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Improvement of energy efficiency in a cement industry

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ABSTRACT
The cement sector consumes noticeable energy of total industrial energy use. Therefore, a state of art review on the energy use and savings is necessary to identify energy wastage so that necessary measures could be implemented to reduce energy consumption in this sub-sector. In this paper, energy use at different sections of cement industries, specific energy consumption, types of energy use and various energy saving measures were reviewed and presented. Various energy savings measures were critically analyzed considering amount of energy that can be saved along with the implementation cost. This study compiled a comprehensive literature on the cement industries in terms of Thesis, peer reviewed journals papers, conference proceedings, books, reports, websites. This study identified that the cement industries are moving towards the use of alternative fuels to reduce environmental pollution along with the conventional fuels. It also observed that cement industries are moving from wet process to dry process as it consumes less energy compared to wet process.

Keywords: Energy Management, Cost Saving, Cement Manufacturing

1. Introduction

Managing and reducing energy consumption not only saves money but also helps in mitigating climate change and enhancing corporate reputation. The primary objective of energy management is to maintain optimum energy procurement and utilization, throughout the organization which may help in minimizing energy costs and mitigating environmental effects. In fact, energy management is widely acknowledged as the best solution for direct and immediate reduction of energy consumption.
Energy should be regarded as a business cost, like raw material or labor. Reduction and control of energy usage is vital for an organization as it:

Reduces costs: Reducing cost is the most compelling reason for saving energy. Most organizations can save up to 20% on their fuel cost by managing their energy use;

Reduces carbon emissions: Reducing energy consumption also reduces carbon emissions and adverse environmental effects. Reducing your organizations carbon footprint helps build a 'green' image thereby generating good business opportunities; and

Reduce risk: Reducing energy use helps reduce risk of energy price fluctuations and supply shortages.

Good energy management practices are compliant with these requirements and help fulfil regulatory obligations. Businesses worldwide are showing interest in appointment of a formal/informal energy manager to coordinate energy management activities. The main task of an energy manager is to set up a system to collect, analyze and report on energy consumption and costs.

In addition to financial benefits, energy management has other significant advantages for an organizations such as:

- Organizations achieve stronger market position by demonstrating 'green' credentials. Energy management improves competitive advantage as most consumers prefer to source from socially responsible businesses;
- Organizations adopting energy management systems can influence supply chains by preferring suppliers who adopt environment management practices; and
- Energy management creates a better workplace environment for employees by improving working conditions.[1]

This study also contains:

- Study of the Cement Industry Statistics
- Energy efficiency opportunities and barriers
- To minimize the energy costs without effecting production and quality
- To reduce the environmental effects
- Developing energy efficiency eradicating the limitations or implementing new processes

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2. Energy Management

"Energy Management System" is a term that has a number of meanings , but we are mainly concerned with the one that relates to savings energy in business, public sector/government organization, industries and homes. Energy management is the use of technology to improve the energy performance of an organization. To be fully effective it needs to be an integral part of an organization's wider management processes. Improving energy efficiency and using renewable energy resources is both important for improving profitability and reducing pollution. Improved energy efficiency will reduce the rate of depletion of fossil fuels and minimize the emission of greenhouse gases and other polluting gases. All organizatons need good management for long term success and efficient program.

Fig.1 Work Plan for Energy Management

Rising energy prices, climate change legislation and need to be enviornmently responsible all require effective energy management. Saving energy makes business sense and having a structured co-ordination and integrated approch to managing energy will maximize these benefits. Without this, cost-effective opportunities can be easily overlooked.

Energy management is the key to saving energy in the organization. Much of the importance energy saving stems from the global need to save energy. This global need affects energy prices, emission targets and legislation. All of which lead to several compelling reasons why you should save energy at your organization specifically.[2]

3. Auditing

An energy audit is a preliminary activity towards instituting energy efficiency programs in an establishment. It consists of activities that seek to identify conservation opportunities preliminary to the development of an energy savings program.[3]

The term energy management means many things to many people. One definition of energy management is:

"The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions"

(Cape Hart, Turner and Kennedy, Guide to Energy Management Fairmont press inc. 1997)

Another comprehensive definition is

"The strategy of 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" [4]

