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Energy and Exergy Analysis of Vallumbra Sugar Mill

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Abstract*—Power supply in sugar refining plants of Vallumbra mill and bureaucracy during the refining have been a major challenge. In addition to this problem is managing of aged equipment and machines, mismanagement from the energy department that affects the entire company and use of aged meter to record displaced energy during production of sugar. The aim of this work is to investigate the energy losses of three power plants and use energy and energy data to create technological solution to achieve energy cost saving and energy stability. As such, the objectives are to create modern system of maximizing profit and minimizing energy consumption, to use energy and energy data to create solution on energy cost saving and energy matter and to encourage effective energy management system. To achieve these objectives, the methodology employed was collection of energy data from Vallumbra sugar mill, evaluation of the present energy consumption of the production plant and evaluation of energy generation power plants. The result obtained showed that the gas turbine energy generation plant contributed 11.2% of energy to produce total of 120.4 metric tons of sugar that was refined, 6.4% was contributed by solar energy to produce 120.4 metric tons of sugar and 3.6% was generated by diesel generating plant to produce the same unit of metric tons. The most efficient of the three generating energy power plants is the gas turbine. The analysis also showed the energy cost reduction and instability of diesel and solar energy generating plant compared to that of gas turbine. It is therefore recommended that aged equipment should be avoided and modern computer monitoring equipment should be installed for the benefit of energy cost saving. During the process of purchasing rightful selection of equipment is very important as the use of inappropriate equipment can lead to low production, energy loss and instability of energy generation. Also, electric meters should be installed in major production and administrative units to monitor and curtail power wastages in each unit thereby reducing energy cost.

Keywords—Gas Turbine, Diesel Plant, Solar Energy Plant, Sugar Mill, Energy Generation

I. INTRODUCTION

Energy is a critical enable and indispensable commodity which is required for the growth and production of the vallumbra sugar refining mill. Is an asset and resources for human survival, without which the human consumption would be impossible. The refining of a unit sugar and sustainability is been intent by the availability of the electrical energy power system, and energy which has the capability to do work and he became a catalyst of the production system which is been generated by the three power plant, namely gas turbine, diesel use power plant, and solar energy from the sun. [1]. In every production process energy is been supported directly or in directly to produce a product, in valumbra sugar refining mail for producing a unit of sugar it takes three important steps or procedure to look the product to be produce if the energy is not stable or capable of producing the quantity or quantity then the maximizing profit and minimizing energy consumption have not be fulfilled and the method of production of unit of sugar is also important because the process is like what technique to use during production. [2]. Equipment and techniques of producing a unit product is important too, if the equipment are of faulty types or age then whatever technique the producer employed on system will be resulting in significant and result low quality and the product would not be encouraging maximum demand to make profit, the energy stability also encourage profitability of sugar refining so the three important things that move the profitability for growth of valumbra sugar refining mail is the product, process equipment/technique.
The quantum of electric power energy that is been used to power a diverse of manufacturing an output is very important.

The interchangeability of equipment, maintenance of equipment for creating solution for electrical power energy stability is also determine the type of product, the process, of manufacturing the product, of industry in-term of relating to many industrial process that require a large volume of heat and equipment or mechanical power been derive by natural gas, solar generator, diesel generator. In addition, some industries may generate fuel or energy from waste products that can be consider to produce their own product, because industrial process are so diverse it is impossible to describe the host of possible opportunity for energy efficiency improvement in such industry.

Many ride on the specific technology and process for providing industrial facility. In valumbra sugar refining mail the electrical energy generation system as a root of energy to power their equipment for production is depending on gas, diesel, solar from the sun source [3]

II. PROPOSED ALGORITHM

The Structure of the electrical energy power system of vallumbra sugar refining mill is been synchronies system. The aim is to optimize the productiveness of the emerging power system. This has led to describe the scenario where the energy power system is completely addressable and power flow can be operatively managed between central generators. An emphasis is put on the three cogenerating plant connection and how the fluctuation nature of power output can be control in such a way of not affecting the electrical energy power system stability of sugar refining and the residential area. Momentary in interruption and voltage sags both are many causes of inefficient of production process and energy system instability [4]. To establish interchangeability of equipment and to installed modern equipment in electrical power energy system and to encourage affective energy system and to encourage affective energy management system that are describe above can improve the cost energy savings process is been presented. The various criteria and method that have been employed to reduce the occurrence of energy losses, energy efficiency empowerment, and cost of energy saving potential has been debate and investigated

