Energy Audit to Evolve Energy Conservation Measures

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Summary

About 60% of the total electrical energy is used in cement industry for grinding the raw materials, coal and clinker. The energy efficiency of grinding systems employed in cement plants is estimated as only about 20%. It means that about 80% of the grinding energy i.e. 48% of plant energy is wasted as heat, sound and vibrations.

During the recession period of last 3 years many cement plants had put in their best efforts to bring down the energy consumption. Specific energy consumption, which used to be above 100 kWh/t of cement has been brought down to below 90 kWh/t of cement and some of the best plants have achieved around 76 units, which can be a bench mark for other inefficient cement plants. This shows that there is wide scope for saving electrical energy in cement plants upto about 20 to 30%.

An energy audit of a cement plant will reveal the energy wastages occurring in the plant. It is then possible to evolve energy conservation measures to bring down specific energy consumption and move towards benchmarks set by best cement plants.

1.0 Introduction

Overall energy efficiency of cement production in a modern plant is quite low. About 60% of total electrical energy is used in grinding of the raw materials, coal and clinker. The energy efficiency of grinding systems employed in cement plants is estimated as only about 20%. It means that about 80% of grinding energy i.e. about 48% of total energy of the plant is wasted as heat, sound & vibration. As such, there is wide scope for energy conservation in cement plants by way of technological developments, which are yet to be innovated.

On the energy supply side, there are shortages, power cuts and rising costs. Government mostly owned energy supply companies. Due to shortage of funds, energy generating capacity could not be raised to meet the shortages. Available sources of energy are also diminishing. Government therefore proposed to make up the shortages by energy conservation measures. To drive home the message, the energy conservation day is being celebrated on December 14.

In view of the energy scenario as above, the following themes have emerged:

- To implement energy conservation measures.
- To improve energy efficiency of production.
- To save on something and switch off something

Apart from the energy scenario as above, there is recession in cement industry since last three years due to drastic fall in cement prices and rise in energy cost upto 50% of cost of production. The cement production was not viable. Many cement units piled up losses. If the losses could not be rolled back, such units were sold out. There was an urgent need to cut down costs. Hence all units aimed at reduction of energy cost.

There were two options to reduce energy cost:

- To reduce energy consumption
- To look for alternative cheaper sources of energy like captive power plants based on DG and TG sets.

Second option reduces the energy bill, but does not reduce energy consumption. It also requires huge investment. Hence both options of reducing energy consumption are pursued by the cement units.

Energy sources to a cement plant are both thermal and electrical. However, the total cost of electrical energy is normally higher than thermal energy. In this paper only electrical energy audit to evolve energy conservation measures in existing plants are discussed.

2.0 Energy Audit

During project stage, energy saving devices are implemented to the extent possible. Any energy saving equipment will increase the cost of the project and make it unviable. Thus, there is some restriction on implementing all energy saving systems and these are deferred to a future date for incorporation.

Apart from this, after commissioning of a project, technological developments and innovative ideas bring about feasible solutions to bring down energy consumption. It becomes an attractive investment for a plant to implement these feasible solutions.

The unforeseen market forces such as drop in cement prices and rise in energy costs etc. also force the plant to look for additional potential areas of energy saving to retain the profitability of the operations.

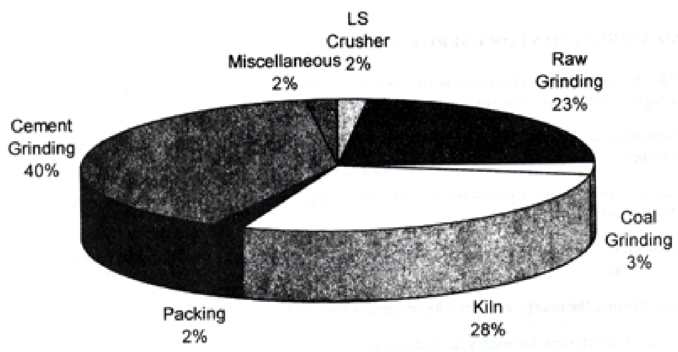
Energy audit involves looking at plant process & operations from energy angle. It exposes the points ignored/ undermined or missing from energy saving point of view. The plant operational data is obtained with the help of an elaborate questionnaire and the data is analysed. Energy audit of an old and inefficient plant is easier, whereas it is tougher to audit an already improved and efficient plant.

It is the first step to know & understand where the energy is being consumed. Specific energy consumption is quantified as units/ t of cement in various sections of the plant. Energy monitoring system to give break-up details of energy consumption for each section is implemented through either by kWh meters or kW transducers, which are calibrated at regular intervals. Energy monitoring and reporting shall be implemented through central control room.

The break-up details of energy consumption are then compared with other similar size energy efficient plants. The additional consumption is studied. The inefficient processes and energy wastages are identified.

The typical energy consumption/ t of cement in percentage for various sections of a large modern cement plant are shown below in a pie diagram for reference. But actual consumption varies from plant to plant depending on hardness of raw materials, fineness of cement, type of coal used etc.

