Confederation of Indian Industry

SHAKTI
SUSTAINABLE ENERGY FOUNDATION

# **Case Study Booklet** on Energy Efficient Technologies in **Cement Industry**

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# FOREWORD

CII-Sohrabji Godrej Green Business Centre, as part of its World Class Energy Efficiency initiative, has been releasing several publications on a regular basis to make the latest information available to all stakeholders in the cement industry. One such initiative is the release of this *Case Study Booklet on Energy Efficient Technologies in Cement Industry in 2015.*

The Case Study Booklet on Energy Efficient Technology in Cement Industry is an outcome of the collection of Energy Efficient Technologies adopted by Indian Cement Industry. This booklet is an effort to accelerate adoption of the energy efficient technologies and to overcome information and knowledge barriers in making transition towards the energy efficiency pathways.

In continuing the Indian cement industry tradition of knowledge sharing it is the right time to learn from the peers on best technology and practices adopted. This booklet will be useful for the entire Indian cement industry to identify the potential of energy efficient technologies.

We warmly invite you to please share your feedback to us at encon@cii.in. We look forward to your continued support in further greening Indian Cement sector. Your feedback will encourage us at CII-Sohrabji Godrej Green Business Centre to take such initiatives in future.

G Jayaraman

Chairman, Green Cementech 2015 &

Executive President, Birla Corporation Ltd.,

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## ACKNOWLEDGMENTS

CII-Sohrabji Godrej Green Business Centre would like to express its sincere and special gratitude to the entire Indian cement industry for their continuous support in this initiative, providing the required data for completing this Case Study Booklet, which makes this booklet more useful to all stake holders.

CII-Godrej GBC acknowledges with thanks the co-operation and the support extended by the suppliers for sharing their technology advancements and case studies implemented in the cement industry.

We would like to place our vote of thanks for the cement technical experts and associations for sparing their valuable time in offering inputs and suggestions in bringing out this booklet.

The interactions and deliberations with the industry, suppliers and sector experts through the workshops and web meeting and the whole exercise was thoroughly a rewarding experience for CII.

We deeply express our sincere thanks to the following Cement Industry for openly sharing the technical information on the energy efficient technology and the write ups provided for the booklet deserve a special mention.

- Jaypee Cement, Rewa
- Ultratech Cement, Rawan Cement Works
- Ultratech Cement, Reddipalayam
- Birla Corporation Ltd., Satna Cement Works
- J K Lakshmi Cement, Sirohi
- The Ramco Cement Ltd., Alathiyur
- Mangalam Cement, Kota
- Kesoram Industries Ltd., Unit Vasavadatta Cement, Sedam
- Ambuja Cement Ltd., Rabriyawas, Rajasthan

## 1.0 EXECUTIVE SUMMARY

Indian cement industry is one of the highly energy intensive industry which has a robust growth trajectory over the past decade. Indian cement industry is the 2nd largest producer of cement in the world with a total installed capacity of 350 million MTPA[1] . The per-capita consumption of cement has increased from 28 kg in 1980-81 to 190 kg[2] in 2013-14, led by the growth in sectors like real estate and construction.

Economic growth is contingent upon the growth of cement industry. Consumption of cement is taken to be an indicator of economic development. The greater the infrastructure growth of a country, greater will be the consumption of cement.

On the energy conservation front, the best levels achieved by the Indian cement industry, at about 680 kcal/kg clinker and around 66 kWh per tonne cement, are comparable with the best achieved levels in the world. However, a large number of plants installed before the 1990's are operating at relatively high energy consumption levels. Although some of these legacy plants have been modernized to a limited extent by retrofitting new technologies, they should, on priority, bring their energy consumption levels closer to the best achieved levels in the industry by further modernization and adoption of best available processes and technologies.

CII-Godrej GBC undertook the initiative of preparing Technology Compendium on Energy Saving Opportunities: Cement Sector to help the Industry achieve the PAT target. The Technology compendium comprises of various best practices and 15 technologies to save thermal and electrical energy along with the cost abatement curve. The technology compendium was circulated to all the Designated Consumers' (DCs) in cement sector. With the objective of facilitating the implementation of energy efficient technology, a questionnaire was also circulated to all DCs seeking their opinion on the technology which can be implemented at their unit. A good response was received from several DCs on the implementation of the technology. Among the identified technology in the compendium majority of the DCs have shortlisted following technologies for the implementation.

