speed

Head Losses: we generally know that some energy is needed to flow liquid in pipe. Because of these frictional losses, viscosity losses, the energy and pressure present in the liquid is decreased. These losses are known as Head Losses. In this project we use to consider these factors.

4.2.6.4 Mathematical Calculation

Firstly we need to calculate the length of pipes required in furnace to increase the temperature of FO from 48°C to 60°C. In the furnace the exhaust air have high temperature and this property is changed according to every temperature. Then we attached a sheet of properties of air.

Temperature	**Density**	**Specific Heat**	**Thermal Conductivity**	**Kinematic Viscosity**
- t -	***- ρ -***	***- c_p -***	***- k -***	***- v -***
(^oC)	***(kg/m^3)***	***(kJ/(kg K))***	***(W/(m K))***	***x 10^{-6} (m^2/s)***
-150	2.793	1.026	0.0116	3.08
-100	1.98	1.009	0.016	5.95
-50	1.534	1.005	0.0204	9.55
0	1.293	1.005	0.0243	13.3
20	1.205	1.005	0.0257	15.11
40	1.127	1.005	0.0271	16.97
60	1.067	1.009	0.0285	18.9
80	1	1.009	0.0299	20.94
100	0.946	1.009	0.0314	23.06

120	0.898	1.013	0.0328	25.23
140	0.854	1.013	0.0343	27.55
160	0.815	1.017	0.0358	29.85
180	0.779	1.022	0.0372	32.29
200	0.746	1.026	0.0386	34.63
250	0.675	1.034	0.0421	41.17
300	0.616	1.047	0.0454	47.85
350	0.566	1.055	0.0485	55.05
400	0.524	1.068	0.0515	62.53

Table 4.1: Properties of air

Parameters

FO (furnace Oil)

Specific heat of FO (C_p) = 0.468 kcal/kg/°C

Density of FO = 920 Kg/m^3

Flash point (°C) = 66

Gross Calorific Value (kcal/kg) = 10500

Furnace Data:

FO (input temperature) = 48°C

FO (output temperature) = 65 °C

Radius of pipes (meters) = 0.0635

Flow rate of FO = 17 liters/hour/furnace = 18.4782 Kg/hour/furnace

Velocity of exhaust air in furnace = 5 meters/ second

Thermophysical properties of Air(200°C)					
Density (Kg/m3)		0.746	Air temp(°C)	200	

Specific heat(kJ/(kg K))	1.026		0.2450559	(Kcal/kg °C)
Thermal conductivity(W/(m K))	0.0386		0.03319	(Kcal/ h.m.c.)
Kinematic Viscosity(x 10-6 (m2/s))	34.63		29.85	(x 10-6(m2/s))
velocity(m/sec)	5			

Table 4.2: Thermophysical properties of Air @ 200°C

Reynolds number

$$\mathrm{Re} = \frac{\text{Diameter of the pipes } \times \text{velocity of air}}{\text{Kinematic velocity}}$$

$$\mathrm{Re} = \frac{0.0635 \times 5}{34.63 \times 10^{-6}}$$

$$\mathrm{Re} = 9168.4$$

Re is greater than 2000 then turbulent flow.

Prandtl's Number

$$\mathrm{Pr} = \frac{\text{specific heat } \times \text{dynamic viscosity}}{\text{Thermal conductivity}}$$

$$\mathrm{Pr} = \frac{\text{density} \times \text{kinematic viscosity} \times \text{specific heat}}{\text{Thermal conductivity}}$$

$$\mathrm{Pr} = \frac{0.746 \times 34.63 \times 10^{-6} \times 0.245}{0.03319}$$

$$\mathrm{Pr} = 0.000191$$

Nusselt Number

$$\mathrm{Nu} = 0.023 \times \mathrm{Re}^{0.8} \times \mathrm{Pr}^{0.33}$$

$$\mathrm{Nu} = 0.023 \times (9168.4)^{0.8} \times (0.000191)^{0.33}$$

$$\mathrm{Nu} = 2.014$$

Heat Transfer Coefficient

$$\mathrm{h} = \frac{\mathrm{Nu} \times \text{thermal conductivity}}{\text{diameter of pipe}}$$