Section	% Energy Consumption/t of cement
L S Crusher	2
Raw Grinding	23
Coal Grinding	3
Kiln	28
Cement Grinding	40
Packing	2
Miscellaneous	2
Total	**100**



After specific energy consumption/ t of cement of each section is known, it has to be estimated as to how much KW load reduction is required in different sections to reduce specific energy consumption by 1 unit / t of cement. For a typical 1.5 million tonnes/ annum cement plant, the KW load to be reduced in each section for achieving reduction of specific energy consumption by one unit are given below for guidance/ reference only. These are based on clinkerisation factor and gypsum ratio.

Section	Capacity (TPH)	KW load reduction to save 1 unit/ t. of cement
L S Crusher	700	490
Raw Mill	375	263
Kiln	200	210
Coal Mill	45	417
Cement Mill	300	300
Packing	540	540

Thus it may be seen that KW reduction to save 1 unit/ t of cement is different in different sections.

For a 1.5 million tonnes / annum cement plant, the cost reduction / annum for saving of 1 unit/t of cement @Rs. 4.5 per kWh works out to $1.5 \times 10^6 \times 4.5 = 67.5$ lakhs. If 10 units are saved, cost reduction / annum will be 67.5 x 10 – 675 lakhs, which is quite substantial. Hence all cement units are tempted to save electrical energy.

3.0 Broad approaches for energy audit

- In-depth study of the processes where possibly with a modified scheme, may help minimize energy wastages and thereby improve energy efficiency.
- Nominating an Energy Manage to conduct internal energy audit and implement energy conservation measures.
- Engaging an External Consultant to carry out energy audit and suggest further measures for energy conservation.
- Establishing the techno-conservation measures and evaluating the results.
- Setting of benchmark for each year and taking steps to achieve the targets.
- Training of personnel through seminars on energy conservation
- Keeping up-to-date on developments in cement technology and innovative ideas for energy conservation.

4.0 Energy saving potential areas in the cement industry

The following potential areas are normally looked into to achieve improved energy efficiency.

Power Distribution Losses

- To locate LT distribution transformer, LT switchboard and MCCs closer to the respective plant departments to reduce losses in LT distribution due to higher currents.
- To improve power factor nearer to unity with capacitors connected near the loads and on busbars to reduce distribution losses.
- To locate grid receiving station/ captive power station in the middle in stead of at one end to reduce distribution losses.
- To add cables in parallel to reduce the distribution losses

Monitoring of maximum demand

Staggering of the loads to minimize maximum demand to reduce the energy bill, where two part tariff exists.

Oversized Motors

- If the load factor is less than 70%, the motor is said to be oversize. Oversizing occurs in both HT and LT motors. Oversizing results in loss of efficiency from 1 to 2%, causing additional energy consumption to that extent. The oversized motors shall be replaced with appropriate rating or supply voltage shall be optimized upto – 5% as per CII recommendation to reduce iron losses and improve the efficiency of the motors. Also if the load is less than 50%, the connection of LT motor can be changed from delta to star to saver energy.

- Those motors having less efficiency shall be replaced by energy efficient motors.
- An efficiency loss upto 5% is observed in case of rewound motors. Hence rewinding of motor is resorted to only in case of small motors, where losses are insignificant.

Micro Processes Bases Voltage Controllers for ESP

Micro processor based voltage controllers with semi pulse mode of control in case of high resistivity dust results in energy saving upto about 40%.

Plant illumination by Energy Efficient Lighting Devices

Inefficient incandescent lamps shall be replaced by fluorescent tubes/ MV lamps/ high pressure sodium vapour lamps. Fluorescent/ MV lamps shall be substituted by more efficient high-pressure sodium vapour lamps, wherever possible. The use of timer switches of photo cells to switch off lights during unwanted hours be considered. Use of modern CFG compact lights in place of fluorescent lamps, electronic ballast for fluorescent lamps and use of electronic speed regulators for fans etc. also result in energy saving in illumination, which consumers substantial energy in a plant.

Process Control & Instrumentation

Control and instrumentation helps in optimizing the process, maintaining homogenous & uniform raw mix etc. through automatic controllers and analytical instrumentation, thereby saving energy. Also by fast start/ stop of the plant from CCR results in energy saving. Incorporating suitably in software to trip after some time delay can save idle running energy, if there is no feed.

Avoiding unwanted frequent trips/ breakdowns

Unwanted frequent trips/ breakdowns can be avoided by daily/ weekly inspection and timely maintenance. Thus energy losses due to frequent start/ stops can be eliminated.

Monitoring of Compressor Loads

- Avoid idle running of compressors in unloaded condition by automatic on/ off controls.
- Arrest compressed air leakages.
- Use soft starter in case load remains below 50% for some time due to load cycle adopted to save energy.

Increasing the capacity of main machinery

Utilising the full capacity of mills using the cushion available will result in energy saving. However, in case of Kiln, energy consumption will go up, since fans consumer power with cube of speed.

Economic of Scale

Larger capacity plants will have lower energy consumption by virtue of economies of scale. Hence at the project stage, higher size plant feasible within the proposed budget shall be considered.