1. Installation of high efficiency clinker cooler
2. Installation of Waste Heat Recovery System
3. Installation of HT VFD/ SPRS in place of GRR for Speed control
4. Installation of High Efficiency Separators
5. Increasing the Thermal Substitution Rates in Cement Plants
6. Increase % addition of Fly Ash in PPC Manufacturing

[1] DIPP report (2014-15): http://dipp.nic.in/English/Publications/Annual_Reports/Annual_report.aspx
[2] http://www.ibef.org/industry/cement-india.aspx

In order to accelerate adoption of energy efficient technologies and to overcome the information and knowledge barriers in making transition towards the energy efficiency pathways CII-Godrej GBC has taken initiative to publish the case study booklet on the above mentioned energy efficient technology to share the information among the cement manufacturers. This booklet is expected to assist the cement industry to improve their energy efficiency levels.

The information presented for each technology is collected from various sources, cement, industry, technology suppliers and CII energy award questionnaire & award presentation.

However, impleme ntation of some of these technologies calls for a sustained effort from the designated consumers. Some of the technologies mentioned in this booklet are capital intensive and time consuming to implement. But implementation of these projects can surely be beneficial in a long term perspective for the sector.

CII-Godrej GBC team has interacted with several technology / service providers to seek their opinion on the best available energy efficient technology (BAT) and to identify existing and in-house development technologies to assess their utility. Exhaustive Interaction happened with cement manufacturers on the benefit of the technology installed at their units.

## 2.0 ENERGY CONSUMPTION TRENDS

Cement industry is an energy intensive industry and third largest coal consumer in the country after power and steel industry[3] requiring both electrical and thermal energy for its operation.

Cement industry accounts for around 10% of the coal and 6% of the electricity consumed by the Indian industrial sector. On an average, cement plants are spending about 35-50% of the total manufacturing cost of cement to meet their energy demands. In fact, energy cost is considered as a major factor in pricing of the cement. The breakup of manufacturing cost of cement is shown below. Around 25% of the manufacturing cost is spent on raw materials for cement manufacturing. The rest of the cost is shared among the manpower and factory overheads.

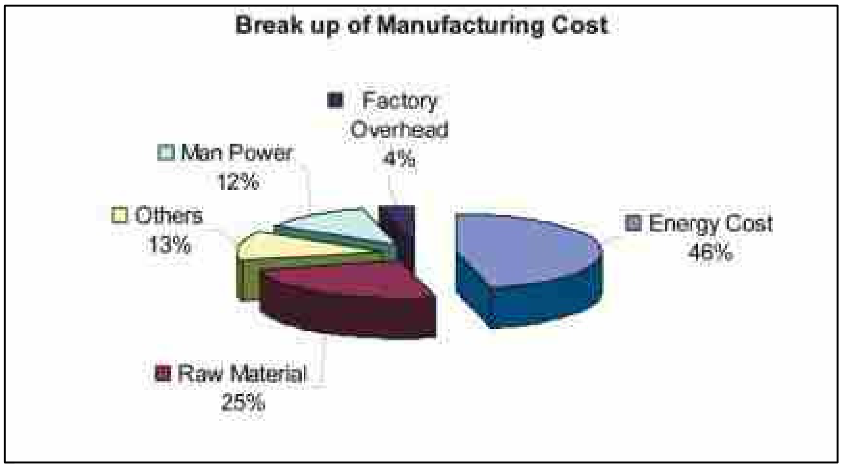
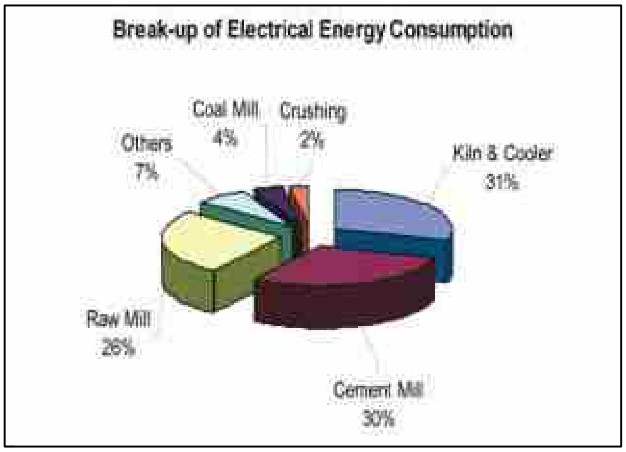



Figure -Cost break-up in cement manufacturing

### ELECTRICALENERGY

Modern cement plants on an average consume about 65-75 kWh[4] of electrical energy for producing one ton of cement. Cement plant requires electrical energy to run its Mill drives, Fans, Conveyors, Packers and for Lighting systems. Kiln and mills are major electrical power consuming areas of the cement plant. In fact, they are consuming about 60 % of total electrical energy requirement. When it comes to old plants, due to the old technology adopted and some inherent barriers, the energy consumption is normally in the range of 80-100 kWh per ton of cement. The typical section wise electrical energy consumption is shown in the graph above.




