

Dissertation

On

Efficiency Improvement By Energy Optimization Program In
Energy Intensive Industries
A Case Study Of Satia Industries Limited, Muktsar (Punjab)

submitted in partial fulfilment of the requirement

for the award of degree of

Masters in Technology

In

Energy Technology And Management

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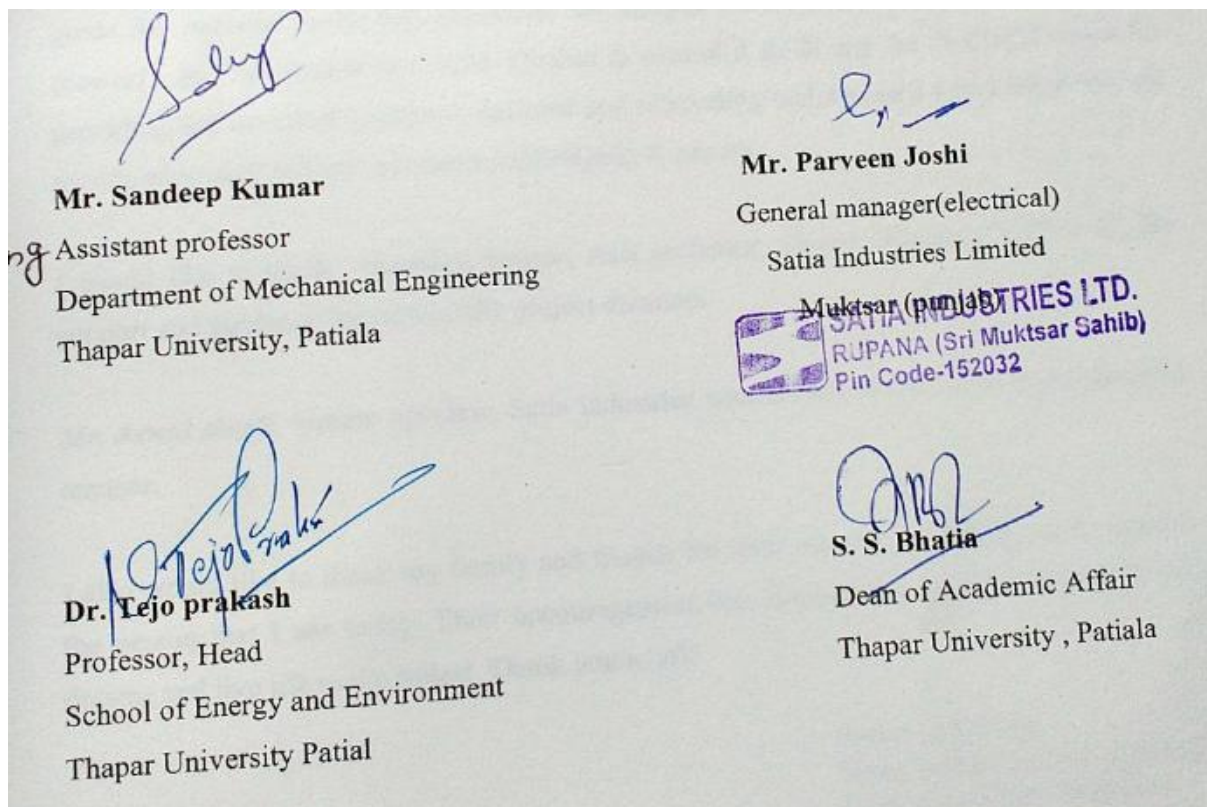
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**SCHOOL OF ENERGY AND ENVIRONMENT
THAPAR UNIVERSITY, PATIALA
(Declared as Deemed-to-be-University u/s 3 of the UGC Act, 1956)
JULY 2016**

CERTIFICATE

This is to certify that thesis entitled, “**Efficiency Improvement By Energy Optimization Program In Energy Intensive Industries**” A Case Study Of Satia Industries Limited, Muktsar (punjab)” submitted by **Mr. Rahul chaturvedi** in partial fulfilment of the requirements for the award of degree of **Masters of Technology in Energy technology & Management** at **Thapar University, Patiala** is an authentic work carried out by his under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not been submitted in part or full to any other university/ institute for award of any Degree.



Acknowledgement

I would like to extend warm thanks to all the people who had been associated with me in some way or the other and helped me avail this opportunity for my one year Internship on the topic “ **Efficiency Improvement By Energy Optimization Program In Energy Intensive Industries**”A Case Study Of Satia Industries Limited, Muktsar (punjab)

I am grateful to the management of *Satia industries limited, muktsar* for selecting me for this one year internship M. Tech Programme. I am thankful to all my colleagues, who helped me in collecting data from the mill. I am indebted and express my gratitude to all associated with Satia paper mill

I acknowledge with gratitude and humanity my ineptness to my One year Internship Project guide *Mr parveen joshi, GM-Electrical, Mr Deepak sharma, Assistant General manager (power)* , *Mr. Madhukar rao* , GM- Quality & control(R & D) and the Technical Team for providing me excellent guidance, material and motivation under whom I completed my six month internship at Satia industries limited(pulp & paper).

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Mr. kewal singh, turbine operator, Satia industries who always assist me in every possible manner.

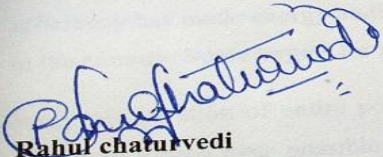
I also would like to thank my family and friends for their support in helping me become to the person that I am today. Their encouragement has allowed me to shoot high with my dreams and live life to the fullest. Thank you to all!

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DECLARATION

I hereby declare that the project work entitled “**Efficiency Improvement By Energy Optimization Program In Energy Intensive Industries**” A Case Study Of **Satia Industries Limited, Muktsar (punjab)**” is an authentic record of my own work carried out at Muktsar 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. Parveen joshi** and **Mr. sandeep kumar**, during **June 16th 2015 to Jun 15th , 2016**.

Further, I declare that no part of this Dissertation has been submitted for a degree or any other qualification of any other university or examining body in India or abroad.



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ABSTRACT

This report is result of efforts to understand key performance indices in Thermal Power Plant & energy conservation and management in industries an attempt to improve them as a student of Thapar university, Patiala during one year internship project. Following paragraphs outline summary of background, analysis & recommendations of the study.

Energy is the necessary in industry to required for production as well as generation of electricity. It is contribute quality of life and economically generation by optimize their resources for economically and quality improvement. future energy demand will be increases so that the resources of fuel decreases in future estimate that the 15% to 20% energy we can save by adopting suitable energy optimize programme. Due to environmental degradation and pollution, world over practices conserve water, reduce co2 emission. Bureau of energy efficiency has made energy audit mandatory for about 680 biggest energy consuming plants in the country. Some targets for reducing energy will set for them. This firm amongst them.

Study of operation of entire power plant and recommend best solution for optimizing the efficiency where ever possible. study of thermal systems as well as electrical system in energy intensive industry. Study of the power plant and achieve maximum efficiency through Analyse the energy performance. Energy performance of heat loss by the system , which include radiation and convection loss by the system. leading to energy and cost savings where ever possible. Performance assessment of steam distribution system which is a valuable source of heat and pure water and condensate recovery through steam trap management

My results reveal that industry does not care about the energy management and there is an energy efficiency gap which is resulting lack of energy technology provided by the industry .It was reveal that the energy saving measures in the industry have potential to recover these energy wastage and implement energy efficient technology.

Keywords: Energy Analysis, Energy Management Plan, Sustainable Development, energy efficiency, energy conservation

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1.1 Energy problem

This report aims to give an overview of status of efficiency improvement initiatives undertaken in satia industries limited (muktsar) Energy is the necessary in industry to required for production as well as generation of electricity. It is contribute quality of life and economically generation by optimize their resources for economically and quality improvement. future energy demand will be increases so that the resources of fuel decreases in future estimate that the 15% to 20% energy we can save by adopting suitable energy optimize programme. Production and uses of energy have affected many area by production or process energy.

Energy production is major source of environmental emission that includes air pollution and water pollution and continuous depletion of natural resources. We can consider the energy management programme in production area as well as process area to optimize the energy demand. Due to this the cost of energy will reduce and strengthen the energy production and position our system utility

Indian paper industries is ranked as the fifth largest energy consumer in the country. The ratio of energy cost to total manufacturing cost is up to 26%. Steam and electricity consuming by the paper industries per tonne of paper production is 11-15 tonne and 1500-1700 kwh respectively in Indian paper industries. The total specific energy consumption of Indian pulp and paper industry ranges from 30 to 51 GJ per tonne of product, which is roughly double comparison to developed country like USA and European countries . The pulp and paper sector highly potential to recover energy resources and energy optimization programme to increase own productivity.

1.2 Energy overview of Pulp and paper Sector in India

Paper is the major utilisation source of the nation. We purchase paper everyday for reading, writing ,packaging ,knowledge purpose. In india Yet the per person annual consumption of paper at about 4 kg in nation is among the lowest consumption use of paper in the world.

Pulp and paper industry is the highly energy intensive among all industrial sector in the world. As per Bureau of Energy Efficiency (BEE), paper industry stand rank with fifth place among all energy intensive industries in india . highly energy intensive sector are steel, aluminium, fertilizer , cement, and iron sector.

Indian paper industry consumes 4 million ton of coal and 2 million electricity purchased. Where 75%- 78 % energy require for process of pulp and 15-25% as electrical power. In future energy requirement of the paper industry is increase further. Indian mills consumes more energy comparatively developed countries mills. Variation between steam consumption and electricity purchased id respectively 6-10 t/ton of paper and 1200-2200 kwh/t of paper in Indian mills. In developed countries use steam from 6-9t/ton of paper and their electricity consumption is 1250-1550 kwh/kg of paper.

1.3 The important of energy conservation

Energy conservation means that saving energy by the optimize solution. When no one person in the room then we turns off the light in our home we are conserving energy.

Energy efficiency is the best method for saving energy because main aim of this energy efficient system is focus on the only how we can save energy from particular system.

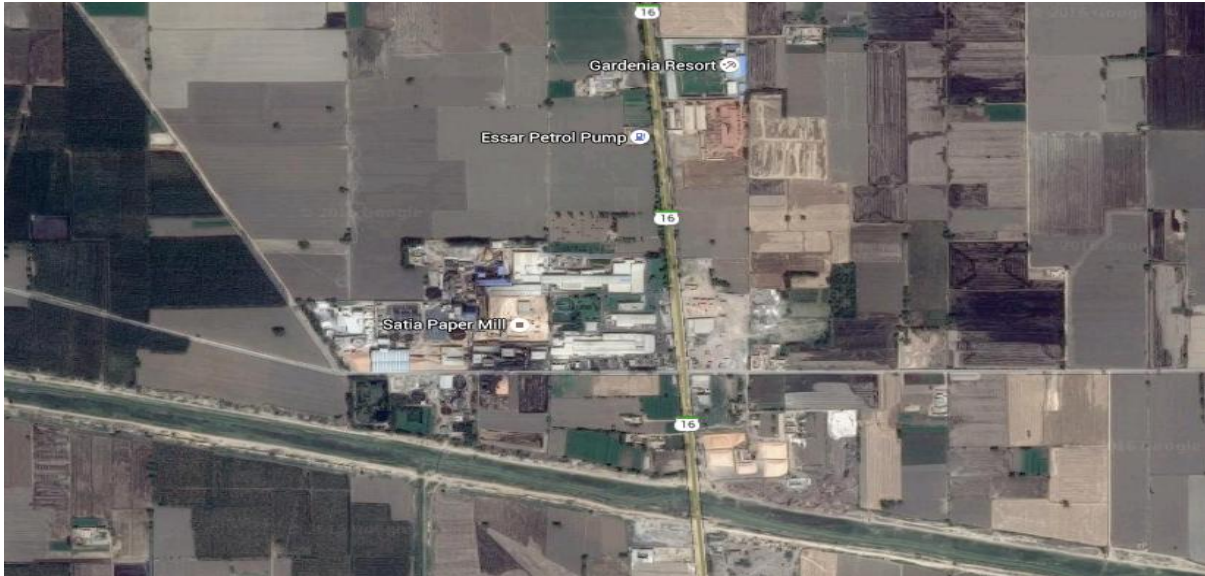
For example ordinary lights bulb convert the heat so energy is wasted. An energy efficient light bulb turns almost energy of electricity to light not waste to heat. It is necessary to save energy because it is not free of cost and unlimited to use so every pay for their energy use means save energy and save money.most of we dependent on conventional energy resources.

1.4 Location

The **Satia Industries Ltd** is located at-

VPO Rupana, Distt. Sri Muktsar Sahib, Punjab, 152026

Source: google map



1.5 Introduction about plant

The plant was set up in 1983. With passage of time, technology & process was upgraded. So it is a mixture of some old and some new technology. But it is well maintained, operated and all concerned are fully aware of energy conservation. Satia Industries Limited is manufacturing quality writing and printing paper from virgin pulp.

The product profile includes Ledger paper, Snow White, Map litho, Cartridge paper, Super Snow White, Duplicating, bond paper with and without watermarks and Chromo (Art) paper from GSM range 42 to 200 GSM, Colored paper These products are extensively used in the envelopes, diaries, calendars, printing of books, computer stationery, directories, copy manufacture annual reports and high class printing segment for domestic as well as export sales.

I checked almost all primary equipment viz. motors , transformers, capacitors, air compressors, rice husk fired boilers , chemical recovery boiler , T.G.Sets, cables, pumps and

lighting etc. with portable, sophisticated & diagnostic measuring instruments. I also made use of company's records to make use of some historical data. Further continuous interaction was held with plant's senior officials about our findings. Based upon all these inputs.

Most of these are well known to plant engineers. Implementation is slightly difficult due to various reasons. One is availability of shut down and retrofitting of old technology with latest available. But the suggestions are realistic, practical & implementable. In detailed report in following pages, we have given theoretical background of all recommendations and it is hoped that these would also serve as guidelines for future. It is pointed out that energy conservation is a continuous task.

1.6 Problem statement

Unprecedented fuel hike and importance of equipment's life assessment and subsequent extension have become extremely important concerns for thermal power stations. Present work is aimed at energy conservation in thermal power plants and also focusing on increasing the life of boiler components by conducting heat transfer analysis. Energy conservation in thermal power plant can be done by:

1. Decreasing energy input i.e. rice husk input by better combustion efficiency.
2. Efficient heat utilization

For this purpose, heat transfer analysis of a thermal power station was quite necessary and this is done by taking a reference unit and doing studies along with the energy audit Report. Most of the Indian thermal power stations are producing power at very high heat rate at one hand and falling in preventing the life deteriorating conditions on the other hand. Exhaustive studies of different parameters of a thermal power plant will be done for efficiency improvement resulting in energy conservation. This may result in costly fuel saving and better capacity utilisation of a reference unit.

1.7 Objective of thesis

Main theme of work is indentified energy consuming are and examine the energy efficiency opportunity in satia industry based on energy management plan will be provide . carry out a preliminary energy audit of satia industries To achieve this main objective of the study, the driving objectives were;

- To establish the energy flow/use per unit function of satia industry.
- To provide possible measures and recommendations on how to reduce energy use so as to have an optimum energy efficient system.
- 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.

1.8 significance of the study

The continuous increase in energy need is putting pressure on power generation, as the country's current generation resources cannot cope with the rate at which demand is increasing. Considering generation is entirely conventional the economics of energy generation and use goes up every day per increase in demand. This is costly to big companies like satia industries were energy is one of the biggest production inputs, hence performing energy audits and identify areas where energy wastages can be reduced will be economically beneficial not only to the company but also to the country's energy sector. This will also benefit the company to fully establish a good energy management plan.