$$\mathrm{h} = \frac{1.685 \times 0.03319}{0.0635}$$

$$h = 1.05 \frac{kcal}{h..m^{2}.C}$$

For Length

$$Q = h.A.\Delta t$$

$$m.Cp.\Delta t(\text{between inlet \& outlet temperature of FO})$$

$$= h.A.\Delta t(\text{between air \& average temperature of FO}$$

$$m.Cp.\Delta t = h.2.\pi.r.l.\Delta t$$

$$\text{length} = \frac{m.Cp.\Delta t}{\pi.d.h.\Delta t}$$

$$\text{length} = \frac{18.48 \times 0.438 \times (65 - 48)}{3.14 \times 0.0635 \times 1.05 \times (200 - 56.5)}$$

$$\text{length} = \frac{137.60}{25.18}$$

$$\text{length} = 4.58 \text{ meters}$$

By calculating the length, we can arrange piping system. We can arrange the pipes with walls, doing these perhaps some bents will be done. And if bents are there then head losses also consider.

Calculation for head losses

Density of FO (kg/m^3): 0.815

Diameter of pipes: 2.5 inches = 0.0635 meters

Flow of FO: 17 Liters/hour = 20.9 kg/hr.

Kinematic viscosity of FO: 1.72×10^{-4} m^2/sec

Total length: 5 meters

Velocity of FO

$$V = \frac{\text{flow of FO}}{(\text{density of FO} \times \text{cross section area of pipe})}$$

$$V = \frac{20.9}{(0.815 \times 3.14 \times 0.0635^2 \times 3600}$$

$$V = 0.5615 \text{ meter/sec}$$

Reynold number

$$Re = \frac{\text{velocity of FO} \times \text{diameter of pipe}}{\text{kinematic viscosity}}$$

$$Re = \frac{0.5615 \times 0.0635}{1.72 \times 10^{-4}}$$

$$\text{Re} = 207.3$$

F for pipes

$$\text{f} = \frac{32}{\text{Re}}$$

$$\text{f} = \frac{32}{207.3}$$

$$\text{f} = 0.1543$$

Elbow number used in design: 8

K for elbows

$$\text{k} = \text{elbows quantity} \times 0.75$$

$$\text{k} = 8 \times 0.75$$

$$\text{k} = 6$$

Total equivalent length

$$\text{total equivalent length} = (\text{total length}) + \frac{(\text{k for elbow} \times \text{dia of pipe})}{\text{f for pipe}}$$

$$\text{total equivalent length} = 6 + \frac{(6 \times 0.0635)}{0.1543}$$

$$\text{total equivalent length} = 8.468 \text{ meters}$$

Head loss in pipes

$$\text{head loss} = (\text{f for pipe}) \times \frac{(\text{total equivalent length})}{(\text{dia of pipe})} \times \frac{(\text{velocity of FO})^2}{(\text{gravitational force})}$$

$$\text{head loss} = (0.1543) \times \frac{(8.468)}{0.0635} \times \frac{(0.5615)^2}{(9.81)}$$

$$\text{head loss} = 0.66 \text{ meter}$$

4.3 Energy conservation project and their implementation

4.3.1 Installation of Solar PV (Photovoltaic) Power System

Renewable energy is most commonly used in these days. The industries are focusing toward renewable energy like solar, wind, biofuels. Mainly these three renewable sources are being used in industries; remaining tidal and wave energy are not applicable for industries.

4.3.1.1 Introduction of Solar Energy

Sun is a great source of energy. Renewable and non-renewable energy are produced/ generated directly or indirectly from Sun. The rate of solar energy falls on the surface of earth is 120 pet watts. If this energy can be collected for one day, it can satisfy the whole world's demand for more than 20 years. Energy storage system is mostly common from all reliable solar technology. Likes, in Solar PV cells, we can use it for storing solar radiation energy in form of electrical energy. In Solar thermal collector we can use it for storing solar heat energy in form of thermal energy. The researches on solar energy are going on.

According to these criteria, solar power plant is installed in engineering industry, of capacity of 48.8 KW. This project serves multiple purposes.

- First, this Project is useful for reducing the load of the admin block approximate 20%. The total load of admin block is 480 KW.
- Second, by this project, industry is going towards renewable energy. (We are thinking to install solar thermal collector too.)
- Third, most of people in industry are attracting towards solar energy.
- Fourth, reduce the $CO_{2\ emission}$.