A. Concept of Energy and Exergy

Energy is the ability to do work or to produce heat as an input for various production processes. In thermodynamics analysis energy can be change from one form to another. In physical sciences state that mechanic energy is the summate of potential energy and kinetic energy it is the energy associated with the motion and position of object. The principle of conservation of mechanical energy state that in a secluded system that is only subjected to constant force, the mechanical energy is constant direction of conservation net for, the potential energy will increase and if the velocity of the object is changed, the kinetic energy [5]. In thermodynamics the energy of a system is the highest work that was produce when the system and the surrounding come to into equilibrium with a heat reservoir. Energy is the implicit to cause a change in the production system, is a property of heat system, quality system, quantity system in the surrounding and reservoir and to achieve maximum production every property must be put in rightful positions when the system achieve good quantity product it means that the energy system is effective During production operation process energy consumed or destroyed because is only control the production process of having maximum product or how the quantity of sugar cane be achieved. He uses analysis method by applying conservation of mass, conservation of energy and the second law of thermodynamic principle to design and improve a production system [6]. In improvement of system efficiencies, energy analysis is a good method to evaluate and have a good significant result and it also disclose whether or not and how to design effective production system by reducing system it efficiency of that production system [7, 8]. Exergy is a joining property of a system and its environment because unlike energy, it turns on the state of both the system and the environment. The exergy of a system in balance with the environment is zero. In the exergy analysis, the exergy is rate with regard to the reference environment. Therefore, the exquisite properties of the reference environment decide the exergy of a system. The outcome of exergy analysis is consequently relative to the specified source environment, which in most cases are modeled after the affiliate environment [9]. Exergy is neither a thermodynamic plat of matter nor a thermodynamic potential of a system

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B. Energy and Second Law of Thermodynamics

According to the First Law of Thermodynamics, energy is never extinguished during a proceeding; it changes from one form to another. In differ, exergy accounts for the irremediable of a procedure a result of increase in entropy according to the Second Law of Thermodynamics. Whenever a procedure involves a temperature change, exergy is always desolate [10]. This desolate is proportional to the entropy expansion of the system together with its surroundings. For an isothermal process, exergy and energy are switchable terms [11].

C. Description and Significance of Exergy

According to [12], the description and significances of exergy can be enumerated as follows:

a. It does not only rely on the state of a system or flow, but also on the environmental state.
b. Energy forms with lofty exergy contents are typically more worth and useful than energy forms with low exergy.
c. It is destroyed whenever energy loses its quality
d. It is the part of energy which is useful so it has economic value and it is worth managing well.
e. The exergy of a system increases as it deviates from the environment.
f. When a system is in full equilibrium with its environment. It does not have any exergy since there will be no distinguish in pressure, temperature etc.
g. Exergy efficiencies are a scale of approach to reversibility which is not right for energy efficiencies.

h. It improves the efficiency of energy and other resort use by identifying efficiencies that always scale the approach to reversibility, locations and magnitudes off wastes and losses.
i. It reveals how much is feasible to design many efficient systems by reducing the inefficiencies in existing systems.
j. It identities whether a system contributes to achieving a supportable environmental or not.
k. It addresses the effect on the environment of energy and other resource utilization by reducing that impact.

The difference between exergy and energy are stated in table I

Table – I. Difference between Exergy and Energy

Energy	Exergy
Is the ability to do work in production it measures in Jouls	Is the maximum work of production system, when the system and the surrounding come to equilibrium within a heat inventory.
When the temperature change it remains constant	When the temperature changes it change with the temperature
It has ability to measure quantity only.	It has ability to measures quantity and quality
It can either be created nor destroyed in thermodynamic prices	It can neither be created nor dissimilated in reversible process.

D. Energy Audit

The aim of energy audit is to enhance energy utilization and to achieve energy of plant equipment. For proper energy audit it is necessary

a. Energy input. The word quality is necessary because the cost of energy depends on energy quality.
b. To measure and record the quantity and quality of waste energy to see whether this energy can be used for some other purpose in the plant (or can be sold) so as to reduce the energy costs.
c. To determine and record all energy losses in the plant. These losses occur in various combustion processes, energy distribution etc.

The energy audit strategy consists of three steps viz., General considerations, Preliminary study and detailed study.

a. **General Considerations**.

This is always the first stage of an energy audit. Generally, a walk through the plant by an experienced energy manager is sufficient to reveal the main reasons for high energy input /costs per unit of production. This stage of audit is very inexpensive and the preliminary energy savings are identified. An optical inspection of the plant and equipment is made to determine the possible energy savings in plant maintenance and operation. In addition, some information required for further stages of audit is also collected during this stage. Some obvious reason for energy losses can easily be identified at this stage. Replacement of expensive energy sources by cheaper ones and utilization of waste heat for some useful purposes may also be possible.

b. **Preliminary Study**.