The challenges faced during the study gave an exposure and experience to the complexity of various energy systems and how such systems can be harmonized to establish an energy management program. Having received exposure to the BEE energy measures during postgraduate studies, the studies conducted during this thesis gave an outlook of how different regions handle energy systems, hence, increasing the understanding and knowledge base of industrial energy systems.

1.9 Scope of limitation of the study

The study and analysis was based on the presented information of satia industries limited and considering that electricity was the only energy carrier of interest, the scope was based only on electrical loads across satia industry. This, however, had limitations in that the area of consideration was too wide to be considered for a detailed audit with regard to the period spent. So the energy audit studies were restricted to only a preliminary audit. The company insisted to do preliminary energy studies on all four departments in preparation to achieve the primary energy objectives of 2015/2016 financial year

The study was constrained by various limitations of which the major ones were;

1. Limited time to do a thorough audit, and the company insisted on performing just preliminary studies as they were planning to establish an energy management program.
2. Limited manpower to handle inspections and measurements. All measurements were manually recorded from energy meters in various substations with help from to company personnel's.
3. Area of consideration was too big compared to the time spent to do the study, hence only few areas especially those on the surface had reasonable measurements done.
4. Limitations in getting information, as some departments could not be accessed due to safety and security reasons, and other areas required the presence of company personnel's who were constantly engaged with other company businesses. This had limitations in that it took too much time to cover one area and to know the company culture of energy use especially in production departments i.e. type of equipment's, in power plant. Most of the information used in this study was based on interviews conducted with electrical engineers and production section heads. Access to plant facilities was also difficult as it involved production sensitive areas, so visits and inspections were rarely done.

1.10 Organization of thesis

The thesis is divided into seven chapters. Chapter one is the synthesis of the thesis with the general background to the study; company overview, problem statement, the objectives of the study, the significance of the study and finally the scope and limitations of the study.

Chapter two covers conceptual framework and literature review of energy audit and management , it covers the theory of Energy management and audit, looks at the two types of energy audits and emphasizes on the audit type used as an approach to this study. It looks at the current company culture in this field and their plans with a newly established energy team.

Chapter three represent methodology of work how we determine the energy survey of the industry and methodology of electrical and thermal system audit

Chapter four presents the method used to carry out this study, the energy survey; describing the company energy use from the information obtained by examining and analyzing the energy bills/invoices it also looks at the energy distribution across departments and the energy balance.

Chapter five gives an analysis of the possible energy measures that can be effected and a brief presentation of the saving potentials that can be realized.

Chapter six gives information about Impediments/difficulties faced during audit work; Suggestions related to work

Chapter seven makes the conclusion and recommendation.

2.1 Energy management

Energy management is the strategy of meeting energy demand when and where it is needed. This can be achieved by adjusting and optimizing energy using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems [1][2]. Energy management began to be considered one of the main functions of industrial management in the 1970s as the result of the rising price of energy and reports about the approaching exhaustion of world energy resources [1].

Nowadays, the role of energy management has greatly expanded in industries. Top management of the company participates in planning various energy management projects on a regular basis. The annual reports of the many companies should mention the details of energy conservation activities and various achievements by the company regarding energy conservation projects. To be effective, energy management programs should include four main sections [1][3]: Analysis of historical data;

- Energy audit and accounting;
- Engineering analysis and investments proposals based on feasibility studies;
- Personnel training and information.

2.1. Objectives of energy management

The objectives of energy management are: To minimize energy costs/waste without affecting production and quality and to minimize environmental effects [12].

2.2. Organizational structure and energy management program

The components of comprehensive energy management program are: the organizational structure, a policy and plan for audit, education, reporting and strategy. All these components are depicted in Fig. 2.1.

2.3. Types of energy savings by management

There are many types of energy saving by management. In this review three types will be discussed as follow:

1. Energy audit.
2. Energy efficiency courses and training program .
3. Housekeeping .

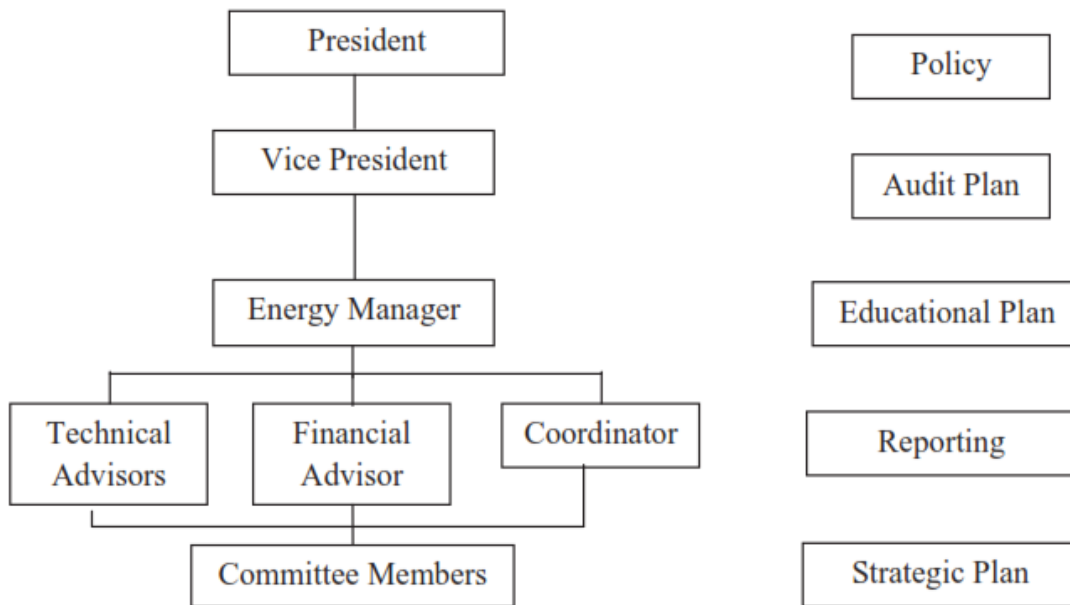


Fig.- 2.1 Organizational structure and energy management program

2.3.1. Energy audit

Energy audit is an inspection, survey and analysis of energy flows for energy conservation to reduce the amount of energy input into the system without negatively affecting the output.

The energy audit is the key for decision-making in the area of energy management. Energy audit is thus a reliable and systematic approach in the industrial sector. It helps any organization to analyze its energy use and discover areas where energy use can be reduced and waste can occur, plan and practice feasible energy conservation methods that will enhance their energy efficiency, serve to identify all the energy streams in a facility, energy usage, in an attempt to balance the total energy input with its use [15].

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labor and materials. If one were to relate to the manage ability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction [12].

2.3.1.1. Energy audit process and resources.

Energy audit requires a systematic approach-from the formation of a suitable team, to achieving and maintaining energy savings. A typical process is outlined in Fig. 2.2. Resources required for an energy audit are shown in Fig. 2.3.

2.3.1.2. Benefits of energy audit.

Many benefits can be achieved through energy audit. Some of these benefits are [15]: Reduction in specific energy consumption and environmental pollution. Reduction in operating costs (approximately 20–30%) by systematic analysis. Improves the overall performance of the total system and the profitability and productivity. Slower depletion of natural resources and narrowing demand supply gap. Averts equipment failure.

2.3.1.3. Types of energy audit.

There can be three types of energy audits:

1. Preliminary audit
2. General audit
3. Detailed audit

2.3.1.3.1. Preliminary audit.

Preliminary audit (alternatively called a simple audit, screening audit or walk-through audit) is the simplest and quickest type of audit and conducted in a limited span of time. It involves minimal interviews with site-operating personnel, a brief review of facility utility bills and other operating data, and a walk-through of the facility to become familiar with the industry operation and to identify any areas of energy waste or inefficiency. It focuses on major energy supplies and demands of the industry. The scope of this audit is to highlight energy

costs and to identify wastages in major equipment processes it sets priorities for optimizing energy consumption. This type of energy audit checks energy use and energy management in factories [15].

Preliminary energy audit is conducted to [12]:

- Ensure top management commitment.
- Establish energy consumption in the organization.
- Estimate the scope for saving.
- Identify the most likely (and the easiest areas for attention).
- Identify immediate (especially no-/low-cost) improvements/savings.
- Identify areas for more detailed study/measurement.
- Preliminary energy audit uses existing, or easily obtained data.

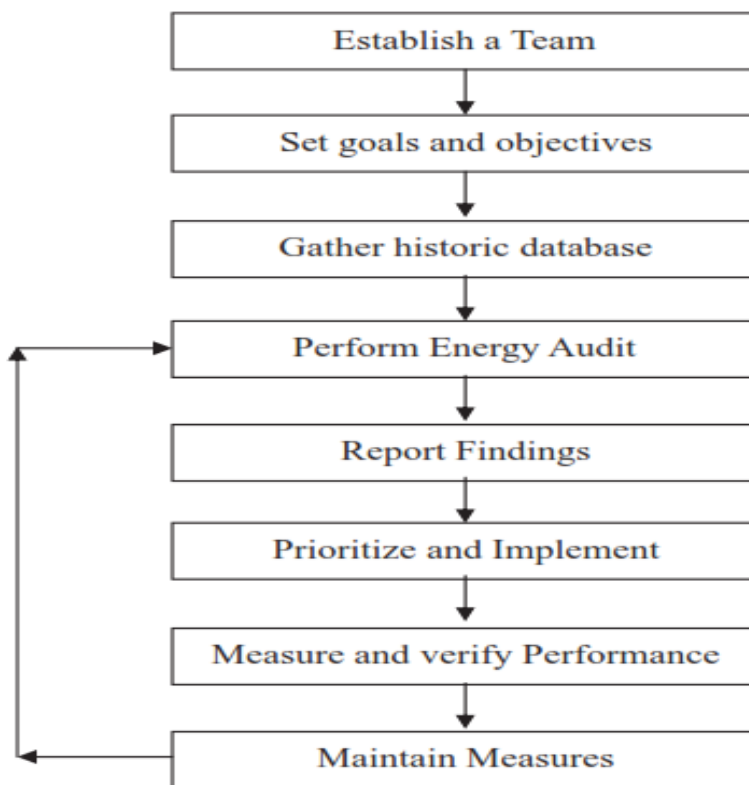


Fig-2.2 typical energy audit program

2.3.1.3.2. General audit.

The general audit alternatively called a mini-audit, site energy audit or complete site energy audit expands on the preliminary audit described above by collecting more detailed

information about facility operation and performing a more detailed evaluation of energy conservation measures identified. Utility bills are collected for a 12–36 months period to allow the auditor to evaluate the facility’s energy/demand rate structures, and energy usage profiles. Additional metering of specific energy-consuming systems is often performed to supplement utility data. In-depth interviews with facility operating personnel are conducted to provide a better understanding of major energy-consuming systems as well as insight into variations in daily and annual energy consumption and demand [15].

2.3.1.3.3. Detailed audit

The detailed audit (alternatively called a comprehensive audit, Investment-grade audit, maxi audit, or technical analysis audit) expands on the general audit described above by providing a dynamic model of energy-use characteristics of both the existing facility and all energy conservation measures identified. The operational calibrated against actual utility data to provide a realistic baseline against which to compute operating savings for proposed measures. Extensive attention is given to understanding not only the operating characteristics of all energy-consuming systems, but also situations that cause load profile variations on short and longer term bases (e.g. daily, weekly, monthly, annual). Existing utility data is supplemented with sub metering of major energy-consuming systems and monitoring of system operating characteristics [15].

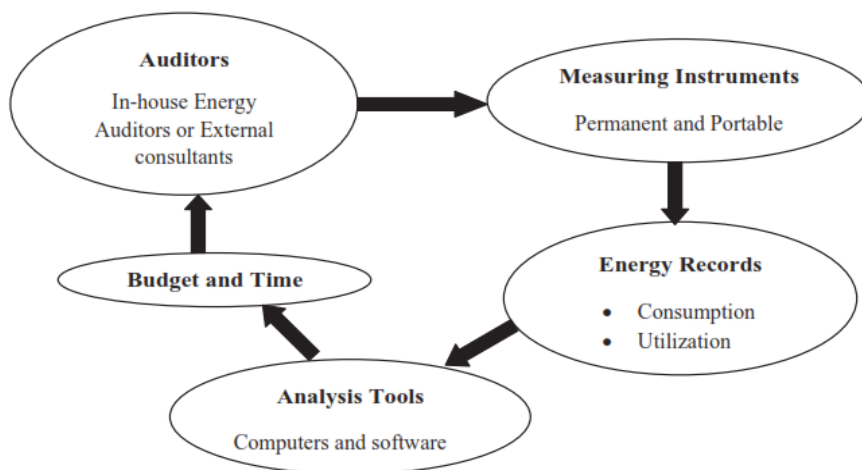


Fig-2.3 Resources required for an energy audit

The thesis presents some guide lines to energy optimization and energy conservation programme in industry. The final aim of this thesis that energy management and audit are to indentify economically viable energy conservation area with this aim in mind I carried out following works in satia industries limited, muktsar

3.1 Preliminary survey of thermal & electrical energy systems

Initial Site Visit and Preparation Required for energy conservation opportunity

First week of month i visited all the primary equipment viz. Motor, pump, transformer, chemical recovery boiler, rice husk boiler, turbine generator set, and lighting etc.

basically my first month at the industry is to get familiar with the working environment and attend basic trainings that are related to my job.

Main Aim Of This Visit Are:

- To identify the main energy consuming areas in plant and find to approach how we increase energy efficiency of particular energy systems
- To identify any energy efficient technology for the systems required.
- To identify the instrumentation needed for measurements of the audit.
- To plan with time period that how much time will take on that particular period.
- To collect on plant energy resources, major energy consuming area
- To meeting with all concern department and gaining knowledge of process in the plant

3.2 Detailed energy audit survey & methodology of thermal & electrical energy systems

Energy analysis consumption and cost analysis for energy wastage in industry

- Depending on the plant complexity it takes several weeks for particular project on energy conservation measures.
- Detailed study of the system carried out by literature and journal papers and interrogate component of plant and improvise energy efficient plan for particular project.
- Analysis of energy conservation measures and technical and economical feasibility of project in plant operation is also important aspect that it is feasible or not

3.3 Literature and journal paper review

From the literature review it tells knowledge about a particular field of study, including theories, method and impact of energy efficiency in particular systems and provides guideline that how we analyze energy conservation measures in industry.

Summarize points of literature review that how approach and analyse my work regarding under energy conservation and auditing

- understanding the structure of the project,
- relating ideas and theory to electrical and thermal energy systems auditing,
- identifying relationships between ideas and practices,
- establishing solution of topic or problem,

3.4 Plans

Energy audit of thermal energy systems survey in industry

The major areas for conducting energy audit in thermal power plants are:

- Boilers and associated utility ,
- Radiation convection losses via exposed area
- Turbine and their associate utility

- Cooling system (cooling water pumping system , cooling towers and condensers)
- Compressed air system,
- Air conditioning & HVAC system,
- Water pumping systems (, boiler feed water pumping system ,condensate extraction make up water pumping, pumping system, DM water pumping system, raw water

energy audit of electrical system survey in industry

- Find the locations in industry with the major electrical energy consumption area ,
- Cost reduction plan for electrical energy analysis and refer purposed method of energy audit method
- Improving of power factor in energy systems we can reduce electrical energy consumption in industry
- Maintenance of electrical appliances and introduce energy efficient technology in industry,
- Benchmarking of electrical systems which is highly energy consuming and play major role in energy bills.
- Major source of electrical appliances eg. Motor loading, compressor, voltage drop in system

4.1 Energy management programme in satia industry

Satia industries limited is committed to conservation of energy through:

- use of energy -efficient and environment friendly technologies
- optimal utilization of natural resources and undertaking a war on wastages
- continual review of the specific energy consumption norms for bench marking with the best in the industry
- carrying out regular energy audits internally and through external experts
- promoting awareness amongst the employees and other stakeholders.