Solar PV Technology

Solar PV technology is one of the best technologies of renewable energy. By this technology we can directly convert sun energy into electrical energy. Due to growing demand for this solar PV technology, the manufacture of solar cell and photovoltaic arrays are in researching area. The researches on this solar panel are growing forward day to day. By this attention on Photovoltaic, this is making the world's fastest-growing energy technology.

Grid Type Solar PV Technology

Grid type solar PV technology is great technology. In this electrical energy from solar cells are directly connected with grid. And doing this, the load of the grid is radially decreased. E.g. if the industry load is 100 KW, the capacity of solar panels is 20 KW then the remaining electrical energy is consumed from the government. This technology is installed in engineering industry.

Area

There are 1025 m^2 free space on the admin block in industry with open area like, no shadow and perfect solar radiations. So, the distributor decided to install solar panel on the admin block of capacity of 48.8 KW.

4.3.1.2 Specification of solar Panels

For solar PV installation, solar photovoltaic cells are used for manufacturing solar panels because these types of solar panels are mostly common and easy to available. The efficiency of these solar panels is approximate 18 % which are good. The solar PV panels' characteristics are following:

Photovoltaic Module	
Company Name:	**Astronergy**
Maximum Power:	305.0 Wp
Open Circuit Voltage(Voc):	45.29 V
Short Circuit Current(Isc):	8.95 A
Voltage at Pmax (Vmp):	35.77 V
Current at Pmax (Imp):	8.53 A
Fuse Rating:	15 A
Nominal Operating Cell Temp(NOCT):	46°C
Cell Technology:	Poly-Si

Table 4.3: Specification of Solar panel

Figure 4.12: Picture of solar PV system

The area of solar panel is 2×1 m^2 and there are 160 solar panels installed; each has capacity of 300 watts. The gap between two rows of panels is about 3 meters because the shadow of one's panel can't effect on others.

Distribution of Solar panels

In engineering industry, there have two individual areas for installation on the roof of admin block. One side 82 solar panels are distributed and another side 78 solar panels are distributed. In 82 panels' side, there have 5 rows of solar panels likes, first row 18s, and remaining 4 rows of 16 solar panels. In 78 panels' side, there have also 5 rows of solar panels likes, first row 18s, and other two rows of 16s, remaining rows of 14s. By that type of distributions, 3 phases (R Y B) are extracted.

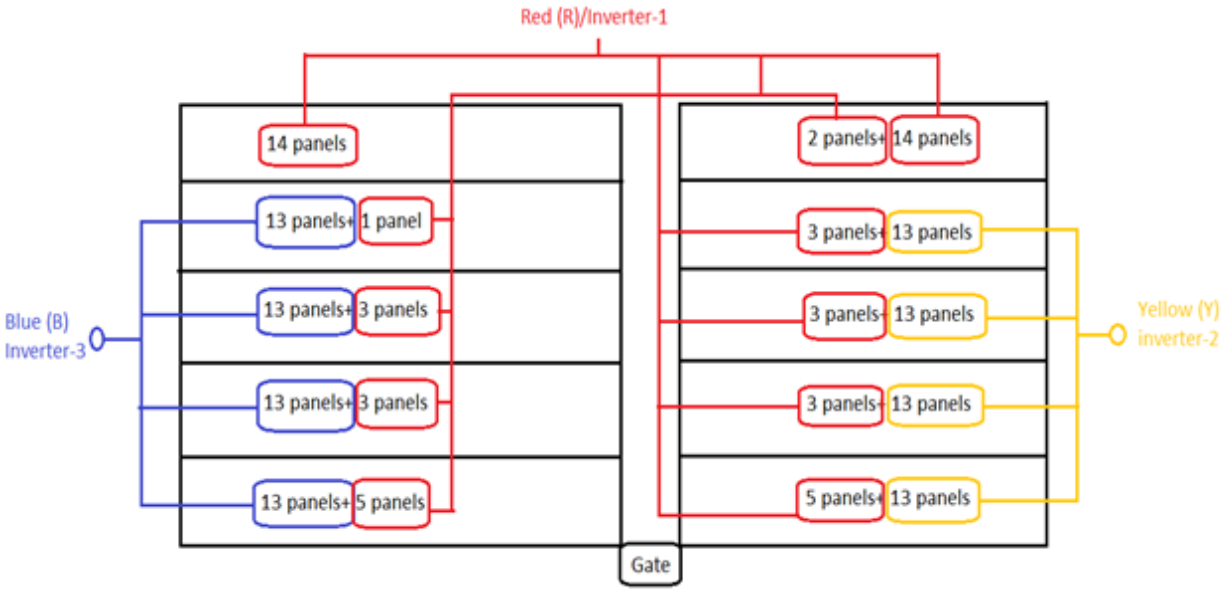

Figure 4.13: Solar panels distribution in engineering industry

Strings

Strings are the bundle of the solar panels, and each solar inverter has four strings input. That why we made 12 strings form the different solar panels (mentioned in above picture).the strings preparations are following:

