Manual on Best Practices in Cement Industry

World Class Energy Efficient Initiative in Cement Industry

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FORE WORD

India is the second largest cement producer in the world, ranking next only to China and surpassing developed nations like the USA & Japan in its overall cement manufacture & consumption. With 160 large plants and over 300 mini cement plants producing over 166 Million Tons of cement every year, this industry represents a turnover of over USD 12 Billion.

India has experienced strong economic growth in recent years. In the last 2 fiscal years, 2005 – 06 & 2006 – 07, the growth in Indian economy had been 9.0% and 9.2% respectively. The Planning Commission has estimated that investment in infrastructure - defined broadly to include transport, electric power, telecommunications, water supply and irrigation - will need to be of the order of about Rs. 14.50 Trillions (US$ 320 billion) during the 11th Plan period. Cement demand in the country grows at 1.5 times the increase in GDP.

Cement industry experts predict the cement capacity to increase by over 100% in the next 5 years. By the year 2012, cement manufacture in the country is expected to cross 300 MTPA.

Indian Cement industry contributes over 8% of the total carbon emissions in India. The emission of carbon-dioxide - both from high energy intensive operation in cement manufacture as well as calcination of lime stone, which is the basic raw material, makes the Cement industry one of the high impact industry as far as carbon emissions are concerned.

Indian cement industry, having realized its impact on the environment, has taken several strides in lowering its carbon emissions. Some of the major steps initiated in this direction are: adopting energy efficient practices in cement manufacture by employing latest energy efficient equipment and waste heat recovery, increased manufacture of blended cement and utilizing waste as fuel to lower impact on fossil fuels.

A few corporate thought leaders have gone way ahead in areas of energy efficiency, technology adoption and sustainable development. Some of the best practices in the global cement industry have its origin from India.

In spite of such progressive & forward-looking corporate groups setting examples in the Indian cement industry, the gap between the industry leaders and the companies not doing so good is very wide. For example, in terms of the specific electrical energy consumption, the difference between the best plant and the worst plant in the country is more than 100%.

There is a vital need, both to encourage the thought leaders in the industry to progress further & set newer benchmarks and practices; and to assist the companies following these units to adopt the best practices established by the leaders in the sector and to bridge the gap dividing them.

'World Class Energy Efficiency' initiative of CII is a small step in this direction. I was personally associated with this initiative over the last 3 years and it is heartening to note the progress happening, extensive sharing of information & the significant tangible & intangible benefits achieved by the participating industries.

While the Green Cementech conferences serve as a platform for deliberations and discussions, manuals like these also go a long way in sharing of information on best practices among all stakeholders.

I am sure, this manual will receive an overwhelming response from the cross section of the industry.

(G. Jayaraman)

EXECUTIVE SUMMARY

Indian cement industry is going through a phase of significant growth and capacity increase. The rate of increase in cement manufacture and demand has been over 25% in the last 5 years and the capacity is expected to double in the next 5 years.

Cement being an energy & resource intensive industry, this kind of increase in the cement demand would impose tremendous pressure on the environment. It is, therefore, necessary to evolve a system for growth of the cement sector in an environment friendly way. Though Indian cement industry has taken several strides in energy efficiency and GHG emission mitigation, several opportunities still exist for further improvement.

There is a vital need, both to encourage the thought leaders in the industry to progress further & set newer benchmarks and practices; and to assist the companies following these units to adopt the best practices established by the leaders in the sector and to bridge the gap dividing them.

With this background, Confederation of Indian Industry (CII), CII – Sohrabji Godrej Green Business Centre (CII – Godrej GBC) had taken up the initiative of facilitating the Indian cement industry achieve 'World Class Energy Efficiency' levels in cement manufacturing.

CII – Godrej GBC defines a 'World Class Energy Efficient' unit as:

- A trend setter in specific energy consumption norms – the lowest in the world
- A leader in implementing the latest technologies
- Has practically "nil" Energy Wastage
- Has adopted the Energy Scorecard
- Has made ENCON an "On-going activity" and incorporated it as a part of the management system

Essentially, a World Class Energy Efficient unit will be operating with the world's lowest specific energy consumption (electrical & thermal).

CII – Godrej GBC has taken the responsibility of overall execution of this project under the able guidance of an advisory group headed by **Mr G Jayaraman, Chairman Green Cementech 2008 and Executive President, Birla Cement Corporation.**

The first set of six cement manufacturing companies participating in this World Class Energy Efficiency initiative of CII – Godrej GBC are:

1. Dalmia Cement Bharat Limited, Dalmiapuram
2. Madras Cements limited, Alathiyur
3. Maratha Cement Works (Gujarat Ambuja Cement Limited), Upparwahi
4. Shree Cement Limited, Beawar
5. Ultratech Cement Limited, Tadipatri
6. Vasavadatta Cement, Sedam

The following activities have been carried out in these six companies:

1. A Comprehensive training program on Energy efficiency
2. Detailed Energy Audit was carried out in all the six participating companies and areas for improvement were identified. Several projects identified were implemented and resulted in significant energy saving.
3. Representatives from the participating cement plants visited each others' cement plants and an open and transparent information sharing was observed.
4. Visit to international cement plants in Germany, Belgium, Switzerland, United Kingdom and Japan was carried out. The mission was designed to focus on the following major areas of high relevance to Indian Cement Industry:
    - ❖ Waste Fuel Utilization
    - ❖ Waste Heat Recovery opportunities
    - ❖ Energy Efficiency

This manual contains the following:

1. World Class Energy Efficiency concept
2. Brief profile of participating companies
3. Progress made in World Class Energy Efficiency initiative and benefits achieved
4. Unique case studies and experiences learnt over the last 3 years

The objective of the 'World Class Energy Efficiency' Initiative will be fulfilled only if the performance of all cement plants in the country improves and achieves world class standards.

We are sure that the Indian Cement plants will make use of this opportunity, improve their performance and move towards achieving the status of World Class Energy Efficiency.

HOW TO USE THIS MANUAL

The objective of this manual is to act as a catalyst to promote energy efficiency activities in Indian Cement Plants towards continuously improving the performance of individual units and achieving the World class Energy Efficiency.

- To set a clear goal for improving the performance and moving towards the world-class standards, unique case studies / experiences learnt over the last few years have been included in this manual.
- These case studies / best practices may be considered for implementation after suitably fine tuning to meet the requirements of individual units.
- Apart from the cast studies / best practices learnt, the progress made by the 6 plants participating in this initiative has also been included.
- Suitable latest technologies may be considered for implementation in existing and future Cement plants for achieving the world-class energy efficiency. Further investigation and statutory requirements need to be verified for the suitability of these technologies for Indian Cement Plants.
- The collated best operating parameters and the best practices identified from various plants need not necessarily be the ultimate solution. It is possible to achieve even better energy efficiency and develop better operation and maintenance practices.

Therefore, Indian Cement Plants should view this manual positively and utilize the opportunity to improve the performance and to achieve World class Energy Efficiency.

BRIEF PROFILE OF INDIAN CEMENT INDUSTRY

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The Indian Cement industry is the second largest cement producer in the world, with an installed capacity of 166 million tonnes. The industry has undergone rapid technological upgradation and vibrant growth during the last two decades, and some of the plants can be compared in every respect with the best operating plants in the world.

The Indian cement industry is a mixture of mini and large capacity cement plants, ranging in unit capacity per kiln as low as 10 TPD to as high as 10000 TPD. There are more than 75 large cement manufacturing facilities having capacities 1 million ton and above and about 365 mini cement plants. Majority of the production of cement in the country (94%) is by large plants.

The cement industry is experiencing a boom on account of the overall growth of the Indian economy. The demand for cement, being a derived demand, depends primarily on the industrial activity, real estate business, construction activity, and investment in the infrastructure sector. India is experiencing growth on all these fronts and hence the cement market is flourishing like never before.

Indian cement industry is globally competitive because the industry has witnessed healthy trends such as cost control and continuous technology upgradation. Global rating agency, Fitch Ratings, has commented that cement demand in India is expected to grow at 10% annually in the medium term buoyed by housing, infrastructure and corporate capital expenditures.

Indian cement industry meets entire domestic demand and is able to export cement and clinker. Indian cement industry produces different varieties of cement like Ordinary Portland cement (OPC), Portland Pozzolana cement (PPC), Portland Slag Cement (PSC), Oil Well Cement, Sulphate Resisting Portland Cement, White Cement, etc. The Ordinary Portland Cement enjoys the major share (nearly 56%) of the total cement production in India followed by Portland Pozzolana Cement and Portland Slag Cement. A positive trend towards the increased use of blended cement can be seen with the share of blended cement increasing to 43%.

Future Outlook

Future growth will be driven by expected GDP growth of more than 8 percent, growth of the housing sector and the development of roads, ports, airports and other infrastructure.

Major Players

The major players in the cement sector are ACC, Gujarat Ambuja Cement Limited, Grasim Industries and Ultratech, India Cements Limited, Jaiprakash Associates and Shree Cement Limited. Foreign players such as Holcim, Italcementi, Heidelberg and Lafarge have also entered the cement market.

Energy Scenario

The industry is highly energy intensive and the energy share in manufacturing cost in some of the plants is as high as 55%.

Although the newer plants are equipped with the latest state-of-the-art equipment, there exists substantial scope for reduction in energy consumption in many plants by adopting various energy conservation measures.

CO_2 Emissions

Due to the dominant use of carbon intensive fuels such as coal in clinker making, the cement industry has been a major source of carbon dioxide (CO_2) emissions. Besides energy consumption, the clinker making process also emits CO_2 due to the calcining process. Increased atmospheric concentration of gases such as CO_2, methane, and nitrous are believed to be responsible for the rise in global mean land and sea temperatures since the 1850s.

The global cement industry contributes about 4% to global CO_2 emissions, making the cement industry an important sector for CO2-emission mitigation strategies. In India, while CO_2 emissions from cement production has increased from 7.32 MT of carbon in 1993 to 16.73 MT in 2003, its share in total CO_2 emissions by India has increased from 3.3% to 4.8%.

In India, CO_2 emissions per tonne of cement production have declined with increased share of blended cements, where energy use and associated emissions are reduced; increased share of dry processes; energy efficiencies; and other emission mitigation measures. Indian cement plants are also beginning to explore the use of alternative and waste fuels, such as municipal solid waste, industrial waste, used tires, rice husk, groundnut shells, etc., to replace the use of coal in cement kilns.

Technological Developments in Indian Cement Industry

Indian cement industry has been a fore-runner as far as energy efficiency in the cement manufacturing process is concerned. Continuous technological upgradation and assimilation of latest technology has been going on in the cement industry.

Some of the Indian cement plants are operating with specific energy consumption numbers which are the best in the world. The cost of energy had been the predominant driving factor for such advancements in energy efficiency. An average cement plant would be operating with energy cost being about 35 – 40% of the total manufacturing cost of cement. This is much higher compared to other western countries.

Energy Efficiency in Cement Industry

Substantial reduction has been observed over the last 10 years in the specific energy consumption figures for all cement plants. The industry's average electrical energy consumption in 2005-06 was 82 kWh/t of cement and thermal energy consumption was 725 kcal/kg of clinker, while the average in the year 1995 was about 112 kWh / ton of cement and 815 kCal / kg of clinker.

This indicates an average reduction in electrical energy consumption by 26.7% and thermal energy consumption by 11.0%. Probably, no other sector in the country would have recorded such a significant reduction in average specific energy consumption figures for all their plants across their country.

It is expected that the industry's average thermal energy consumption by the end of Year 2011-12 will come down to about 710 kcal/kg of clinker and the average electrical energy consumption will come down to 78 kWh/t of cement.

The improvements in energy performance of cement plants in the recent past have been possible largely due to:

- ❖ Retrofitting and adoption of energy efficient equipment
- ❖ Better operational control and Optimization

- Upgradation of process control and instrumentation facilities
- Better monitoring and Management Information System
- Active participation of employees and their continued exposure in energy conservation efforts etc.

When one looks back at how cement industry has been able to achieve such a significant reduction in its specific energy consumption, there had been no external or government pressure. It had been driven by the tremendous competition in the open market and the need to sustain that fierce competition. It is also an excellent instance where several stakeholders like the cement manufacturers, cement machinery & equipment suppliers, consultants, etc, came together with concerted efforts to reduce the energy consumption in the Indian cement industry.

Another excellent practice in the cement industry had been the sharing of knowledge among other units. The openness of information sharing, either at plant level or in seminars, conferences and workshops has resulted in significant information dissemination and benefit to all. Cement industry today, stands as an example for several other sectors of industry, leading the way in following the path of learning by sharing.

What should be the future target for the Indian cement industry?

After discussions with several stakeholders – cement manufacturers, equipment suppliers, consultants, etc. the committee felt that the future target for the Indian cement industry should be as under:

Future energy consumption targets for Indian cement industry		
Electrical Energy Consumption	:	56 – 62 kWh / Ton Cement
Thermal Energy Consumption	:	650 kCal / kg clinker

Break-up of electrical energy consumption:

Area of activity	Electrical consumption (kWh / Ton of Cement)
Crushing	1.50
Raw mill	12.00 to 18
Kiln and Cooler	18.00
Coal mill	2.50
Cement mill	18.00
Packing	1.00
Miscellaneous	3.50
Total	**56 to 62 kWh / T of cement**

Break-up of thermal energy consumption

Parameter	Specific Fuel Consumption (kCal / kg Clinker)
Theoretical heat consumption	410
Pre-heater loss	105
Cooler loss(Clinker & Cooler vent gases)	90
Radiation loss	75
Heat input	(-) 30
Total	**650 kCal / kg Clinker**

WORLD CLASS ENERGY EFFICIENCY

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Energy conservation practices have acquired top priority, in the present context of increasing energy prices, acute energy shortage and the ever-widening demand - supply gap.

The opposite of world class companies is not average or bad units – it is only the good units !

All industrial units have adopted several measures to optimize the energy costs. Significant reduction in power consumption and substantial reduction in cost has been achieved by these units.

On achieving significant reduction, some units reach complacence. The open mind to look forward to further avenues of improvement no longer exists.

Some units, not succumbing to complacence, continue to strive and achieve excellence in energy management.

This document attempts to bring out the subtle differences between these units, which have achieved excellence in energy management ("World Class" units), and the other units (the "Good" units) which have stopped without exploring full potential.

The various characteristics and the differences between world class units and good units are elaborated below:

Good units Vs World Class Units

Bench marking & Trend setting

World Class units follow "next" practices – not "best" practices !

'Benchmarking' is the approach adopted by the good units. They try to identify the best unit in its class, and plan to match themselves their performance in line with the best unit identified.

With the benchmarking approach, at the best, the good units can reach a performance level only closer to the best units, leaving them at the second level only.

On the other hand, the world class units adopt an approach of 'trendsetting'. They start with a 'zero' base, look for innovative opportunities in each area of operation and implement them.

This approach facilitates the plant to look for the most efficient design / technology / operating practices without being bounded by the 'Benchmark'. World class plants thus are trendsetters and emerge as leaders in the field.

Information Sharing

Good Companies – Share information 'Within'. World Class companies – Extensive and quick sharing & dissemination of information

Information sharing could be a major differentiator between the good units & best units

The information, either sourced within or obtained elsewhere, in good companies is shared only within the organization. It takes a long time for this information to percolate even to other group companies.

World Class companies, on the other hand, believe in information dissemination as quick as possible. The fact that the time lost due to delay in information transfer could result in a significant monetary (energy) loss is well appreciated.

Some units like Philips, Birla Group and Coca Cola share best practices across their units worldwide at a very quick pace and ensure its implementation to achieve the benefits at the earliest.

Implementation of latest technologies

Good Companies – look for proven technologies.
World Class companies – look for pioneering technologies

A good unit plays a very conservative & defensive role in implementing latest technologies.

Good units are comfortable with proven technologies and are risk averse. These units want successful case studies of this technology implemented elsewhere, before considering implementation.

A World Class unit, on the other hand, sees this situation as opportunity to be a pioneer.

They are willing and have the capacity to take this risk at all levels of the organization. Several rewards accompany this risk. They become the technology developer's first preference, and get the technology at a very low price. The technology developer also works hand-in-hand with the plant team in making the new technology successful.

Once the first few trials are successful, the technology supplier would then sell this to "good" units at a much higher price (than the best units) to recover the development costs of that technology and the subsidy offered to best units.

Ultimately, the good unit pays for the world-class unit to get still "better" !!. This competitive advantage accumulates in the world-class plants and the gap between the world class and good plants increases with time.

Energy wastage

Good Companies – leakages visible.
World Class companies – leakages not apparent

Energy wastages in a good unit are minimal but will be visible to a trained eye.

In a world class unit, these are not apparent. Further energy saving avenues need to be evolved after a detailed and exhaustive study.

EnCon Culture

In a good plant, a good idea waits for funds; in a World Class Unit, funds await good ideas

Energy conservation activity in a good plant is driven by external factors. An increase in energy costs, cheaper imports, etc. generally drive the plant towards energy efficiency. The energy efficiency activities are therefore momentary and part of the management culture.

In a world class unit, it becomes a routine activity. Every top management is committed to energy conservation, but has different ways of expressing it and finally achieving benefits.

In good units, it could be setting targets or fixing budgets.

In a best unit, it works based on resource allocation. The top management allocates resources to each department. This mode of operation has 2 benefits – it ensures faster implementation of energy saving projects once technically proven and drives people to identify newer avenues for utilizing the resources allocated.

Monitoring & energy scorecard

Good units as well as the best units have an excellent energy monitoring system.

Good units – Data Generation
World Class units – Energy Scorecard

In a good unit, it stops with data generation.

On the other hand, the World Class unit compiles this data in a presentable format (Energy Scorecard) which could be used as a tool to evaluate the performance of the individual. In some excellent units, the yearly performance appraisal of an individual or departments is based on the energy scorecard.

EnCon activity

In a good unit, the energy manager tries to identify and implement all the energy saving projects himself. This not only results in reduced number of projects but also results in longer gestation time.

A World Class unit has a facilitator in an Energy Manager. The energy conservation culture is well entrenched in the organization, that the operation & maintenance team approach the energy manager with projects. He engages experts with domain expertise to identify newer areas. This results in more number of projects identified & faster implementation.