4.2 Company practice and energy management strategies

satia has no choice other than to establish a good energy management program. Currently, the company practice shows that energy is managed in individual departments. This system empowers departments, to use energy in whichever way to meet the production targets as long as it falls within the declared value.

The energy management is quite poor and the company has responded by introducing an energy team made up of selected individuals from each department. The energy team which they are calling ‘the energy Champions’ has objectives of minimizing energy use in their respective departments and reduce on maximum demands.

The only problem is that these goals are not primary objectives as they come as extra duties to these individuals and the other concern is, looking at the previous energy meetings held, there is no structured management plan.

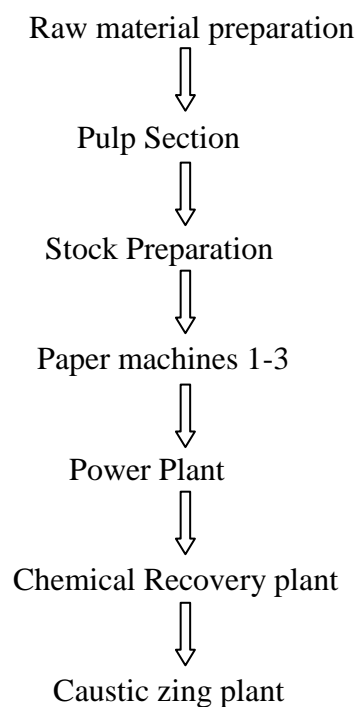
4.3 Brief description of manufacturing process

Pulp and paper in Satia Industries Ltd are manufactured from agricultural residues. In Satia, pulp and paper manufacturing exist as an integrated operation. An integrated mill is one that

conducts pulp manufacturing onsite. Thus, Satia has the advantage of using common auxiliary systems for both pulping and papermaking such as steam, electricity generation, and wastewater treatment. Transportation cost is also reduced. The paper manufacturing process has several stages starting from raw material preparation and handling to pulp manufacturing, pulp washing and screening, Chemical recovery, Bleaching, Stock Preparation, and Papermaking.

Satia has three paper machines installed. Each machine can make a single grade of paper or a variety of papers. The basic process of papermaking remains the same despite the type of paper manufactured or the size of the machine.

Paper production is basically a two-step process in which a fibrous raw material is first converted into pulp, and then the pulp is converted into paper. The agro based residue is first processed so that the fibers are separated from the wheat and rice straw. Pulp making can be done mechanically or chemically. The pulp is then bleached and further processed, depending on the type and grade of paper that is to be produced. In the paper factory, the pulp is dried and pressed to produce paper sheets. an increasing fraction of paper and paper products is recycled. Non recycled paper is either land filled



Agro based paper mill of Satia industries use wheat and rice straw as their input raw material which before being transferred to the Continuous digester of pulp section is cleaned through air deduster and wet washing.

In the pulp section, it contains continuous digester, blow tank, vibrating screen, brown stock washer 1-3, unbleached tower, pressure screen, centri-cleaner, final brown stock washer, unbleached storage tower, ODL reactor, Blow tank, ODL washer, TRP-1, TRP tower, Alkali tower and washer, Chlorine tower and washer, Hypo 1 & 2, Final storage tower.

In the stock preparation, centri-cleaner and low density (LD) and high density (HD) cleaners are there, and their purpose is to prepare the pulp so as to transfer to the head box of the paper machine.

4.4 Summary and classification of energy(2015-16)

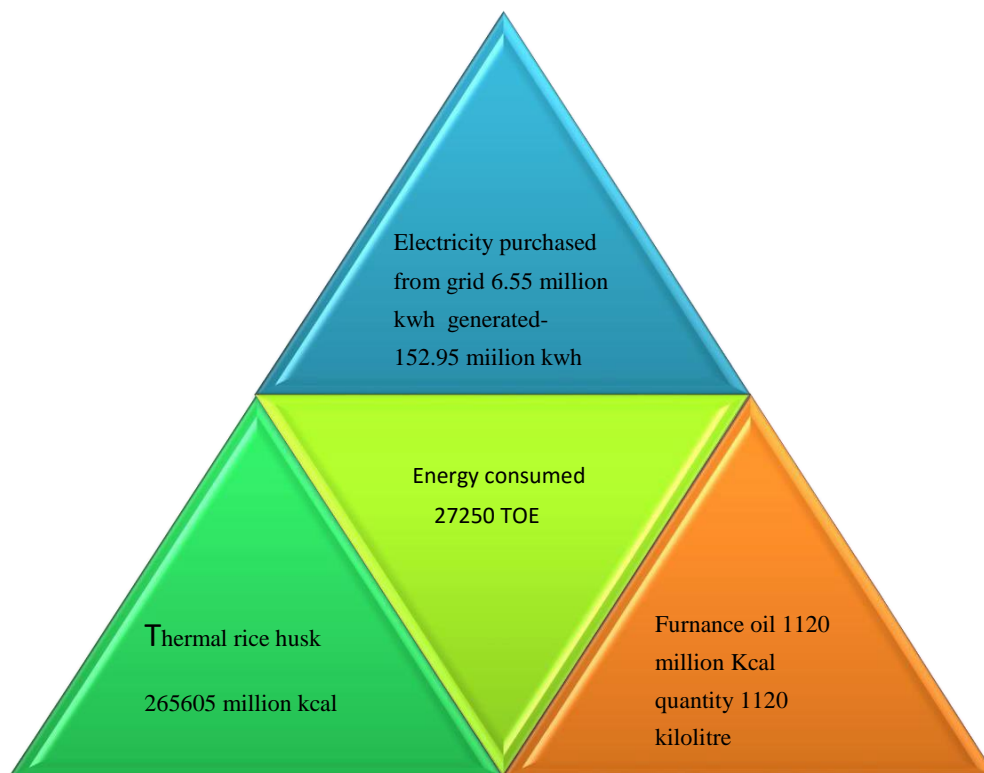
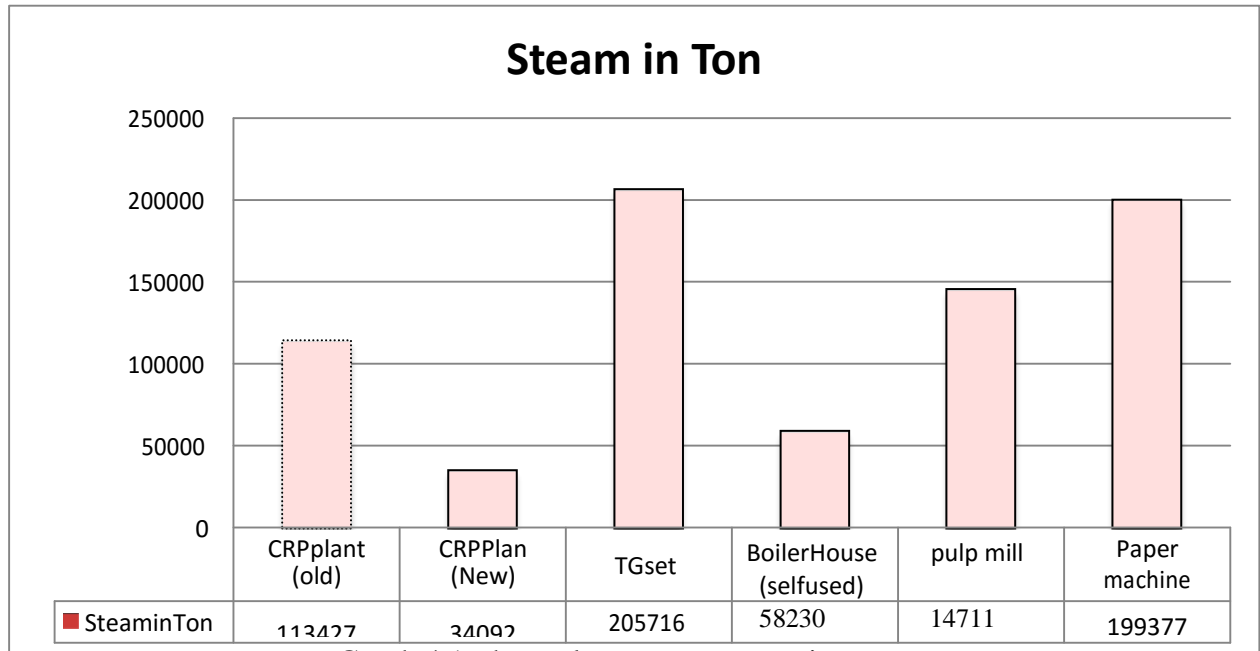


Fig 4.1 Energy summary for time period(2015-16) source-satia industries

4.4.1 Major Energy Use Area

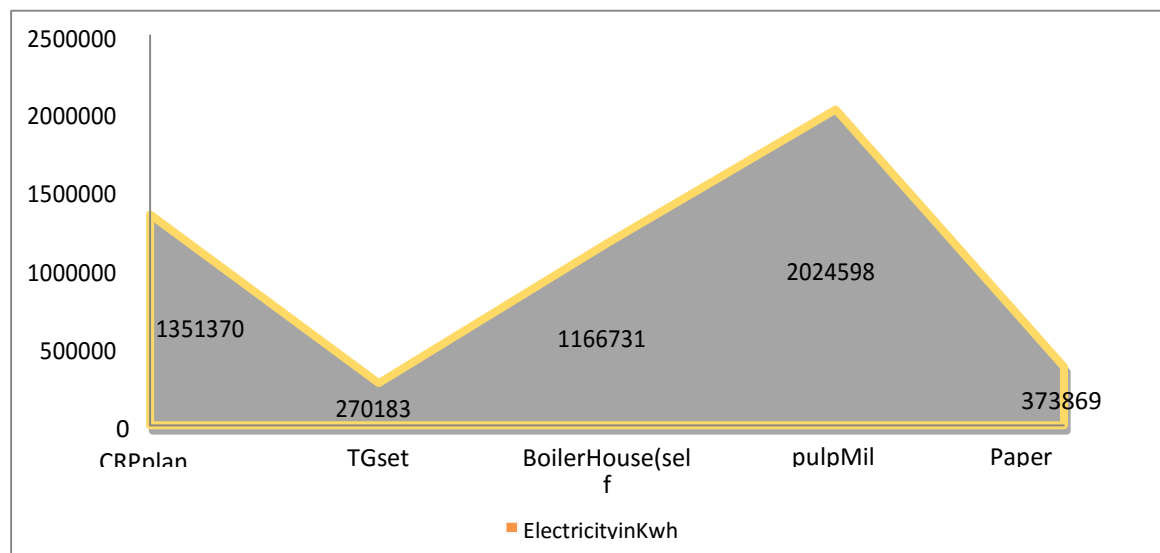
4.4.1.1 Thermal energy for section wise: (2015-16)

Source: data taken from form-I



Graph 4.1- thermal energy consumption

4.4.1.2 Electrical energy for section wise: (2015-16)



Graph 4.2-electrical energy consumption

4.4.2 Detailed Process Flow Diagram And Energy And Material Balance

(1) Water balance trend for satia paper industries

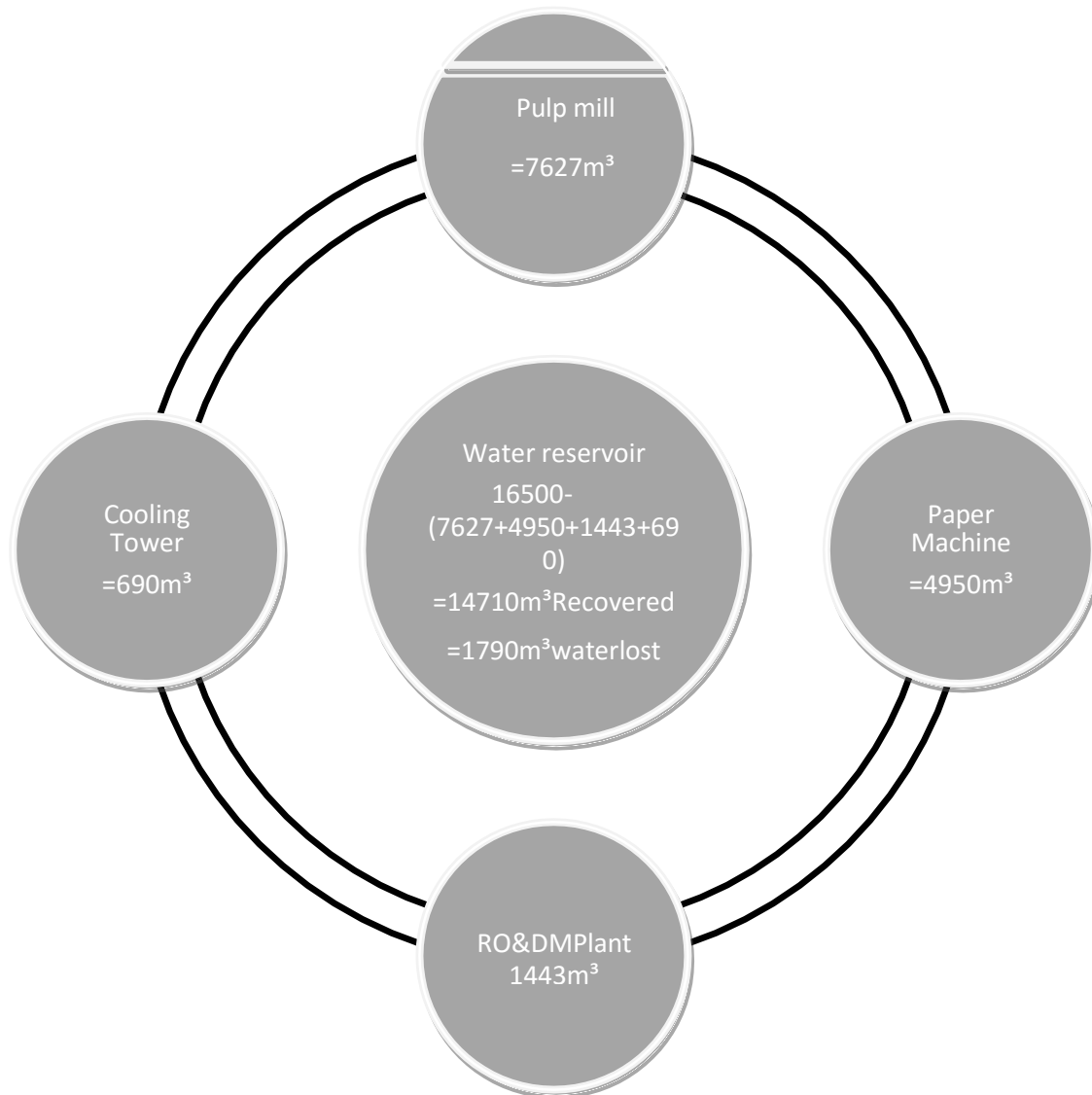


Fig 4.2- water balance for satia paper industries per day

(2) Thermal Energy consumption trend (2015-16)

Source- satia industries

Raw Material	Quantity Used(Tone)		GCV(Kcal/Kg)		Total Million Kcal Used		
	Power Generation	Process	Power Generation	Process	Power Generation	Process	Total
Rice Husk	146570	6252		3900	571623	24382.8	
Furnace Oil	932		10500		1120.5		1120.5

Table 4.1- thermal energy consumption

(3) Electrical energy consumption trend (2015-16)

Year	Input			Output		
	Purchase From Grid (Million kWh)	Gross Power Generation (Million kWh)	Total (Million kWh)	Aux. Consumption (Million kWh)	Used in process (Million kWh)	Total (Million kWh)
2014-15	65.5	152.95	218.35	141.6	848.4	990

Table 4.2- electrical energy consumption

4.6 Auxiliary Utility installed at power plant in Industry

(1) AFBC Boilers installed

Item	Boiler-75 Tph	Boiler- 45 Tph
Boiler Id And Code	Cheema Boiler	Ibl
Year Of Make	2011	1996
Boiler Capacity Rating	75 Tph	45 Tph
Type Of Boiler	Water Wall,Water Tube	Water Wall,Water Tube
Surface Temperature Of Boiler(C)	48	52
Type Of Fuel Used	Rice Husk	Rice Husk
Super Heated Temperature(C)	490±5	490±5
Wind Velocity Around The Boiler(M/S)	3	3
Waste Heat Recovery System	Yes	Yes

Type Of Draft	Fd & Id	Fd & Id
Chimney Height In Meter	70	58
Working Hours	8640	8640

Table 4.3- Boiler specification Installed In Industry

There are 3 nos. atmospheric fluidized boilers and 2 no. chemical recovery boilers have been installed for co-generation and process steam.