- 4 strings for inverter 1 are made by 14-14 solar panels.

- 4 strings for inverter 2 are made by 13-13 solar panels.
- 4 strings for inverter 3 are made by 13-13 solar panels.

Combiner String box

These combiner string boxes are situated between solar panels and inverter. There are 6 combiner boxes; each inverter has 2 combiner string boxes. In combiner box there have safety fuses of 15 A and MCB DP DC of 32 A. And two strings are situated in one combiner box.

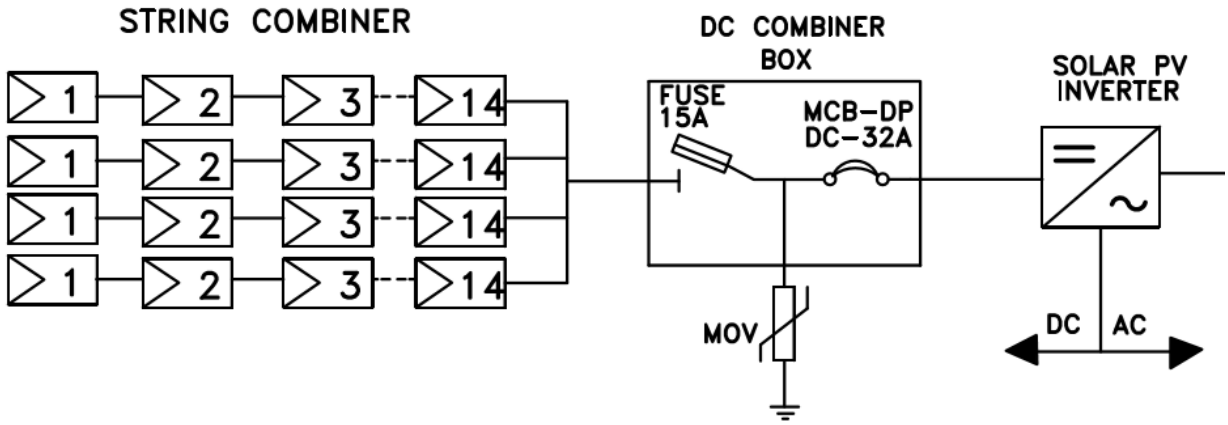

Figure 4.14a: Combiner box

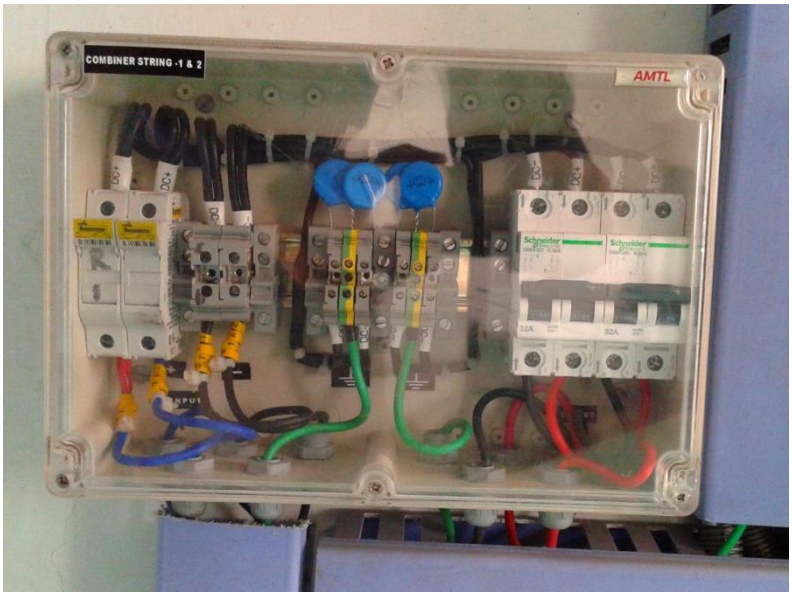

Figure 4.14b: Combiner box

Solar Inverter

We generally know inverter use to convert DC voltage to AC voltage. DC voltages are generated by solar panels and our electrical appliances in industry are mostly operated by AC voltage. So we need to convert DC voltage into AC voltage. Therefore we take help through inverter. SAM inverters are very efficient and reliable in industry purpose. There are three inverters for each phase. One inverter has four strings input and one Ac output. Those strings are made by the solar panels. This solar inverters need electricity to start and the initial electricity are consumed by main electricity line. After starting, it will automatically operate.

Figure 4.15: Solar inverter

There is a LED display. By this we can calibrate the important data like E-Today, E-Total, and Pf etc.

- E-Today: it indicates the energy generated by today. Means after every night it is reset.
- E-Total: it indicates the total energy generated from installed till now.
- Pf: it indicates the power factor of generated energy.

Grid Box

Grid box is installed after inverters. And all individual three phase with neutral line are connected with grid system. In it many safety fuses, MCCB etc. are inbuilt.