Approach to EnCon

Good Unit -
'EnCon' seen in isolation;
World Class Unit -
Holistic approach
- Life cycle cost considered

In a Good Plant, Energy conservation is seen as an isolated activity which involves reduction of operating costs.

World Class units have a holistic approach to Energy conservation. The Life cycle cost of implementing Energy Conservation is considered.

Characteristics of World Class Energy Efficient Units

A World Class Energy Efficient unit is:

- A trend setter in specific energy consumption norms – the lowest in the world
- A leader in implementing the latest technologies
- Has practically "nil" Energy Wastage
- Has adopted the Energy Scorecard
- Has made ENCON an "On-going activity" and incorporated as a part of the management system

Essentially, a World Class Energy Efficient unit will be operating with the world's lowest specific energy consumption (Electrical & Thermal).

World Class Energy Efficiency in Indian Cement Plants

CII – Sohrabji Godrej Green Business Centre (CII – Godrej GBC) started an initiative "World Class Energy Efficiency in Indian Cement Plants" with a vision to promote energy efficiency in Indian cement plants and thereby making Indian cement industry **'greenest'** in the world.

The World Class Energy Efficiency initiative of CII – Godrej GBC has evoked tremendous response in the Indian cement industry. The activities of World Class Energy Efficiency have been divided in three phases.

Phase – I (First 6 Months)

Participating company & CII-Godrej GBC form a team and work together with the objective of identifying maximum number of Energy Efficiency projects in the plant.

The Phase - I activities include the following:

- ❖ A Comprehensive training program on Energy efficiency to the technical personnel of the plant
- ❖ A Detailed Energy Audit covering all areas
- ❖ Missions to world class National & International cement plants to adopt latest technologies

The objective of the training program is to increase the awareness & capacity building of the technical staff of participating company, and also increase the involvement of the plant team in the project.

A comprehensive detailed energy audit is the next step and is jointly conducted by the plant and CII teams.

This approach creates to identification of specific energy conservation projects and creates ownership for the projects identified. This would also facilitate quicker implementation of the projects.

CII – Godrej GBC also plans for **National & International Missions to World-Class Plants.** These activities facilitate generation of newer ideas and also provide a platform for continuous training.

Phase – II (Next 12 Months)

The phase – II activities include the following activities:

- ❖ Implementation of projects identified in phase – I
- ❖ Development of Energy Scorecard
- ❖ WHR system in Kiln & Cooler system – Independently or integrating with Power plant
- ❖ Feasibility of utilizing Waste fuels in kiln
- ❖ Global Benchmarking

The plant team should prioritize and implement the specific energy saving projects identified during the detailed energy audit in Phase – I. The entire processes in Phase–II are aimed at putting in place effective management and monitoring systems.

The development of **"Energy Scorecard"** could help in full-fledged implementation. This would be a logical extension of the specific energy consumption targets developed under phase – I. The energy scorecard helps in developing ownership at the operational level and generation of self-targets.

Waste Heat Recovery (WHR) from the Kiln pre-heater and / or Cooler is an excellent alternative, which can substantially improve the operating efficiency of the plant. The feasibility of installing a WHR system either independently or through integration with the power plant is explored during Phase – II.

The Cement Kiln is an excellent source for **utilizing the waste fuels**, such as, municipal wastes, hospital wastes, tyres, biomass etc. The long-term feasibility of installing such a system is explored.

Global Benchmarking is one of the major activities of this phase, besides the energy audit. CII-Godrej GBC assists the plant team in mapping of technology adopted and equipment installed in the World Class units. This helps in developing target specific energy consumption figures for the plant. The targets developed would include overall plant targets as well as section wise and equipment wise targets.

Phase – III (Next 18 months)

The objective of Phase – III activities is to sustain the implementation of "Energy Efficiency projects" and make this a permanent "on-going" activity at the plant.

This leads to continuous generation of newer ideas and implementation of major investment projects. The ownership for these activities would be with the individual department heads.

Activities carried out in various units so far …

Six cement companies have evinced interest in availing the services of CII – Godrej GBC to facilitate their units to achieve world class energy efficient levels. The phase-I activities of "World Class Energy Efficiency" have been completed in first set of 6 Indian cement plants.

The first set of six companies participating in this initiative are:

1. Dalmia Cement Bharat Limited, Dalmiapuram
2. Madras Cements limited, Alathiyur
3. Maratha Cement Works (Gujarat Ambuja Cement Limited), Upparwahi
4. Shree Cement Limited, Beawar
5. Ultratech Cement Limited, Tadipatri
6. Vasavadatta Cement, Sedam

The following activities have been carried out in these six companies:

1. A Comprehensive training program on Energy efficiency was carried out for the technical personnel in the plant team. The objective of the training program was to increase the awareness & capacity building of the technical staff, and also increase the involvement of the plant team in the project.
2. Detailed Energy Audit was carried out in all the six participating companies and areas for improvement were identified. Several projects identified were implemented and has resulted in significant energy saving. The comprehensive detailed energy audit in the plants was jointly conducted by the plant and CII energy teams. This approach led to identification of specific energy conservation projects and creating ownership for the projects identified. This has also facilitated quicker implementation of the projects.
3. Visit among the participating companies was carried out. Representatives from the participating cement plants visited each others' cement plants and an open and transparent information sharing was observed. The whole idea was to facilitate adoption of all best

practices among these 6 units participating in this initiative. Under the chairmanship of Mr G Jayaraman, a target was set that each plant should identify and implement a saving potential of at least 100 kW from each visit. All the plants achieved a minimum saving potential of 100 kW and some of the plants achieved upto 200 kW saving potential.

4. Visit to international cement plants in Germany, Belgium, Switzerland, United Kingdom and Japan was carried out. The mission was designed to focus on the following major areas of high relevance to Indian Cement Industry:

   - Waste Fuel Utilization
   - Waste Heat Recovery opportunities
   - Energy Efficiency

Some of the plants like, Ultratech, Shree cement and Vasavadatta have taken initiative and implemented waste heat recovery system.

Benefits Achieved

Significant reduction in specific energy consumption was achieved by all the 6 plants with continuous efforts of the plant teams. The specific energy consumption values are tabulated below:

Company	Specific Energy consumption (SEC)	
	Electrical (kWh/T of cement)	**Thermal** (kCal/kg of clinker)
Dalmia Cement, Dalmiapuram	75.0	760
Madras Cement Ltd, Alathiyur	59.9	684
Maratha Cement Works, Chandrapur	80.7	715
Shree Cement Ltd, Beawar	63.5	710
Ultratech Cement, Tadipatri	87.1	692
Vasavadatta Cement, Sedam	65.5	712

Dalmia Cement Bharat Limited

Dalmia Cement Bharat Limited, Dalmiapuram implemented around **29 energy saving projects** during last 3 years and achieved a benefit of **Rs 497 Lakhs.** The specific electrical energy consumption has reduced from 74.9 kWh/ton to 71.5 kWh/ton of cement. The specific thermal energy consumption is almost same at 745 kCal/kg of clinker.

Madras Cement Limited

Madras Cement Limited, Alathiyur implemented around **21 projects** during last 3 years and achieved a total saving potential of **Rs 181.4 Lakhs** with an investment of **Rs 60 Lakhs**. Madras Cement Limited also implemented a coal based power plant couple of years back to reduce the energy cost. This project alone required an investment of **Rs 9,500 Lakhs** and the annual savings achieved in energy cost is **Rs 1,100 Lakhs**. The specific electrical energy consumption reduced from 61 kWh/ton to 59.9 kWh/ton of cement and specific thermal energy consumption reduced from 685 kCal/kg to 684 kCal/kg of clinker. Madras Cement Limited is operating with one of the lowest specific energy consumption values in the world.

Maratha Cement Works

Maratha Cement Works (Gujarath Ambuja Cement Limited), Upparwahi has implemented several energy saving projects and achieved substantial energy savings. There is a reduction in specific electrical energy consumption from **88.32 kWh/ton** to **80.88 kWh/ton** of cement over the last 3 years.

However, there is an increment in specific thermal energy consumption from 704 kCal/kg to 715 kCal/kg of clinker. This increase in thermal energy is due to:

- High moisture content in the coal
- Decreased production rate due to high ash content in the coal
- Fine granulation of clinker

Shree Cement Limited

Shree Cement Limited, Beawar implemented 30 number of energy saving projects during last 3 years and achieved an energy saving potential of **Rs 736.7 Lakhs.** Shree Cement Limited has significantly reduced the specific energy consumption in last 3 years. Specific electrical energy consumption has reduced from 69.17 kWh/ton to 63.57 kWh/ton of cement. Specific thermal energy consumption has reduced from 715 kCal/kg to 710 kCal/kg of clinker.

Ultra Tech Cement

Ultra Tech Cement Limited, Tadipatri implemented **79** energy saving projects during last 3 years and achieved energy saving potential of **Rs 1166.9 Lakhs.** Specific electrical energy consumption has increased recently from 76.67 kWh/ton to 87.14 kWh / ton of cement. Specific thermal energy consumption has also increased from 682 kCal/kg to 692 kCal/kg of clinker.

The reasons for increase in specific energy consumption are:

- High blain requirement of product
- Increase in OPC quantity
- Low quality of coal
- High one day strength requirement

Vasavadatta Cement

Vasavadatta Cement, Sedam has implemented several energy saving projects during last 3 years which resulted in reduction in specific energy consumption. There is an increase in specific electrical energy consumption for unit-2 due to increased OPC quantity.

Way Forward

Upon completion of phase-I activities and after achieving tremendous benefits, all the six plants have decided to carry out the phase-II activities. The phase-II activities in the above plants would commence soon.

These 6 plants have become trend setters and created impact in Indian cement industry. Another set of six cement plants would be taking part in this initiative and Phase 1 activities would be taken up in these plants. This shows the commitment and enthusiasm of every cement plant to compete with the world class cement plants and to become one of the world class cement plants.

If this trend continues in the future, many Indian cement plants will emerge as world class cement plants and some of the plants will become 'the best' in terms of energy efficiency.

CII Learnings

CII has learnt many things during the interaction with various cement plants. Many plants have implemented innovative projects on their own which resulted in either energy savings or increased production or both. CII has collected some of the new ideas and case studies which could result in similar potential in other plants.

These new ideas and case studies are presented here in this manual in order to disseminate the information across the industry.

The objective of the 'World Class Energy Efficiency' Initiative will be fulfilled only if the performance of all cement plants in the country improves and achieves world class standards.

We are sure that the Indian Cement plants will make use of this opportunity, improve their performance and move towards the world class Energy Efficiency.

BRIEF PROFILE OF PARTICIPATING COMPANIES

BRIEF PROFILE OF PARTICIPATING COMPANIES

DALMIA CEMENT BHARAT LIMITED

Introduction

It was in the year 1939, during the pre-independence era, the company started its cement unit as a venture towards Building up a self-reliant India with respect to one of the country's essential commodities / Core Sectors. Of the four units so started, one was located at Dalmiapuram, which was later incorporated as **"DALMIA CEMENT (BHARAT) LIMITED"** (whilst two units got absorbed in Pakistan due to partition).

In 1939, a 250 Tons per day kiln was started by the Company to manufacture cement by Semi-dry process. It is a tribute to the engineers of Dalmia Cement that this unit is still actively functioning at Dalmiapuram Works. In 1949, a 500 TPD Wet Process Unax Kiln was installed. Again in 1959, expansion was undertaken with the installation of another 500 TPD wet process Folax Kiln. In 1982, a 200 TPD Vertical Shaft Kiln (First of its kind in India) was installed using Coal Slurry Process.

Indian cement industry witnessed Partial Decontrol in the year 1983 and full Decontrol in the year 1984. In the year 1983, Captive Power Gensets supplied were installed. In the year 1984, Oil well cement production was started and in 1986 the prestigious API Monogram certification was received from American Petroleum Institute, USA.

In the year 1991, a Regional Training Centre sponsored by World Bank DANIDA was started at the Plant to cater to all South Indian Cement Plants. This is recognition of our Plant as center for excellence for transfer of Technology.

In the year 1997, Cement grinding was modernized by introducing Vertical Roller Mill. A substantial expansion project was completed in 2002 with upgradation, enhancing the capacity to 3300 TPD, by installing energy efficient low pressure cyclones and the Kiln Cooler with the latest technology for improved thermal efficiency. A major capacity expansion project was commissioned during the year 2006 to enhance the total cement capacity by putting up a most modern & energy efficient 3800 TPD Plant. To meet the increased power requirement at optimum cost, a 27 MW Captive Thermal Power Plant was put up during the year 2005.

Technical highlights and unique projects implemented

- ❖ The plant team has implemented a unique case study "CFD analysis for Preheater down comer duct". This is probably the first case study of this nature in Indian cement industry. This study has resulted in reduction of pressured drop across the duct from 110 mmWC to 73 mmWC which resulted in reduction in fan power consumption by 63 kW.

- ❖ In their new brown field cement plant of capacity 3800 TPD, Dalmia Cement has incorporated several energy efficiency measures by design. All the major fans were fitted with Variable Frequency Drives at the design stage itself. This required an additional investment of Rs. 2.0 Crores but Dalmia Cement, during the design stage itself, anticipated saving from damper loss alone is about Rs. 84 Lakhs per annum. Other benefits such as smooth speed control, improved motor life due to reduction in surges, less stress on the equipment due to smooth start & stop, etc were also considered during the design stage.

- Moisture in raw material is very high at Dalmia Cement, and becomes critical during the rainy/winter months. This aspect was to be considered while deciding on the number of pre-heater stages. Dalmia Cement decided to go ahead with 5 stage pre-heaters to save on thermal energy consumption during 8 months of the year, where the moisture levels are relatively low. During the 4 months where the moisture levels are very high, provision was made for hot air supply from Hot Air Generators (HAG). This has resulted in a significant energy saving of about Rs 92 Lakhs per annum.

- Compressed air system has also been considered for optimization at the design stage itself. Unlike its old line, the new line had a centralized compressed air system for the entire plant. This has reduced the cost of maintenance, reduced idle running of compressors and reduction in overall leakage air quantity. Compressed air system retrofits such as intermediate controllers and monitoring systems were incorporated by design. The additional investment was Rs. 15.0 Lakhs while the anticipated energy saving was Rs. 22 Lakhs per annum.

- Other aspects considered at the design stage itself at Dalmia Cement are installation of pipe conveyors. This has reduced the investment on transfer points and main bag filters. Pipe conveyors operate with no spillage or dust emission, providing an environment friendly atmosphere at the workplace. Installation of energy efficient motors by design in over 400 applications had been another notable factor at Dalmia Cement's new plant.

MADRAS CEMENT LIMITED

Ramco Group

Under the stewardship and vision of the present chairman Sri P.R. Ramasubrahmaneya Rajha, the group has grown into Rs 2000 Crores conglomerate consisting of well diversified companies and has become one of the most reputed business groups in India.

The group's business interests are:

- ❖ Cement
- ❖ Cotton yarn
- ❖ Software systems
- ❖ Fibre Cement products
- ❖ Wind Energy

Madras Cements Ltd

Madras Cements Ltd is the flag ship company of Ramco Group. The main product of the company is Portland cement manufactured through the four advanced production facilities spread over South India. The company is the sixth largest cement producer in the country and the second largest in South India.

MCL also produces Ready Mix Concrete and Dry mortar products. In addition, the company also operates one of the largest wind farms in the country.

The plant has won many prestigious awards and is considered as one of the most energy efficient company in the country.

Madras Cements Ltd operates four production facilities:

- ❖ R R Nagar, Tamil Nadu (1.2 MTPA)
- ❖ Jayanthipuram, Andhra Pradesh (2.6 MTPA)

- ❖ Alathiyur, Tamil Nadu (3.0 MTPA)
- ❖ Mathod, Karnataka (0.2 MTPA)

The R R Nagar plant commenced operations in 1962 with 200 TPD. It commissioned the first 1200 TPD dry plant in 1976. A second Kiln with a Capacity of 650 TPD was added in the year 1993-94.

The Jayanthipuram Plant started the operations in 1988 with 2500 TPD and was upgraded to 3200 TPD in 1992. It is equipped with a modern computer based quality control system. A new line of 1 MTPA capacity was commissioned early this year.

The Alathiyur plant Commenced operations in 1997 with 0.9 MTPA Capacity and was upgraded by 0.2 MTPA in 1999-2000. It started the Line-2 in 2000-01 with a capacity of 1.5 MTPA. Alathiyur is the first plant in India to go in for 100% Mining by Surface Miners. It has an environ-friendly and energy Efficient MMD Crusher for Lime Stone Crushing Plant Operations

Technical highlights and unique projects implemented

The Alathiyur unit of Madras Cements Limited operates with one of the lowest specific energy consumption numbers in the world. In spite of the achievement, MCL Alathiyur has been an excellent example of continuous improvement. Over the last few years, several energy saving projects have been implemented resulting in substantial energy saving. A few of them are as under:

- ❖ MCL Alathiyur has carried out extensive modifications in its raw mill and cement Vertical Roller Mills (VRMs). The plant team has done well to install VRMs for raw and cement grinding by design stage itself. This has reduced the energy consumption significantly. During the operation, the plant team has been continuously exploring for opportunities to improve the performance of the mills. Some of the modifications carried out in the VRMs are:

  a. Modification in the width of the static flaps of the classifier

  b. High efficiency dynamic classifier rotor diameter was altered

c. Classifier blades in the VRM were modified from flat surface to curved surface and the configuration of the static blades were modified.

d. Replacement of fans operating with lower efficiency with new high efficient fans

e. Armour ring angle modification and grit cone extension

- Some of the other case studies implemented at MCL Alathiyur are:

  a. Providing software interlock to stop the dedusting fan whenever feed conveyor stops

  b. Providing dampers in inlet of dust collector fans in packer to control the suction whenever packer operates with single discharge

  c. Installation of intermediate controller in compressed air system

  d. Installation of separate conveying and dosing system for alternate fuels

  e. Installation of bypass duct for cement mill booster fan from cooler vent fan

  f. Replacement of several fans with lower operating efficiency with new high efficiency fans

  g. Modifications in fan inlet box to minimize pressure drop, and thereby power consumption

- Installation of 2 x 18 MW coal based thermal power plant to reduce the overall cost of energy

MARATHA CEMENT WORKS

(Ambuja Cements Limited), Upparwahi

Maratha Cements Works - a company promoted by **Ambuja Cements Ltd.** is operating a 2 million plant at Village Bhendvi / Upparwahi in District Chandrapur in the State of Maharashtra. The plant has subsequently gone through modernization and achieved the consented capacity of 2.85 Million MT per annum.