[3] Indian Coal Sector by IIFL

[4] CII Energy Award questionnaire

## THERMAL ENERGY

On an average, Indian cement plants require 723 kcal/kg[5] clinker of thermal energy for producing one kg of clinker. The major use of thermal energy is in the kiln and pre-calciner systems. Thermal energy is needed for the raw meal processing specifically for converting the raw mix to Clinker. Pyro processing (Conversion of raw meal to clinker) is the most energy-concentrated stage in cement production. The number of stages in the pre-heater system has a major bearing on the thermal energy consumption in Kiln system.

Continuous technological up gradation and assimilation of latest technologies have been steadily increasing in the cement industry. Today, 99% of the plants use dry process technology compared to 6% in 1960.

Indian cement industry has always been a trend setter for adopting the best available energy efficient technologies. The best thermal and electrical energy consumption presently achieved in India is 680 kcal/kg clinker and 66 kWh/T cement which are comparable to the best figures of 650 kcal/kg clinker and 65 kWh/T cement in a developed country like Japan.

The specific energy consumption of the Indian Cement Plants has been reducing with continuous up-gradation of technologies and the change in process technologies. The table given below shows the progressive reduction in specific energy consumption by Indian cement industry.

| Parameters | Year | | | | |
|---|---|---|---|---|---|
| | **1950-60** | **1970s** | **1980s** | **1990s** | **Post 2000** |
| Heat Consumption (kcal/kg clk) | 1300-1600 | 900-1000 | 800-900 | 750-800 | 650-750 |
| Power consumption (kWh/MT cement) | 115-130 | 110-125 | 105-115 | 95-105 | 80-100 |

[5] Average value from CII Energy Award questionnaire

# CASE STUDIES

# ON

# ENERGY EFFICIENT TECHNOLOGIES

# ENERGY EFFICIENT TECHNOLOGY 1:

## Installation of latest generation high efficiency clinker coolers

The Indian cement industry, over the last several years, has increasingly adopted reciprocating grate coolers with great success. With more than 50% of cement produced from kilns less than 10 years old, reciprocating grate coolers have become common practice in the industry today, with cooler loading of about 45–50 tpd/$m^2$ of cooler area. Heat from hot clinker is recovered to preheat the incoming secondary and tertiary air to improve thermal efficiency. Based on the cooling efficiency, technology adopted, and desired clinker temperature, the amount of air used in this cooling process is approximately 2.5–3 kg/kg of clinker

Conventional grate coolers provide a recuperation efficiency of 50–65%, depending on the mechanical condition and process operation of the cooler. This corresponds to a total heat loss from the cooler of about 120–150 kcal/kg clinker. Several cement kilns in India, as a result of continuous productivity increase measures, are operating at significantly higher cooler loading range than rated, with a range of 50–65 tpd/$m^2$ of cooler area; increasing the total heat loss from the cooler.

The reciprocating cooler has undergone significant design developments; the latest generation clinker coolers offering better clinker properties, and significantly lower exit gas and clinker temperatures. As a direct consequence, secondary and tertiary air temperatures offered by latest generation coolers have also increased to about 1,250°C and 1,000°C, respectively. The cooling air requirements of such coolers have also gradually reduced to about 2.2–2.4 kg/kg clinker.

While it is very attractive to adopt latest generation coolers for new plants by design, retrofitting existing conventional reciprocating coolers with latest generation coolers also offers a significant potential for electrical and thermal energy saving in the Indian cement industry. The total heat loss of latest generation clinker coolers is less than 100 kcal/kg clinker, and has a recuperation efficiency in the range of 75–80%.

## Case Study No. 1

## Up gradation of conventional cooler with IKN cooler at Jaypee Rewa, Madhya Pradesh

Jaypee group is the 3rd largest cement producer in the country. The group's cement facilities are located in the Satna Cluster (M.P.), which has one of the highest cement production growth rates in India.