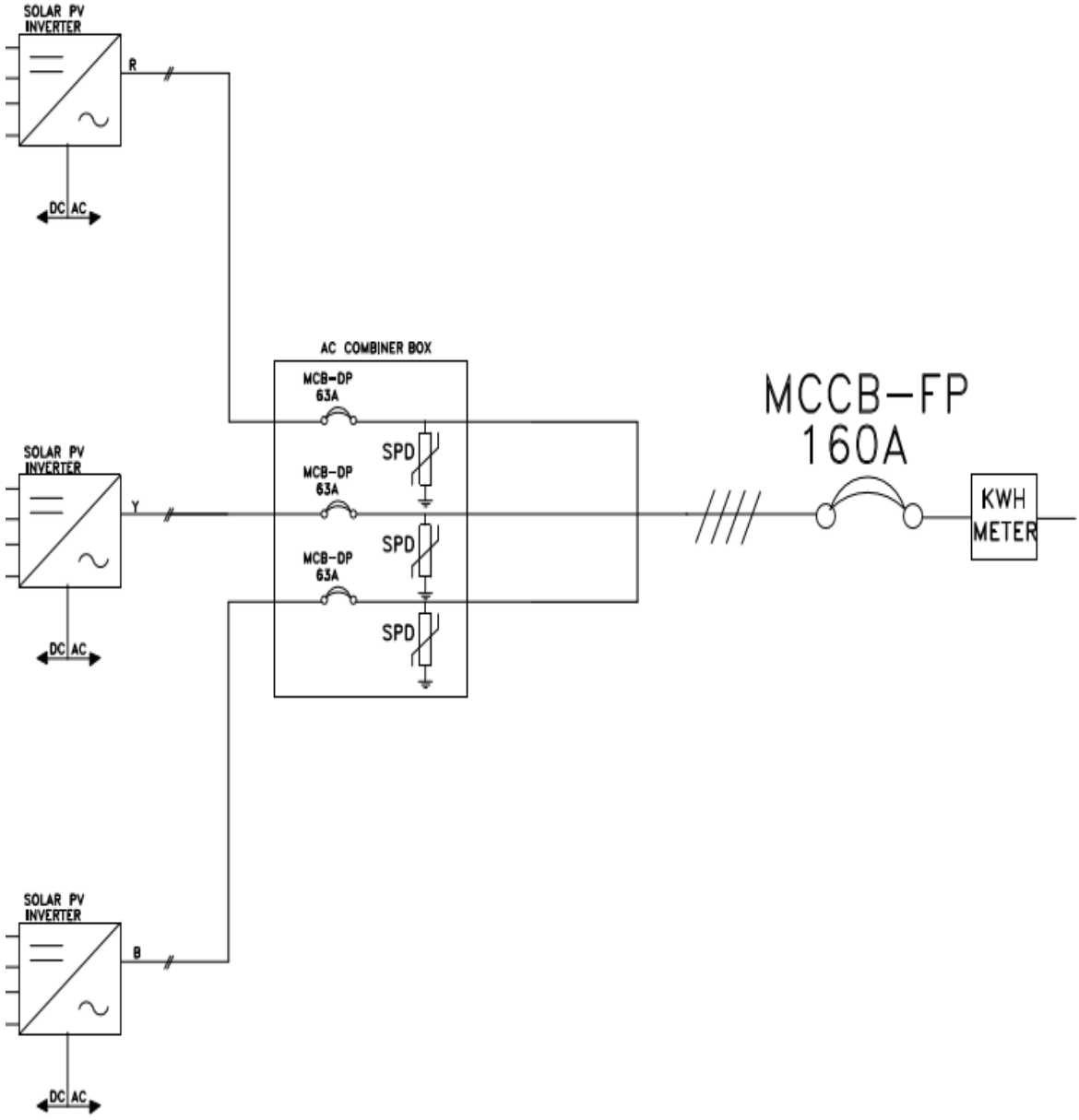

Figure 4.16a: Grid System

Figure 4.15b: grid system

In it there are 3 MCB-DP of 63 A and SPD for each phases. And after the AC combiner box there has a MCCB-FP of 160 A. Grounding is necessary.

4.3.1.3 Electricity Generation

The total cost of this 48.8 KW solar plant installation is 36, 60,000 and it is started on 1-October-2015. Total generation in October month is 4985 Kwh with average 160 Kwh/day. In October month there has clear sunny day. But in November month, this generation was 3650 Kwh because of cloudy day and short days, with average 120 Kwh/day. On the paper the payback periods is mentioned 5.5 years.

Total units	**October**	**November**	**El. Cost**	**October**	**November**	**Total Saving**
8632	4987	3645	7.3	₹ 36,405.10	₹ 26,608.50	₹ 63,013.60

Table 4.4: saving after installation of solar PV system

As well as analyzing the cost data, the monthly solar PV power generation chart has been prepared.

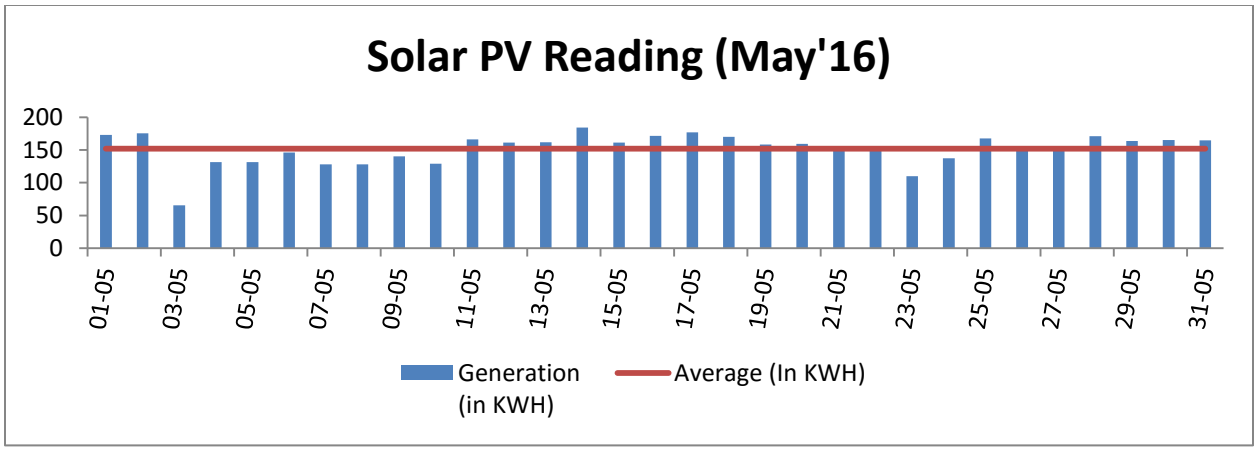

Figure 4.17: chart of solar power generation

4.3.1.4 Problems during installation

Many problems were faced during installation.it has many technical devices and connectors, to connect positive negative polarity of solar panels. The various problems are following during installation:

- Technical problems in connectors
- Neutral problem

There was a major problem in neutral, because those inverters are sensitive devices. If the inverter started without neutral then that would damage the inverter. So it is major issue but after few hours that problems have been solved.

4.3.1.4 Problems after installation

After installation, the Readings of solar panels generation were taken in every working hour. So during these works, many problems were faced. These problems are following:

- There were the problems with Kwh meters, those are not working properly, so I used to check it and after the checking those meters, I send the mail to solar installer service center and solved the problems.
- A major problem that we faced was grounding problems. The electrician connected the phase to ground for safety purposes but they forgot to connect neutral line with ground.