(2) Turbines

There are 4 nos of Turbine installed in the plant which makes total installed capacity to 24 MW. In which 12.5 M, 5.5 MW, 5 MW and 1MW back pressure turbine.

1. Turbine performance (TG-4) (condensing cum exhaust and bleed)

Main steam Temp in °C	480
Main Steam flow rate (TPH)	43.9
Turbine heat rate (Kcal/ Kwh)	2084.18
Unit heat rate	2615.03
Turbine Cycle efficiency%	41.26

Table 4.4- Turbine performance (TG-4) (condensing cum exhaust and bleed)

2. 5MW condensing Turbine performance (TG-1)

Main steam pressure Kg/cm ²	32
Main steam Temp in °C	410
Main Steam flow rate(TPH)	18
Turbine heat rate(Kcal/Kwh)	3872.18
Unit heat rate	4852.96
Turbine Cycle efficiency%	22.21

Table 4.5-5MW condensing Turbine performance (TG-1)

3. Extraction & exhaust turbine performance

Main steam pressure kg/cm ²	62.88
Main steam Temp in °C	420.02
Main Steam flow rate(TPH)	32
Turbine heat rate(Kcal/Kwh)	1101.82
Unit heat rate	1575.15
Turbine Cycle efficiency%	78.05

Table 4.6- Extraction & exhaust turbine performance

1 MW extraction pressure turbine performance

Main steam pressure kg/cm ²	40
Main steam Temp in °C	400
Main Steam flow rate (TPH)	18
Turbine heat rate (Kcal/Kwh)	1097.3
Unit heat rate	1380.25
Turbine Cycle efficiency%	78.37

Table 4.7- 1 MW extraction pressure turbine performance

ENERGY CONSERVATION OPPORTUNITY IN SATIA INDUSTRIES LIMITED

Table 3: Energy saving opportunities

Energy efficient technologies	Typical % of site energy consumption	Typical range of savings	Areas for improvement
1 Refrigeration	15-30%	15-45%	Reducing plant load, plant optimisation, equipment upgrade : improving condensing unit location, upgrading to glycol/CO2 systems, upgrading to ammonia plant, fan and compressors on VSDs, heat recovery.
2 Thermal Energy (Hot Water and Steam)	40-80%	0-15%	Boiler efficiency, Boiler blowdown Piping, steam traps and leaks, condensate recovery
3 Lighting	3-5%	20-50%	More efficient technology, lighting controls, voltage optimisation
4 Compressed Air	3%	10%	Equipment, controls, air quality and temp
5 High Efficiency Motors	5%	2-4%	Refrigeration compressors, conveyors belts, processing equipment, hydraulic equipment, fans and pumps.
6 Variable Speed Drives (VSD)	2-5%	25-40%	Fit VSDs to fixed-speed pumps, fans and compressors.

5.1 IMPROVING ENERGY PERFORMANCE OF BOILER SYSTEM

5.1.1 Literature Review

[7]R.A Zeitz has described the various losses in boiler which is decreases the boiler performance And boiler engineer calculate the boiler efficiency by these measurement .these losses due to unburnt carbon in fuel ash, heat loss due to moisture in fuel, heat loss due to dry flue gas losses, heat loss due to formation of carbon mono oxide, heat loss due to moisture from burning hydrogen, some unaccounted loss which is negligible effect boiler performance that blow down, radiation and convection losses.

Energy research institute [8] described the strategic operation for minimize the heat loss. The loss which is highly due to dry flue gas and heat loss due to moisture from burning hydrogen the maximum boiler efficiency achieved through in terms of an optimum value which depends upon fuel being burnt that waste product of combustion takes away heat with them.

[9] state that when considering boiler efficiency and savings there are several application which we defined the efficiency of boiler and different meaning of efficiency uses in different application.

1) thermal efficiency- in this type of efficiency the heat exchange between the material considered and how much heat contribute to exchange heat one to another form. Radiation and convection loss did not consider as a loss in thermal efficiency.

2)combustion efficiency-its include the ability of burn fuel completely with the help of burner without generating other harmful gases like carbon-mono-oxide and hydrocarbon

3)boiler efficiency-its define boiler performance that compare energy put into the boiler with energy coming out.

5.1.1.1 boiler efficiency and performance assessment :

[10] state that efficiency measuring gives us to help the efficiency of boiler floats from the design efficiency any observed irregular abnormalities could be find in boiler. hence it is necessary to know the present level of efficiency for daily basis performance evolution, which is important for energy management and conservation in industry. It is an indicator for measuring daily basis and seasonally variation in energy efficiency and boiler efficiency improvement.

[11]describes that Basically efficiency of boiler can be tested by these two method

A. Direct Method or Input Output Method.

B. Indirect Method or Heat Loss Method

A. Direct Method-

This is also called as “input-output method” due to the fact that it required only the useful output (steam) and the heat input (i.e. fuel) for calculating the efficiency

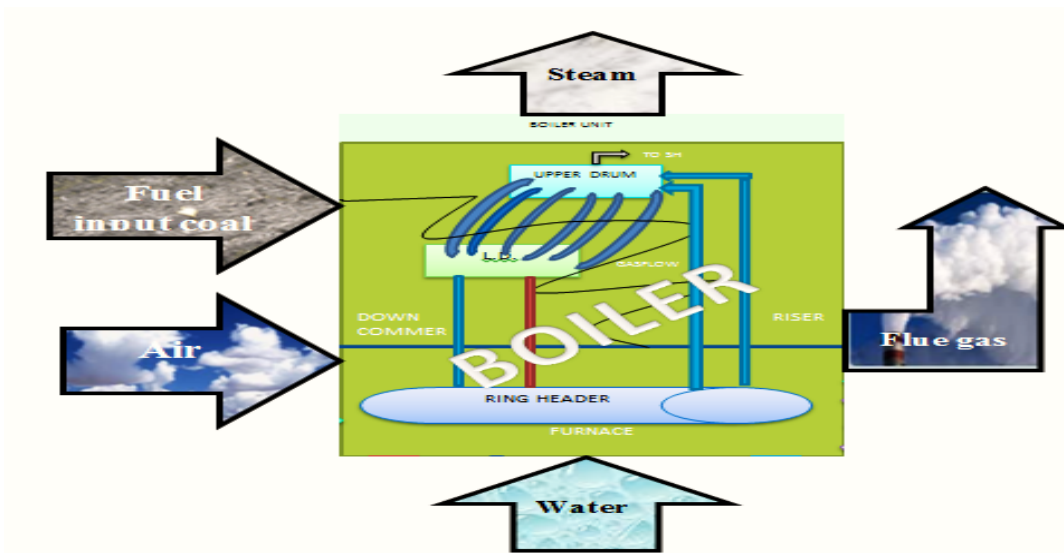


Fig 5.1-fuel input output method

$$\text{boiler efficiency, } \eta\% = \frac{\text{heat output} * 100}{\text{heat input}}$$

Pros and Cons of Input Output Method:

Pros:

1. Plant engineer can evaluate the efficiency quickly.
2. less instruments are needed.
3. Requires less parameter for calculation

Cons:

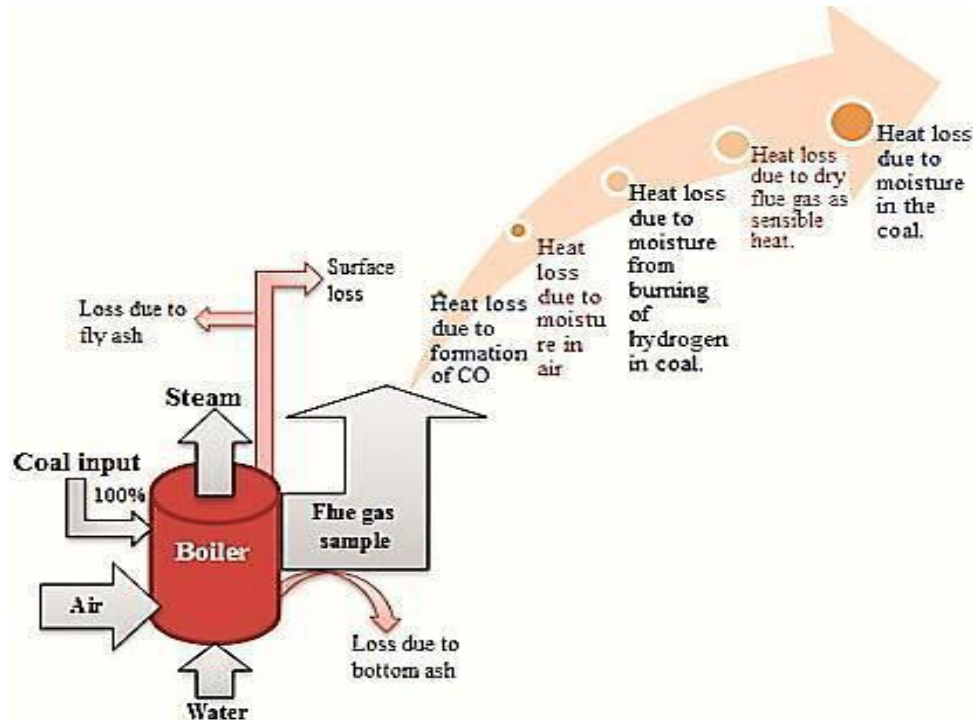
1. Does not gives appropriate conclusion that why efficiency is less .
2. Various efficiency levels Does not estimate various losses in system.
3. efficiency and Evaporation ratio may be wrong, if the steam is highly wet due to water carryover.[11]

B. Heat Loss Method or Indirect Method :

This method measured all losses indentified in the boiler process. which is calculated various losses in the boiler. The efficiency can be limited by subtracting losses percentage from 100.

This method does not account, soot blowing loss, blow down, standby losses, heat loss, energy loss auxiliary system such as burner, fans and pump. [10],[11]

Fig 5.2- different loss associate with boiler



5.1.1.2 Components of efficiency improving of boiler system

5.1.1.2.1 Excess Air

Excess air is the extra air supplied to the boiler beyond the required air for complete combustion of the fuel. [10] state that Oxygen and carbon contain in non fossil fuel such as biomass and alcohol in their molecular structure. When fuel burns the fuel oxidized to carbon-di-oxide and hydrogen to water vapour. But incomplete combustion creates dangerous product. Excess air play vital role in combustion process. more air (21% oxygen by volume) is passed through a burner excess air provide speed to the fuel mixing with air and prevent the fuel completely from exploding within the boiler.

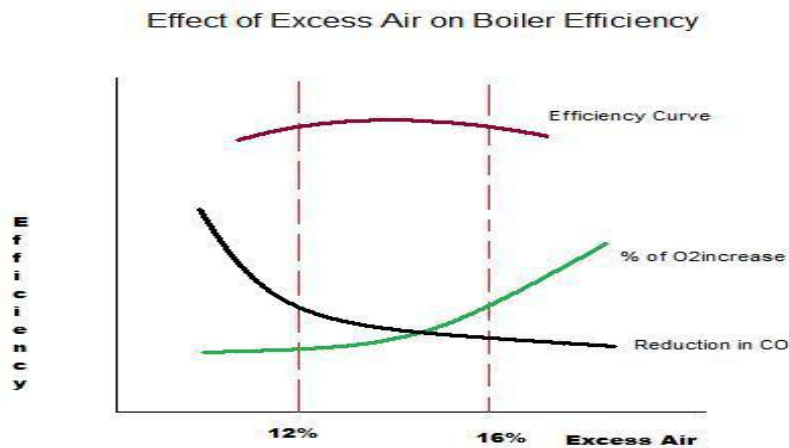


Fig 5.3-effect of excess air on boiler efficiency

[12] Harish Ghrilahre observed the amount of air required for the complete combustion of fuel. In practically combustion condition are never ideal. The excess air calculation measured by O₂% level in the flue gas and concentration level of oxygen in air. generally the excess air percent in combustion is 20% to 30%. So the air needed for complete combustion has 120%.the excess air is approx 3% to 5% for liquid and gas fuel. 11% for solid fuel. unneeded excess air draws the high flue gas temperature and incomplete combustion.

5.1.1.2.2 Flue gas temperature:

Flue gas efficiency plays a significance role in determining boiler efficiency with effective utilization of flue gas temperature will impact on following parameters. flue gas temperature mainly depends upon the heat exchanger provides in the boiler system.[13] Economizer is heat exchanger which is reduce boiler fuel requirement by heat transfer from the flue gas to incoming feed water.[14] effect of stack temperature on efficiency of boiler shown below. boiler efficiency increases when heat supplied and decreases when heat rejected. Stack temperature is minimum as possible. But minimum temperature of stack is also create problem when we reduce below their desired temperature at that condition corrosion of metal will increases because of presence of sulphur in flue gas. The sulphur reacts with water and forms dilute sulphuric acid which can corroded the stack or material. boiler efficiency is a function of stack temperature and it decreases by increase stack temperature

[15]Effecting parameter due to flue gas temperature

Air Temperature at APH

% Heat loss due to dry flue gas (L2)

% Heat loss due to formation of water from H₂ in fuel (L3)

% Heat loss due to moisture in fuel (L4)

% Heat loss due to moisture in air (L5)

Reduction in flue gas temperature can save approx. 5.50 lac Rs/Day

5.2 METHODOLOGY

- In satia industry 3 no. Atmospheric fluidized boiler and 2 no. Of chemical recovery boiler have installed for co- generation and process steam
- identify the main energy consuming areas in boiler and find to approach how we increase energy efficiency of particular in boiler systems
- analyze energy consumption and boiler efficiency of boiler
- go through literature review for efficiency improvement for boiler system
- calculate efficiency improvement by excess air and flue gas temperature of boiler
- cost benefit analysis after calculate efficiency improvement by excess air and flue gas temperature of boiler
- documentation and report presentation to the top management in industry

5.3 RESULTS AND IMPACT

Field Observations And Evaluations

Their broad specification and operating parameter are shown at annexure. The brief about boiler are shown below

	Boiler-1	Boiler-2	Old CRP	New CRP
TPH	45	75	400	220
Type	Water wall	FBC	Not working	Water wall
Fuel	Rice husk	Rice husk		Black liquor
Heat recovery	Yes	Yes		Yes

5.1 Table- operational characteristics of boiler in industries

Rice husk chemical composition

SN.	Parameter	Actual
1	Ash	12.00
2	Carbon	42.30
3	Hydrogen	5.33
4	Oxygen	8.10
5	Sulphur	0.03
6	Moisture	8.00
7	Nitrogen	0.77
8	GCV	3400