Project Iplementation

GACL's (Gujarat Ambuja Cement Limited) first plant was commissioned in 1985-86 within **22** months. The second plant was commissioned in 1993 in just **13** months time. The company enjoys recognition for high productivity, low power consumption, low fuel consumption, best pollution control and environmental preservation.

Technical highlights and unique projects implemented

Maratha Cement Works (MCW) has been implementing energy saving projects on a regular basis and has reduced its specific energy consumption continuously.

Some of the projects implemented at Maratha Cement Works are:

- During end cone reclaiming (start and end of the pile), MCW observed that the Raw Mill output was getting reduced from 550 TPH to 370 TPH in spite of increase in drive speed from 1100 rpm to 1500 rpm. After detailed analysis, MCW team replaced the drive with a higher rpm motor, changed the speed settings accordingly and maintained the mill output steady during end cone reclaiming also. This has resulted in significant energy saving.

- With an objective to minimize radiation losses, the cooler take off duct was modified. The velocity of cooler take off duct was reduced significantly and the refractory thickness was increased to reduce the shell temperature. Significant thermal energy was achieved after installing this project.

- MCW has also provided a kiln outlet duplex seal to minimize air infiltration. Replacing the conventional kiln outlet seal with graphite block seal reduced the leak air quantity by nearly 70% and increased the secondary air temperature by about 90^{o}C. This corresponds to a net energy saving of 1.50 kCal/kg clinker

- Tertiary duct diameter increase was carried out after the plant team reviewed the duct velocities. The plant capacity has increased from 6000 TPD to 8000 TPD. After the increase in duct diameter, the tertiary air temperature increased by about 75 – 90^{o}C. The net benefit in thermal energy consumption was about 5 kCal /kg clinker

- Other projects carried out

  a. CFD analysis for reducing / minimizing duct pressure drops

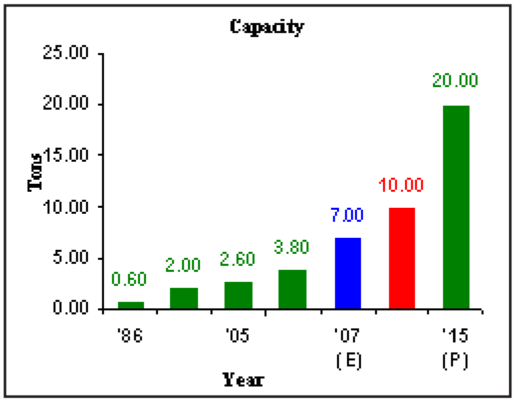
  b. Optimization of RA fan and Bag House fan power consumption

  c. Damper removal to minimize pressure drop in the fans

  d. Installation of several Variable Frequency Drives (VFDs) for energy efficiency

SHREE CEMENT LIMITED, BEAWAR

Shree cement is an energy conscious and environment friendly sustainable business origination. Bangur Cement Unit (III, IV, V & VI) is located at RAS, 28 km from Beawar in Pali District of Rajasthan. Shree Cement Grinding Unit (KKGU) of capacity 2 x 1.5 million tons is located at Khush Khera Dist.



The present capacity of Shree Cement Limited (SCL) is 8 million ton/annum out of which 3.3 million tons is produced from Beawar plant and 4.5 million tons is produced from Ras plant.

Shree Cement is marching ahead with a vision of attaining 20 million ton capacity by year 2012.

In 2003, in order to become self sufficient in power, Shree Cement installed its own 2x18 MW captive power plant to meet the entire power requirement of the plant including its peak demand. The capacity of the plant was further enhanced to 44 MW in year 2006.

Productivity

SCL has a track record of over 100% capacity utilization in the eighteenth year of its existence. In 2006-07 SCL registered its **highest ever production with capacity utilization of 126 % against industry average of 94 %.**

Energy Conservation

SCL consumed 118 kWh/ton of cement in 1985, which has come down to **63.57 kWh/ton of cement in 2006-07**, compared to industry average of 82 kWh/ton of cement.

Sustainable Development Initiatives:

The concept of sustainable development pre-empts a world order where it would be the only mode of progress. Taking a proactive stance, Shree joined a forum of International cement companies formed to help the industry make a transition to the sustainability ethos. Called the cement Sustainability Initiative (CSI), it has Shree as the first Indian Cement company joining it and partnering the World Business Council for Sustainable development (WBCSD), Switzerland, in its efforts. Sustainable development involves meeting commitments pertaining to climate protection, responsible use of fuels & materials, employee health and safety, emission reduction, local impact on land and community and reporting. Also joined Global Reporting Initiatives as a organizational stake holder in 2005.

Research & Development

Shree R & D center, one of the few in the cement industry, is duly **recognized by Department of Scientific & Industrial Research, Govt. of India**. The R&D efforts are directed towards development of new product and process technologies, improvement of product performance and reduction in costs through use of alternate fuels and raw materials.

People Philosophy

Institutionalized a suggestion scheme called **Jo Soche Woh Paave** to bring all members to main stream, created **leaders at every level** results in strong sense of emotional ownership, implemented recognition & reward scheme, **concepts of multi skilling** to optimize manpower enhance skill and to facilitate cross functional development, **small group activities** for energy conservation, to achieve **total prosperity** ASCENT groups have been formed,

SCL has received several awards, national & international, for its efforts in the areas of energy efficiency, environment friendly technologies, productivity and safety.

Technical highlights and unique projects implemented

Shree Cement has been a forerunner in the Indian cement industry in energy efficiency and environment friendly practices. Several energy saving measures have been implemented on a regular basis and has resulted in continuous reduction of specific energy consumption. Some of the major projects implemented at SCL are as under:

- Installation of third cyclone in Preheater tower of unit II
- Upgradation of cement mill in Unit II
- Replacing fans of lower operating efficiency with new fans of higher operating efficiency
- Installing VFDs for several fans for energy saving
- Installation of downcomer water spray system
- Installing several high efficiency fans in dust collector systems

Apart from these, many other projects were implemented by small group activities:

- Delta to permanent star conversion in under load motors
- Usage of high mast lighting tower / energy efficient lights
- Optimisation of operating frequency
- Power capacitor provided at motor end
- Usage of electronic starter in air conditioners
- Usage of FRP fan blades in place of conventional aluminum fan blades
- Usage of transparent sheet for maximum daylight capture
- Very high power factor near to unity is maintained
- Modification of reclaimer-II harrow resulted in increased reclaimer feeding & reduced power consumption.

Installation of Waste Heat Recovery System

Shree Cement Ltd (SCL) has installed a waste heat recovery system in its Unit 1 at Beawar to recover the waste heat from the pre-heater exit gases, currently being dissipated into the atmosphere, for steam generation. SCL has integrated the waste heat recovery system with its captive power plant and the steam generated in waste heat recovery is utilized for pre-heating the feed water in the LP & HP heater of existing power plant.

Waste heat recovery system generates steam of 27.6 TPH at a temperature of 375^{o}C and pressure of 27 kg/cm^2. This steam is utilized in the captive power plant for feed water preheating.

With and without this waste heat recovery system, the difference in power output from the captive power plant is about 5-6 MW. The fuel saving from this project is anticipated at over 20000 tons per annum and carbon dioxide emission reduction would be over 76000 tons per annum.

ULTRATECH CEMENT LIMITED
ANDHRA PRADESH CEMENT WORKS (APCW)

To meet the southern market demand, UltraTech is operating 2.7 MTPA cement plant near Bhogasamudram village in Tadipatri Mandal in Anantapur district of Andhra Pradesh. This plant is referred to as Andhra Pradesh Cement Works (APCW). APCW serves approx. 11% of south Indian market. This Cement Plant has adopted many latest technologies during its installation:

- Cement plant is fully automated and is Centrally controlled by process Computers linked to the plant machinery.
- It has two raw mills having a roller diameter of 5 m ATOX 50 mills, these are the two biggest mills in the country and first of its kind.
- It has a covered circular limestone store of 95-m dia with a stacker-reclaimer for feeding limestone to two raw mills simultaneously. This system with a storage capacity of about 45,000 m^3 is the largest in the country, and one of the few limestone stacker-reclaimers of such huge storage capacity in the world.
- The RCC chimney at the plant is the tallest in the Indian cement industry of 142 meter height.

- The production unit and the packing plant have been located at different elevations. Plant is located at the hill top (351.5 m.MSL) and Packing plant & wagon tippler are Located at foot of hill (266.0 m.MSL).

Ultratech Cement, APCW has received several awards for its excellent energy efficiency and environmental friendly practices.

The other state-of-the-art Equipment and facilities installed at APCW are:

- A large size single-stage limestone crusher with a maximum capacity of 1,300 tph
- Continuous storage-cum-blending controlled-flow raw meal silo of 22.4 m dia and 60 m height of capacity 30,000 tonnes for continuous feeding to the kiln with uniform and homogenised kiln feed.
- 8,000 tonnes per day kiln equipped with six-stage double-stream pre-heater cyclone system.
- The plant is equipped with vertical coal mill of capacity 71 tph combining drying, grinding and classifying operations in one unit.
- Two clinker storage silos – one of 65 m dia with a capacity of 150,000 tonnes and the other of 40 m dia having 57,000 tonnes capacity.
- The two roller presses in APCW for grinding clinker provide an advantage with respect to specific power consumption and the seven cement storage silos each with a storage capacity of 6,000 tonnes help in dispatching different varieties of cement as per the market requirement.
- Six electronic packers are installed for packing cement in bags.
- In view of the anticipated power shortage in future, APCW is provided with two diesel generator sets of 23.74 MW (i.e., 2 x 11.87 MW) which is around 60% of total power requirement of the plant.
- APCW is ISO certified, ISO 9001:2000 for Quality Management system, ISO 14001:2004 for Environmental Management & OHSAS 18001 for Occupational Health & safety management system.

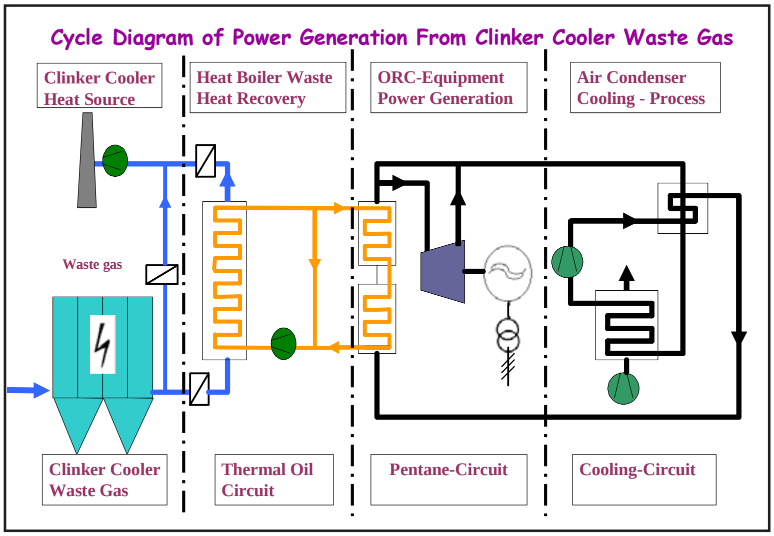
Technical highlights and unique projects implemented

Some of the projects implemented at APCW over the recent years are as under:

- ❖ Installation of HT VFD for cooler ESP fan to minimize damper loss
- ❖ Installation of several VFD's in various sections of plant to minimize energy consumption
- ❖ Pressure drop reduction exercises in several areas:
  - a. Modification in CS 3rd & 5th cyclone riser duct room
  - b. Installation of dedusting cyclone in KS 2nd cyclone
  - c. Increasing kiln downcomer duct diameter
  - d. Modification in fan inlet suction boxes
- ❖ Optimization in compressed air system by installing intermediate controllers, reducing overall pressure of operation and avoiding idle operation
- ❖ Several projects in electrical areas such as voltage optimization, energy efficient lighting ystems, avoiding idle operation in several sections, etc.

Installation of Waste Heat Recovery System at APCW

Ultratech Cement Limited has installed an Organic Rankine Cycle based waste heat recovery system of rated output 4.8 MW at its cement plant in Tadipatri. The energy converter is supplied by ORMAT Systems Limited, Isreal while the Waste Heat Oil Heater (WHOH) was supplied by Transparent Energy Systems, Pune.



This system is the first of its kind in India and the second application in the world. This project was commissioned in March 2007 and meets about 10% of power requirement at APCW.

This system recovers heat from the cooler vent gases to heat 247 TPH of thermic fluid in Waste Heat Oil Heater (WHOH) from 120°C to 270°C at design pressure of 7.5 Bar. The ORMAT energy converter is a two stage impulse type turbine with air cooled condenser and with pentane as the motive fluid. While the gross output of the power plant is designed at 4,0 MW, the net output is 3.35 MW excluding auxiliary power consumption of 665 kW. The anticipated annual power generation was 25 Million kWh.

The plant team had future actions of installing **14.4 MW** wind power plant and **20 MW** solar power plant and a vapour absorption system of **200 TR.**

VASAVADATTA CEMENT

A product of the prestigious **BK Birla Group** of Companies, Vasavadatta Cement stands for everything that is unique and above the ordinary. Builders over a short span of time have recognized the quality, strength and technology, which clearly have become a tradition, translating into relationships strong and cemented. Vasavadatta Cement is an ISO 9001 Company.

Vasavadatta Cement is a state-of-the-art Cement Plant of 4.0 MTPA located at Sedam in the state of Karnataka, India.

Line –1 of the Vasavadatta cement plant was conceived in the year 1983 – 84, Line-2 in the year 1997 and Line-3 was commissioned in the year 2006. The plant is based of Dry process Precalciner Technology.

Vasavadatta Cement has got it's own two power generation stations of 15.7 MW & 9.5 MW capacities. The latest power station, Unit – III is of 18.0 MW capacity.

Cement being highly Energy Intensive Industry, Energy conservation has been a constant endeavor at Vasavadatta Cement by regular Energy Audits & Continuous monitoring of Energy Consumption.

Technical highlights and unique projects implemented

Vasavadatta Cement has been implementing energy saving projects on a regular basis and has reduced its specific energy consumption on a continuous basis. Some of the projects implemented at Vasavadatta Cement are:

- Installation of belt bucket elevator for kiln feed in line II
- Poldos – SC system for main firing in Kiln 1
- Modifications in Raw Mill – outlet duct modification, body modification, etc.
- Retrofitting low efficiency cooler fans with new fans having higher operating efficiency
- Expert control system for cement mills
- Vasavadatta Cement observed during a detailed study in its cement mills that the material, which was going from the V – Separator cyclones to the mill inlet, was very fine. This cyclone material was going to the mill along with the v– separator rejects. Circuit sample study indicated that the cyclone material was having specific surface area of 2300 – 2500 cm^2/g. After several discussions and observations, Vasavadatta Cement had diverted the cyclone material of the separator to the mill outlet leaving the coarse material from SEPOL casing to go to the cement mill inlet.
- An innovative idea of operating a Ball Mill in tandem with the existing Vertical Roller Mill was conceived by Vasavadatta Cement and implemented. The objective of this unique exercise is low cost capacity upgradation. As per the plant equipment supplier, M/s Krupp Polysius, this unique idea is the first of its kind in the world. After the successful implementation of this project, Vasavadatta Cement had several visitors from India and abroad to see the project implemented. Ball mill feed was taken from the reject cone of VRM Classifier through a variable speed screw conveyor. Ball Mill is vented through VRM. Ball mill product is fed by bucket elevator to existing air slide below ESP conveying raw meal to Silo.

BEST PRACTICES

&

CASE STUDIES

Case Study No 1

OPTIMIZE OPERATION OF CEMENT MILLS

Background (Grinding and Separation)

Grinding and separation are distinct operations that occur in grinding systems. Both of them have a great influence upon the other and therefore cannot be seen in isolation. This case study will describe the separator's function in a grinding system, the techniques used to evaluate separator performance, and the separator's effect on the resulting product.

The main function of any separator in a grinding system is to separate all the material that has not yet been reduced to the desired product size, without removing any of the product material. The larger material or rejects are returned to the mill for further grinding, while the smaller material or product is conveyed to storage. Any coarse material that remains in the product can hurt its quality, and any product-sized material that is carried with the rejects will be further ground. This wastes energy and may affect the product by creating too many fines.

Separator evaluation should be carried out as part of a mill system audit, where the conditions in the mill and the rest of the system are also determined and optimized. During the audit, the mill is normally crash stopped and the internal conditions are noted, including axial sampling, powder levels in the compartments, mechanical condition of the internals, the charge level, and the extent of ball charge classification. Also, the system conditions such as specific mill power, feed size & grindability, product quality, air flows, and material temperatures are evaluated at the same time.

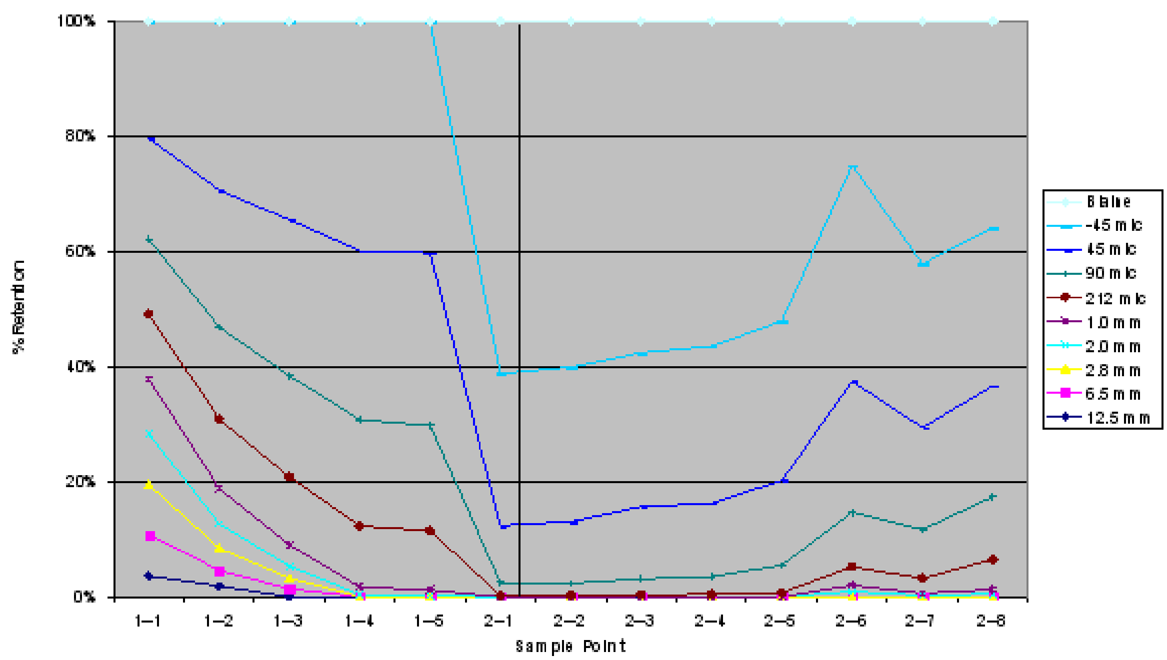
By evaluating all components at one point of time, the performance of a grinding system can be compared to a previous time or to other similar grinding systems. The techniques used to evaluate the separation process are the size distributions of the circuit samples, the circulating load calculations, and the separator efficiency calculations. The separator evaluation techniques and their significance will be described in detail.