Figure 4.18: faults in grid box

So unfortunately, electric current may be flow in large amount. It damaged the whole phase wiring and burns it. So I immediately call the electric department and switch off the whole electrical supply. And also send the mail to solar installer service center to solve this problem immediately.

- One more problem that we faced was to take the reading of Kwh. Because after the meters problems, the meters were changed and put new meters. But a minor problem was. The meters were reset after every 999 Kwh. But after auditing by me that was not a serious problem. Those meters were based on new technology. There have three LED displays. The last LED display shows the Kwh till 999 Kwh but after 999 Kwh a one count is increased on second LED display. That was problem with meters.

4.3.2 Monitoring the project (LPG to Propane)

LPG (Liquid Petroleum Gas) is also a main energy source in engineering industry because the production and heating process is being preceded by LPG gas in engineering industry where I had completed my one year internship. There is a department under Ranger unit where the cycle joints are joined with the help of liquid brass. Firstly, the raw tubes are degreased then the frame and fork are manufactured manually and automatically. This type of assembly is not too good then for the good, smooth and rigid joint, the brass wires are melted with the help of the combustion of LPG and oxygen gas. The mixing ratio of LPG and oxygen is 1:3 that is economically good. The liquid flux of borax and boric acid is coated on the joint where the brazing is being done. The assembled frames are fitted on the rotatory machine. The function of this rotatory machine is to

heat the frame joint gradually and then drop the liquid brass on the joint. This liquid joint makes the joint smooth and rigid for long life.

These above processes are also done in tubular plant for some ladies' bicycles. LPG are also used or consumed in bonderising plant. The components are dried after phosphating in bonderising plant and there are four bonderising plants in engineering industry. Some amounts of LPG gas are also being used in saddle plant because the basic frames of the saddle are needed to dry.

There were two bullets of LPG gas capacity 10 MT (Metric Ton) each. These tanks were needed to fill by the unloading tanks. The filling process was occurred when the both bullets were being empty. After the long discussion with the members of engineering industry, a plan was considered to replace LPG gas with propane gas. LPG gas is the mixture of propane, butane, propylene, butylene and other hydrocarbons. The calorific value of the LPG gas is 11900 Kcal/kg and the pressure in the bullets was 9.2 kg/cm^2. There had many following reasons for going toward propane gas,

1. The calorific value of Propane gas is higher than LPG gas.
2. The obtained pressure of Propane gas is higher than LPG gas.
3. The Propane gas is lighter than LPG gas in weight.
4. The main factor, the price of propane gas is lesser than LPG gas.

When the calorific value of propane gas is higher, then the heating quality of the material is much larger than LPG gas. The material is heated quickly and the production of cycles will be increased. The pressure factor is beneficial because when the pressure is higher, then the material will also be heated quickly. The light weight factor, if in any worst case the propane gas will be leaked by some reasons then due to its light weight it will be mixed with the atmosphere and the accident will not be taken placed. In case of LPG gas it wasn't occurred. The main factor is price factor; the price of the Propane gas is much cheaper than LPG gas. These were the reason for preferring the Propane gas.

4.3.2.1 Components on Propane Bullets

There are many types of components are taken placed on the bullets. These components are very useful and safety purposes. The capacity of each bullet is 10 MT and the water capacity is 19990 liters. There are following components which are placed in bullets for safety purposes.

1. **ROV (Remote operating Valve):** this is a special type of valve, it can be operated by both type manually and automatically. A pipe of compressed air is provided in ROV. Because this compressed air helps to operate ROV manually.
2. **Sandwich valve:** sandwich valves are provided before the connection of ROV, drain pipe and pressure gauge. When we open ball valves immediately then the gas or liquid can't pass out form the bullets.
3. **Safety valve:** the two safety valves are provided on each bullet. The purpose of this safety valves is when the pressure in the tank is exceed than 21.5 kg/cm^2 then these safety valves will automatically operate and the pressure in the bullets is maintained less than 21.5 kg/cm^2.
4. **Inlet and outlet valves**: One liquid inlet, one vapor inlet and one vapor outlet valves are provided on each bullet.
5. **HLA (High level alarm):** this is a safety alarm are provided on each bullet. At liquid filling time in bullets, when the liquid is being filled in the bullets will reach the value 85% of liquid then the HLA will cut off the pump supply. Because the liquid filling process are done by the pumps.
6. **Drain pipe:** For hydro test, the bullets had to be filled by water. When the gas is filled then then the whole water have to drain. so this drain pipe is provided in each bullets.
7. **Roto gauge**: Roto gauge is the mechanical device to find the percentage of liquid gas remain in the bullets. The reading on the roto gauge is mentioned in percentage.
8. **Pressure gauge and temperature gauge:** one pressure gauge and one temperature gauge is provided in each bullets.