4. Methdology

The main issues of the proposed methodology are: historical data analysis, energy consumption characterization, energy consumption forecasting, energy consumption control, energy budgeting and energy machines management optimization. The methodology supports an industrial plant to:

- Identify areas of energy wastage - for example by determining the proportion of energy that does not directly contribute to production and that is often a source of energy savings;
- Understand energy consumption of the processes - by establishing a relationship between energy use and production;
- Highlight changes to energy consumption patterns - these are either a result of a specific action to improve efficiency or due to an unknown factor which may have a detrimental effect upon efficiency and may lead to process failure or poor quality product;
- Reach an optimal condition in terms of supplying, generation, distribution and utilization of energy in a plant by means of a continuous improvement approach based on energy action cost- benefit evaluation.[5]

The single operation described in the methodology steps has its own effectiveness in a context showing an awareness lack about energy management concept. Nevertheless, our intent is to point out the importance of introducing each step in a non-ending loop, granting continuous energy management improvements and a constant reduction of energy consumptions and costs.

Accordingly, in the following sections each step characterizing the proposed methodology will be described in detail. The different phases are:

- Energy cost & consumption data collection;
- Energy cost & consumption data analysis;
- Energy forecasting at plant level;
- Sub-metering energy use;
- Tariff analysis and contract renewal;
- Energy budgeting and control;
- Energy monitoring and control;
- Power plant management optimization;

5. Cement Manufacturing Process

Cement is a gray, finely ground combination of minerals which, when mixed with water, sand, gravel, and other materials forms concrete. Cement provides the chemical bond that holds the other materials together. Concrete, when newly mixed, is plastic and malleable, which allows it to be cast into shapes to build homes, sidewalks, superhighways, dams, skyscrapers and many other objects. Concrete is inert, nontoxic, naturally waterproof, and fire resistant. It is the world's most commonly used construction material.

The raw materials used to produce cement are primarily limestone, clay, shale, and silica sand. These materials are quarried, crushed, and, for economy, are usually transported to a nearby cement plant. The cement plant proportions the raw materials to the correct chemical composition and grinds the material to a fine consistency. Small quantities of iron ore, alumina, and other minerals may be added to adjust the raw material mixture.

Cement manufacturing requires exacting measurements and careful controls to produce a product that meets precise chemical and physical specifications. The first step in the cement manufacturing process is the quarrying of a combination of raw materials that when sized, blended, and processed yield the exact chemical composition required. These raw materials then undergo a series of high temperature chemical reactions and physical changes after which they are ground into a very fine, carefully sized powder. The steps of cement manufacturing are-

- Extraction of raw materials used in cement production;
- Preparation of raw materials (including grinding and mixing);
- Warehousing of meal;
- Baking of raw material meal (production of clinker);
- Maturing of clinker;
- Milling of clinker into cement;
- Warehousing of cement
- Packing and dispatch.[6][7][8]

6. Barrier to Energy Efficiency

A number of barriers to increased energy efficiency were identified in discussions with cement customers and utility representatives who are in close contact with their cement customers.

Following are some key barriers identified in the interview process.

***Limited capital*:** many of the energy efficiency equipment improvements in the cement industry involve large capital investments, and most customers cited limited capital availability as a key factor limiting increases in energy efficiency. One customer cited a $4 million capital budget, and another cited a $1 million capital budget. Two other customers did not indicate that they had any set budget to work with and had to justify all new capital expenditures on a case by case basis. Many targeted project cost many millions of dollars, so even the customers with assigned capital budgets are severely constrained.

***Production concerns*:** for all customers, keeping equipment operation and avoiding production disruptions was of the highest priority. Additionally, cement plants do not like to shut down except for once a year, largely because shut down stresses the ceramic insulation in the kiln.

Heat-up and cool down has to be done very carefully or the ceramic insulation will deteriorate.

***Limited staff time*:** staffing limitations were another key barrier to increased energy efficiency.

While all customers want to stay as efficient as possible, staff's number one priority is "keeping things running."

***Information*:** while all customers feel they have access to the information they need to make energy efficiency improvements, several customers indicated that they did not have time to focus on this information. Also, it appears that customer knowledge is mostly directed towards the "big ticket" equipment that are the primary energy users, and their understanding of the energy saving aspects of smaller items such are preventative O&M appears to be lower.