Case study:

In a 2.0 MTPA plant, detailed assessment of its cement mills were carried out to optimize the power consumption in its grinding circuit. Detailed flow, pressure measurements & sieve analysis was conducted in its Cement grinding system. The following observations were made on the system.

The cement mill was operating with a high efficiency separator in closed circuit. The following were the results of the sieve analysis.

Cement Mill Analysis



From above observations and grindabilty curve it was evident that, grinding the last areas of the cement mill is not doing any useful work. After the mill diaphragm and there is sharp rise in residue in chamber 2.

The following opportunities were explored to improve the mill output and grindabilty in cement mills.

- ❖ Utilizing the separator to the maximum
- ❖ GM size optimization
- ❖ Monitoring of cement product

The latest trend in plants operating in closed circuit with high efficiency separator is to grind as coarse as possible in the mill and load the separator to the maximum extent possible.

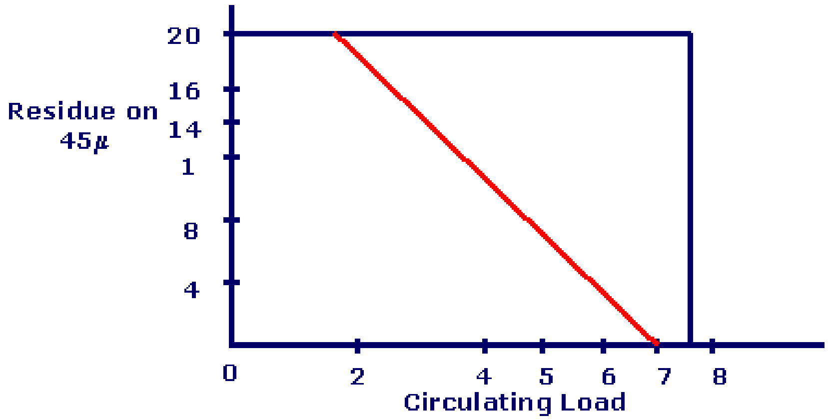
This will result in coarser feed to the separator which in turn would increase the separation efficiency of the separator. This would increase the capacity of the cement mill and corresponding reduction in specific energy consumption.

One of the ways of doing this is by increasing the air velocity through the mill. This would increase the coarser material load at the mill outlet. The operation of the separator has to be fine-tuned accordingly. In some cases, the bucket elevator could be a bottleneck for additional loading. This has to be ensured before increasing the mill velocity

Once the mill velocity is increased the grindabilty curve of the mill has to be plotted again. Presently from the grindability curve of this cement mill under study, the last 2 metre length of the cement mill is not doing any useful work. So once the grindability curve is drawn after increasing the mill velocity the grinding media size should be optimized accordingly.

Monitoring of cement product

In many cement plants, it is a common practice to monitor cement fineness by measuring the Blaine, but Blaine is a measure of the porosity of cement. With high efficiency separators and varying circulation loads Blaine is not a true measure of fineness of cement.



An experiment was conducted in a ball mill to prove that the measurement / monitoring of cement product by Blaine alone would not be indicative. In this experiment, the circulating load in a closed circuit mill with a high efficiency separator was varied between 0 and 8 and the cement product was maintained at a same Blaine value of 3000 cm^2/gram. The residue measurements indicated that as the circulating load was increasing, the residue on 45µ kept on reducing. The residue on 45 µ dropped from 20% to 0.8% as the circulating load was increased from 2 to 7. The corresponding increase in power consumption was from 24 units/ton to as high as 36 units/ton.

This experiment clearly indicates that for closed circuit mills with high efficiency separators, Blaine can no longer be the only method of evaluating the product fineness. Blaine measurements should be in conjunction with residues for a given circulating load.

The result of cement analysis done at various occasions in the cement mill also supports the experiment described above.

IDENTITY	READING #1	READING #2	READING #3
Blaine	3320	3270	3380
212	0.0	0.0	0.0
90	0.32	0.5	0.48
45	8.16	12.48	10.68

From the above analysis we can infer the following

- For the same Blaine range (3270 to 3320) the residue on 45 micron is varying from 8.2 to 12.5%.
- For the same mill and for same Blaine values, the variation in 45 micron residue is about 4%, which will have a significant impact on the power consumption of the mill

The reason for such a variation in residue for same Blaine is due the variation in circulating load. From this it was evident that the Blaine is not the true measure of cement fineness.

Over-grinding in cement mills

As proved over repeated studies and experiments, the particle sizes responsible for maximum strength of cement would be in 3 to 30μ range. The ultimate objective is to increase the 3 to 30 micron fraction in the final product. To achieve this, the latest trend to analyze the entire Particle Size Distribution (PSD) for the cement product.

From the PSD of cement product, <3m residue fraction is analyzed and efforts should be taken to minimize the 3m residue (affects the cement strength due to over grinding and corresponding increased power consumption) if greater than 5%.

Coarse grinding with higher mill velocity will help to reduce the <3m residue and optimize the power consumption of cement mill.

Ultimately, it is essential to establish a relation between the strength developed and residues on 45 / 63 mic sieves. Residue should be maintained as basis for monitoring the performance of Cement Mill.

Thus increasing the mill velocity would result in increased mill output, reduced Blaine for same strength and corresponding lower grinding power. Thus there is good potential to optimize the grinding in cement mill which would result in at least 1 unit/ton reduction in power consumption.

The following activities were carried out in a cement plant to optimize the grinding power consumption:

- Carring out fresh sieve analysis (PSD) for all mills
- Increasing the mill velocity for coarser grinding and fine tune separator accordingly
- Re-Grading grinding media (GM) composition
- Reducing larger size grinding media from 90 mm to 70 mm (Avg)
- Ultimately establishing a relation between strength & 45 / 63 mic residue. This residue is maintained as basis for monitoring the performance of Cement Mill.

Benefits :

Optimizing the operation of cement mill resulted in an annual energy saving potential is Rs. 45.00 Lakhs. This required an investment (for Grinding Media Re-Grading) of Rs. 50.0 Lakhs, and had a simple payback period of 14 Months.

Case Study No 2

LOWER DISPERSION BOX IN RAISER DUCTS OF PRE-HEATER CYCLONES AND INCREASE HEAT TRANSFER

Background

Pre-heater system in cement plants are an excellent example of heat transfer, where the overall system is counter current while each stage of heat transfer happens in co-current mode of heat transfer. This system offers the advantages of both co-current and counter current heat transfer systems.

It is also proven over repeated studies and experiments that in a pre-heater system, maximum heat transfer between the kiln & calciner exit hot gases and the inlet feed material takes place in the riser ducts. Almost 80% of the entire heat transferred from the hot gases to raw meal is in riser ducts. In the pre-heater cyclones, the separation of feed material and air takes place. The feed material is then fed to the lower cyclone and the hot air moves to the next higher cyclone.

The Preheater system is one of the major areas for potential reduction in thermal energy consumption in the plant. The main aim of the PH system is to recover maximum heat from the kiln exhaust gases and to reduce overall thermal energy consumption.

One of the excellent opportunities in utilizing the preheater system to maximize the heat transfer is to lower the feed pipe to utilize the maximum length of riser duct.

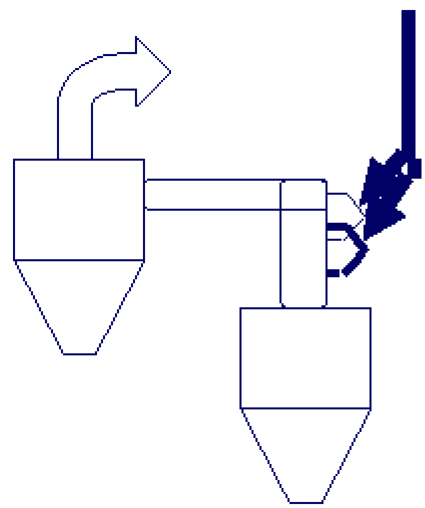
Therefore, to ensure maximum heat recovery in the riser ducts, the feed pipe from the higher stage should be lowered as much as possible.

This increases the heat transfer between the hot gases and feed material in each stage, before they are separated in the cyclone. This will result in lowering of exit gas temperatures from the PH system.

Case Study:

The feed box heights of the preheater cyclones top at one of the cement plant are given below:

- KS – Cyclone 2 – 3.15 m
- KS – Cyclone 3 – 3.26 m
- KS – Cyclone 4 – 3.47 m
- KS – Cyclone 5 – 3.90 m
- CS – Cyclone 4 – 4.15 m
- CS – Cyclone 3 – 4.41 m



The feed pipe in the identified cyclones could be lowered by at least2 m. The optimum point of feed inlet to the riser duct is at 1.0 m height from the cyclone top. The lowering of the feed pipe has to be taken up after detailed discussions with the suppliers and after taking their consent for the same.

One of the issues normally encountered during the feed pipe re-location is the possibility of 'fall through'. In 'fall through', the material coming in from the feed pipe would not be lifted by the air going out of the next cyclone. In this case, the material would fall through the cyclone and join the separated material from the cyclone to the next stage. This will result in improper calcinations of material. While lowering the feed pipe, this aspect has to be kept in consideration. This can be checked by measuring the temperature profile of material at cyclone bottom by inserting 4-6 thermocouples across the cross section of feed pipe. If the variation between the temperature values is very low, it is an indication of no 'fall through'. However, if the temperature variation is more than 80-100°C, it indicates fall through. If fall through is observed, corrective action can be taken in the dispersion plate to create enough dispersion of material for the air to pick up.

The lowering of feed pipes in the identified cyclones would result in additional heat transfer area available. This results in a reduction of about 7-10^{o}C in preheater gas exit temperature. This would amount to atleast 3.0 kCal/kg reduction in the thermal energy consumption of the plant.

Detailed discussion with the suppliers and other cement plants reveals that lowering of dispersion box in riser duct had been a common practice. This project had been implemented in several plants and achieved tremendous benefits.

Lowering the feed pipes can be done in stages by modifying in any one of cyclones. After modifying, the entire PH system should be closely monitored for changes in PH exit temperature. Once satisfied with performance of the PH system the other cyclone can be taken up one by one for further modifications.

The temperature & pressure measurements should be monitored after each reduction and recorded.

Benefits:

Lowering the feed pipes in the Preheater riser ducts would result in an annual energy saving of Rs. 51.25 Lakhs. This calls for an investment of Rs. 12.00 Lakhs and has an attractive simple payback period of 3 Months.

Case Study No 3

OPTIMIZE BLENDING SYSTEM TO MINIMISE THERMAL ENERGY CONSUMPTION

Background - Blending system

Blending operation in a cement plant is very vital for both optimal quality parameters and energy performance. The electrical energy consumption for blending operation varies between 1.0 to 1.5 kWh/ton. Blending operation is very vital as far as thermal energy consumption of the cement operation is concerned.

The homogenization of raw meal prior to the calcination process has always been a very important step in the production of clinker. It is widely known that there are four methods of raw meal homogenization utilized in the cement industry. The first and the traditional one is the slurry mixing practiced in the wet-process plants and other methods are adopted in dry process plants and include mechanical systems, pneumatic systems, and gravity systems.

The mechanical system consists of multiple storage silos, each of which is provided with regulated withdrawal facilities. Blending is achieved by an orderly withdrawal of material at variable rates from all silos. While this type of mixing consumes lower power, the system requires a great deal of material handling that increases power consumption. In addition, the required of number of silos is obviously more than in other systems. As a result of these shortcomings, this kind of homogenization system is not in wide use in the cement industry.

Pneumatic fluidization: The most common homogenization system used over the past several decades is the pneumatic unit, based on the air fluidization method. Air introduced through a permeable medium in the silo bottom causes the raw meal to behave almost like a fluid. This agitational method is known to provide high blending efficiency for dry material, But at the same time this method is the highest consumer of power in relative terms.

The gravity approach to homogenization has been conceived only with the compulsion of achieving reduced power consumption. This is in many ways comparable to the mechanical system. While the mechanical system utilizes multiple silos, the gravity method can work with even one silo but with multiple discharge points operating on a time cycle.

Continuous blending silos, which are connected in parallel and fed by a material flow divided over the respective silos and whose discharge flows are recombined, can further improve the blending effects.

Homogenization system	Power consumption for raw meal, kWh/t
Mechanical	2.00 – 2.50
Pneumatic fluidization	1.0 – 1.50
Gravity (inverted cone)	0.25 – 0.50
Gravity (multi-outlet)	0.10 – 0.13

Notwithstanding the effectiveness and extensive adoption of pneumatic blending systems in the cement industry, the following issues have kept the pressure on to search for other options:

1. High power consumption
2. Maintenance problems, particularly of porous media
3. Difficulties of providing clean air and the high cost of installing oil-free air compressors

Continuous homogenization with one silo can offer a blending factor of 5-7, and it may improve to 7-12 with two silos.

Blending Chemistry:

The key reaction in cement operation is one unit of C_2S reacting with one unit of C to form one unit of C_3S. This reaction between C_2S and C is a diffusion controlled reaction. The rate controlling parameter in this process is the meeting of one unit of C_2S and one unit of C to form one unit of C_3S.

A good blended material would have an even distribution of C_2S and C indicating lesser distance to travel for their meeting and reaction. This results in faster rate of reaction. This will also result in lesser free lime at the end of the reaction.

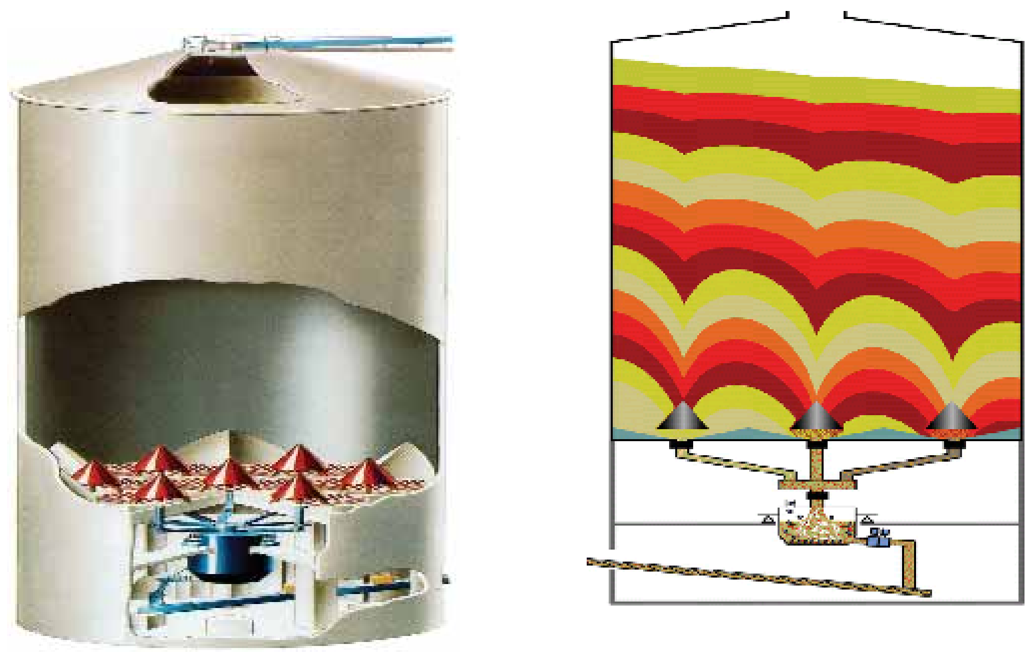
A poor blended material, on the contrary, would have slower rate of reaction and higher free lime. A higher burning zone temperature would be required to achieve the same free lime content as a good blended material. This, in turn, would result in higher thermal energy consumption.

Case study

The Controlled Flow system including suitable kiln feed equipment ensures stable kiln feed composition at minimum power consumption and investment cost. Two criteria must be met to achieve a high degree of homogeneity in a continuously operating, through-flow silo where blending is not achieved simply by air agitation:

1. All the raw meal in the silo must be kept in constant movement towards the outlets.

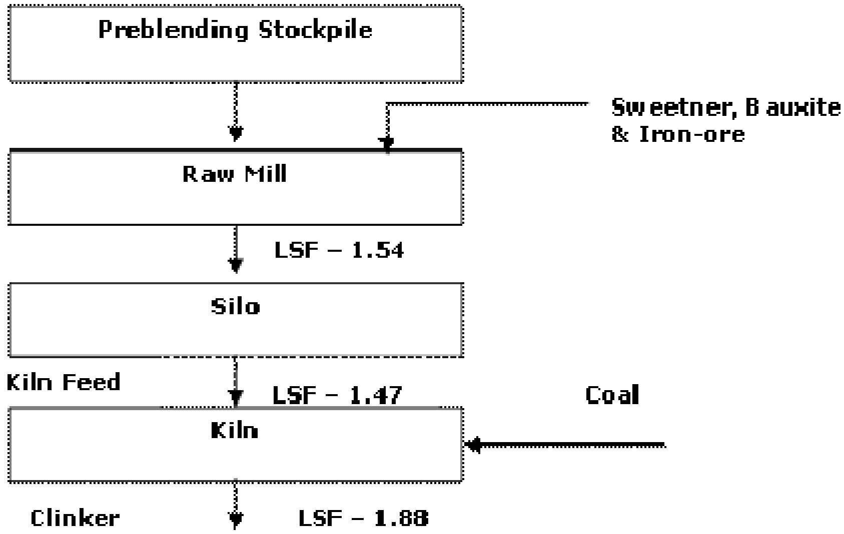
2. The raw meal must pass through the silo in flow zones with different residence times.