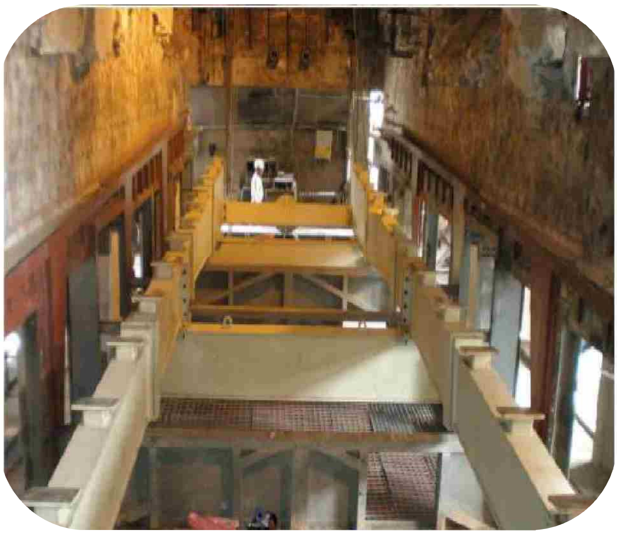
Jaypee Rewa Plant (JRP) Unit II started as a 4500 TPD SLC kiln with a twin string five stage pre-heater, precalciner and a Folax grate cooler. The capacity was gradually enhanced 5400 TPD with several in-house improvements, including modification of pre-heater fans, replacement of cooler fans, increase in pre-calciner volume. The earlier cooler was conventional cooler and demanding too many maintenance interventions and suffered frequent breakdowns so the company decided on a complete upgrade of the cooler. Jaypee selected IKN's pendulum cooler for up-gradation.

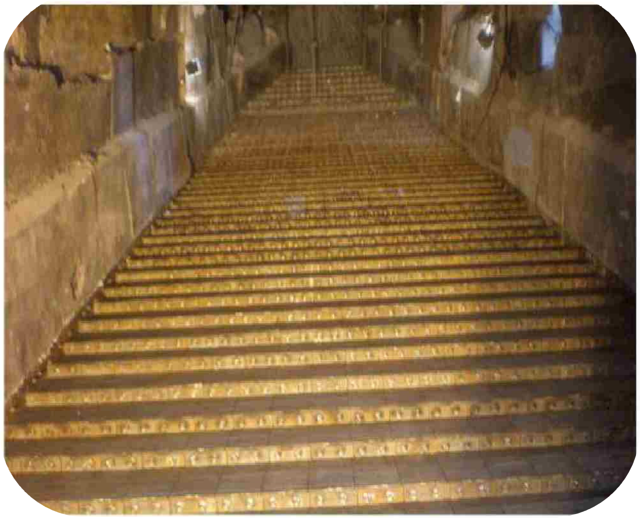
An upgrade with IKN pendulum cooler resulted in improved productivity, enhanced run time, and lowered thermal and electrical energy consumption.

**Operating Results:**

Below table shows the operational parameters before and after the IKN upgrade. A significant improvement was achieved in the run days after the upgrade. Specific heat consumption was reduced by 15-20 kcal/kg of clinker, productivity increased by approximately 200 TPD. The power in cooler section was also lowered by approximately 0.59 kWh/MT clk.

| Parameters | Before | After |
|---|---|---|
| Production rate (TPD) | 5550 | 5750 |
| Tertiary Air Temp (°C) | 760 | 930 |
| Specific Heat Consumption (kcal/kg clk) | 710 | 690 |
| Power in cooler section (kWh/MT clk) | 4.47 | 3.88 |
| Cooler vent air temp (°C) | 220 | 200 |
| Clinker temp (°C) | 152 | 132 |





The upgrade has resulted in improved productivity and run time and reduced thermal and electrical energy consumption.

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## Case Study No. 2

## Installation of IKN cooler at Ultratech Cement, Rawan Cement Works

Ultratech Cement, Rawan Cement Works is situated at Rawan, Dist. Baloda bazar, Bhatapara, in the state of Chhattisgarh. UTCL, Rawan has commissioned a new clinkerization unit of capacity 10000 TPD clinker, with 6 stages, 4 strings and 2 calciner ILC. The new clinkerization unit is the state of the art plant that is highly automated. The kiln & PH is KHD make whereas clinker cooler is IKN make.