Table 5.2 chemical composition of rice husk in

1. Boiler -1 (45 TPH): energy performance

Operational parameter of boiler-1(45 TPH)

SN.	Parameter	Actual
1	Quantity of steam generated (Kg/Hr)	265833.33
2	Quantity of fuel (Kg/hr)	6333.33
3	Steam pressure in kg/cm ²	42.00
4	Steam temperature in °C	440.00
5	Feed water temperature in °C	105.00
6	Flue gas temperature in °C	166.00
7	O ₂ % in flue gas	8.10
8	CO ₂ % in flue gas	9.12
9	Ambient temperature in °C	32.00
10	Surface Temperature of boiler °C	55.00
11	GCV of Fly Ash in kcal/kg	807.00
12	GCV of Bottom Ash in kcal/kg	0.00
13	Wind velocity around the boiler, m/s	1.50

14	Surface area of boiler (m ²)	53
15	Humidity in air in kg/kg dry air	0.30
16	Fly ash in (%)	90.00
17	Bottom ash in %	10.00
18	Enthalpy at Kg/cm ² pressure , Kcal/kg	789.46

Table-5.3 boiler 45 TPH operational properties

Indirect method calculations		
Step-1	Theoretical air in kg/kg of coal	6.41
Step-2	Excess air (EA) in %	62.79
Step-3	Actual mass of air supplied (AAS) in kg/kg of coal	7.16
	Find Actual mass of dry flue	
	Mass of CO ₂ in flue gas	1.55
	Mass of N ₂ in fuel	0.01
	Mass of N ₂ in air	5.76
	Mass of O ₂ in flue gas	0.85
	Mass of SO ₂ in flue gas	0.00
	Actual mass of dry flue gas in kg/kg of coal	8.16
Step-4		
1.	% loss from dry flue gas (L1)	7.39
2.	% loss from due to formation of water from H ₂ infuel(L2)	7.90
3.	% loss from due to moisture in fuel (L3)	1.75
4.	% loss from due to moisture in air (L4)	0.28
5.	% loss from due to radiation and convection (L5)	0.39
6.	% heat loss due to un burnt in fly ash(L6)	1.20
	Radiation loss due to Boiler surface(Kcal/hr)	21042
	Amount of fly ash in 1 kg of coal	0.11
	Amount of bottom ash in 1 kg of coal	0.01
	Heat loss due to unburnt carbon in bottom ash, (kcal/kg of coal)	0.56
	Efficiency of boiler-45 tph %	79.69

Table-5.4boiler 45TPH energy efficiency

2. Boiler (75 TPH): energy performance

SN.	Parametre	Actual
1	Quantity of steam generated (Kg/Hr)	265833.33
2	Quantity of fuel (Kg/hr)	6333.33
3	Steam pressure in kg/cm ²	62.00
4	Steam temperature in °C	440.00
5	Feed water temperature in °C	110.00
6	Flue gas temperature in °C	145.00
7	O ₂ % in flue gas	5.5
8	CO ₂ % in flue gas	9.12

Table-5.5 boiler 75 TPH operational properties

Indirect method calculations		
Step-1	Theoretical air in kg/kg of coal	6.41
Step-2	Excess air (EA) in %	35.48
Step-3	Actual mass of air supplied (AAS) in kg/kg of coal	5.96
	Find Actual mass of dry flue	
	Mass of CO ₂ in flue gas	1.55
	Mass of N ₂ in fuel	0.01
	Mass of N ₂ in air	7.37
	Mass of O ₂ in flue gas	0.85
	Mass of SO ₂ in flue gas	0.00
	Actual mass of dry flue gas in kg/kg of coal	9.68
Step-4		
	% Heat loss in dry flue gas (L1)	5.28
	% Heat loss due to formation of water from H ₂ in fuel(L2)	7.78
	% Heat loss due to moisture in fuel (L3)	1.72
	% Heat loss due to moisture in air (L4)	0.20
	% Heat loss due to radiation and convection (L5)	0.39
	% heat loss due to un burnt in fly ash(L6)	1.20

	Radiation loss due to Boiler surface(Kcal/hr)	19515
	Amount of fly ash in 1 kg of coal	0.11
	Amount of bottom ash in 1 kg of coal	0.01
	Heat loss due to un burnt carbon in bottom ash, (kcal/kg of coal)	0.56
	Efficiency of boiler 75 TPH %	82.02

Table-5.6 boiler 75 TPH energy efficiency

The above is subject to accuracy of steam flow, its temperature and pressure gauges & feed water temperature and average calorific value of 3400 Kcal/kg

After analyzing efficiency of boilers there is no much difference of b/w direct and indirect method except for Boiler 1 a lot of factors influencing efficiency like O₂% (excess air), air ingress etc .

5.1.3. Effect Of Boiler Performance

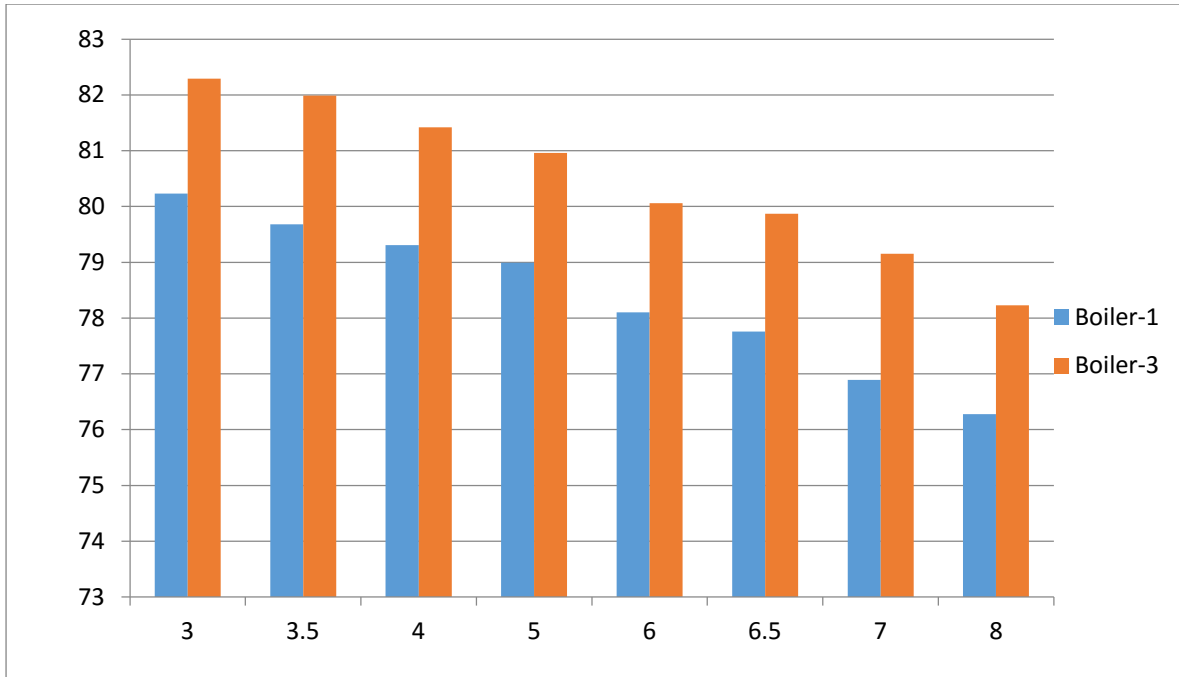
5.1.3.1 impact of O₂(excess air) control on boiler performance

%O₂ of Different Boilers and values are tabled below

Particulars	Boiler-1	Boiler-3	Desired value
% O ₂ in flue gas	8.10	5.5	3 to 4
% CO ₂ in flue gas	9.5	12.8	14-16
Excess air %	62.79	35.48	17-25
% Efficiency	79.69	82.02	
% Efficiency @4.5% O ₂	80.99	82.17	

Table 5.7-%O₂ of Different Boilers and values

By Decreasing 8.10% & 5.5% O₂ in flue gas boiler efficiency will increase to **80.99 & 82.17** % in boiler 1&3 respectively. High O₂ in Boiler-1 due to under loading of boiler

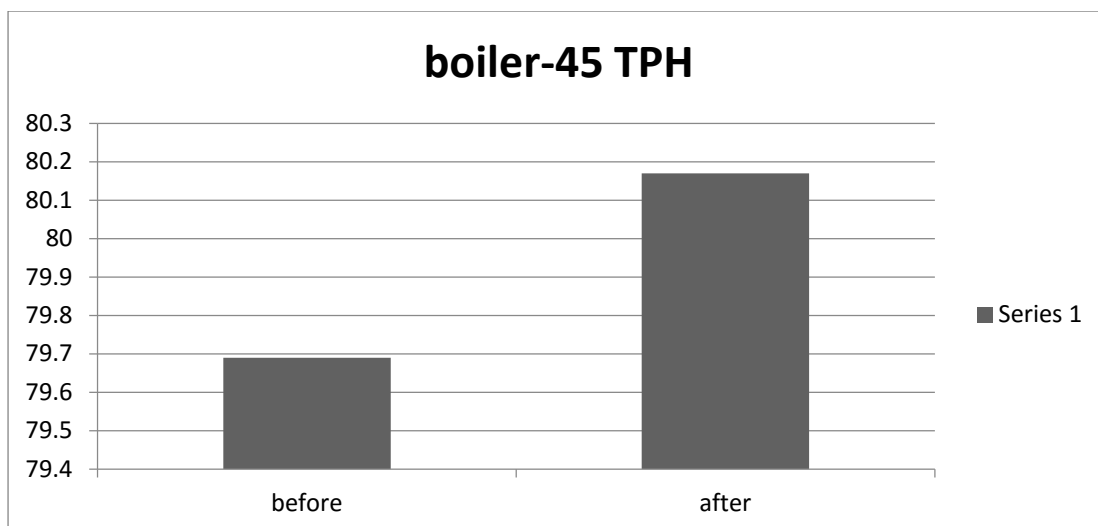


Graph-5.1 effect of excess air in boiler efficiency

5.1.3.2 Impact of flue gas temperature on boiler performance:

Particulars	Boiler-45 TPH		Boiler-75 TPH
	Before	After	
Flue gas temperature APH O/L	166	145	145
% heat loss dry flue gas loss(L1)	10.68	8.43	7.35
% Heat loss due to formation of water from H ₂ in fuel (L2)	9.36	8.93	9.20
% Heat loss due to moisture in fuel (L3)	2.56	1.48	1.53
% Heat loss due to moisture in air (L4)	1.35	0.32	0.28
Efficiency of boiler	79.69	80.17	80.29

Table-5.8 effect of stack (flue) temperature on boiler efficiency



Graph 5.2 - Comparison of efficiency of different flue gas temperature

5.1.4 PAYBACK AND SAVING ANALYSIS

Boiler-75 TPH

Parameter	Existing Condition	After Improvement
%O ₂	5.5	5
%Excess Air	35.48387097	31.25
Theoretical Air Requirement (Kg/Kg Of Fuel)	4.40075	4.40075
Actual Mass Of Air Supplied	5.962306452	5.775984375
Mass Of Dry Flue Gas	6.962306452	6.775984375
Affecting Parameter		
Dry Flue Gas Loss	5.289243113	5.147694796
Loss Due To Moisture In Air	0.206970383	0.201431536
Boiler Efficiency%	82.02380181	82.17088897
Financial Profit		
Annual Saving In Fuel Input(Tons)	282.8276702	
Rice Husk Price/Ton	4500	
Total Saving(Rupee)	1272724.516	

Table -5.9 savings and pay back calculation for boiler 75 tph

Boiler-45 TPH

Parameter	existing condition	after improvement
%o ₂	8.1	5
%excess air	62.79069767	31.25
therotical air requirment (kg/kg of fuel)	4.40075	4.40075
actual mass of air supplied	7.164011628	5.775984375
mass of dry flue gas	8.164011628	6.775984375
affecting parameter		
dry flue gas loss	7.397089323	6.139452509
loss due to moisture in air	0.289451321	0.240239446
boiler efficiency%	79.69146693	80.99831562
annual saving in fuel input(tons)	2623.871119	
rice husk price/ton	4500	
total saving(rupee)	11807420.03	

Table -5.10 savings and pay back calculation for boiler 45 tph

5.1.5 RECOMMENDATION AND CONCLUSION

Conclusion

For the excess air

1. by measuring the percentage of O₂ We have to first determine excess air level (by volume) in the flue gas path, [16] poddar state that when the boiler running at normal load for the O₂ analysis damper and induced draft fan should avoided for flue gas analysis it is suggested that there is no air leakage at path. when boiler need high excess air than reading of O₂ is 8% to 10% it depends upon boiler design & reduce air quantity slowly and monitor O₂ reading quantity reducing O₂. Quantity of oxygen prefer 3% to 5%
2. Any further reduction of O₂ below 3% chimney results smoke and light brown smoke indicate proper combustion.
3. [17]The maximum efficiency of the boiler does not occur at full load. But at about two third of the full load. If the load on the boiler decreases further efficiency tends to decrease.

4. [18] by regulating the air supply If we are not able to achieve at least 4% O₂ reading without causing smoke, may be burner defective. boiler is always operated at the air and fuel setting that have been determined

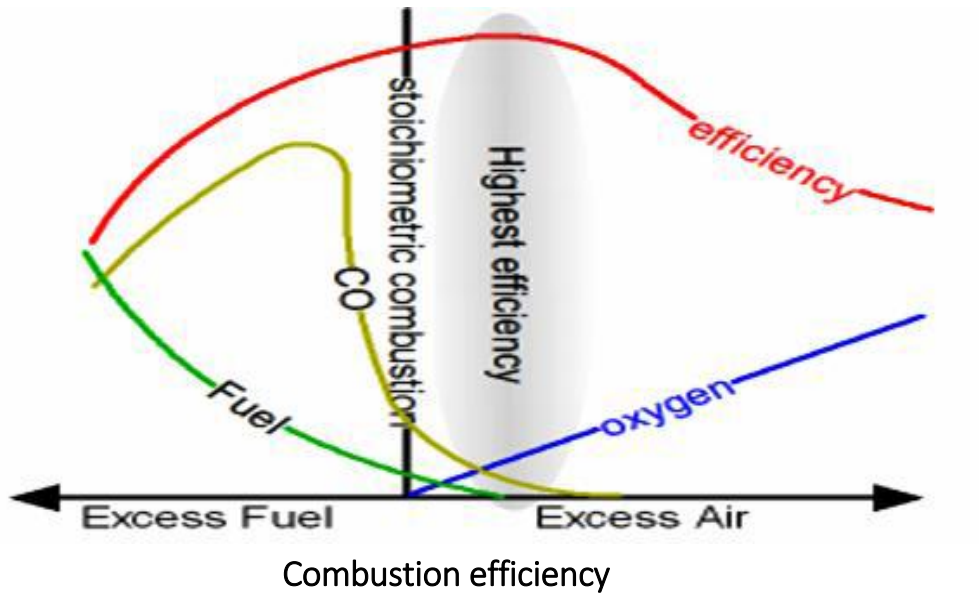


fig 5.4- combustion efficiency balanced graph

Excess Air Control 1% excess air reduction = 0.6% efficiency rise

Use of Flue gas Temperature Every 9°C reduction in flue gas temperature in APH outlet = 1% increase in efficiency

For the stack temperature Graph Shows comparison of efficiency of effective utilization of flue gas temperature. Flue gas temperature can be effectively utilized through proper maintenance of boiler Maximum Utilization of boiler resulted ESP I/L Temperature in Higher side. Flue gas Exhaust Temperature is higher due to Maximum load on boiler.