[Source : FLS CF Silo Article]

The blending system at one of the cement plant was studied in detail for possible thermal energy saving opportunities. The variations in LSF from the lime stone till clinker was studied in detail. The possible reasons for variations and opportunities for minimizing the variations were explored in detail.

Observations made regarding the variation in LSF in the entire system is as under:



Based on the variations in the LSF, it is observed that the blending homogenization efficiency is lower. One possible reason could be the addition of the bag house material. While the material collection from bag house is not uniform, this material is very high on LSF. Uneven addition of the bag house material could result in wide variation in product LSF.

Installing a bin & continuous extraction system for steady feed of bag house material to the silo can lower the variation in LSF significantly. Low homogenization at the blending silo is a cause of concern at plant. The typical blending efficiency in modern silos is about 8 to 10 while the blending efficiency at this bending silo is very low presently. After the installation of bin and continuous extraction system for the bag house material, the standard deviation (SD) of the material should be established. The target homogenization for latest high efficiency silo in this plant should be at least 7. Some of the steps to be taken up after the continuous feeding system of bag house material is installed are:

1. Comparing the design extraction vis-a-vis actual extraction

2. Re-measuring the actual extraction during stoppage and matching the flow with design rates by adjusting the gates and modifying the timing suitably

3. Discuss with supplier on the possible reasons for low blending efficiency and seek comments to rectify the same.

Optimization in Stacker

The normal practice in cement plants is to stack at a constant speed (of about 2 m/s). Stacker belt stops when there is a no-load condition. This is a good step as far as overall blending system is concerned. Regulating the stacker traverse speed with the load could be an excellent opportunity to improve the overall blending system. Installing a provision for this interlock is possible in almost all the stackers. The additional requirement is only to incorporate a PI control with bulk analyzer weighing system.

LSF Variation due to coal

Significant increase in the LSF standard deviation of kiln feed and clinker was observed. The only reason for this variation could be the coal added. With the use of pet coke / imported coal, the quality of coal is fairly consistent and the variations are minimal. This being the case, the variation in the LSF could be due to the quantity of coal fired. The latest trend in the cement plants now is to adopt Solid Flow based measurement and control system for coal firing. The advantages of this system are as under:

1. Precise control of coal firing
2. Consistent kiln operation
3. Marginal increase in production
4. Lower thermal energy consumption

The benefits reported from the optimization of blending system and coal firing system from various cement plants are as under:

❖ Optimizing the blending system by improving the blending efficiency in silos would result in 2.5 kCal/kg Clinker reduction in thermal energy consumption

- Installation of solid flow meter based coal firing system would result in a reduction of 5.0 kCal/kg clinker in thermal energy consumption

Benefits:

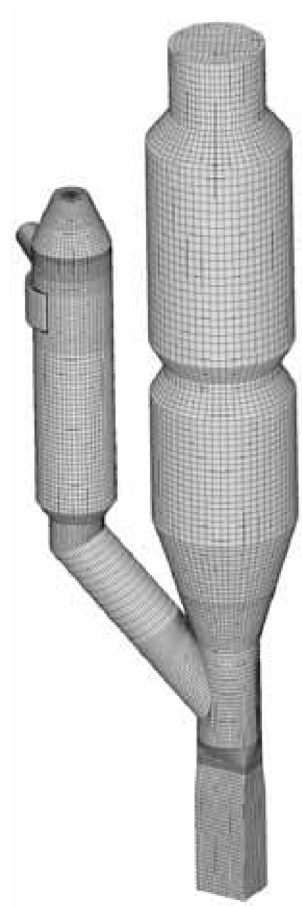
Improving the blending efficiency in silo and modernization of coal firing system would result in an annual energy saving of Rs. 220.00 Lakhs. This calls for an investment of Rs. 400.00 Lakhs (Solid Flow meter based coal firing system) and has a simple payback period of 22 months.

Case Study No 4

UTILIZATION OF COMPUTATIONAL FLUID DYMANICS (CFD) FOR ENERGY EFFICIENCY RETROFITS IN CEMENT INDUSTRY

Back ground

Computations Fluid Dynamics (CFD) is an excellent tool to study the behavior of fluids in ducts and paths. Extensive adaptations of CFD are in use now and its use for energy efficiency and performance enhancement has been adopted by various industries. Cement industry, being extremely aware of the benefits of this study, has adopted CFD study in its performance optimization.



CFD study has been utilized to study the following:

- Reduction of pressure drops in duct , cyclones, mills and ESP
- Studying the performance of separators in mills
- Devolatilisation of coal
- Gaseous phase reaction/combustion
- Mass, momentum, and energy exchange between gas and particle
- Alkalis formation with possible deposition in the system

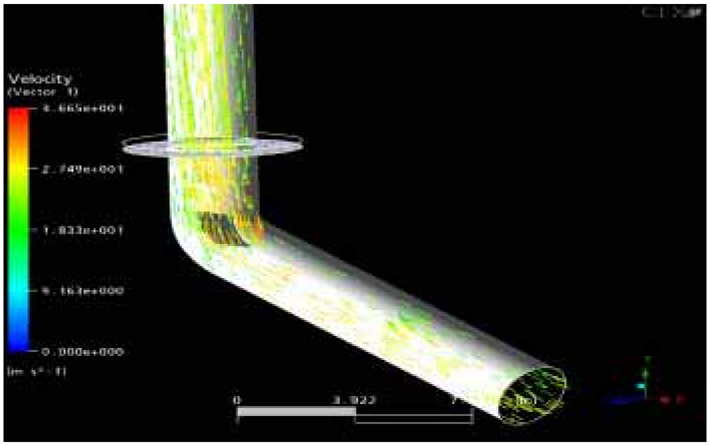
This has resulted in significant benefits in energy consumption and performance optimization in Indian and international cement plants

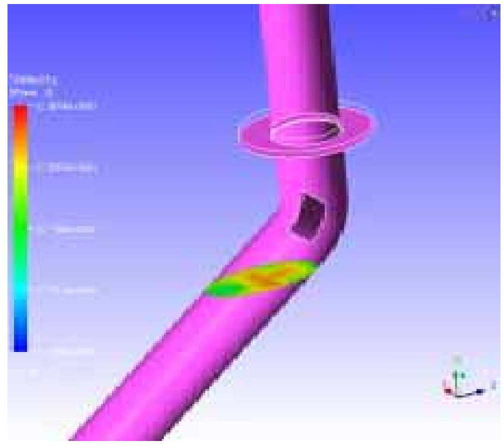
i. Case study :

REDUCE PRESSURE DROP IN PREHEATER DOWNCOMER DUCT

Preheater fan is one of the major energy consumers in the cement plant, accounting almost 10% of the total energy consumption in the plant. With continuous capacity increase in cement industry, increased material loading and flow rates, the pressure drop across the preheater downcomer is one of the common causes of concern for cement plants.

The conventional mention of overcoming the pressure drop in the preheater downcomer is to expand the downcomer ducts. This step involves lot of time, effort, investment and requires a long shutdown of the kiln.





Utilizing CFD for analyzing the preheater downcomer pressure drop and suggesting ways to reduce the same has evoked tremendous response in Indian cement industry. This step involves low investment, lesser time and very low shutdown requirement.

Preheater down comer duct (as shown in the picture) in one of the cement plants was of a total length of 140 m from top stage cyclone to preheater fan.

Though the gas velocity inside the duct was found to be at optimum level (19 m/sec), the plant team was facing the problem of high pressure drop across the duct .The pressure drop in the duct was about 130 mmWC against the calculated value of 50mmwC. Detailed pressure measurements indicated that the pressure drop was maximum near the two bends, one at the top and the other at the bottom, offering nearly 60% of the total pressure drop. To ascertain the exact reason for the high pressure drop, CFD analysis was employed to check if improper flow distribution was resulting in high turbulence and hence pressure drop in the downcomer duct.

Computational fluid Dynamic study was conducted and based on the same flow, distribution plates were installed at both the bends (two at the top bend and one at the bottom). This has smoothened the flow and resulted in reduction in pressure drop by 33 mmWC.

Benefits:

CFD analysis and retrofit in the downcomer duct has resulted in energy saving of 63 kW corresponding to cost saving of Rs 17.5 Lakhs per annum. The investment made was around 1.5 Lakhs with an attractive payback period of less than a month.

ii. Case Study :

REDUCE THE PRESSURE DROP IN PREHEATER CYCLONE AND REDUCE THE DUST LOSSES

Back Ground:

Computational fluid dynamics (CFD) techniques is used to verify the performance of cyclones in the preheater system. The model is composed of several time differential equations in a two-dimensional (2-D) space domain with a three-dimensional (3-D) symmetric cyclone inlet. The model is solved using the finite volume method with staggered grids. The results on collection efficiency and pressure drop of an experimental study were used to validate the proposed model. After validation of the model, it was possible to examine the performance of the cyclone separators through a comparison of the numerical results and information obtained in the cement industry. The material that is not collected by the cyclone in the system leaves through the preheater as dust.

In one of the cement plants, dust losses in the preheater system are 10.5% which indicates the efficiency of the top cyclone is 89.5% against the design efficiency of 94%.

The dust loss of 10.5% indicates that the dust coming in the system as feed material at about 75^{o}C leaves the system as dust at about 290^{o}C. This, in terms of its heat content, indicates an equivalent heat loss of about 6 kCal/kg Clinker.

Increasing the efficiency of top cyclone by about 5% gives an opportunity to reduce the thermal energy consumption by about 3 kCal/kg clinker, resulting in significant energy saving.

Extensive discussions were held with consultants on reducing the dust loss by improving the top cyclone collection efficiency through Computational Fluid Dynamics (CFD) analysis. Based on the discussions, the CFD analysis can reduce the dust loss without increasing the pressure drop across the top cyclone. This has been successful in several plants and can yield good results.

The design efficiencies of other 5 cyclones (apart from the top cyclone) were also offering good scope for improvement. The design efficiencies are as under:

- Cyclone 2 – 87 %
- Cyclone 3 – 85 %
- Cyclone 4 – 83 %
- Cyclone 5 – 78 %
- Cyclone 6 - 75 %

The actual collection efficiencies of the other 5 cyclones could even be lower than the design as in the case of the top cyclone. The CFD analysis on the other 5 cyclones could also offer excellent scope to reduce the overall return dust loss without increase in the pressure drop across the cyclones.

Optimizing the return dust by improving the cyclone efficiency, both in the top cyclone and in the other cyclones offered excellent potential for thermal energy reduction.

Immediate – As an immediate measure, CFD analysis was carried out in the top cyclone. This study offered opportunities to reduce the top cyclone dust loss without increasing the pressure drop. This study resulted in improving the top cyclone efficiency by at least 5% from the previous values.

Long term – After successful implementation of CFD in top cyclones and tapping the benefits, CFD analysis was carried out on all other 5 cyclones. Implementing the findings of CFD resulted in increase of all other 5 cyclones efficiency by at least 4-5%. Over and above the benefits in the top cyclone, this step resulted in benefit of at least 4 kCal/kg Clinker without any increase in the overall pressure drop of the system.

Benefits

Immediate – carrying out the CFD analysis for top cyclone and reducing the dust loss resulted in an annual energy saving of Rs. 60.00 Lakhs. This called for an investment of Rs. 20.0 Lakhs (for carrying out CFD analysis, engineering and implementing necessary modifications) and had a simple payback period of 4 months.

Long term – Carrying out CFD analysis in all other 5 cyclones (apart from top cyclone) and improving the cyclone efficiency resulted in an annual energy saving of Rs. 82.0 Lakhs. This called for an investment of Rs. 150.0 Lakhs and had a simple payback period of 22 months.

Case Study No. 5

INSTALL VARIABLE FREQUENCY DRIVE (VFD) FOR REVERSE AIR (RA) FAN AND OPTIMISE POWER CONSUMPTION OF BAG HOUSE FAN

Background-Reverse air and Baghouse

All reverse air fabric filters are divided into a set of compartments operating in parallel. The kiln gas flow through a compartment is stopped during cleaning, and filtered gas is passed in a reverse direction through the bags.

Reverse air bags are hung from support frames near the tops of the compartments. The bags are tensioned to 27 to 54 kg force by spring assemblies on the top frame .The tension minimizes mechanical flexing and abrasion of the vulnerable fabrics. Most reverse air bags installed in cement kilns have heights ranging from 6 to 9 meters.

The inlet unfiltered gas stream enters the baghouse near the top of the hopper and then enters the inside of each of the reverse air bags. The dust cake accumulates on the interior surfaces of the bags. The dust cake provides most of the filtration of particles from the inlet gas stream. Bag cleaning must be performed properly to ensure that a residual dust cake remains in the bag to maintain high efficiency filtration, even immediately following a compartment cleaning cycle.

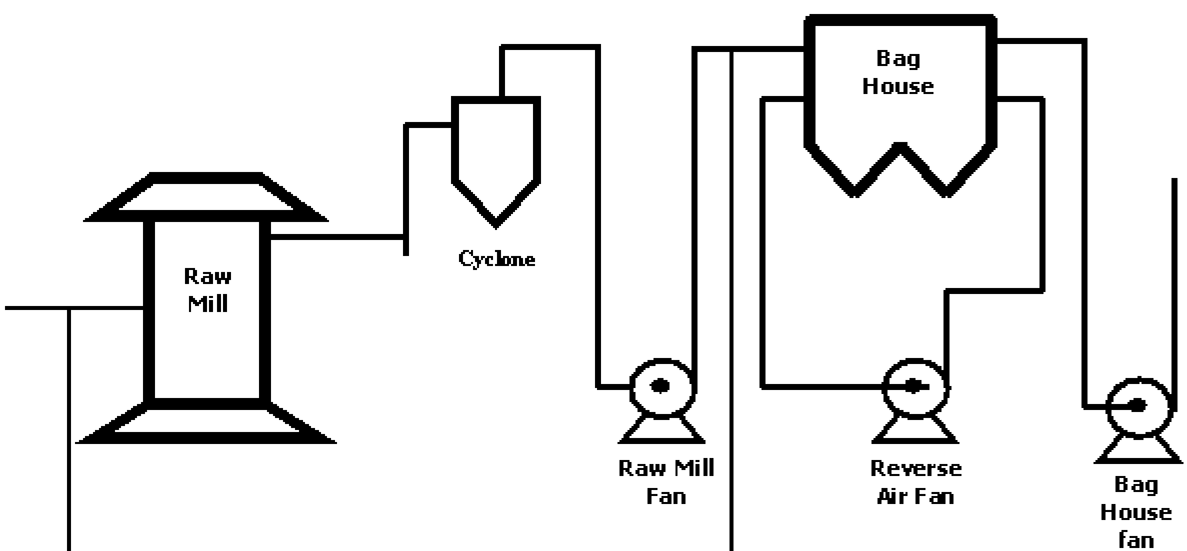
During the filtering mode, the compartment's outlet and inlet gas dampers are open. When it is time to clean the compartment, the outlet damper is closed to block gas flow. After a short time to allow the bags to relax, the reverse air damper located near the top of the compartment is opened to permit filtered gas from the baghouse outlet to be recycled through the compartment. This reverse flow is sustained for as little as 30 seconds or as long as several minutes. During this time, large clumps of dust cake from the interior of the bags are dislodged and fall by gravity into the hopper. Gravity settling is obviously important during the cleaning operation. Particle movement to the hopper is aided by the reverse gas movement downward in the bag. As long as the reverse air flow rate is adequate (volume and flow time), the particles are carried out of the bag by this gas stream.

The reverse air passes through the compartment's inlet damper (which remains open during cleaning) and reenters the duct leading to the inlet side of other compartments, which continue on-line in the filtering mode. Large clumps and sheets of dust cake dislodged during cleaning are collected in the hopper underneath the compartment.

Case Study:

One of the cement plants utilizes a bag house for raw meal collection apart from cyclones in the raw mill section. The bag house is provided with reverse air fan. The operation of RA fan is to remove the bag house dust, which operates based on the pressure drop across the bag house. The operation of reverse air fan is ON/ OFF control based on the pressure drop across the bag house.

Operating RA fan in ON/ OFF control is a good step towards optimization and reducing overall bag house system power consumption.



The Reverse Air fan is ON when the pressure drop across the bag house is 130 mm WC and gets OFF when the pressure drop is 90 mm WC. During the normal course of operation, the fan is in ON mode for 40% – 50% of time.

The reverse air fan is damper controlled. The power consumption of the reverse air fan is varying between 60 kW to 110 kW. Operating the fan with damper control results in loss of pressure across damper and hence loss of energy. This also indicates the excess capacity available in the fan.

Good potential for energy saving exists by optimizing the operation of the reverse air fan by installing Variable Frequency Drive. Once the Variable Frequency Drive is installed, the damper should be gradually opened and the speed of the fan should be reduced correspondingly.

Variable Frequency Drive for reverse air fan is a proven project and is successfully working in several other cement plants.

As a next step, the damper could also be removed permanently and could be completely controlled with Variable Frequency Drive.

Installing a Variable frequency drive to RA fan further offers good potential to optimize the entire bag house system, which offers a tremendous opportunity to reduce the power consumption of bag house fan.

The following observations were made on the entire bag house system:

The bag house fan is fitted with SPRS, a speed control device. Any decrease or increase in the DP across the bag house is sensed by SPRS and varies the speed of the fan accordingly.

The trend analysis of DP across the bag house and the corresponding power consumption of the bag house fan were studied in detail from the data available from the CCR. The trend analysis indicates the following:

- The DP across the bag house varied between – 94 mm to – 142 mm WC
- The power consumption of the bag house fan also varied in accordance with the bag house DP. Whenever the bag house DP increases the SPRS control of bag house fan senses the DP and increases the speed of bag house fan to maintain same flow rate leading to increased power consumption and vice versa.