The specific heat consumption of the plant is 697 kcal/kg clinker and the total power consumption of kiln section is 13.0 kWh/MT clinker considering the core equipment power (PH fan, kiln drive, PA fan, cooler fans, cooler vent fan, cooler drive & roll crusher). The overall savings if compared with a similar plant of 10000 TPD is 8 kcal/kg clinker in specific heat consumption and 2.5 kWh/MT clinker in cooler power.

The clinker temperature is 60+ambient. The power consumption of cooler is 4.67 kWh/MT clinker (includes cooler fans, cooler drive, roll crusher & cooler vent fan). The other parameters reported are as below:

| Parameters | Guaranteed | Achieved |
|---|---|---|
| Production rate (TPD) | 10000 | 10308 |
| Specific Heat Consumption (kcal/kg clk) | 698 @ HOR 410 kcal/kg clk | 697 @ HOR 417 kcal/kg clk |
| Standard cooler losses (VDZ) kcal/kg clinker | 90 | 77.6 |
| Cooler vent air temp ($^{o}C$) | -- | 230 |
| Clinker temp ($^{o}C$) | 65 + ambient | 60 + ambient |
| Cooler fan power (kWh/MT clk) | -- | 4.06 |
| Cooler drive+ roll crusher | -- | 0.35 |
| Cooler vent fan | -- | 0.27 |

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## Case Study No. 3

## Upgradation of conventional cooler with FLS Cross Bar cooler at Ultratech Cement, Reddipalayam, TamilNadu

UltraTech Cement Limited, Reddipalayam unit is located at Reddipalayam village of Ariyalur District in Tamilnadu. It has one kiln of 3250 TPD clinker production capacity.

Ultratech Cement, Reddipalayam has upgrade its 3250 TPD conventional cooler with FLS cross bar cooler. Below table shows the operational parameters before and after the cooler upgrade. Productivity increased by 250 TPD of clinker, cooler loss was reduced by 37 kcal/kg clinker, power consumption is cooler section is reduced by 0.53 kWh/MT clinker and clinker temperature at cooler discharge was reduced by 97°C.

| Old | New |
|---|---|
| Type – CFG 1054 with 1007 CIS | Type – CB 10 X 48 Cross bar cooler with ABC Inlet |
| Grate Area – 71.2 $m^2$ | Grate Area – 81.4 $m^2$ |
| Cooler Vent Fan – Capacity 105 $m^3/s$ Static Pressure (– 784 )pa | Cooler Vent Fan – Capacity 119 $m^3/s$ Static Pressure (– 1500 )pa |
| 11 Cooler Fans | 7 Cooler Fans |
| Clinker Breaker (CC 110 X 300) | Heavy duty roller Breaker (MF HRB 310) |
| Cooler ESP dust conveying – 2 drag chains | Cooler ESP dust conveying – 4 drag chains with Bag Filter |

| Parameter | Unit | Before | After |
|---|---|---|---|
| Production | TPD | 3150 | 3400 |
| Cooler loss | kcal/ Kg Cl | 135 | 98 |
| Specific Power Consumption | kWh/MT | 5.7 | 5.17 |
| Clinker temp | Deg C | 195 | 98 |

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## ENERGY EFFICIENT TECHNOLOGY 2:

### Installation of Waste Heat Recovery System

In the case of dry process cement plants, nearly 40% of the total heat input is available as waste heat from the exit gases of the preheater and cooler. The quantity of heat from pre-heater exit gases ranges from 180–250 kcal/kg clinker at a temperature range of 300-400$^{0}$C. In addition, 80-130 kcal/kg clinker heat is available at a temperature range of 200-300$^{0}$C from the exhaust air of the grate cooler. In some cases, it is observed that although the quantity of thermal energy through preheater discharge gases of the grate cooler exhaust is high, the quality of such heat is low. These heats have various applications such as drying of raw material and coal or generation of power.

As raw material drying is important in a cement plant, heat recovery has limited application for plants with higher raw material moisture content. Often drying of other materials such as slag or fly ash requires hot gases from the cooler or preheater and, in that case, waste heat recovery potential will be further decreased.

Power production utilizing hot gases from the preheater and hot air from the cooler requires a heat recovery boiler and a turbine system. Power generation can be based on a steam process Rankine cycle, the Organic Rankine Cycle (ORC) process or the Kalina process. The steam turbine technology is best known from power plants. While in modern power plants, electric efficiency comes up to 45-46%, the relatively low temperature level from the cooler (200-300$^{0}$C) limits the efficiency to a maximum of 20-25%.