This study needs to be conducted by the energy management team with the help of energy specialist. During this study a survey of the daily/weekly energy requirement and the associated costs is done. Some data is also collected during this study. Many times, a questionnaire concerning different devices and processes is also prepared. This questionnaire should cover energy management systems, raw materials, energy supply systems, cogeneration, energy conversion devices (boilers, electric motors, heat exchangers etc.) and activities and problems of energy conservation in the plant. Many times, the results of a preliminary study are prepared in a graphical form for easy and quick identification of possible energy saving measures. In some cases, this study is considered sufficient.

c. Detailed Study.

This study involves a detailed analysis of energy inflows and outflows in the plant. The preliminary study has already identified the relatively inefficient devices and equipment. The detailed study is generally taken up only for these inefficient devices and equipment. Thus, this study needs to be carried out for a process or a unit or a system. Most of the time some measurements are also necessary as a part of a detailed study. A model analysis and computer simulation may also form a part of this study. Data about energy input, energy output, energy consumption, energy flow and distribution, losses, efficiencies, temperatures, waste heat etc. are also necessary for a detailed study [13].

E. Increasing the Efficiency of the Power System

Energy audit is a strong tool for exposure operational and equipment improvements that will reduce energy costs, lead to bigger performance and save energy. Sometimes, the energy audit is also called an “energy imposition” or “energy study”. Energy audits can be achieved as a stand-alone effort but may be operated as part of a bigger analysis across an owner’s entire group. The reason of an energy audit is to find out how, when, where and why energy is given. The energy audit is also used to know opportunities to enhanced efficiency. Energy auditing services are tender by engineering firms, energy services companies and energy consultants. The energy auditors do the audit process. The first thing energy

auditor needs to be aware of end user expectations and then audit starts with an analysis of historical and current utility data. This prepared the stage for an onsite inspection. The most consequential outcome of an energy audit is a list of commend energy efficiency measures (EEM). Energy audit serves the objective of identifying energy usage within a facility, process or equipment, and then shown opportunities for conservation, called energy conservation measures (ECM). Audit gives the most perfect picture of energy savings opportunities. Energy audits can be mark to specific systems i.e. boiler, turbine, generator and any motor. All audits should include the following:

a. Data acquisition
b. Data analysis
c. Recommendations

The complication and documentation required will usually suggest the type of audit being performed along with the available budget. Most audits will typically fall within the following three categories:

a. Collection
b. Analysis Steps
c. Report Preparation.

Data Collection

a. **Meeting with Key Facility Personnel**

Set Lip a meeting with all key operating personnel and to go over audit objectives and roles and responsibilities of project team members, facility rules and regulations, scope of work and a description of scheduled project activities.

b. **Site and Facility Walk-Through**

Conduct a walk-through of the facility to study the various operations and focusing on the main energy consuming systems.

c. **Existing Available Document Review**

Review existing facility documentation with facility engineering representatives. This documentation should include all existing architectural and engineering plans; facility operation and maintenance processes and utility bills for the previous three years

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d. **Facility Inspection**

After a complete breakdown of the construction and operating documentation, the main energy consuming equipment and procedures in the facility should be further investigated.

III. Analysis Steps

a. **Utility Analysis**

The utility breakdown is a detailed analysis of energy bills from the former 12 to 36 months. This should involve all purchased energy agreements and including liquefied petroleum gas, electricity, fuel oil, natural gas, and purchased steam.

b. Calculate Feasible ECM

Energy audits should expose both smaller operation modifications and bigger facility modifications requiring particular economic analysis offering simple or fast paybacks. Develop a list of most important ECM for each of the bigger energy-consuming systems i.e. envelope, lighting, HVAC, process and power.

c. Economic Analysis

Within the calculation, involve the implementation cost, energy savings and simple payback for each of the ECM. A lot of the detail and complexity is unnecessary or unjustified for many applications.

IV. Report Preparation

a. Prepare Audit Report

Go over the results of research and recommendations in a final report. The report should involve a description of the facilities and their processes. It should also involve a debate of all bigger energy-consuming systems and a clarification of all recommended ECMs with their specific energy influence implementation costs and benefits.

b. Present and Review Report with Facility Management

Clarify the procedure and all activities performed to confirm the report's summary. Shown economic results as a formal presentation of the final recommendations. Explain the data on the advantage and costs which make a statement or set priorities on implementation of ECM. After the audit: Read the crash and understand the contents and give the important improvements according to choose i.e. Energy reduction, Cost, Need (equipment failure).

F. Power System Stability Problem

Power system stability is a very consequential aspect to supply continuous power. It is defined as that property of a power system that allows it to remain in a state of operating equilibrium in normal operating conditions and to have an acceptable state of equilibrium after being content to a disturbance. Instability of power system can happen in many different situations depending on the system configuration and processing mode. One of the stability challenges is maintaining synchronous procedures or synchronism particularly that power system relies on synchronous machines. This phase is influenced by the dynamic of generator rotor angles and power-angle relationships. Other instability problem that may be faced is voltage collapse that is

likely related to load behavior and not synchronous speed of generators.