- The power consumption of the bag house fan is varying significantly during different operating conditions like Coal Mill & Raw Mill in operation and Raw Mill alone in operation.
- When Coal Mill & Raw Mill is in operation
  - DP across the bag house varied between – 94 mm WC to – 134 mm WC
  - Bag house fan power consumption varied between 690 kW to 854 kW
- When Raw Mill alone is in operation
  - DP across the bag house varied between – 104 mmWC to – 137 mmWC
  - Bag house fan power consumption varied between 1021 kW to 1175 kW
- When Reverse air fan in operation
  - Bag house fan power consumption reduces by 80 kW to 170 kW

From the above observations, the following approach would result in tremendous reduction in power consumption of the entire bag house system.

- Increase the reverse-air fan flow rate, which will reduce the DP across the bag house. This will result in corresponding decrease in the power consumption of the bag house fan.
- After installing Variable Frequency Drive for Reverse air fan, its operation could be effectively optimized by operating it in closed loop with bag house DP as the feedback to VFD.
- The optimum flow rate of reverse air fan could be attained by conducting trials in closed loop with VFD for various DP settings across the bag house.
- The optimization procedure would be as follows:
  - Operate RA fan in closed loop with Bag House 'DP'.
  - Operate with different pressure settings of – 90 mmWC, – 100 mmWC, – 110 mmWC, – 120 mmWC, – 130 mmWC, – 140 mmWC etc.

❖ Monitor the total power consumption of the BH fan and RA fan

❖ Fix the 'DP' setting, which gives the lowest total power.

The Plant team conducted the above trial and achieved significant reduction in power consumption of both RA fan and Bag house fan. This Bag house system optimization has been implemented in several cement plants and has resulted substantial benefits.

The two major steps carried out were:

1. Installed Variable Frequency Drive for reverse air fan and avoid the loss across the damper.

2. Optimized the operation of reverse air fan based on the optimum 'DP' across the bag house.

Benefits

Optimizing the operation of reverse air fan resulted in an annual energy savings of Rs. 44.00 Lakhs with an investment (for RA fan VFD) of Rs. 10.00 Lakhs and had an attractive payback period of 3 months.

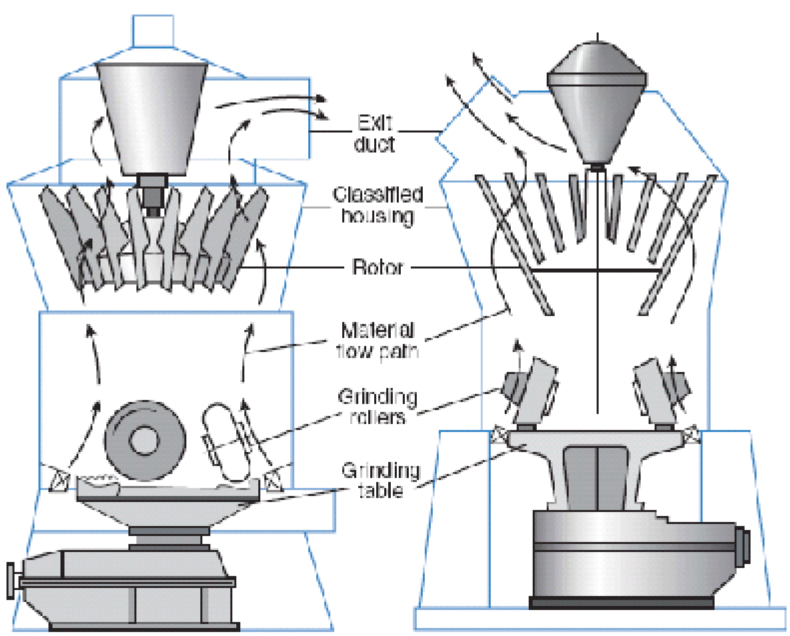
Case Study No. 6

OPTIMIZING AIR FLOW THROUGH VERTICAL ROLLER MILL (VRM)

Back ground

In vertical roller mills, the material is ground on a table rotating about a vertical axis onto which rollers are pressed down by spring or hydraulic pressure. These mills are air-swept, using hot gas for drying while grinding, with a classifier incorporated in an airtight casing within the body of the machine. The table is driven through the trains of gears below it.

The external material recirculation for vertical roller mills was first introduced and resulted in saving power. Since then, numerous developments have been incorporated into the design of the mill internals, such as variable-area louvre rings and high-efficiency classifiers. These developments have resulted in lower pressure drop, improved pre-classification of coarse fractions, and optimum material conveying velocities. Consequently, the potential power savings from the external material recirculation is not as high in today's vertical roller mills.



Case Study :

OPTIMIZE RE-CIRCULATION AIR QUANTITY THROUGH RAW MILL

The Raw Mill uses hot gases from the preheater and a part of hot air from the Raw Mill fan discharge is recirculated to the raw mill. Remaining air from the RM fan discharge passes through bag house / ESP before venting out through bag house / ESP fan.

Air flow through Vertical Roller Mills are governed by three major factors:

1. Nozzle velocity requirement
2. Separator air flow requirement
3. Drying requirement of raw material

In many vertical mills in the Indian cement industry, there is a good potential to optimise the amount of re-circulation air to the raw mill by conducting trials/ experiments.

The design specification and actual operating condition of the Raw Mill Fan is:

- Design Head : 982 mm WC
- Design Flow : 234.35 m^3/s
- Design Power : 3200 kW
- Actual Head : 784 mm WC
- Actual Flow : 221.96 m^3/s
- Actual Power : 2249 kW

A trial was initiated with an objective of reducing the re-circulation air quantity through the Raw Mill, thereby reducing the flow rate handled by Raw Mill fan. The ultimate objective is to reduce the power consumption of raw mill fan. During the trial both the quantity and quality of the raw meal handled by the Raw Mill is maintained constant.

The procedure adopted for conducting the above trial is given below:

- Present operating condition of the Raw Mill system should be noted
- Remove 'DP' vs. 'Feed' loop in Raw Mill and operate in manual mode
- Remove 'Flow' vs. 'Fan Speed' loop in Raw Mill Fan and operate in manual mode
- Reduce re-circulation air damper gradually and reduce separator speed equally. Maintain mill feed rate constant
- Monitor Raw Mill vibrations, if vibrations increases reduce separator speed.
- Reduce re-circulation air damper to the minimum possible
- Redefine 'DP' vs. 'Feed' loop in Raw Mill and 'Flow' vs. 'Fan Speed' loop in Raw Mill Fan for new parameters
- Check raw meal quality for fineness. If raw meal becomes coarser increase the separator speed.

The above trial resulted in significant reduction in power consumption of Raw Mill fan of about 80 kW. After conducting this trail, it was clearly evident that there was a need to arrive at an optimum point at which the Raw mill remains stable while the re-circulation air is minimum.

The whole objective of this trial should be 'Lowest Possible Re-Circulation air'. This trial required no investment, but required a series of trials / experiments to arrive at the lowest possible re-circulation air quantity

Benefits:

Optimizing the re-circulation air through Raw Mill resulted in an annual savings of Rs. 17.58 Lakhs. This project did not require any investment.

Case Study No 7

INTERLOCK APRON CONVEYOR TO CRUSHER MOTOR TO ENSURE MAXIMUM LOADING OF CRUSHER

In a cement plant, the feed material to the crusher was fed through an Apron conveyor. The present loading of crusher motor varying from 447 kW to 950 kW. The capacity of the crusher is 1200 TPH and operating capacity is about 1150 TPH. The operating trend of Apron conveyor, which transfers the limestone from hopper to crusher, was studied in detail. The apron conveyor is found to operate only at 42% of its full speed and manually controlled based on crusher motor loading current.

The speed of the conveyor is constant irrespective of the loading of crusher motor. There was a good potential to interlock the Apron Conveyor speed with the Crusher loading there by reducing the crusher operating time. The speed of the apron conveyor should be varied depending on crusher loading.

The apron conveyor has already been fitted with Variable Frequency Drive (VFD). The load current signal from the crusher motor can be given as a feed back to apron conveyor VFD.

There was a good potential to increase the loading of crusher by interlocking Apron conveyor speed with crusher loading. This will result in substantial reduction in operating hours of the crusher for same throughput of crusher.

The overloading of Crusher can be avoided by implementing "Adaptive Predictive Control system", which ensures optimised loading of crusher. This system is in use in some of the crushers in Indian cement industry and is resulting in significant benefits

This proposal is highly applicable in many cement units and can result in significant energy savings.

Procedure followed to implement this project is given below:

- Interlocked Apron Conveyor speed with the crusher loading. Increasing / decreasing the speed of conveyor depending on the load of the crusher.
- Installed "Adaptive Predictive Control system" for the whole crushing system, which ensured optimum loading of crusher and minimised operating time of crusher for same output.

Benefits:

Interlocking Apron Conveyor speed with Crusher loading resulted in an annual savings of Rs. 12.50 Lakhs and the investment required for the implementing Adaptive Predictive control System was Rs.15.0 Lakhs. The simple payback period for the investment was 14 Months.

Case study No. 8

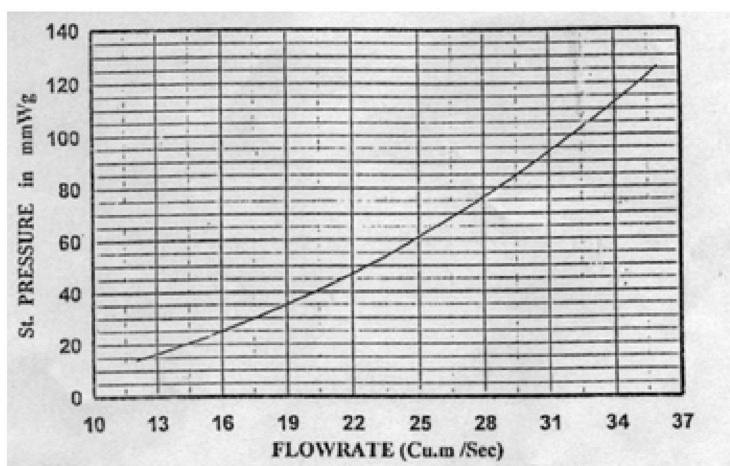
MINIMIZE SUCTION SIDE PRESSURE DROP IN IDENTIFIED COOLER FANS

Back Ground:

Over the last few years, Indian cement industry has adopted several energy conservation measures in cooler fans. One of the significant changes had been to move to speed control instead of Inlet Guide Vane (IGV) mode of control in cooler fans. This has resulted in substantial energy saving in the cement industry.

Studies in cooler fans over the last few years indicated another significant area for energy saving. It was observed that several cooler fans are operating with very high suction side pressure drop. The pressure drop in the suction ducts, over a length of less than one metre, was measured to be in the range of 70 to 140 mm WC. This corresponds to about 10 to 22% additional power consumption in the cooler fans

Detailed discussions were held by the cement plants with the leading fan manufactures to identify possible reasons for such high pressure drop. The suppliers also agreed that the suction pressure drop of any cooler fan should be in the range of -20 mm WC to -25 mm WC only. However, detailed discussions indicated that the high suction pressure drops are maintained intentionally.



The present trend in the cooler fans in the cement industry is to use a piezometer ring to indicate the flow in the CCR.

Piezometer rings measure the pressure at the fan suction and indicate the corresponding flow rate. Each piezometer ring has a characteristic curve (a sample curve is indicated in figure below).

The variation in pressure at the piezometer ring is calibrated to flow reading. Discussions indicated that the flow measurements from the piezometer ring were found to be accurate only when the pressure drops were 60 – 70 mm WC and above. Lower pressure values made the measurement inaccurate.

Further from the characteristic curve of piezometer ring it is apparent that as the flow rate of the fan increases the suction side pressure drop of the fan also proportionally increases leading to energy loss across suction.

To artificially create the high pressure drop at the piezometer ring measurement point, the velocity of air entry in the cooler fans is increased. While the ideal velocity for air entry in cooler fans should be around 10 – 12 m/s, several cooler fans are operating with velocities greater than 45m/s.

Case Study:

In one of the cement plants in the country, the plant team had already installed variable frequency drive (VFD) controls for all the cooler fans. This has substantially reduced the power consumption of the cooler fans.

The measured suction pressure at the inlet in the cooler fans is as high as -170 mm WC (the corresponding velocity of air entering the cooler fan was over 42 m/s), which is about 20% of the total pressure rise of the fan.This indicates that nearly 20 % of power consumed by the cooler fans is lost at the suction of fans.

S No	Suction Pressure drop	Total Head developed by the fan	% Loss Across	Measured Power
	mm WC	mm WC	%	kW
Cooler fan	-170	869	20	90

This suction side pressure drop is comparatively on the lower side in some of the cooler fans due to the lower flow rate handled by the fan, which corresponds to the lower suction side pressure drop in the piezometer installed.

There is a good potential to reduce this suction side pressure drop in cooler fans by modifying the existing suction and adopting a well designed bell mouth for air entry to the fan. The typical radius of the bell mouth should be 0.25 times the effective diameter.

Alternate methods of flow measurement can be adopted in lieu of the piezometer ring. One of the methods for fan flow measurement is by using an aerofoil in the discharge of the fan. The pressure differential between the top and bottom of the aerofoil can be calibrated to flow measurement. Pressure drops across aerofoil is substantially lower compared to the piezometer ring measurement.

Another method of measuring the flow is to estimate it from the characteristic curve of the fan. The characteristic curve of the fan can be defined as an equation using the curve-fitting method. Once the curve is defined as an equation, measuring the total head developed by the fan and the speed of the fan can indicate the flow of the fan in the CCR.

Many cement plants which were previously utilizing the piezometric flow measurement system have now shifted to other relative indications in CCR like speed of cooler fans or aerofoil flow measurement. Once alternate methods of flow measurement has been established, plants can then remove the piezometric rings and modify the suction of the fan to minimize the pressure drop. This has resulted in tremendous reduction in power consumption of cooler fans in several cement plants.

This case study is highly applicable both as a retrofit in existing cooler fans, as well as defining the specifications for any new cooler fans procurement.

Steps to be followed

- Modify inlet of the identified cooler fans by providing “Bell Mouth” which reduces the suction drop to less than -20 mm WC.
- Once the Suction drop is reduced, due to less suction resistance the fan starts delivering more flow, since the overall system resistance has reduced.

- Reduce the speed of the fan by VFD to match the actual flow requirements.
- Good potential for energy saving exists by suitably modifying the suction pressure drop and reducing the speed of the fan.

Benefits:

By modifying fan suction with bell mouth will result in Rs 5.50 Lakhs and will require an investment of Rs.5.00 Lakhs which will have a payback period of 12 months.

Case Study No 9

INSTALLATION OF CORRECT SIZE FANS OF HIGHER OPERATING EFFICIENCIES

Back ground: Fan Performance Assessment

Fans are the major energy consumers in a cement industry, only next to grinding. Indian cement industry, having realised this, has worked upon continuously in improving the operating efficiencies of its fans. High operating efficiency fans are available for all the applications in the cement industry.

Replacement of fans of lower operating efficiency with ones of higher operating efficiency has been a practice of the Indian cement industry over several years. However, the understanding of the reasons for lower operating efficiencies is improving and newer case studies are surfacing over the last few years.

Typical target efficiency

>82% for all major fans

>75% for all other fans

Fan performance evaluation at site is one of the major opportunities in the Indian cement industry today. The fans are tested for field performance by measurement of flow, head, temperature and damper position on the fan side and electrical motor kW input on the motor side.

The fan flow is measured using Pitot tube manometer combination or a flow sensor (differential pressure instrument) or an accurate anemometer. Care needs to be taken regarding number of traverse points, straight length section (to avoid turbulent flow regimes of measurement) up stream and downstream of measurement location. The measurements can be on the suction or discharge side of the fan and preferably both where feasible.

Pressure (draft) developed by the fan can be measured by Pitot tube manometer combination, or an accurate digital draft gauge. The temperatures of the gases / fluids are measurable by a digital temperature indicator and the damper position documented as percentage opening or notch position. In case of fluid couplings, the % scoop position can be the reference. Pulley diameter and fan rpm measurements help in assessing scope for derating. Fan design performance curves are needed to compare the actual efficiency with respect to design values.

Drive motor input volts, amps, pf frequency and kW can be measured by a load analyzer, to assess input kW, pf, motor loading voltage imbalance if any.

The parameters to be considered while fan selection are:

1. Design operating point of fan – volume and pressure
2. Normal operating point – volume and pressure
3. Maximum continuous rating
4. Low load operation
5. Ambient temperature
6. Density of gas at different temperatures
7. Composition of the gas
8. Dust concentration and nature of dust
9. Maximum temperature of the gas
10. Control mechanisms (proposed)
11. Altitude of the plant

The control mechanisms for fans are also undergoing a phase of sea change. Older plants were complacent regarding the performance of fans once a good control system was installed. However, with deeper understanding of reasons for lower operating efficiency, Indian cement industry has seen several cases where the installation of a good control mechanism for fans alone does not suffice. For the overall system to be efficient, it's important for the control mechanism as well as the fan to be efficient. One of the case studies that has been observed in several plants is the case of fans installed with latest Variable Speed Drives (VSD) operating with low efficiencies. The detail of one such fan is explained in case study below:

Case Study:

The design and operating parameters for one of the process fans in Cement mill were observed to be as under:

The design details of the fan are as follows:

- Capacity : 60,000 m^3/hr
- Head : 465 mm WC
- Power : 150 kW
- Speed : 980 rpm

The operating conditions are given below

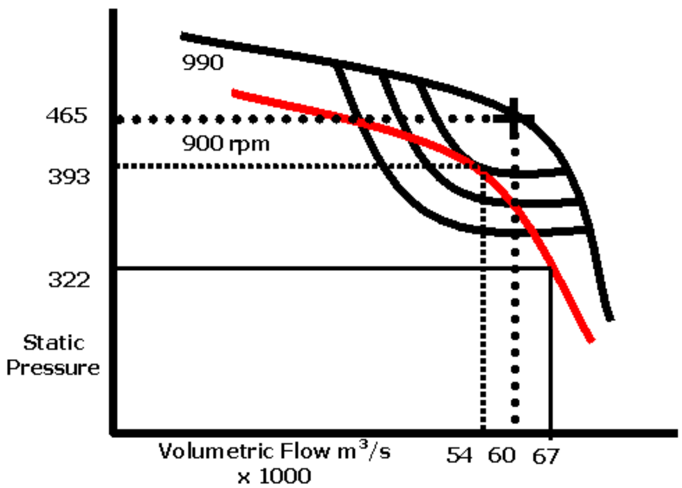
- Capacity : 69,000 m^3/s
- Head : 322 mm WC
- Power consumption : 110 kW
- Speed : 900 rpm

The actual operating efficiency of the fan is estimated to be 61%, which is on the lower side when compared to the design operating efficiency of the fan of 79%.