In large plants, about 22-36 kWh/tonne clinker (25-30% of total requirement) can be generated. This power is considered sufficient to operate the kiln section on a sustained Basis. The electrical efficiency of these WHR installations varies from 10-20%.

The Organic Rankine Cycle (ORC) and Kalina technologies use organic substances or Ammonia ($NH_3$) as cycling medium, which evaporate at lower temperatures and can therefore produce electric power at a temperature level at which steam turbines cannot otherwise efficiently manage. Nevertheless, the efficiency is normally less than 15%.

Based on the chosen process and kiln technology, 8-10 kWh/t clinker can be produced from cooler exhaust air and 9-12 kWh/t clinker from the preheater gases if the moisture content in the raw material is low and if it required only a little hot gas/air for drying. So in total up to 22 kWh/t clinker or up to 25% of the power consumption of a cement plant can be produced by using these technologies without changes in kiln operation. If higher power production is needed, WHR is in certain competition with the energy efficiency of clinker production, but finally both techniques are aimed at a minimization of unused waste heat. If kiln operation is modified in order to produce more electricity, (higher preheater exit gas and cooler exhaust air temperature) up to 30 kWh/t clinker is possible. Power generation can be further increased by additional co-firing into the boiler or by operating the kiln system with less cyclone stages or bypassing upper stage(s).

The adoption of waste heat recovery systems in Indian cement manufacturing facilities has been relatively slower compared to its global peers. Out of over 190 large cement plants in the country, only about 20 cement plants have adopted WHR systems. Estimates indicate that the waste heat recovery potential in Indian cement industry is close to 500 MW while the installed capacity till date is only about 275 MW. This indicates the huge opportunity for adoption of waste heat recovery in Indian cement industry.

Waste Heat Recovery System installed capacity in Indian Cement Industry

| Sl. No. | Company | Installed Capacity (MW) |
|---|---|---|
| 1 | Shree Cement Ltd., Ras | 48.0 |
| 2 | Shree Cement Ltd., Beawar | 18.0 |
| 3 | Birla Corporation Ltd, Satna Cement Works | 15.0 |
| 4 | J K Cement, Nimbahera | 13.2 |
| 5 | J K Lakshmi Cement, Sirohi | 12.0 |
| 6 | The India Cements Ltd., Vishnupuram | 7.7 |
| 7 | Birla Cement, Chanderia | 7.5 |
| 8 | The KCP Ltd., Macherla | 2.5 |
| 9 | Ultratech Cement APCW I | 3.8 |
| 10 | Penna Cement | 14.0 |
| 11 | J K Cement, Mangrol | 10.0 |
| 12 | Chettinad Cement | 7.3 |
| 13 | Rajashree Cement | 22.7 |
| 14 | Ambuja Cement, Rabriyawas | 6.5 |

| | | |
|---|---|---|
| 15 | Vicat Sagar | 8.4 |
| 16 | Shree Cement, Line 8 | 9.8 |
| 17 | ACC Ltd., Gagal | 7.5 |
| 18 | Aditya Cement | 20.0 |
| 19 | Ultratech Cement, Rawan | 15.2 |
| 20 | Ultratech Cement, Hirmi | 12.5 |
| 21 | Ultratech Cement, Awarpur | 13.2 |
| Total | | 275 MW |

# Case Study No. 4:

## Installation of WHRS at Birla Corporation Ltd., Satna Cement Works, Satna, Madhya Pradesh

Birla Corporation Ltd., Satna is situated in the state of Madhya Pradesh. It comprises of two cement manufacturing sub-units i.e. Satna Cement Works (SCW) & Birla Vikas Cement (BVC). The SCW has one kiln of installed capacity 4500 TPD clinker and the BVC has one kiln of installed capacity 5200 TPD clinker.

Waste Heat Recovery System is installed in both the lines. WHRS installed capacity at both the lines is 7.5 MW each and generating 6.0 MW each. WHR system project at Satna Cement Works was commissioned in October 2010 & WHR system at BVC was commissioned in February 2011. The hot waste gases coming out from the preheater and clinker cooler is used to generate power thus the greenhouse gas emissions into the atmosphere are being reduced substantially.

