# Optimizing Thermal Energy Consumption in Cement Process Plants: Strategies for Energy Conservation and Sustainability

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**Abstract:** ***With rapid industrialization and urbanization there is a tremendous demand for energy. There are today greater differences than ever before among the communities of man in their access to energy in their material standard of living and in their potential for survival. The lifestyles that have evolved in recent times are energy intensive in character. The resources for coal, oil, natural gas, petroleum, hydro power and nuclear power are very finite and get depleted at a very faster rate as these are exploited and explored to meet the demand of energy. The burning of fossil fuel has created air pollution and it leads to ecological imbalances. Industrial pollution leads to global warming and sea level rise. Keeping in view the above facts there is great need for energy conservation. Energy conservation means the most efficient use of energy or to minimize the utilization of energy. In order to tackle energy crisis renewable energy sources are the alternate sources of energy. Industrial sector is the foremost sector of an economy. The progress and economic development of any nation depends on industrial growth. Besides raw material and man power, energy plays a dominant role in industries. Cement industry is one of the major energy consuming industries and the optimum use of energy is at present important for our national economy. The energy cost is the highest component of cost structure of cement manufacture. Energy cost in Indian cement industry account for over 40 to 50 percent of the manufacturing cost of the cement. Out of this the share of thermal energy alone in the form of fuel is about 30 to 35 percent while the remaining 15 to 20 percent accounts for mainly electrical energy. The major sources of energy to Indian Cement Industry are coal and electrical power. In cement industry thermal energy is used for many operations like raw mix proportioning, optimizing particle size distribution of raw mix etc., The present paper deals with the methods and technologies that can be adopted in cement process plants to optimize thermal energy consumption to conserve energy.***

**Keywords:** Cement industry, Energy conservation, Thermal energy, Optimization

## 1. Energy Conservation

The most efficient use of energy which is termed as Energy Conservation is an important step to tackle the Energy crisis. Energy conservation has become necessary in almost all chemical industries mainly for two reasons. Firstly there is a sharp rise in the cost of energy which sometimes makes the product uneconomical. Secondly there is an increasing awareness that the sources of Energy depleting at a very fast rate must be conserved until alternate sources of Energy are developed. With population explosion, ever increasing demand for industrial products, Energy conservation is inevitable and Need of the Hour.

Cement Industry is an energy intensive industry and the energy consumption accounts for 40 - 50% of the total manufacturing cost. Hence there is a great need to evolve ways and Methods for conserving energy in this industry.

In cement Industry, conservation of energy can be done by two principal methods, (i. e) by Optimization and Modernizations, Optimizing the operating parameters at existing conditions and also by adopting the energy saving process and installing machines as a part of modernization.

## 2. Optimisation of Thermal Energy

**General applicability to any cement industry**

**Potential areas of conservation of thermal energy can be identified as follows**

***Raw Materials and Raw mix proportioning***

Judicious selection of raw materials helps in conservation of energy. Utilisation of energy saving argillaceous raw materials having fuel potential materials (fuel, ashes, coal mine wastes etc) and materials which can contribute to calcium in carbonate free oxide state reduces fuel consumption.

Proper raw mix design to ensure good burnability is a prerequisite for improving clinker quality and ensuring smooth and stable kiln operations, which will indirectly contribute to energy saving. To achieve fuel economy, a moderately low burnability index is desirable which is achieved primarily by controlling the raw meal composition. Lowering of alumina modulus ($A1_2$ / $Fe_2O_3$ ratio) in raw meal by 0.2 can result in lowering of clinkering temperature by 20°C or a thermal energy saving of about 20 Kcal / Kg. Likewise, a lowering of silica modulus by 0.2 is estimated to reduce the clinkering temperature by 10°C and leads to thermal energy saving of 10 Kcal / Kg clinker.

***Efficient Feeding Systems for Raw Meal and Fuel***

Efficient kiln operation with minimum fuel consumption demands a steady feed rate of raw meal and corresponding proportioned fuel in various sets of operating conditions. Improper and inefficient feeding control systems can give rise to fluctuating conditions in the kiln thereby hampering the productivity and energy consumption level. Overfeeding of coal results in increased exit gas temperature and energy


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consumption e. g gas 1°C rise in back end temperature increases the heat consumption by 1 Kcal / Kg clinker.

***Optimising Particle Size Distribution of Raw Mix***

The burnability of the feed is related to fineness of raw mix and any undesirable variation of raw mix could affect the burnability and consequently resulting in increased fuel consumption and reduce clinker production.

The optimum fineness of the raw mix depends on the nature of raw materials and efficiency of grinding equipment used. The reactivity and burnability of each cement raw mix varies from plant to plant depending upon the chemical, physical and mineralogical properties of the mix and ash content of the coal received, so a detailed investigation of the raw materials, burnability studies, etc need to be carried out to assess the optimum desired fineness. Oversize grinding of the kiln feed is also to be avoided.

***Coal Beneficiation***

One of the promising techniques which can be utilised to solve the problem is removal of ash forming mineral matter present in the coal through beneficiation. For beneficiation of non - coking coals, location of washeries can be considered at three different places, e. g washeries at pit head, washeries at a central place to cater to the needs of a group of cement plants in each region (Regional Washeries), washeries at cement plant site. Studies conducted by NCB have indicated that setting up such units at the pit head is the only viable solution due to techno - economic considerations.

***Blending of coal***

Coal is the only source of energy in the manufacture of cement. In India except few plants all of them are situated far from collieries. Besides high cost of transportation, the quality of coal available is too poor (ash content about 35 - 40%) as the calorific value is about 3500 - 4500 Kcal / Kg. This poor quality of coal causes entire process performance upset including kiln and increase fuel consumption. To overcome this difficulty, the blending should be done at received site.