The comparison between the measured parameters with the design parameters indicates that the fan is oversized for the application in terms of head required by the system.

Designed head of fan is 465 mmWC with the flow rate of 60,000 m^3/hr at 990 rpm. Calculating with the empirical laws of fan performance with change in rpm, the revised design point for a reduced speed can be calculated. With operating speed of 900 rpm (91% of rated speed), fan should be operating at 54000 m^3/hr and with a total head of 393 mmWC (corresponding design point at lower operating speed).

However, fan was measured to be delivering 67000 m^3/hr with the total head of 322 mmWC. This indicates that the fan is delivering excess flow with lower operating head compared to the revised design point at lower operating speed. This indicates a mismatch between the rated head and operating head of the fan. This fan, delivering excess flow and operating with lower head developed compared to the design point, operates with low efficiency.



This results in operating point of the fan shifting to an inefficient zone on its performance curve.

Thus, there was a very good potential for energy saving by installing a new correct size of high efficiency fan in place of existing fan.

Recommend correct size fan Specifications

Flow : 85,000 m^3/hr

Head : 400 mmWC

(With margin available for capacity up gradation. The fan is optimally sized for present application with proportional margins in capacity and head. The operating efficiency of the fan was good at 77% while the rated efficiency of the fan was 79%)

Power : 150 kW (Existing motor)

Benefits :

Replacing the existing fan with correct size fan resulted in an annual saving of Rs. 11.00 lakhs. This required an investment for proposed new fan only of Rs. 10.00 lakhs (the existing motor and VFD were utilized for the new fan), which had a simple payback period of 11 months.

Case Study No 10

WASTE HEAT RECOVERY FOR COGENERATION FROM PREHEATER EXIT AND COOLER VENT

Back Ground:

Cement industry is energy intensive. Even a modern high efficiency plant would consume thermal energy of about 700 kCal/kg clinker and electrical energy of about 70 kWh / ton of OPC. For a 1 MTPA plant, the approximate power requirement would be to the tune of about 13 - 14 MW.

Waste heat recovery has been one area where the Indian cement industry has a lot of opportunity still untapped. Two major sources of waste heat recovery available in the cement industry are:

1. Pre-heater Exhaust at 280 – 350^{o}C
2. Cooler vent at 250 – 300^{o}C

Waste gas discharged from the clinker cooler system and the kiln pre-heater system all contain useful energy that can be converted into power.

Now technologies are available to recover the heat from exhaust gas streams from preheater and clinker cooler and generate electrical energy. More cement plants in India are expected to adopt such waste heat recovery systems mainly to counteract the power shortage as well as to reduce the consumption of natural resources. Now these latest proven technologies are supplied with better financial models by the suppliers.

There are about 150 larger capacity cement plants operating in India and potential power generation from each plant is about 5-6 MW. This indicates atleast 750 MW power generation is possible through waste heat recovery in Indian cement industry.

Over the last few years, Indian cement industry has started adopting waste heat recovery systems. Some of the cement plants like India cements, Shree Cement, Ultratech Cement, Tadipatri, etc took an excellent initiative in installing Cogeneration system for power generation in their plants and many more under active consideration. The present installed capacity through waste heat recovery in India is around 12-14 MW while the potential is much higher.

Case Study:

Factors considered while designing the effective system:

1. Avoidance of dust: Methods of avoiding Deposition of Cement Powder on the Heat Transfer Surface which otherwise results in fouling and lesser heat recovery.

2. Design to deal Sticky dust/Abrasive gases: Appropriate design of the system to perform against gases Sticky dust from pre-heater and abrasive gases from Clinker cooler should be made.

3. Make surface free of dust: Methods of dislodging deposited dust and keep the heat transfer surface free of dust.

4. No gases to cold surfaces: Avoiding exposure of the flue gases to cold surface of the equipment during start-up or interruptions, otherwise these results in condensation of the flue gas moisture and when this moisture comes in contact with the cement powder, cement gets "set" on the surfaces which are difficult to remove. Hence slow build-up of such patches results in choking of the system & reduction in effectiveness of heat transfer surface.

5. Design to conserve water: Availability of the water and its appropriate utilization to conserve the water by designing the system judiciously.

6. Select correct electricals: Selection of appropriate electrical power generation system to maximize the power generation.

7. Reduce final exhaust temp to maximum extent: Bringing down the flue gas exhaust temperature to sufficiently low level, so that less expensive method of Gas cleaning (after Heat Recovery) of cement powder separation from flue gases can be utilized.

8. Maintain Low Pressure drop: Keeping flue gas pressure drop as low as possible

Brief Description Of Some Of The Waste Heat Recovery Systems In Indian Cement Industry

INDIA CEMENTS LIMITED, VISHNUPURAM

India Cements Limited, in partnership with New Energy Development Organization (NEDO), installed the first waste heat recovery system in Indian cement industry at its plant in Vishnupuram. This waste heat recovery system meets about 30% of the total power requirement in the cement plant and about 40% of the waste heat available is recovered for power generation.

Heat recovery systems are installed both at pre-heater exhaust and cooler vent. Pre-heater boiler is installed in the pre-heater exhaust gas path after the pre-heater system and before the waste gas fan. The steam generated from the pre-heater boiler is about 28 TPH at 315^{o}C and 15.7 kg/cm^2.

The cooler vent heat recovery system is located between the cooler and the cooler ID fan. A pre-duster is installed to reduce the dust load on the boiler. The steam generated from the cooler vent boiler is about 14.5 TPH at 345^{o}C and 15.7 kg/cm^2

This system has been in operation since September 2004 and the average load generated is about 8.5 MW. Excluding the internal power consumption, the net power generation is about 7.6 MW and the average cost per unit (excluding depreciation) works out to be about Rs. 0,16 / kWh. The benefit of reduced carbon dioxide emission into the atmosphere is about 45000 MT per annum.

ULTRATECH CEMENT LIMITED, AP CEMENT WORKS, TADIPATRI

Ultratech Cement Limited has installed a Organic Rankine Cycle based waste heat recovery system of rated output 4.8 MW at its cement plant in Tadipatri. The energy converter is supplied by ORMAT Systems Limited, Isreal while the Waste Heat Oil Heater (WHOH) was supplied by Transparent Energy Systems, Pune.

This system is the first of its kind in India and the second application in the world. This project was commissioned in March 2007 and meets about 10% of power requirement at APCW.

This system recovers heat from the cooler vent gases to heat 247 TPH of thermic fluid in Waste Heat Oil Heater (WHOH) from 120°C to 270°C at design pressure of 7.5 Bar. The ORMAT energy converter is a two stage impulse type turbine with air cooled condenser and with pentane as the motive fluid.

While the gross output of the power plant is designed at 4,0 MW, the net output is 3.35 MW excluding auxiliary power consumption of 665 kW. The anticipated annual power generation was 25 Million kWh.

SHREE CEMENT LTD, BEAWAR

Shree Cement Ltd (SCL) has installed a waste heat recovery system in its Unit 1 at Beawar to recover the waste heat from the pre-heater exit gases, currently being dissipated into the atmosphere, for steam generation. SCL has integrated the waste heat recovery system with its captive power plant and the steam generated in waste heat recovery is utilized for pre-heating the feed water in the LP & HP heater of existing power plant.

Waste heat recovery system generates steam of 27.6 TPH at a temperature of 375°C and pressure of 27 kg/cm^2. This steam is utilized in the captive power plant for feed water preheating.

With and without this waste heat recovery system, the difference in power output from the captive power plant is about 5-6 MW. The fuel saving from this project is anticipated at over 20000 tons per annum and carbon dioxide emission reduction would be over 76000 tons per annum.

Case Study No. 11

ENERGY CONSERVATION ASPECTS IN AIR COMPRESSORS & COMPRESSED AIR SYSTEMS

Back Ground- Compressed air systems

Compressed air systems are one of the most important utilities in cement industry. Compressed air systems are used in different parts of the plant, in the bag house Pulse-Jet or Plenum Pulse dust collector filters, in blasters and other parts. Total energy consumption by compressed air systems is relatively high in cement plants. Still, energy efficiency improvement measures may be found in these systems. Compressed air is probably the most expensive form of energy available in a plant because of its poor efficiency. Some of the practices followed for lowering the energy consumption in compressed air systems are briefly mentioned below:

Maintenance of compressed air systems: Inadequate maintenance can lower compression efficiency and increase air leakage or pressure variability, as well as lead to increased operating temperatures, poor moisture control, and excessive contamination. Improved maintenance will reduce these problems and save energy.

Keep the compressor and inter cooling surfaces clean and foul-free. Blocked filters increase pressure drop. By inspecting and periodically cleaning filters, the pressure drop may be kept low. Also, consider adding filters in parallel that decrease air velocity, and, therefore, decrease air pressure drop. *A 2% reduction of annual energy consumption in compressed air systems is projected for more frequent filter changing.*

Keep motors properly lubricated and cleaned. Poor motor cooling can increase motor temperature and winding resistance, shortening motor life, in addition to increasing energy consumption. Compressor lubricant should be changed at regular intervals and checked to make sure it is at the proper level. In addition to energy savings, this can help avoid corrosion and degradation of the system.

Inspect drain traps periodically to ensure they are not stuck in either the open or closed position and are clean. Some users leave automatic condensate traps partially open at all times to allow for constant draining. This practice wastes substantial energy and should never be undertaken. Instead, install simple pressure driven valves. Malfunctioning traps should be cleared and repaired instead of left open. Some auto drains, such as float switch or electronic drains do not waste air.

Maintain the coolers on the compressor to ensure that the dryer gets the lowest possible inlet temperature

Check belts for wear and adjust them. A good rule of thumb is to adjust them every 400 hours of operation.

Check water cooling systems for water quality (pH and total dissolved solids), flow, and temperature. Clean and replace filters and heat exchangers per manufacturer's specifications. Also try keep 5^{o}C as temperature difference across the inter coolers and after coolers and reduce the water flow if it is lower which will lower the cooler water pump power consumption.

Reduce leaks : Leaks can be a significant source of wasted energy. A typical plant that has not been well maintained will likely have a leak rate equal to 20% to 50% of total compressed air production capacity. Leak maintenance can reduce this number to less than 10%. Overall, a 20% reduction of annual energy consumption in compressed air systems is projected for fixing leaks. The most common areas for leaks are couplings, hoses, tubes, fittings, pressure regulators, open condensate traps and shut-off valves, pipe joints, disconnects, and thread sealants. A simple way to detect leaks is to apply soapy water to suspect areas. The best way to detect leaks is to use an ultrasonic acoustic detector, which can recognize the high frequency hissing sounds associated with air leaks. After identification, leaks should be tracked, repaired, and verified. Leak detection and correction programs should be ongoing efforts.

Reducing the inlet air temperature : Reducing the inlet air temperature reduces energy used by the compressor. In many plants, it is possible to reduce inlet air temperature to the compressor by taking suction from outside the building. As a rule of thumb, each 3°C will save 1% compressor energy use.

Maximize allowable pressure dew point at air intake : Choose the dryer that has the required pressure dew point, and best efficiency. *A rule of thumb is that desiccant (heated / heatless) dryers consume 7 to 14% of the total energy of the compressor, whereas refrigerated dryers consume 1% to 2% as much energy as the compressor.*

Sizing pipe diameter correctly : Inadequate pipe sizing can cause pressure losses, increase leaks and increase generating costs. Pipes must be sized correctly for optimal performance or resized to fit the current compressor system. *Increasing pipe diameter typically reduces annual energy consumption by 3%*

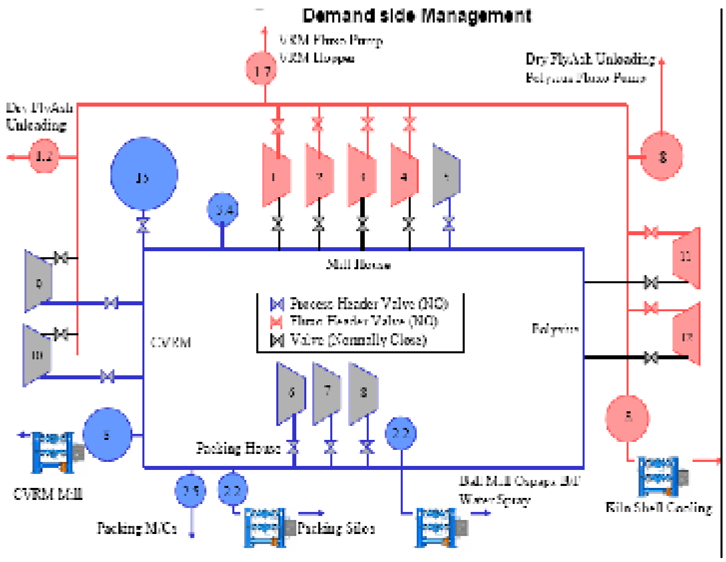
Case study

Introduction

In a 1 MTPA cement plant, over last several years, 39 compressors (Reciprocating as well as Screw type) of different makes with a total installed capacity of 20081m3/h were installed to meet compressed air demand for various applications. The total installed drive power is 1908.5 KW.

Compressors Energy Consumption

The Compressors were installed near to each application, but connected / interconnected with all applications – literally - like a spider web. Almost any compressor's air can go to any application – resulting in un-optimized use of Air and consequent wastage of Energy.



To monitor the energy consumption, the plant team had installed energy meters for individual Compressors and recorded the energy consumed by each compressor on a daily basis. The total energy consumed by all compressors was approximately 2, 41,000 units per month.

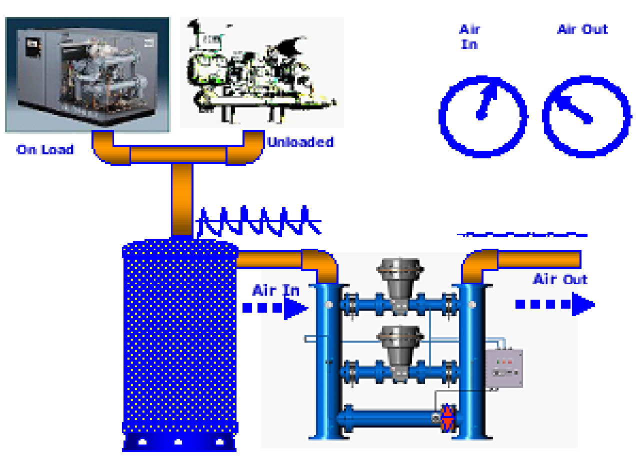
From the preliminary study, it was understood that it is adequate to operate only 12 Screw compressors with total installed capacity of 9507 m3/h (and power consumption of 1003.5 kW) to meet the compressed air demand for all sections. The rest of the compressors were stopped. It was observed that the continuous operation of these 12 Screw compressors was also not required indicating surplus capacity. There existed further scope for energy saving.

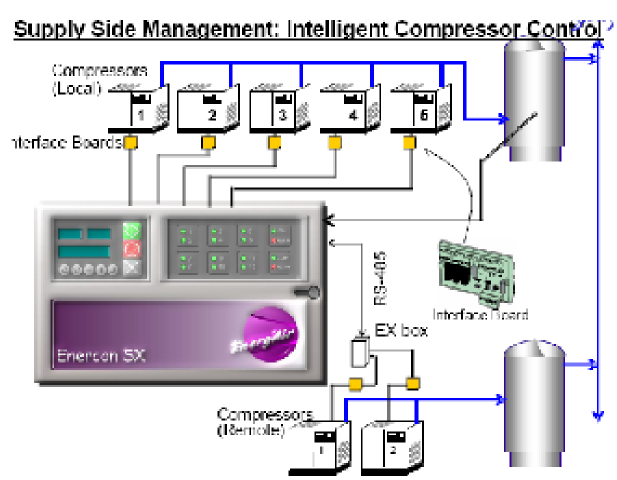
However, this optimization and consequent energy saving was possible if a supervisory monitoring and control system to operate all screw compressors was procured and installed.

Optimization System

EnergAir Automation system for Supply side Management and Control Air System for Demand side Management was installed. Basically this system classified plant Air applications in Two Groups – one set of users that consumes compressed air at Steady rate (Process Applications) and the other that consumes at Cyclic pattern (Fluxo Pump Applications). Two headers were formed - one dedicated for each group. Selected applications were provided with Pressure/Flow controllers – where application pressure can be set. All twelve screw compressors were connected to Central Controller – which can switch on and off each compressor depending on Demand.

All screw compressors supply air to process header at preset Pressure. From this header, process applications received air through Flow controller at lesser but steady pressure. The compressors are run to maintain header pressure within a set range.





Benefits:

Achieved Energy Savings based on observation for a week = 27% & Stoppage of 2-3 Compressors.

Energy Savings with EnergAir & ControlAiR system = 3,060 kWh / day

% Energy Savings with EnergAir & ControlAiR system = 27.12%

This system has a simple payback period of less than a year.

Case Study No 12

INSTALL NEW CORRECT SIZE COOLER VENT FAN

Back Ground:

In a typical cement plant, the cooler vent fan consumes about 0.8 – 1.0 kWh / ton of Clinker. Cooler vent fans offer excellent potential for reduction in energy consumption. Some of the lowest numbers recorded for cooler vent fan ranges between 0.08 – 0.1 kWh / ton of clinker offering a potential of about 0.7 – 0.9 kWh / Ton of clinker reduction opportunity.

One of the major reasons for such energy saving opportunity in cooler vent fans is over designing for higher capacities & head. This over design on both head and capacity of the cooler vent fan is primarily to avoid pressurization in system if the pre heater fans trip. To avoid this condition the cooler vent fan would be designed to vent all the pressurized gases present in the kiln and preheater system. Latest plants operate with several interlocks that cut off few cooler fans when the pre-heater fan trips. This avoids the over design of cooler vent fan, thereby providing an opportunity to optimize power consumption.