***Reliability concerns*:** since maintaining production is such a high priority, cement customers are very concerned about the reliability of all new equipment, including high efficiency equipment.

While the customers don't perceive differences in reliability between energy efficient and standard equipment, any installations of new equipment at the plant will generate some reliability concerns.

***Hassle*:** since staff time is limited, smaller energy efficiency projects are not pursued because they "are not worth the trouble."

***Facility uncertainty*:** one customer indicated that they were currently investigating the feasibility of a complete plant overhaul. Uncertainty over the overhaul project has halted any possible efficiency projects.

***Cost effectiveness*:** most customers have severe cost effectiveness criteria. Two customers (with less efficient plants) have payback cutoffs of 1.0 to 1.5 years. Only one customer indicated that they would consider projects with paybacks of up to three years.

***Exit fees*:** Customers have not proceeded to install cogeneration equipment that would utilize waste heat because they would be subject to departure charges. Without the departure charges, on-site generation with waste heat would be very close to being economic.

8. Case Study

8.1. Compressor

Compressed air is one of the most important and exclusive components in a plant where energy is used. Approximately 5% of the total energy of a cement industry is used to run compressor. So by taking some necessary steps to control air compressors consumption of energy, there could be significant savings for business.

Description about Existing system

In Seven Rings Cement industry there are three compressors. From those compressors one compressor is from the beginning of the industry. So the old one cannot give its maximum efficiency. The compressor needs to keep off at least 15 minutes over a day due to overheating. So it can be said that the compressor consume more electricity but give low efficiency and needs higher maintenance.

Losses calculation of the existing system

Capacity of the unit =180 ton/hour

Loss of cement production by the old compressor in 15 minutes=180/3*4ton/day

=15 ton/day

Cost of cement per 50 kg=450tk

So cost of the losses cement=15*1000*450/50

=135000tk/day.

Monthly losses=135000*25

=3375000tk.

Approximate maintenance cost=25000tk/month

Total loss per month=3375000+25000

=3400000tk

Cost of a compressor is 3000000tk

So, we can replace the compressor with the new one and sell the old compressor.

8.2 Motor

Increasing motor efficiency and taking measures to reduce the amount of energy it requires to run a motor can directly impact the bottom line of business. By replacing inefficient motors with premium efficient motors equates to significant cost savings over the life of the motor , not to mention the additional benefits of reduced down-time and increased productivity and reliability.

Electric motors are efficient at converting electric energy into mechanical energy. If the efficiency of an electric motor is 80%, it means that 80% of electrical energy delivered to the motor is directly converted to mechanical energy. The portion used by the motor is the difference between the electrical energy input and mechanical energy output.

Various Electric Motor Parameter

Efficiency=746*HP output/ watts input

%slip= (Synchronous speed – running speed)*100 / Synchronous speed

RPM= 120* frequency / no. of poles in winding

Power factor, P_f= Active power / Apparent power

Equations

For loads not sensitive to motor speed

Same horsepower and difference efficiency:

kW saved= HP *0.746*(100/Estd – 100/ Eee)

Annual saving, S= HP *L*C*N*(100/Estd- 100/ Eee)

For loads sensitive to motor speeds

Above equation should be multiply by speed ratio correction factor (SRCF).

$SRCF=(RPM_{EE} / RPM_{STD})^3$

Where,

S= Savings, L= % Load

HP=Horsepower, N=Operating hours

C= Energy cost (tk/kWh)

E_{EE}=% Efficiency of Energy Efficient Motor

E_{STD}=% Efficiency of Standard Motor

Available data

HP= 4760 HP for main motor

L= 90%

C= 7.5 tk/kWh, N=7200 hours

E_{STD}=91%, E_{EE}=94.1%

RPM_{STD}= Speed of the Standard Motor=786

RPM_{EE}=Speed of the energy efficient motor=810

Annual Cost Saving:

For loads not sensitive to motor speed:

S=4760*0.746*0.9*5.6*7200*(100/91 – 100/94.1) tk

=4664870 tk

For loads sensitive to motor speed:

S=4760*0.746*0.9*5.6*7200*(100/91 – 100/94.1) * $(810/786)^3$

=5105370 tk

Therefore it shows that the use of energy efficient motor for an existing system is not very effective because implementation cost is so high but for a new plant it may be little profitable.