RECOMMENDATION:[19]

Oxygen Trim Systems: when load on boiler is vary in many times in day. oxygen trim system should recommend for this solution .oxygen analyser or trim system gives feed back to the control and turn automatically minimize excess air to the boiler system

5.2 IMPROVING INSULATION OF POWER PLANT & MACHINES

5.2.1 LITERATURE REVIEW

Radiation and Convection losses

radiation and convection losses deliver the heat losses radiating from boiler surface or exposed area of steam and water line. Sometime without radiation and convection losses boiler efficiency measured.[20] These losses depends upon the temperature of the boiler outer surface . poor insulation and poor design characterised tend to have maximize radiation and convection loss. These losses increases when boiler operates under low loads.

When the boiler with better insulation will have lower surface temperature and lower loads and temperature. When compared with un insulated surface the boiler maximize higher radiating loss and wasting energy every time.

Insulating material

As we are using here **calcium silicate** heat loss capability is higher than the glass wool. **calcium silicate wool** also prefer as a **High-temperature insulation wool** (HTIW),[16].this type of insulation can tolerate temperature 1200 c. Calcium silicate insulation is made mostly of hydrous calcium silicate; it is found in moulded and rigid forms. Temperature exist between 35 c to 815 c. Strength and flexibility of HTIW differentiate to other insulation also have water strength property .it is non combustible which is not effected by the hot burning surface of the system. Calcium silicate is particular applied on high-temperature pipe in boiler and equipment in power plants .its main property that industries prefer most of the time.

- It is light weight
- Also have less thermal conductivity It is high temp. and chemical resistive

5.2.1.1 Energy performance and assessment by radiation & convection loss in power plant

if system with un insulated area create maximize heat loss in the system. When hot metal exposed to the surrounding it deliver own heat to the open surrounding thus extra heat is

generate and extra fuel consumption increases. Recovery of this solution we can insulate the exposed area to minimize the heat loss

[21] govern calculation based upon heat loss by the radiation and convection this calculation based upon entire flat plate per meter² area rather than whole area of the surface any given length. Pipe insulation area is greater than inner area

To calculate heat loss we can find this formula to observe how much heat extracted by the exposed system

$$Q = \sigma \epsilon A (T_H^4 - T_C^4) \text{ WATT}$$

Emissivity- a body that does not absorb all incoming radiation some times grey body emits less total energy than black body and is characterised by an emissivity

Non black bodies emit less radiation than non black bodies emits less radiation than black bodies, which also happen to perfect emitter where ($0 < \text{emissivity} < 1$) When radiation exchange between two bodies that are not black

A = surface area of the pipe

σ = stefan boltzman constant (5.67×10^{-8})

5.2.2 METHODOLOGY

Preliminary survey of steam line hot water and boiler section where

- I saw some places where insulation is not available on the surface of boiler section and steam line
- By Infrared thermometer and inch tap. I found area of exposed
- The total area of un insulated exposed area is 130 m²
- We have measured exposed area temperature in degree Celsius, same as the process temperature . Ambient temperature of surrounding is 36 C.
- The steam system serving this site is in operation 24 hours a day and 345 days a year; in other words 8280 hours per year
- At paper machine section approx. 200 m² area was exposed

5.2.3 RESULTS

1. CASE STUDY I – Heat Loss From Un insulated Area In Boiler Section



Fig- 5.5 exposed area in boiler section

Specification		Boiler 45 TPH section	Boiler 75 TPH section
Item description		Missing insulation	Missing insulation
Exposed area	m ²	97	33
Heat loss by radiation	kcal/hr	21682.80	7376.70
Heat loss by convection	kcal/hr	13254.10	4509.12
Emissivity of metal		0.64	0.64
Heat loss after insulation	kcal/hr	1828.61	258.50
Reduction in heat loss	kcal/hr	33108.29	11627.70
Annual hr		8400	8400
Annual heat loss	kcal/hr	278109636	97672680
Efficiency %		76.20	80.29
Calorific value of fuel	kcal/kg	3300	3300
Annual saving	kg	196313.3358	
Rice husk price	rupee	4	
Total	rupee	785253.256	

Table 5.11- heat loss by exposed area and savings

Saving and payback analysis

Glass wool insulation cost-1500/meter²

Total exposed area-130 m²

Total expenditure-1500*130 =195000 rs

Net annual saving- 785253.256 rs

payback period- $\frac{\text{total expenditure}}{\text{net annual saving}}$

Period-3 month 09 days

5.2.3.2 CASE STUDY II- Thermal Heat Loss by paper machine 1 & 2 (Hot Air duct)

Hot air, supplied to machine through main duct main branch to each cylinder

	Paper m/c—1	Paper m/c-2
Material	Aluminium (oxidized)	Aluminium (oxidized)
Main air duct size area	65.85	79.63
Temperature (c)	90	90
Air duct branches area	25.50	25.50
Temperature	70	70
Ambient temperature	36	36

Table 5.12 - machine area and temperature

In both cases the main and branch air duct is uninsulated which is supplying hot air to individual cylinder in paper machine-1 & 2. And it connected to each cylinder outside hood.

MATERIAL	ALUMINIUM(OXIDIZED)			PREPARED BY	RAHUL CHATURVEDI (TRAINEE)	
EMISSIVITY(E)	0.19				M.TECH(ENERGY MANAGMENT)	
BOLTZMAN CONSTANT(σ)	5.67E-08				SATIA INDUSTRIES	
HEAT TRANSFER COEFFICIENT(h) Watt/m ²	3.5					
WATT TO KCAL/HR	0.860421					
HEAT LOSS AFTER INSULATION(WATT)	3292.667099					
$Q = \sigma \epsilon A (T_1^4 - T_2^4) \text{ WATT}$						
PAPER MACHINE-2	AREA(M2)	SURFACE TEMPERATURE(K)	AMBIENT TEMPERATURE(K)	ABSOLUTE ΔT^4	ENERGY LOSS BY RADIATION(WATT)	ENERGY LOSS BY CONVECTION(WATT)
TOP ROOF SURFACE DUCT(CENTRA)	36.91	363	309	8246448000	3279.046911	6975.99
TOP ROOF SURFACE DUCT(RIGHT)	22.61	363	309	8246448000	2008.649435	4273.29
TOP ROOF SURFACE DUCT(LEFT)	25.06	363	309	8246448000	2226.304947	4736.34
TOP BLOW BOX	6.65	348	309	5549557455	397.5727934	907.725
BOTTOM BLOW BOX	18.84	348	309	5549557455	1126.356606	2571.66
TOTAL DUCT AREA	110.07				9037.930691	19465.005
PAPER MACHINE-1						
TOP ROOF SURFACE DUCT(CENTRA)	43.96	363	309	8246448000	3905.36175	8308.44
TOP ROOF SURFACE DUCT(RIGHT)	8.67	363	309	8246448000	770.2339939	1638.63
TOP ROOF SURFACE DUCT(LEFT)	13.22	363	309	8246448000	1174.451372	2498.58
TOP BLOW BOX	6.65	348	309	5549557455	397.5727934	907.725
BOTTOM BLOW BOX	18.84	348	309	5549557455	1126.356606	2571.66
TOTAL DUCT AREA	91.34				7373.976515	15925.035



Fig 5.6 – exposed area in paper machine

5.2.4 HEAT LOSS SAVING & PAYBACK ANALYSIS

Approximate area of uninsulated duct	M2	196.46
Ambient temperature	C	36
total losses	Kcal/year	120386725.8
average temperature after insulation	C	40
total losses after insulation	Kcal/year	116909744
amount@4.5 kg rice husk	Kg	44240
Total saving Rs	Rs	199078
Pay back period	6 Month 10 days	

Table 5.13 saving calculation and heat loss by paper machine

5.2.5 RECOMMENDATION AND CONCLUSION

it is difficult to calculate saving due to above roughly we assume 5% in electrical power and 5% in steam for machine 1&2. In paper machine 1&2 the lower portion of hood area is open. the total lower cylinders are totally exposed. If hood is properly closed and air infiltration is minimised .this would reduce steam consumption. saving will be 10 to 15% This will enable to recover more heat Reduce infiltration will reduce load on blower and exhaust fan.

If hood is properly closed and provides insulation on hot air duct at paper machine 1 & 2 Approximate we can save 80000 rs electrical saving with thermal saving Around 2 lac rupee per year

5.3 IMPROVING STEAM TRAP MANAGEMENT

The reason of putting in the steam traps is to gain rapid heating of the product and equipment by means of securing the steam lines and system freed from condensate and water hammering

A large temperature drop throughout the entire way that steam trap is not draining condensate and it is defective. When trap is closed and does not drain condensate water it doesn't mean that energy is wasted by the trap. It reduces production of steam, poor quality of steam generated and water hammering problem created by the defective steam trap

5.3.1 LITERATURE REVIEW

Testing and maintenance of steam trap described by many authorities. And researcher e.g. [22, 23, 24-26] these papers describe four methods to approach steam trap testing. Using visual, temperature, and sound testing methods. By the temperature testing we can check steam and condensate pressure B/W the trap

Several researchers and practitioners e.g. [27, 28-31] have in the past reported comparative performances of different traps. Tsyrlunikov [29] and Shada Abu-Halimeh [30] performance of steam trap evaluated by many practitioners and researchers. They developed comparative performance of different traps. They did their experiments and tell about performance of the traps that it did not affect overall performance at industrial sector but it would affect after several months/year of running. Rate of leakage of trap increases with time. Practical performances of steam trap on their own can not give conclusion data on trap

Overall performance of trap factored into three categories

- Rate of air discharge rate
- Back pressure effect
- Susceptibility to failure

Webb [28], Dickerson [32] and Hanekom [33]. They suggested that trap performance can be improvised and we can developed practical approach to trap performance. If two traps install on charge line and monitored their performance of over a period of time. Such practical approach by these literature Wardell [34] and Currie [35]. They were motivated to use of energy efficient trap system

Testing Methods Of Steam Trap

5.1 Visual Testing [36]

Trap testing by visual by naked eye or sight glasses it includes variation of condensate flow by traps and observed timing of condensate drain with the help of visual testing we can see how much pressure of flash stem is out. It is least feasible.

5.2 Sound Testing

When trap release flash steam. We cant see leakage in the trap that's it includes sound testing. in sound testing includes ultrasonic detectors with the help of these detector We can identify where all the leakage is. This method best with trap

5.3 Temperature Testing

[37] discharge temperature of flash steam or condensate water is differ from charge line. When trap is defective it shows same temperature on before and after trap respectively. When it functioned properly then temperature after the trap less than before. Temperature checks for condensate and steam pressure after and before the trap. Typically discharge temperature on the out let drain we use infrared gun to measure trap temperature.

5.3.2 METHODOLOGY

- Preliminary survey of steam trap in boiler section and paper machine section
- I checked steam trap by the visual and temperature testing I found
- Approximate 75% of the steam traps have been defective and also steam continuously drain at medium pressure at *chemical recovery boiler*
- it has failed & is in poor condition
- Failed steam trap either closed or open
- Calculate energy wastage by the defective steam trap and report to the concerned department

5.3.3 RESULT

Site	No Of Traps	Remark
Mp line near chimney	1(open)	Need to be changed
Near ID fan	2(close)	Need to be changed
Mp line near esp outlet	1(open)	Need to be changed
Near pa fan	1(open)	Need to be changed
Near feed pump	1(close)	Need to be changed
Near SA fan	2(open)	Need to be changed
Near AB tank	1(close)	Need to be changed

Fig 5.7 & table 5.14 defecting steam trap on site



**Defective Closed steam trap
Near ID fan line**



**Defective open steam trap
near ESP line**

5.3.4 SAVINGS AND PAY BACK CALCULATION

Scope of saving due to steam trap	%	1
Total steam consumption/month	MT	4719
Steam savable/annum	MT	566
Boiler efficiency%(80*80)		64
Equivalent rice husk of 3600 kcal/kg-MT	MT	87
Annual modest saveable	%	50
Rice husk saveable	MT	43
Amount savable@4000/ton	Rs	152216
Approximate expenditure	Rs	200000
Pay back period	month	1.31

Table 5.15 saving and payback period from steam trap

5.3.4 RECOMMENDATION

Recommend installed new steam trap and maintenance required for old steam trap which is installed in boiler section all over plant steam trap were in poor condition no one care about steam trap.

Set right or replace all defective by pass valves and steam trap to prevent escape of live steam or excess use of steam

Check the main charged and saturated line where we can use steam trap. And where you would like to install steam trap. renew all the trap and piping section of steam line

5.4 CONDENSATE RECOVERY FROM STEAM TRAP

5.4.1 LITERATURE REVIEW

Reasons for Condensate recovery

- Reduces water charges,
- Cooling cost of water reduced and effluent charges,
- Reduced fuel cost,
- Condensate recover from boiler blow down that reduced cost of fuel and less energy loss,

Experimental set up

- Approximate 140 meter pipe line required
- Pipe Grade DN 25 (25 mm dia)
- Insulation of pipe
- PUMP required

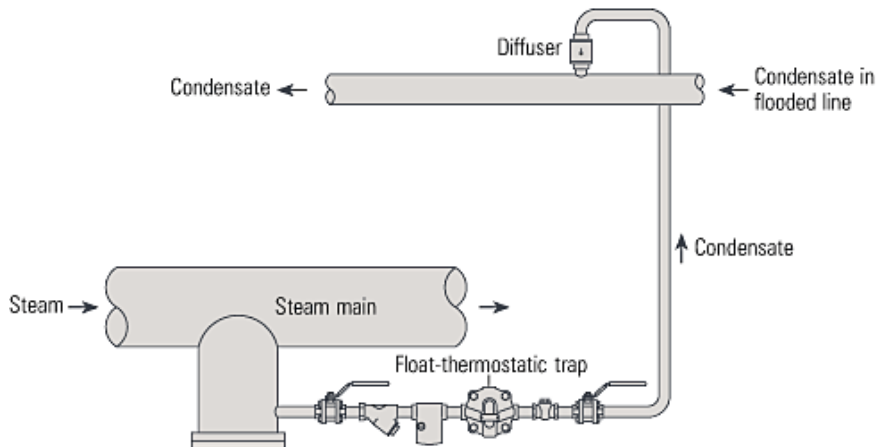


Fig 5.8 Condensate recovery by steam trap

Drain of condensate and incondensable gases should flow from the trap with installed drain piping which is connected to condensate recovery line which recover most valuable condensed water.

[37] drain piping line or discharge line can collect condensed water from trap. condensed water does not flash in this line. Gravity is the driving force and condensed water flow along the pipe. The situation of discharge line to terminate below the trap.

5.4.2 METHODOLOGY

- Preliminary survey of steam trap
- Where I found 12 steam trap which is working properly, condensate water via steam trap wastage continuously. Condensate is a useful source of energy
- Determine the mass of water we use bucket condensate collection. And temperature of condensate water is 90 C, Digital stop watch make- casio
- Calculate energy loss, savings and pay back period of the condensate
- the stop watch indicate discharge time of water that how much time will take on discharging

- when we recorded final temperature of water. then we removed water bucket. this method repeated on every steam trap and finally we calculate total mass of condensate water

5.4.3 RESULT

heat transfer rate

$$Q=m \cdot C_p \cdot (T_h - T_a)$$

m=mass flow rate(kg/hr)- 810 kg/hr

C_p=specific heat of water- 1 kcal/kg C

T_h=hot water temperature- 90 C

T_a =surrounding temperature- 35 C



Fig 5.9- drain condensate from steam trap & boiler blow down in industry

Condensate Loss Calculation		
Mass Flow Rate Of Water	Kg/Hr	800
Specific Heat Of Water	Kcal/Kg C	1
Hot Water Temp.	C	90
Surrounding Temp	C	35
Total Energy Loss By The Condensate	Kcal/Hr	44000
Annual Saving Of Fuel Kg	Kg	140000
Annual Saving Of Fuel Rupee	Rupee	560000

Table 5.16- Savings from condensate recovery

5.4.4 PAYBACK PERIOD & SAVING ANALYSIS

Pay Back Calculation		
Total Investment Of Project	Rupee	200000
Net Annual Saving	Rupee	560000
Water Treatment Cost (Approx)	Rupee	150000
Pay Back Period	Month	3.42723005

Table-5.17 savings by steam trap condensate

5.4.5 RECOMMENDATION

- Installed a new line with insulation below the main line and saturated line where steam traps are downstream.
- installed better quality of trap like the inverted bucket which is best for energy efficiency and effectiveness.
- renew the piping line and maintenance also required for plant operation
- every last of month inspection of trap recommended.