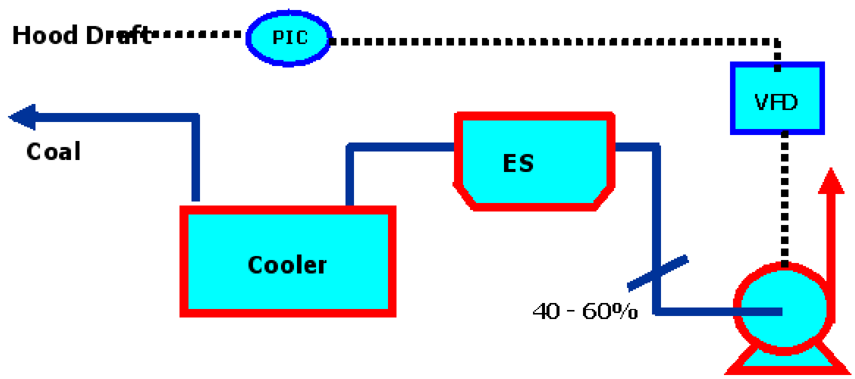
Optimum utilization of this natural draft and further increase in stack height could also result in significant reduction in power consumption of the cooler vent fan.

Case Study:

The cooler vent fan is designed for a flow rate of 15793 m^3/min, pressure rise of 150 mm WC and the motor is rated for 585 kW. The actual power consumption of the fan is 210 kW.

The actual operating condition of cooler vent fan is:

- Actual Flow : 11686.8 m^3/min
- Actual Head : 52 mm WC
- Operating Speed : 65%
- Actual Power : 210 kW



From the above observation, it is evident that the fan is designed for excess head. This results in operating point of the fan shifting to an inefficient zone on its performance curve. The operating efficiency of the fan is estimated to be 52.5%.

The study on the fan control mechanism indicates that the fan has been controlled by SPRS control. The fan is operating at 65% speed. To control the fan further, the suction of the fan is damper controlled. This shows that the fan had been highly over designed for head.

Pressure measurements indicate that the loss across the damper is almost 100% when the damper position is 40% open. The fan is controlled because the fan is highly over designed for head. The design head of the fan is 150 mm WC whereas the actual requirement is only about 15 mm WC.

Further the height of the stack is 40 m, which is sufficient to provide draft, and the draft measurement in the stack almost equals the static pressure before the damper of cooler vent fan. Optimum utilization of this natural draft and further increase in stack height could result in significant reduction in power consumption of the cooler vent fan.

Thus there is a good potential to install a correct size cooler vent fan for normal operation and keeping the existing fan (in line) as stand by catering to emergency conditions. Good potential for energy saving exists by installing a correct size fan of higher operating efficiency.

Therefore the plant team installed a new correct size fan with higher operating efficiency.

The design specifications of the new fan were as follows:

- Flow rate : 12,000 m^3/min
- Pressure rise : 15 mm WC
- Motor rating : 60 kW
- Power consumption : 45 kW

The existing fan was kept as standby, to meet any emergency requirement.

Benefits:

Installing a correct size cooler vent fan resulted in an annual energy saving of Rs. 37.68 Lakhs. This called for an investment of Rs. 8.00 Lakhs (for new fan and ducting), which had an attractive payback period of 3 Months.

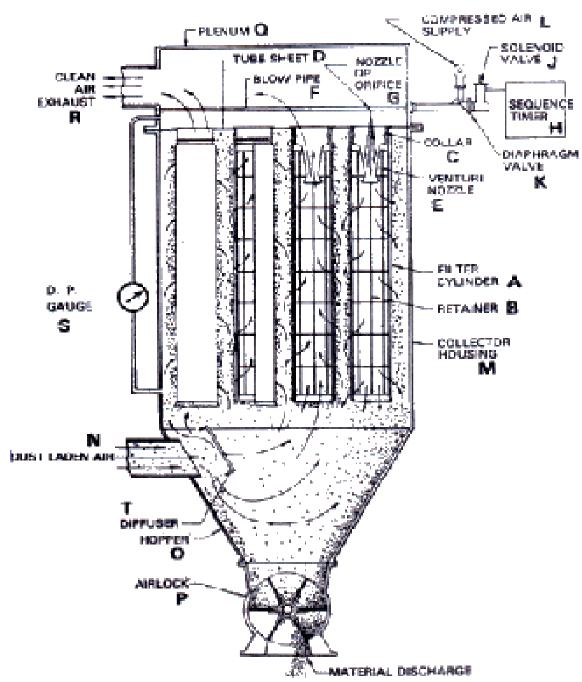
Case Study No 13

OPTIMIZE THE OPERATION OF BAG FILTERS

Back ground:

Bag filter fans though accounting to small energy consumption individually, when taken in total contributes to significant energy consumption. Normally, a 1 MTPA capacity cement plant will have around 40 numbers of bag filters and the power consumption of bag filter fans varies from 8 kW to 12 kW on an average.

This indicates around 400 kW power is consumed by bag filters alone and which is equivalent to 3 to 3.5 kWh/ton of Cement. Also compressor takes a major role in the operation of bag filter. There is good potential to reduce at least 1-1.5 kWh/ton of cement by optimising the operation of bag filters alone.



The total bag filter fan static pressure consists of the following

- ❖ Hood Entrance loss
- ❖ Friction losses in Ducts
- ❖ Loss through dust collector
- ❖ Exhaust stack

Case Study - Optimise Operation of Raw Mill Silo top bag filter fan

In a 1.0 MTPA cement plant, Raw mill Silo top bag filter was used to remove air from material in the silo. The objective of the bag filter fan was to remove the air from the silo before extraction of the raw meal to avoid flushing.

Plant had earlier installed pneumatic conveying system for transporting the material to silo. The flow through the bag filter fan was measured to be 21,200 m3/h and the actual power consumption is 33 kW against rated capacity of 45 kW.

As an initiative towards energy conservation, the plant team replaced pneumatic conveying system with mechanical conveying system and this has substantially reduced the volume of air to be handled by the fan. The same bag filter fan continued its operation for mechanical conveying system too. When the flow requirements reduced, the fan was damper controlled. The position of the damper was about 20-30%, which resulted in pressure drop and consequently higher power consumption. Damper control in a fan is an energy inefficient method.

The Plant team removed damper control and installed variable frequency drive to the existing fan to reduce power consumption. This resulted in marginal savings since the fan efficiency came down because of mismatching in design and operating flow and head.

Plant team took an excellent step by replacing the existing fan with new correct size fan with higher efficiency with variable frequency drive.

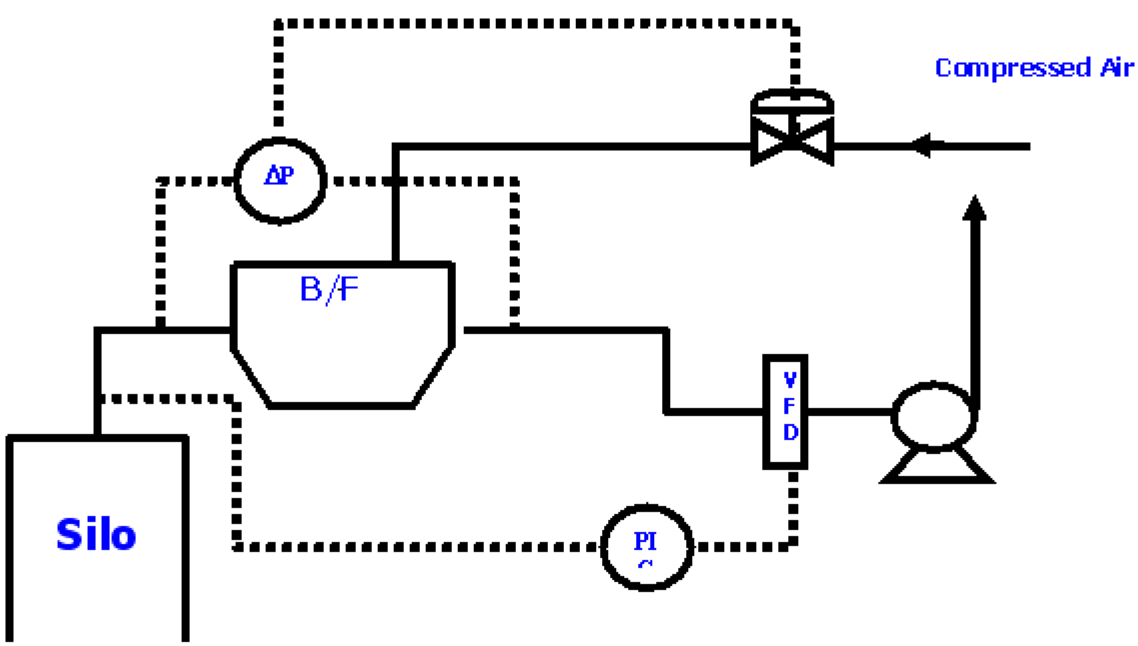
The specifications of the new fan are given below.

- Flow : 8000 m3/hr
- Head : 200 mmWC
- Power : 9 kW

This has resulted in substantial reduction in power consumption of raw mill silo top bag filter fan. Plant team felt that further potential was available in bag filter fan by reducing the flow.

As a thumb rule 2 kg of air has to be vented out per one kg of material from the silo. With this objective, plant team had conducted many trails to further reduce flow to reduce the power consumption of bag filter fan.

Finally Plant team arrived at an arrangement after conducting many trials. The bag filter fan VFD feedback signal has taken as silo top draft for smooth operation. The air flow to be vented out from the silo was observed to be significantly lower than the design of the fan of 8000 m3/hr. Also, it was observed that the bag filter was operating with much lower DP.



The compressed air consumption for the bag filter is higher and the bag filter fan operates at flows higher than the rated flow of the fan. Hence, there is a good potential to increase the DP of the bag filter and reduce the bag filter compressed air consumption. The increasing of the DP of the bag filter will also increase the pressure resistance of the fan reducing the power consumption of the bag filter fan also.

The DP of 125 mm WC across the bag filter was given as a feed back to vary the purging air line. This also resulted in substantial power savings in bag filter fan as well as compressor power consumption.

Benefits:

Optimizing the Raw mill silo top bag filter fan resulted in an annual saving of Rs. 5.30 Lakhs This required an investment for proposed new fan only of Rs. 1.50 Lakhs (With VFD) which had a simple payback period of 4 months.

Case Study No. 14

INSTALLATION OF VARIABLE VOLTAGE CONTROLLER FOR BELT CONVEYORS AND BUCKET ELEVATORS

Background

Belt conveyors and bucket elevators are also the major loads in a cement plant. Usually, the load on these equipments varies continuously depending upon the process requirement. Majority of the time, the motors of these equipments are under loaded.

The power factor and operating efficiency of under loaded motor will be poor and hence it will consume higher power than requirement.

The capacity of motor is proportional to the square of operating voltage. Therefore, it is possible to operate the motor at higher efficiency by continuously varying the voltage according to the loading. This is achieved by installing Variable voltage controller for continuously variable loads.

Variable voltage controller is an electronic device which senses the load current for every 0.01 sec. and varies the voltage and load current accordingly. Variable voltage controller always matches the motor torque with the load torque. Therefore, the capacity of the motor is virtually varied to match the load requirement. The performance of the motor will be improved and the power consumption will reduce.

Variable voltage controller also has a built-in software and filter to take care of harmonics generated. Variable voltage controller is well suitable for continuously varying loads, like, bucket elevators, crushers and belt conveyors. 20 to 25% savings on average load is possible by installing Variable voltage controller.

Case study

In a 2.0 MTPA cement plant, the average load on the bucket elevators was varying from 30 to 50%. Majority of the time, the motors of few bucket elevators were under loaded.

The plant team decided to install a variable voltage controller for one of the bucket elevators on a trial basis. The plant team installed a variable voltage controller for raw mill bucket elevators rated for 67.5 kW. Before installing the controller, the raw mill bucket elevator was consuming 30 kW and the load on the motor was about 44%.

After installing the variable voltage controller, it started consuming 22 kW keeping the feed material constant as previous.

Benefits:

There was a reduction in power consumption by 8 kW after installing variable voltage controller. The annual savings achieved was Rs 1.96 Lakhs. This required an investment of Rs 2.50 Lakhs which was paid back in 16 months.

After successful trial, the plant team decided to install variable voltage controller for other under loaded equipment also.

Potential

Similar saving potential exists in belt conveyors, bucket elevators and crushers in many plants across the industry.

Case Study No 15

OPTIMIZE THE OVERALL OPERATING FREQUENCY

Background

The speed of all electrical driven equipment is proportional to the operating frequency. Majority of the loads in a cement plant are centrifugal in nature. In centrifugal loads, such as fans and pumps, the power consumption is directly proportional to cube of operating speed.

Affinity laws of centrifugal loads:

- Flow delivered α speed
- Pressure developed α $speed^2$
- Power consumption α $speed^3$

The power consumption in other linear loads is directly proportional to operating speed.

Therefore, any attempt to reduce overall operating frequency leads to substantial reduction in power consumption.

However, to reduce the overall operating frequency of the plant, two conditions have to be satisfied.

1. The plant should be supplied from an island power source i.e., from the captive power plant which is not connected to grid
2. There must be cushion in operating parameters of all the major loads. Because any reduction in frequency will cause reduction in flow and pressure which may affect the process.

Usually all the equipments are designed with excess capacity. Therefore, any reduction in frequency does not affect process parameters in centrifugal equipments.

Effect of frequency in fans, blowers and pumps

In centrifugal loads such as fans, blowers, pumps etc., the rpm is directly proportional to frequency of the electrical supply and power consumption is proportional to the cube of rpm (or frequency).

Hence, any reduction in frequency would result in reduction in power consumption.

Effect of frequency on Alternator & Motor cooling

There will be no effect on cooling of alternator and motors due to reduction in frequency. In practical, reduction in frequency will reduce the frequency related losses in motor and also mechanical losses which depend on the operating speed.

Effect of frequency in Compressors

Majority of the compressors in any plant operate in load & unload mode due to higher designed capacity. During the unload time, the compressor does not deliver useful work, but operates only to overcome its internal losses. The power consumption during unload time of the compressor is an indication of wastage of energy.

Reduction in frequency will reduce the speed of compressor. The output of compressor is reduced due to reduction in operating speed of the compressor. This will reduce the unload time of compressor and thus resulting in energy savings.

In case of reciprocating compressor, reduction in frequency reduces the speed of lubricating pump. If the operating speed of the lubricating pump is reduced below 30%, the lubrication system will be failed. However, reduction in frequency by 1 – 2 % will marginally reduce the speed and the lubrication system will not be affected.

Effect of frequency in Ball mills and VRM's

1 – 2 % reduction in frequency reduces the speed of ball mill by 0.2 to 0.25 rpm. The effect of marginal reduction in speed over the performance of the ball mill has not been reported from any of the cement plants.

The effect of frequency reduction on VRM is also very negligible. Therefore, reduction in overall operating frequency will reduce the energy consumption in all centrifugal loads to a greater extent.

Many of the Indian cement plants, operating with island power source, have reduced the operating frequency from 50 Hz to 48.5 – 49 Hz and achieved substantial benefits.

V/F ratio

All the motors are designed to operate at constant V/F ratio. Therefore, voltage should also be reduced correspondingly to maintain the ratio constant when the frequency is reduced.

Operating voltage and frequency are very critical with respect to the power consumption of equipment. Optimum voltage and frequency will result in lower power consumption.

Case Study

A 2.6 MTPA cement plant had a captive thermal power plant (TPP) of 45 MW. TPP was operating at 6.6 kV and 50 Hz in isolation with grid.

The plant team has studied all the individual equipment to identify the feasibility of reduction in operating frequency. The capacity utilisation of all the major fans, pumps was studied in detail. All the major fans are operated with speed control and the actual operation was at the higher resistance step. This indicated that there were margins in all major fans.

The plant team gradually reduced the frequency in steps of 0.2 Hz. The overall operating parameters of all major equipment was reviewed and the reduction in energy consumption was noted. Carrying this over 3-4 steps, the plant team finally optimized the frequency at 49.4 Hz. Operating at lower frequency gave substantial energy saving opportunity

Benefits

The plant team has reduced the operating frequency from 50 Hz to 49 Hz in steps of 0.5 Hz. This has resulted in energy savings to the tune of Rs 37 Lakhs per annum.

ACTION PLAN AND CONCLUSION

ACTION PLAN AND CONCLUSION

Action Plan

- The individual cement plants have to assess the present performance and should develop its own individual target for improving all the parameters.
- The target figure should be based on the collated best performance parameters.
- Set and achieve voluntary target of at least 3-5% reduction in specific energy consumption every year
- The best practices and the performance improvement projects compiled in this manual may be considered for implementation after suitably fine tuning to match the individual plant requirements.
- If required, CII-Godrej GBC will help the individual cement plants to improve the performance by providing energy audit services and identifying performance improvement projects specific to individual units to achieve the targets.
- The present level of performance and the improvements made by the individual units have to be monitored.
- The performance improvement of these units will be reviewed in the "Cementech" every year and the information will be disseminated among the Indian Cement plants.

Phase – 1

- The best practices and the performance improvement projects compiled in this manual may be considered for implementation after suitably fine tuning to match the individual plant requirements.
- Units can establish their present performance levels as Baseline and review all improvement activities against this Baseline.

- ‘Green Cementech’ will serve as a platform every year for information dissemination among all the Cement Plants.

Phase – 2

- Each plant has some unique projects implemented against their name. Sharing such best practices during inter-plant visits would be the most cost effective way of improvement. Each visit to a good operating plant should fetch us ideas to save at least 1 kWh/ton of cement.

Phase – 3

- Indian Cement Plants have a few unique features to observe and implement from international cement plants in the areas of:

    i. Waste fuel utilization

    ii. Waste heat recovery opportunities

    iii. Automation

- One such visit to Germany, Belgium, Switzerland, United Kingdom and Japan was organised in the year 2006 and has received a good response from the participants. Such experiences would give us a wider perspective on global operations of cement manufacturing and to adopt the best practices practiced therein.

CII - Godrej GBC will be glad to extend all possible assistants to units in all the three phases of action plan proposed.

For further details regarding the contents of this manual or any assistance in the action plan proposed, please contact:

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Conclusion

The objective of the project will be fulfilled only if the performance of all cement plants improves and achieves world class standards.

We are sure that the Indian Cement plants will make use of this opportunity, improve their performance and move towards the world class Energy Efficiency.

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