There are 240 different types of motor in the factory.

Among them we work on-

Motor Name	Power (kW)	Speed (RPM)	Number
a)Mill main motor	3550	786	1
b)Roller press	900	987	2
c)Main fan motor (ID)	710	980	1
d)Separator motor	250	1485	1
e)Inlet bucket elevator motor	160	1470	1
f)Outlet bucket elevator motor	110	1470	1
g)Bag filter ID fan motor	75	1450	1
h)Air Slide	7.5	1450	8

Table 7.1- Different Types of Motors We Observed

8.3 Lighting

Enhancing lighting efficiency is one of the easiest ways to lower the energy bills. When planning o replacing lighting, consider the types of lights, the location, the lighting conditions, the appropriate lamp technology, the correct control systems by using PLC and other components of a commercial lighting system.

Name of lights	number	Power (Watt)	Working Hours
Tube light Set	214	40	24
Mercury light	20	1000	12
Street light	90	600	13
Energy Saving Bulb	100	63	24
Energy Saving Bulb	60	30	24
Energy Saving Bulb	40	35	24

Table 7.2- Different Types of Lights We Observed

Calculations

Total power used for lighting=

(214*40*24+20*1000*12+600*90*13+100*63*24+

60*30*24+40*35*24)

=387.572 kWh/ Day

Cost for lighting/year =387.572*365*7.

=1060980 tk

From the above data taken from the Seven Rings Cement Industry it can be said that they use very effective lighting system. So it is very much difficult to save energy from there. As in there total lighting system controlled manually sometimes it is not possible to switch off of street lights in time. By automatic control of lights in which switching of lights would be controlled by daylight intensity using Programmable Logic Control (PLC) this problem can be solved. This process also can save money. If every day one hour can be saved it will help to save money.

Calculations:

Cost for street lighting/ year=

(600*13*90*365*7.5+1000*12*20*365*7.5) /1000

=2578725 tk/ year

After using PLC systems

Cost for street lighting/ year =

(600*12*90*365*7.5+1000*11*20*365*7.5) /1000

=237150 tk / year

Therefore it shows that the use of PLC system is not very much effective but it is little profitable.

8.4. Dust Collection:

Dust collectors are used in many processes to either recover valuable granular solid or powder from process streams, or to remove granular solid pollutants from exhaust gases prior to venting to the atmosphere. Dust collection is an online process for collecting any process-generated dust from the source point on a continuous basis. Dust collectors may be of single unit construction, or a collection of devices used to separate particulate matter from the process air. They are often used as an air pollution control device to maintain or improve air quality.

Mist collectors remove particulate matter in the form of fine liquid droplets from the air. They are often used for the collection of metal working fluids, and coolant or oil mists. Mist collectors are often used to improve or maintain the quality of air in the workplace environment.

Fume and smoke collectors are used to remove sub-micrometer-size particulates from the air. They effectively reduce or eliminate particulate matter and gas streams from many industrial processes such as welding, rubber and plastic processing, high speed machining with coolants, tempering, and quenching.[6]

Five main types of industrial dust collectors are:

- Inertial separators
- Fabric filters
- Wet scrubbers
- Electrostatic precipitators
- Unit collectors

9. Conclusion

Energy efficiency in the cement industry and cost effective energy that can be achieved in the near future are analyzed in this report. The report focuses on the analysis of energy used in different sections, specific energy efficiency technologies and measures to reduce energy use without hampering product quality and quantity and the energy efficiency for cement production.

There is a lot of opportunities to reduce the energy consumption in both industrial and residential sector in Bangladesh. As there is a lack of energy in both electricity and fuel in Bangladesh therefore by proper management of energy the energy efficiency can be increased to 20% to 30%.

The whole auditing process was carried out by walk through audit and a very little engineering audit. In this thesis the field study is largely based on interviews with employees at the industry. When gathering information from personnel it is always a risk that it is affected by the interviews own opinion, standpoint and interests. A detailed auditing can be applied to avoid this mentioned risk and hence for the better solution.

There was a lack of provision of data as the data was considered highly confidential. And the auditing process was carried out within a short time. Therefore detailed and long term audit was not possible to carried out which would be more effective.

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