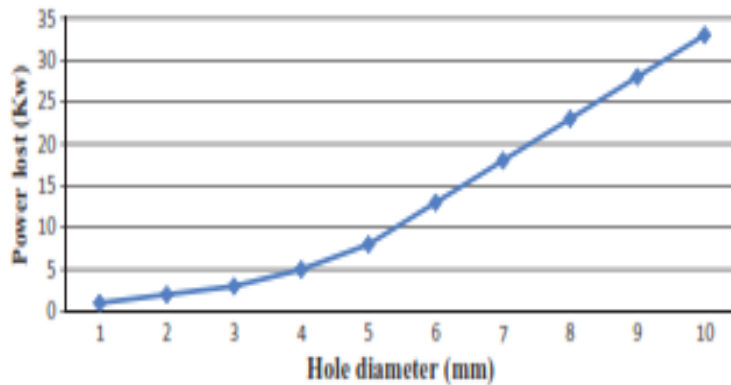
5.5 IMPROVING COMPRESSED AIR SYSTEM

5.5.1 LITERATURE REVIEW

Energy savings through leak prevention in air compressors

In compressed air system leaks is very wasteful source of energy in industrial application. Energy consumption of the air compressed system in industry is play major role .leaks may increases consumption of energy this is the single greatest source of energy. 20% to 50% energy wastage from air leaks in compressed system. Leaks can be reduced by the replacing faulty equipment [38]

Due to leaks pressure drop in system and its affecting production of industry. Also degrade the efficiency of compressed system, maintenance cost, equipment life is short. Un schedule down time increased when diameter of hole is increased energy consumption also increased exponentially [39].



Graph 5.3-dependence of power loss on hole diameter at 600 kpa

Energy required for the compress air is lost by the leaks. Due to leaks energy required for compress volume of air is the cost of compressed air leaks. Air leaks increases with the diameter of hole increases[40].

When plant operation is in idle condition apart from that leaks may indentified by their hissing sound. In shut down plants leaks can repairs by replacing by clamp over the leak [41].

Compressed air system inlet air temperature should be less than the ambient temperature at industrial sector because compressor consume more energy rather than idle condition because some plant compressor room is closed with exhaust duct so temperature of room will increases efficiency of compressor will decreases. [41].

5.5.2 METHODOLOGY

- Preliminary survey of compressors room
- As we measure Inlet temperature at Compressor room in Paper M/c-3 stood at 36 C with ambient temperature stood at 34.
- There is no exact reason behind it but it can be prevented with exhaust duct temperature stood at average 60 Ć with all 5 compressor exhaust temp stood at same by insulating duct temperature of room can be brought down.

- All these are connected. Air is always blowing out from common outlet as all have been crack opened. 1 /4” pipe is always blowing from main receiver tank in paper machine -3.
- Air worth about 20.19 kW is being wasted continuously.
- We calculate energy loss by the compressors and savings and payback period

5.5.3 RESULT

Inlet Temperature

For every 4 degrees centigrade increase in inlet air temperature, energy consumption increases by 1%. The intake and ambient temperatures were noted. The same are as below

Items		Summer*8	Winter*4
Ambient temperature	C	36	16
Compressor room temp.	C	34	15
Decrease in temp. due to insulation	C	2	1
Excess energy consumption due to 1% for 4C		0.5	0.25
Annual energy consumption@ 13500kwh		16200	4050
Total energy saveable		20250	
Amount saveable@4.5kwh	rupee	91125	
Expenditure	rupee	15000	
Pay back calculation	month	2	

Table 5.18-saving potential by insulating exhaust duct

5.5.4 SAVINGS AND PAY BACK

Power savable in kw	20.19
Energy savable @ 50%	10.095
Total energy savable for 320 days	72684
Amount savable@4.5kwh	327078
Expenditure in rupee	100000
Payback period	0.31

Table-5.19 saving potential by compressor air leaks

5.5.5 Recommendation

Here some of energy saving measures in compressor:

- Decrease the inlet temperature of air
- Clean Air-inlet filter regularly. Compressor efficiency will be reduced by 2 percent for every 250mmwc pressure drop across the filter.
- If More than one compressor is feeding to a common header, compressor must be operated in such a way only one small compressor should handle the load variations whereas other compressors will operate at full load.
- Keep the Minimum possible range between load and unload pressure settings.
- Automatic timer controlled drain traps wastes compressed air every time the valve opens. So frequency of drainage should be optimized.
- It is suggested that the manual moisture draining be replaced with automatic moisture draining devices, this ensures regular moisture drainage automatically and keeps the pneumatically operated equipment in good health.

5.6 IMPROVING MOTOR LOAD ANALYSIS

5.6.1 LITERATURE REVIEW

Major source of electricity consumption in industry is by electric motors For the use of process and activities in industry. motors is essential in every electrically part of the systems eg. Mixing, cutting, compressed, air pump, and refrigeration

- Core losses sum of the hysteresis or eddy current losses of the laminated rotor core and laminated stator.
- Rotor and stator losses losses ($I^2 R$ losses in stator and rotor windings).
- Stray losses; this is the lump sum of all losses in the motor which cannot be attributed to one of the other four components.
- Friction and windage; this is the loss due to fans and the bearing friction.[42]

Standard motor have already energy efficiency range in 80% and above at full load it work on 90% efficiency. researcher has able to increases motor efficiency [43]

Energy efficient motor define by its labels as EFF1 ,EFF2 and EFF to make it much easier to purchase high energy efficient motors. Manufactures of motors will labelled their motors with efficiency logos

High efficient motor benefits:

- It gives better tolerance to thermal stress and provide frequent starting.
- Provide Higher power factor.
- Prevent low factor utility.
- Higher tolerance to poorer voltage and current wave shapes.

5.6.1.1 Energy saving by high efficient motors

Replacing a standard motor to high efficient motor with high efficiency can be estimate following equation:

$$\text{Annual energy consumption with SD connection} = \frac{\text{Motor hp} * 0.746 * \text{No.of motor} * \text{hours}}{\text{Efficiency of std motor}}$$

$$\text{Annual energy consumption with VSD} = \frac{\text{Motor hp} * 0.746 * \text{No.of motor} * \text{hours}}{\text{Efficiency of efficient motor}}$$

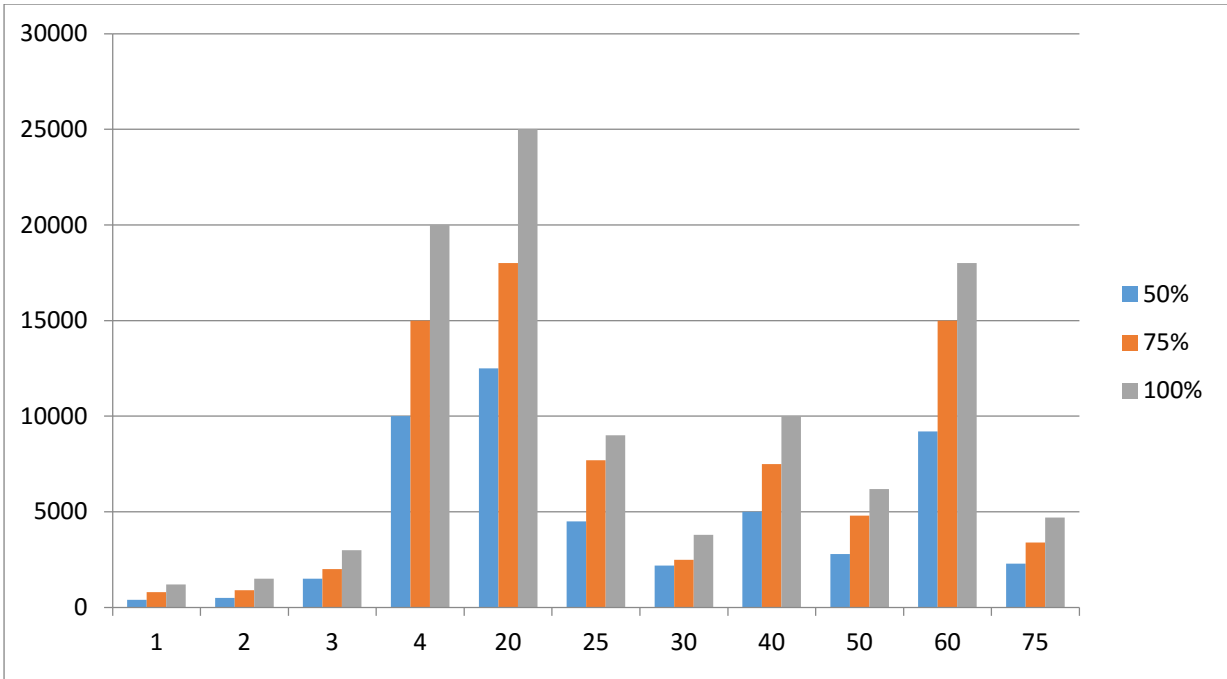
Annual energy savings with high efficient Motor

$$= \text{Annual energy consumption with SD connection} - \text{Annual energy consumption with VSD}$$

5.6.1.2 Energy saving results when by high efficient motors

According to Saidur et al. [30], installing high efficient motor on Eqs. (1)–(2) based on, the results of total annual energy saving in MWh are illustrated in Graph. 5.5

Energy saving vs motor power(kw)



Graph 5.4- Energy savings (MWh) for high efficient motor [44].

5.6.1.3 Cost–benefit results when using High efficient motors.

Mathematical formulations to estimate cost–benefit analysis when using HEM.

when using HEM. When using HEM, annual bill saving is related to annual energy saving and the unit price of energy. The formula that associated with the above cost savings method can be calculated as:

$$\text{annual bill saving when using high efficient motors} = \text{annual energy saving with HEM} \times \text{unit electricity price}$$

Payback period is the function of the incremental cost of HEM divided by the annual bill saving of HEM in a particular year.

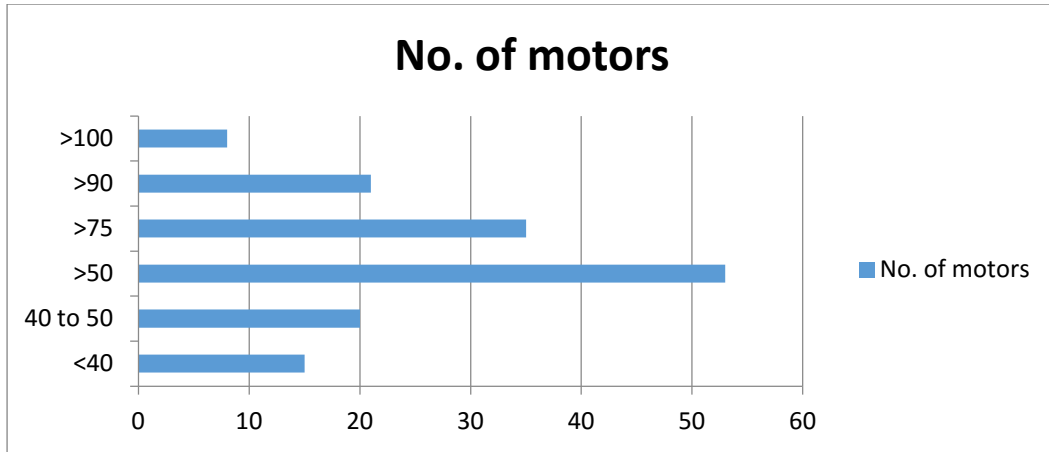
Payback period can be expressed mathematically from the following equation:

$$\text{Pay back period} = \frac{\text{total cost of high efficient motor}}{\text{Annual bill saving with using high eff. motor}}$$

According to Saidur et al. [44], when installing high efficient motors in the industrial motors and based on Eqs. (4) and (5), the results of total annual bill saving and payback period are shown in table 5.16 & 5.17

5.6.2 METHODOLOGY

- The checking of load indicates the compatibility of motor with driven equipment & also the efficient / proper working of the driven equipment. Thus it indicates possibility for saving power.
- There are more than 400 motors of various capacities. Some motors are standby and some are not operated after some energy conservation measures. We have checked 238 nos. motors during this project - almost of all types, for current, voltage, KW, Power factor, frequency etc. with the help of energy meter. Clamp meter, temperature gun checked motor having rated capacity 30 HP and above motors. Factors to be consider for motors
- Due to under loading of motors leads lower efficiency and power factor. It is also due to under utilization of the equipment
- When we select a large motor instead of low capacity motor because of requiring of the equipment high torque. High starting torque designed for high capacity motor which work on only these condition.
- Below graph shows most of motors in the plant are operating above 50% of loading its good sign as efficiency will be maintained at higher level. As graph shows increase in percent of loading will increased in efficiency.
- But some motors are working above 100% its nothing but its overloaded so at certain point efficiency of motors will get deteriorate may its over used (or) due rewinding.



Graph 5.5 - % loading in motor

5.6.3 RESULT

List of Motors overloaded and under loaded listed below:

Description	Power in kw		Current in amp		Volta ge in volt	Power factor	Motor efficien cy	Mode of control	Actual loading in %
	rated	actual	rated	actual	actual	actual	rated		
Seal tank-4 pp-3	30	36	46	59.1	390	0.90	0.9	SD	120
Centrifugal screen no.1	30	10.2	46	22.71	401.4	0.72	0.9	SD	34.07
Bleach chest agi 1	22	4.2	34	20.7	436.4	0.82	0.9	SD	19.09
Bleach chest agi 2	30	4.87	46.0	29.63	442.1	0.68	0.9	SD	16
B/W wire pit pp-2	22	24.45	38	38.4	404	0.91	0.9	SD	111.14
Booster pp-1	22	25.11	38	42.2	419	0.82	0.9	SD	114.15
Couch pit pump	15	16.03	26	24.6	409	0.92	0.9	SD	106.8
Primary feed pump	22	26.48	38	41.3	416	0.89	0.9	SD	120.38

Table 5.20 overloaded & under loaded motors in industry

From table its clearly shows that some motors are unloaded and overloaded, by calculating efficiency on loading percentage savings are calculated. It can be replacing of motors as per process requirement.

s.no	Particulars	Actual loading %	Actual efficiency %	Saving in 50% kwh	Saving in rupee	investme nt	payback
1	Seal tank-4 pp-3	120	80	2.08	67500	80000	1.19
2	Centrifugal screen no.1	34.07	80	2.08	67500	70000	1.19
3	Bleach chest agi 1	19.09	60	6.11	198000	80000	0.35
4	Bleach chest agi 2	16	50	13.33	432000	80000	0.19
5	B/W wire pit pp-2	111.14	82	1.19	40000	70000	1.81
6	Booster pp-1	114.15	80	1.52	49500	70000	1.41
7	Couch pit pump	106.8	82	0.81	26342	35000	1.33
8	Primary feed pump	120.38	80	1.52	49500	70000	1.41

Table 5.21 saving potential from the motors

5.6.4 SAVINGS AND PAYBACK PERIOD

Total saving and payback are shown below:

Replacement of motor	
Energy savable@50% for 300 days 24 hrs	206450
Expenditure for maintenance	55500
<u>Saving@4.5 kwh</u>	928975
Pay back time	0.60

Table 5.22 total savings and payback period

5.6.5 RECOMMENDATION

At present energy efficient motors, whose efficiency is higher than normal standard motors are competitively available in market. these have higher efficiency, high power factor and longer life than normal standard motors. motors in this plant are operating for more than 7200

hours. Replacement of some small size motor, which have been rewound, can be considered. all new purchase should be of energy efficient motors.