Apart from beneficiation, pre - blending of coal before it is pulverised to very fine, is another important operation which could be used successfully to even out the ash content in pulverised coal and to reduce the maximum ash content in the coal being fed to the kiln. Coal as received at site from one particular consignment can be mixed by dozer with the coal of different consignment to get the homogenous quality and as well as nearly fixed ash content and calorific value. For this the government should think it liberally and quota should be allotted from one particular mine only to one particular industry so that the quality will remain same.

***NCB coal quality modulation system***

To overcome the problem of high ash coal, a better solution has now been found at NCB with the development of a system known as "NCB coal quality modulation system".

The system enables maintaining uniformity and consistency in burning conditions even when there are fluctuations in the quality of coal used in any industrial process especially in cement plants. This is achieved through a modulation system comprising on - line or off - line rapid analysis of coal as supplied to the burner, analysis of monitored data instantaneously by computer system and accentuations of the computerised controls for feeding of collective fuel into a multi - channel burner as separate stream or in a single channel burner as a mixed stream. The computer software developed by NCB is versatile enough to also carry out additional adjustments of the coal feed through the same computerised system, if required.

***Improved burners***

As the ultimate objective of any burner design is to provide a stable, short and intense flame, it was felt that the limitations of the conventional straight jet burners for high ash coals may be overcome by stepped or swirl jet burners by ensuring intimate mixing of coal and air at a higher velocity. In line with above, NCB developed a new design of stepwise burner nozzle. The NCB stepped burner has been so designed that it can replace the conventional burner nozzle of a cement rotary kiln with the minimum modifications.

***False Air Infiltration***

Since false air increases the quantity of gases and consequently the fan power requirements and reduces the gas and necessitates more fuel to be burnt to maintain the desired heat transfer, proper design and maintenance of air seals to stop in leakages and false air entry requires careful attention, eg. Every 0.1 Kg of false air entry through the kiln inlet air seals and riser duct increases the heat consumption by about 1%.

***Oxygen enrichment in the case of low grade coals***

Oxygen enriched air results in lower exit gas volume per kg clinker thus enabling burning of increased quantity of fuel with consequent increase in production.

***Improved refractory lining practises***

Heat loss due to radiation is as much as 10 – 15% of total heat consumption and nearly 2/3 of this heat is dissipated in the burning and calcining zone of the kiln. These losses can be reduced through improved refractory linings. Recent developments in refractory practises for achieving better fuel economy are new periclase - spinel refractories light - weight insulating bricks which can give better thermal insulation. A fuel saving of 2 – 3% can be achieved by using insulating and semi - insulating bricks in the preheating and calcining zones of the kiln.

***Moisture reduction in wet process***

Fuel saving can be realised by reducing the slurry moisture to the extent of up to 7% with the use of slurry thinners. It has been estimated that each percent of water reduction in wet slurry increases the kiln capacity by about 1.5%, simultaneously the heat consumption drops by about 1%.

***Use of Mineralisers***

The potential use of mineralisers like Fluoride, Fluro - silicates, Chlorides, Sulphates, Blast furnace slag, chromium slag etc. as possible means of energy conservation. Most mineralisers act both as Flux and Catalyst (i. e) reducing the temperature of the melt formation as well as accelerating the


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reaction rates. Use of mineralisers could reduce the clinkering temperature by 50 to 100°C and saving of heat by 50 to 100 Kcal/Kg clinker in wet process and 30 to 60 Kcal / kg clinker in dry process in addition to improved output and quality of clinker.

***Use of industrial waste***

***Manufacture of blended cements and special cements***

The utilisation of waste by - products like fly ash, slag for the manufacture of Portland pozzolana cement (PPC) and Portland slag cement (PSC) are worth considering from the point of energy conservation up to 25% pozzolanic material in PPC and 65% slag in PSC are permissible as per Indian standards. The percentage of pozzalana in PPC presently produced by Indian cement plants ranges from 11 – 15% and that of blast furnace slag in PSC ranges from 35 – 50%.

***Special Cements***

Special cements like reactive belite cement with lower firing temperature of 1325 - 1365°C entail heat energy saving to the tune of about 10% in addition to the use of marginal grade raw materials. Sulpho – aluminate cements can also be manufactured at temperature below 1300°C results in fuel savings. Alinite cement clinkering of which takes place at a temperature of 1100 - 1200°C is another example of special cements requiring lower energy for manufacture.

***Process conversion***

Though the programme of conversion from wet process to dry process is capital intensive, it is to be noted that every 1% of moisture content in the raw meal charged to the kiln needs 15 - 18 Kcal/kg clinker. In Indian cement industry, conversion of the present 14.4 million tones of capacity in the wet process to dry will result in a saving of about 2 million tones of coal per year.

However, any proposal of such conversion must take into account the various factors like techno - economic, availability of sufficient raw materials reserves, overall increase in capacity as well as the likely increase in the power consumption.

***Dust collection and Antipollution equipment***

The emission of dust particles in a cement plant causes loss of energy and production as well as creates air pollution. This should be studied urgently because it is a loss of semi - finished and finished product on which energy has already been spent. To check the performance of the various dust collectors, an extensive measurement in necessary at various locations. For kiln exhaust gas, coal mill vent air and cement grinding plant the Electrostatic precipitator (ESP) of latest technology should be installed so that we can optimize the dust control and hence energy is saved.

## 3. Conclusion

Today energy conservation has greater relevance than that was in the before. The energy conservation covers the improvements in efficiency and use of energy in existing technologies and processes. Energy technologies available worldwide provide substantial opportunities for improving energy efficiencies.

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