Before cane sugar is being manufactured the cane sugar is being harvested from plantain farm and being harvested by modern technological method and carried by a cargo truck from the farm to where they are stored called ware house.
To know the weight of the truck and mass of cane sugar he carried there is weight balance to read and record the total mass, 40,000 tons. Depending on the production process and quantity needed for a number of times, the transportation and quantity of the cargo truck must complete the register, the number which the truck would go and when the requested quantity is completed then the truck can be reweighed back to know the balance which is 10,000 tons. The factory is shown in figure 1 and flow chart in figure 1.

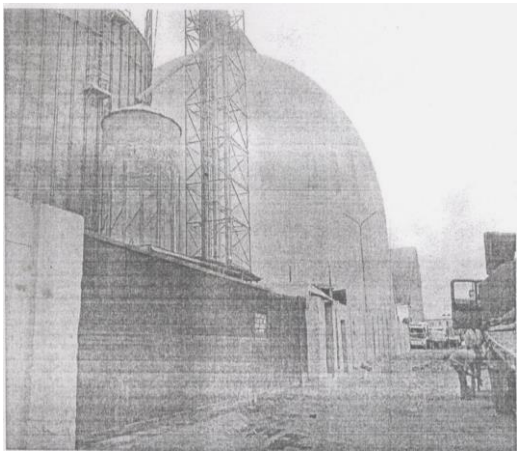

Fig. 1. Dome Silo

Where the production factor is 0.22 and constant specific heat capacity is given to be 4.1868 in table 1

Cp = 4.1868 (0.3823+0.6183×0.22) = 2.170kj/kg

The exergy change in heat production is given as

$$E_{heat} = (\Delta hfg - \Delta sfg \times \Delta T.x) \quad (1)$$

$$= 2489.57 - 8.9496 \times 10 \times 0.22$$

2489.57 – 19.68912

2469.9 = 2.470kj

E_{mass} = m(E_{heat} * Cp * X)

= (2.470×2.170×0.22)

= 125.88kj

Therefore, exergy change in use of energy of gas turbine

ΔE = En + Em (2)

4560+1250.88 = 4685.9

4.6859kj

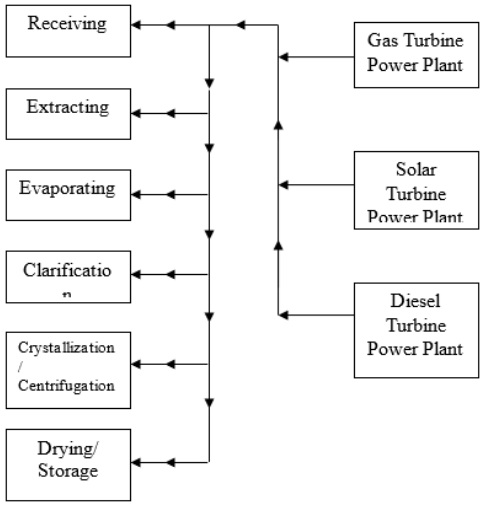

Fig. 2. Flow chart diagram of sugar Refining

G.The Exergy Analysis of Gas Turbine

Table 1 shows the exergy Analysis of Gas turbine

Operational	Reception
Mass Production MT	213.4
Gas Turbine KWh	458
Diesel Generator KWh	2160
Enthalpy Δhfg	2489.57
Entropy Operation Δsfg	8.9496
Temperature Δ*T*	10
Production X	0.22

H.Exergy Change in use of Energy of Solar Turbine

ΔE = Es + Em = 2880+125.88 = 3.006Kj

Exergy change in use of energy of diesel turbine
ΔE = Ed+Em = 2160+125.88 = 2.286Kj

This can be repeated for all the production process and it took the same procedure to prove the solution.
2489.59 – 19.6891
= 2469.9 = 2.470Kj

E_{mass} = m(E_{heat} * Cp * x)
= 213.4(2.470×2.170×0.22)
251.64kj

Exergy change in use of solar turbine plant (Ibrahim and Rosen, 2007)

ΔE = Ed + Em = 2160+251.64 = 2.4116MJ

V. CONCLUSION

This research project is been summarized in respect of the findings which actually affect the vallumbra sugar mill. The identification of the major factors, methods, techniques and solutions have been figured out and discussed. It has summarized that the simplest method is generally easier to use, more consistent and more effective in improving stable electrical energy system.

Despite of what factors are the course of the system power failures, limited treatment of alternatives must be avoided and modern equipment, computerized system, an effective maintenance, energy auditing, energy and exergy data, good facility management and recommended materials must be encouraged to achieve stable electrical energy system.

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