Top Management knows about energy conservation, but there is not much information about it in the Engineers simply focus on operational work

CHAPTER- 6

BARRIERS AND DIFFICULTIES

From our visits to the facilities through energy conservation and interviews with the top management and engineers that have the responsibility on maintenance and production, four categories of barriers to energy conservation and efficiency in the satia industry sector were identified:

- Management
- Knowledge /information
- Financing
- Behavioural
- Policy & Framework

1. Lack of management awareness

- The most important barrier that management is focused only production of the product apart from they are not aware and concentrate on more efficient use of energy systems and reducing production cost
- Lack of awareness of energy efficiency and resources also create immature system to manage To energy

2. Limited knowledge and information

- Top Management knows about energy conservation, but their engineers is not much information about it. they focused on only operational work
- The reason for poor monitoring by the engineers and no actively managed energy system despite of energy cost can be high in industry

3. Lack of financing

- All companies limitation of implementing energy efficiency and energy conservation project

- Common barrier is lack of financing whether company will benefit from energy conservation project or not on this suspicion they do not invest

4. Behavioural Barriers

Behave of individual of people is also important aspect for energy conservation. We recognise some behavioural parameter like credibility, values, trust can act to improving energy efficiency

1. Credibility and Trust

If the source of information provided by the energy engineers to implement energy efficiency project when it is not trust worthy company do not invest money based on that information

2. Values

When industry well knowledge and information about energy conservation measures more likely they will invest in energy efficiency projects. but without values of a industries think no one care about energy efficiency and environment and lets running as running in past

CONCLUSION AND SUMMARY

We identified saving potential worth 160 lacs rupee with an investment of rs 75 lac. Most of these are well known to plant engineers. Implementation is slightly difficult due to various reasons. But the suggestions are realistic & practical. One is availability of shut down and retrofitting of old technology with latest available.

1. Reduce Excess %O₂ and excess air in AFBC Boiler 1 & Boiler 3 by Installing Oxygen Trim system

Boiler-75 TPH

Financial Profit	
Annual Saving In Fuel Input(Tons)	282.8276702
Rice Husk Price/Ton	4500
Total Saving(Rupee)	1272724.516
Investment (rupee)	1000000
Pay back period(month)	9.15

Boiler-45 TPH

Financial profit	
annual saving in fuel input(tons)	2623.871119
rice husk price/ton	4500
total saving(rupee)	11807420.03
Investment (rupee)	5000000
Pay back period(month)	3.15

Conclusion

Some excess air is needed for efficient combustion of fuel. In rice husk fluidized bed boiler, normal excess air level is 6 to 8%. In every well maintained & operated boiler, it is possible to maintain it at about 5%. It is on the higher side in both rice husk fired boiler.

For such rice husk fired boiler it should be under 130 or 140 but in boiler 45 TPH flue gas temperature is 166 measured. Flue gas temperature of boiler 45 TPH should be near around 140.

2. Radiation and convection loss by the system

Skin temperature up to 40 C is excellent, up to 55 C satisfactory and up to 60 C is tolerable. But if it is more, it should be reduced by providing, improving or redoing insulation. Here skin temperature is mostly satisfactory. Several places of boiler section found exposed area.

Case study-I at boiler section

Savings and payback		
Annual saving rice husk	kg	196313.3358
Rice husk price	rupee	4
Total	rupee	785253.256
Investment	rupee	250000
Pay back period	month	3 months

Case study-2 paper machine

Savings and payback		
amount@4.5 kg rice husk	kg	44240
Total saving	rupee	199078
Investment	rupee	300000
Pay back period	month	6 month

3. Replacement of Defective steam traps at steam line

For proper steam utilization, these need to be maintained properly. In this plant, most need immediate attention required in industry.

Savings and payback		
Rice husk saveable	MT	43
Amount savable@4000/ton	Rs	152216
Approximate expenditure	Rs	200000
Pay back period	month	1.31

4. Condensate recovery by steam trap drain

Savings and pay back		
Annual rice husk saving	TON	140
Total Investment Of Project	Rupee	200000
Net Annual Saving	Rupee	560000
Water Treatment Cost (Approx)	Rupee	150000
Pay back	month	3.42

- Condensate recovery from steam trap it is valuable source of heat and pure water.
- In this plant, the whole system need renovation and up gradation
- Steam leakage these need to be reduced. it can be attend online also.

5. Reduce inlet air of compressor and air leakages

The efficiency of compressed air from production to use is 5 to 10 % For every 1kg/cm² increase in pressure, 9% extra energy required. Similarly every 3.5 increase in inlet air temperature, increase consumption by 11% every 125 mmwc drop in suction pressure reduce efficiency by 1% base upon these others, some energy savings potential.

Savings through decrease inlet air temperature

Amount saveable@4.5kwh	rupee	91125
Expenditure	rupee	15000
Pay back calculation	month	2

Saving by compressor air leaks

Power savable in kw	20.19
Amount savable@4.5kwh	327078
Expenditure in rupee	100000
Payback period	0.31

6. Maintenance & even replacement of over load and under load motors

Motors operated at maximum efficiency between 75 & 100% of rated capacity, the fall is very little up to 60 %, about 1-2.5% up to 50% but very sharp when load reduces below 40% over loading/excess no load losses of motors are generally due to bad design, construction, bad maintenance of motors or drive equipment & repeated rewind etc. there is a optimum voltage for every load. Here are some savings by maintenance & replacement of overload and under load motors

Savings and pay back		
Annual savings in	KW	233280
Annual savings in	rupee	1049760
Investment	rupee	600000
Payback	month	6.9

References

- [1] Petrecca G. Industrial energy management: principles and applications. USA: Kluwer Academic Publisher; 1992.
- [2] Bureau of Energy Efficiency. Energy management and audit; 2010 [Online] Available at: <http://www.em-ea.org/Guide%20Books/book-2/2.8%20Waste%20Heat%20Recovery.pdf> [Accessed 5.10.09].
- [3] Kannan R, Boie W. Energy management practices in SME—case study of a bakery in Germany. *Energy Conversion and Management* 2003;44:945–59.
- [4] Saidur R. A review on electrical motors energy use and energy savings. *Renewable and Sustainable Energy Reviews* 2010;14:877–98.
- [5] Hepbasli A, Ozalp N. Development of energy efficiency and management implementation in the Turkish industrial sector. *Energy Conversion and Management* 2003;44:231–49.
- [6] Sola A, Xavier A, Kovaleski J. Energy efficiency in production engineering courses. In: Third international conference on production research—Americas' region; 2006.
- [7] R.A Zeitz, Energy efficiency hand book, council of industrial boiler owner (CIBO-Burke VA), PP 25-65, 2003
- [8] M. J. Poddar, Mrs. A.C. Birajdar (2013), —Energy Audit Of A Boiler-A Case Study Thermal Power Plant, Unit-Iii Parli(V) Maharashtra, *International Journal Of Engineering Research & Technology (IJERT)* ISSN: 2278- 0181, VOL. 2 ISSUE 6, PP.1660-1666.
- [9] Mudita Dubey¹ Prof. Abhay Sharma² M.Tech Iv Sem1 Dept. Of Mechanical Engg.2 Ggits, Jabalpur Improving The Efficiency Of Thermal Equipments Of 210 Mw Tps Through Thermal Audit *International Journal Of Engineering Research & Technology (Ijert)* Vol. 1 Issue 5, July – 2012 Issn: 2278-0181
- [10] Moni Kuntal Bora And S. Nakkeeran (2014), —Performance Analysis From The Efficiency Estimation Of Coal Fired Boiler, *International Journal Of Advanced Research* , Issn 2320-5407, Volume 2, Issue 5, Pp.561-574
- [11] Bureau of Energy Efficiency, Ministry of Power Govt. of India, Energy Auditor guide book volume- 4, 2005, Chap-3, 45-53.
- [12] Harish Ghritlahre¹ , Tej Pratap Singh² Assistant Professor, Mechanical Engineering Department, Parthivi College of Engineering & Management, Bhilai-3, CG, India
- [13] Anjum Munir*, Jahan Zeb Alvi, Sidrah Ashfaq “Performance Evaluation Of A Biomass Boiler On The Basis Of Heat Loss Method And Total Heat Values Of Steam” *Pak. J. Agri. Sci., Vol. 51(1), 209-215; 2014 ISSN (Print) 0552-9034, ISSN (Online) 2076-0906*
- [14] Naterer GF, Regulagadda P, Dincer I., Energy analysis of a thermal power plant with measured boiler and turbine losses, *Applied Thermal Engineering*, 30, 2010, 970–976.

[15] Dan Einstein, Ernst Worrell, Marta Khrushch, Lawrence Berkeley National Laboratory
Steam Systems in Industry: Energy Use and Energy Efficiency Improvement Potentials

[16] Mr. M. G. Poddar. Mrs. A. C. M.B.E.S. College of Engg, Ambajogai. M.B.E.S. College
of Engg, Ambajogai. Maharashtra. International Journal of Engineering Research &
Technology (IJERT) ISSN: 2278-0181 www.ijert.org Vol. 2 Issue 6, June – 2013

[17] Rafal Strzalka¹, Prof. Roman Ulbrich¹, Prof. Ursula Eicker² ¹Opole Technical
University, St.Mikolajczyka⁵, PL-45-271, Opole, Poland Energy and environmental
performance of a biomass cogeneration plant

[18] International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-
0056 Volume: 02 Issue: 01 | Apr-2015 www.irjet.net p-ISSN: 2395-0072” DETAILED
ENERGY AUDIT IN A CAPTIVE COGENERATION PLANT”

[19] Amit Kumar Vishwakarma¹, Gopal Kumar Choudhary² “ To Improve Thermal
Efficiency of 27mw Coal Fired Power Plant” | IJMER | ISSN: 2249–6645 |Vol. 4 | Iss. 2 |
Feb. 2014

[20] Study on Comparison of Boiler Efficiency Using Husk and Coal as Fuel in Rice Mill JP
Yadav^{1*} and Bharat Raj Singh² S-JPSET : ISSN : 2229-7111, Vol. 2, Issue 2

[21] Yen-Hsun Chen, King-Leung Wong*, I-Pin Kuo, Chuan-Huang Lin “The Heat Transfer
Characteristics of an Insulated Circular Duct Considering and Neglecting the Influence of
Heat Radiation” Proceedings of the International MultiConference of Engineers and
Computer Scientists 2009

[22] Sandeep, B.N. (2008) “Energy & fuel savings by adapting steam trap maintenance in
textile processing industries - Experiences from user group, Tirupur” User group conference
presentation, Tirupur, India, 2008: Available on line at:
http://www.emt-india.net/Presentations2010/05Buildings_20Feb2010/Conquest.pdf

[23] US Federal Energy Management Programme (1999) “Steam Trap Performance
Assessment: Advanced technologies for evaluating the performance of steam traps” Internet:
<http://www.eren.doe.gov/femp>

[24] Armstrong Steam and Condensate Group: “Steam Trapping and Steam Tracing”
Equipment Catalogue pp 64; Available on line at:www.armstrong-intl.com

[25] Spirax Sarco, (2007) “Energy Losses in Steam Traps” Module 11.15 in *The Steam and
Condensate Loop Book, 2007*

[26] Swagelok Company (2009) “Steam System Best Practices Steam - Trap Leak Rates”
Swagelok Energy Advisors, Inc. Document No. 3, 2009: Available on line at:
WWW.SWAGELOKENERGY.COM

- [27] Tucker, J. (2000) “Energy and Cost Savings through the installation of low maintenance traps” – *New Practice Case study of the UK Energy Efficiency Best Practice Programme* . Aug, 2000
- [28] Webb, T. (1977) “Steam trapping” *International Journal of Energy Research* Volume 1, No. 2, pp179- 185.
- [29] Tsyurul'nikov, I.M. (1998) “Methods of and means for testing steam traps” *Chemical and Petroleum Engineering, Vol. 34, Nos. 7-8, 1998*
- [30] Shada Abu-Halimeh (2004) “Summary Of The Performance Analysis Of Venturi Orifice Steam Traps” *MSc Thesis, Queen’s University Belfast Faculty of Engineering Chemical Engineering Department*
- [31] Joy, D.A. (1987) "Evaluating steam trapperformance data in light of the ANSJ/ASME Test Code," *Chemical Processing*. (USA), 50, No. 13, pp 92-94, 96 (1987).
- [32] Dickerson, D. (2003) “Clariant Experience of GEM Steam Traps” – *Letter from Clariant UK Ltd to Gardner Energy Management Ltd, 25th June 2003: Available on line at http://www.gemtrap.com/industry_references.php*
- [33] Hanekom, Hans (2009) Un titled: -*Letter from SwartlandBoudienste, to Delta Industries, 31 March 2009: Available on line at <http://www.deltaindustries.com/Swartland%20letter%20for%20website.pdf>*
- [34] Wardell, L. Lee (2002) “GEM Steam Trap Efficiency Test” *Letter from DSM Composite Resins UK Ltd to Gardner Energy Management Ltd, 21st June 2002: Available on line at http://www.gemtrap.com/industry_references.php*
- [35] Currie, R., (1998) “GEM Trap Reliability” *Letter from BAA Glasgow to Gardner Energy Management Ltd, 7th Aug 1998: Available on line at http://www.gemtrap.com/industry_references.php*
- [36] Sreedevi K. P. STEAM TRAP ANALYSIS AT PROCESS PLANTS (IRJET) e-ISSN: 2395 -0056 Volume: 02 Issue: 04 | July-2015 www.irjet.net p-ISSN: 2395-0072
- [37] kant E kanyarusoke, ian noble-jack Failed Steam Trap: First Step To Replacement March 2012 ISSN: 2231-1963 *International Journal of Advances in Engineering & Technology*,
- [38] Kaya D, Phelan P, Chau D, Sarac HI. Energy conservation in compressed-air systems. *International Journal of Energy Research* 2002;26:837–49.
- [39] Galitsky C, Worrell E. Energy efficiency improvement and cost saving opportunities for the vehicle assembly industry. Lawrence Berkeley National Laboratory 2008 [LBNL-50939-Revision].
- [40] PS (Plant Support). Compressed air ultrasonic leak detection guide; 2010, Available online at: <http://www.plantsupport.com/download/UCAGuide.pdf> [Accessed 24.05.10].
- [41] Saidur R, Rahim NA, Hasanuzzaman M. A review on compressed-air energy use and energy savings. *Renewable and Sustainable Energy Reviews* 2010;14: 1135–53.

[42] Saidur R. A review on electrical motors energy use and energy savings. *Renewable and Sustainable Energy Reviews* 2010;14:877–98.

[43] PTMPusat Tenaga Malaysia. High efficiency motors for industrial and commercial sectors in Malaysia; 2010, Available online at: <http://www.ptm.org.my/mieeip/pdf/High%20Efficiency%20Motors%20for%20Industrial%20and%20Commercial%20Sectors%20in%20Malaysia.pdf> [Accessed 14.05.10].

[44] Saidur R, Rahim NA, Masjuki HH, Mekhilef S, Ping HW, Jamaluddin MF. Enduse energy analysis in the Malaysian industrial sector. *Energy* 2009;34: 153–8.