4.3.2.2 Components in yard (except Bullets)

Propone gas is very dangerous gas so safety is also much important part. So to make the safe and clean yard, the following components are placed in yard.

1. **Vaporizer:** Vaporizer is connected at the center of the bullets and the observer. The working of the vaporizer is to convert liquid to vapor gas by using the heat of vaporizer. In this vaporizer, the water pipes are surrounded in vaporizer. This water is heated by electrical heater. This heat is absorbed by the liquid and converts liquid to vapor.

2. **Pumps:** pumps are provided in the yard for filling liquid from unloading tank to loading tanks. There are two pumps. At a time, only one pump is in working condition. These pumps are connected with HLA (High Level Alarm)
3. **Compressor:** one compressor is provided in the yard. Sometime the vapor was remaining in the unloading tank and it couldn't be extracted. So for extracting this remaining vapor, the compressor is being used.
4. **Pop action valves**: this is one type of safety valve. When the pressure in the pipes is exceeded than rated PSI then this valve operates and maintain the pressure in the pipes.

4.3.2.3 Tanker Unloading Procedure at commissioning of storage tanks

1. Unloading hose liquid and vapor line connected.
2. Leakage checked of the unloading point : No leakage found
3. All vapor line valves open for transferring of the vapor to storage tanks.
4. After filling the vapor to the storage tanks, we start de-watering from the storage tanks.
5. Completion of the watering, we have done after flushing of the tanks with the vapor pressure (3-4 times) and clear all water particles through flushing from the storage tanks.
6. We have started liquid transfer from tanker to storage tanks and before starting, we have checked all leakage from the joints/flanges/elbows etc.
7. After completion of the liquid we have started recovery compressor receiving vapor from tanker and transfer to the storage tanks.
8. After completion of the vapor recovery, we have disconnected both hoses and closed all the liquid/vapor ball valves.
9. After commissioning of propane yard, road tanker handed over to store department.
10. Checked all parameters of storage tanks are found satisfactory.
11. We had transferring the vapor to SLR/Powder coating/Bonderising/Tubular shops found satisfactory and good operational.

CHAPTER 5

CONCLUSION

Many innovative ideas and projects have been implemented in the engineering industry. My vision are on saving of electrical and thermal energy, during this, the guidance of these saving projects and idea have been discussed with employers and workers because saving energy projects and ideas can implement all human being.

Much energy has been saved. After installing Solar PV power system, the electrical load of admin block of the industry are reduced by 20% and average daily 180 Kwh are generated by 48.8 KW capacity of solar PV plant. As well as after changing the fuel from LPG to propane, the fuel has been saved and lots of money can be saved. Motor efficiency also has been evaluated and the convectional motors also have been changed with energy efficient motors. Some of wasted thermal energy also been used in work like heating of furnace oil has been done by thermal energy rather than electrical energy. New latest technologies are also introduced with machines like VFD drive installation. As well as these innovative and fabulous projects, the energy saving data of entire industry also has been prepared. These are the projects which are implemented during the industrial internship.

These implemented projects and ideas are very useful and helpful for saving energy. By these projects, lots of electrical and thermal energy can be saved and save the money of industry. As well as these projects can save directly or indirectly the environment. The projects have been discussed with the knowledgeable person and for implementing many of new people were interested for saving energy. If these types of energy saving projects run in industry then make sure every people will focus on projects and will participate in the projects. Many types of people meets in industry few are literate and few are illiterate. So we should understand them as the basic of environment like if we turn off the fans which are running uselessly, then this amount of greenhouse gases will not be produced. This is a suitable way for focusing people toward energy conservation.

Many small energy saving ideas can save lots of energy saving. Everybody in industry should be active for energy saving and energy conservation because the earth is ours so it is our responsibility to save and clean it.

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