Blended Cements

Manufacturing of blended cements such as PPC and PSC will help to reduce energy consumption.

Parallel running of captive power plants

This helps in continuous running of kiln on captive power plant, when grid supply fails and thus helps to save the energy losses of frequent start/ stops, apart from other benefits.

Compact plant layouts

Compact plant layout helps to minimize energy consumption of intermediate material handling.

Fans selection of drives and installation

- The fans are designed with 15% margin and hence the load factor of fans is around 60 to 85%. The power drawn by the fan varies with cube of the speed. Hence substantial savings can be achieved by using variable speed motors. For example, if the fan speed is reduced to 85% of rated speed, the power drawn by the fan is reduced to about 61.4% of that drawn at rated speed with a power saving of about 38.6%.

- Eddy current coupling and fluid coupling, shall be the last choice, since efficiency goes down linearly with lowering of speed.
- Replacing inefficient eddy current coupling, fluid coupling, fluid rotor controllers and grid resistance controllers with variable speed drives and slip power recovery systems in case of large slipring motors.
- Direct coupling shall be used wherever possible to avoid losses of "V" belts.
- Variable speed drives shall be applied only when the fan is operating with partially closed damper. Dampers in fan circuits with variable speed drives shall be deleted, wherever possible to save energy.
- Inefficient fans such as radial fans shall be replaced by more efficient fans with backward curved blades having an efficiency of above 80%.
- Elimination of leakage are in fan circuits reduces energy consumption of fans.
- Improper ducting design results in higher-pressure drop and hence more energy loss. The following aspects are to be considered for ducting design.

    - Minimise duct lengths, bends and any sudden changes in cross-section
    - Fan inlet suction of proper length and diameter.
    - In case of unavoidable bends, use of guide vanes in the bend reduces the loss by about 50-60%.

Material conveying systems

Mechanical conveying systems comprising of air slide, belt conveyor and bucket elevator consume less energy than pneumatic conveying by air life/ FK pump. However, the initial cost of mechanical conveying systems is very high. Also belt drive bucket elevator consume less energy as compared to chain driven. The comparative power consumption for different conveying systems is given below.

	kWh/ t/ 100 m
• Air lift	1.10
• Dense phase pump	0.59
• Screw pump	1.20
• Bucket elevator	0.41

Installation of ESP in place of Bag Filter or Multiclone

In many plants, bag filter and multiclones are used for coal mill and clinker cooler respectively. ESP has got a lesser pressure drop as compared to bag filter or multiclone and hence energy saving for the fan is possible in case of ESP, though this solution is high on capital investment. Typical pressure drops for ESP, cyclone and bag filter are given below.

	Mm WG
• ESP	15-20
• Cyclone	50-150
• Bag Filter	150-250

Expert systems

Implementation of kiln optimisation results upto about 2% fuel saving and 3 to 5% energy savings in cement grinding due to consistent quality of clinker, apart from increase in production upto about 5%.

Expert system also helps in optimisation of operations of mills for raw grinding, cement grinding and it will improve the production and decrease energy consumption.

Technological developments

The following technological developments have contributed to energy saving.

- High efficiency separator for mills to prevent over grinding in mills.
- Vertical roller mills for raw material and coal grinding with saving upto about 15%.

- Roll Press in hybrid mode for raw material, cement and slag grinding with saving upto about 20%.
- High cyclones in preheater tower with saving in pressure drops upto about 200 to 300 mm WG.
- Modern efficient grate coolers.
- Pregrinder before cement mills

Technological developments especially in the area of grinding mills, which consume maximum energy, is urgently required in cement industry to improve energy efficiency.

5.0 Total energy saving potential

Going by the technology available today, it has been proved that there is scope for energy reduction upto 20 to 30% since some of the cement plants, which used to consume around 100 to 110 units/t of cement have come down to 75 to 80 units/t. of cement. Many cement plants are gradually reducing energy consumption.

After implementing energy conservation measures, the specific energy consumption of modern large dry cement plant can be brought down upto about 75 to 85 units/ t of cement in gradual steps. For other medium size plants, it can be brought down to between 80 to 95 units/ t of cement depending upon their type of machinery, raw material, fineness of cement etc.

6.0 Conclusion

- Energy conservation team in every cement plant has to monitor the energy consumption on regular basis and to generate consciousness about energy conservation among the work force.
- Based on energy audit both internal by the plant personnel and external by experienced consultants, the energy conservation projects should be identified and implemented on priority basis.
- Energy consumption targets should be lowered every year and efforts should be put in to achieve the same.
- Energy efficiency should be the main consideration for purchase of new equipment. Suppliers should declare the energy efficiency of each equipment.
- Since technology is changing fast, the latest available energy saving technologies should be pursued/ absorbed on a continuous basis to achieve more and more energy efficient production.

Reference

- Otto Laban: Cement Engineers Handbook 239 & 240 P.
- Philip A Alsop: The cement plant operations handbook 2nd ed. 1998, 75 & 147 P.

Reference book:

7th NCB International Seminar on
Cement and Building Materials
New Delhi, 21-24 November 2000