Below table shows the operational parameters of WHRS.

| Description | Designed Parameter | | Operating Parameter | |
|---|---|---|---|---|
| | Unit-1 (SCW line) | Unit-2 (BVC Line) | Unit-1 (SCW line) | Unit-2 (BVC Line) |
| Year of installation | 2010 | 2011 | | |
| Make | Qingdao Jieneng, China | Qingdao Jieneng, China | | |
| Rated capacity | 7.5 MW / 3000 RPM | 7.5 MW / 3000 RPM | 6.0 MW | 6.0 MW |
| Kiln capacity | 4500 TPD | 5200TPD | 4100 TPD | 4900 TPD |
| PH exit temperature (WHR boiler inlet temperature) | 365 $^0$C | 350 $^0$C | 405 $^0$C | 330 $^0$C |
| WHR boiler outlet temp. | 205 $^0$C | 206 $^0$C | 188 $^0$C | 190 $^0$C |
| AQC inlet temp | 365 $^0$C | 375 $^0$C | 445 $^0$C | 350 $^0$C |
| AQC outlet temp | 91 $^0$C | 91 $^0$C | 98 $^0$C | 110 $^0$C |
| Savings in Rs. Lakhs/annum | | | 2500 Lakhs | 2500 Lakhs |



Turbine details:
Model: BN7.5-2.29
Maximum power: 7.5MW
Rated power: 6.0MW
Economic power: 5.4MW
Rated speed: 3000r/min
Rated primary steam pressure: 1.27~2.45MPa
Rated primary steam temperature: 310~390°C
Rated secondary steam pressure: 0.1~0.3 MPa
Rated secondary steam temperature: saturated to 175°C
Rated exhausted steam pressure: 0.008 Mpa
Voltage at generator outgoing terminal: 6.6kV

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## Case Study No. 5:

## Installation of WHRS at J K Lakshmi Cement Ltd., Sirohi

J K Lakshmi Cement is situated at Jaykapuram in Sirohi district of Rajasthan. It has 3 kiln of design capacity 2000 TPD, 4500 TPD & 4500 TPD clinker. The WHR system was installed in 2010 in all three kilns.

The total generation capacity of WHRS installed in 12 MW. The feasibility study was carried out jointly with TECO, Japan.

Sources of heat for boilers

1. Exhaust gases from Preheater & Cooler of Kiln-1
2. Exhaust gases from Preheater & Cooler of Kiln-2
3. Preheater exhaust gases of Kiln-3. It was not feasible to install AQC boiler because waste gases from Kiln-3 cooler are being used in fly ash drier.

Offer for WHR system has been received from the supplier (Thermax in Association with TECO, Japan) for installation of 5 Nos. of Boiler (03 PH Boilers & two AQC Boiler). Recently the plant have added one new boiler in kiln-1 cooler side which has been supplied by Veeson Energy system (P) Ltd.

## Waste Heat Recovery System at J K Lakshmi Cement, Sirohi

| WHR PARAMETER – Generation Capacity-: 12 MW | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S.NO | PARAMETER | UNIT | KILN -1 | | | KILN -2 | | KILN-3 |
| | | | PH-1 | AQC-1A | AQC-1B | PH-2 | AQC-2 | PH-3 |
| 1 | Year of installation | year | 2010 | 2010 | 2013 | 2010 | 2010 | 2010 |
| 2 | Make | | Thermax Limited | | Veeson Energy | Thermax Limited | | |
| 3 | Rated Capacity of Steam Generation | TPH | 12 | 4.1 | 6.2 | 21.8 | 9.4 | 20.7 |
| 4 | Operating Capacity | TPH | 12.13 | 6.15 | 5.01 | 17.31 | 12.55 | 17.6 |
| 5 | Net Generation | Units/ Day | 294997 | | | | | |
| 6 | Kiln Capacity | TPD | 4300 | | | 5000 | | 5000 |
| 7 | Boiler Inlet temp(Design) | °C | 320 | 363 | 366 | 320 | 360 | 320 |
| 8 | Boiler Inlet temp(operating) | °C | 300±5 | 390±20 | 370±20 | 315±5 | 400±20 | 315±5 |
| 9 | Boiler Outlet temp(Design) | °C | 205 | 105 | 165 | 205 | 80 | 205 |
| 10 | Boiler Outlet temp(operating) | °C | 205±10 | 200±5 | 170±5 | 205±5 | 150±10 | 205±5 |
| 11 | Investment | Rs. 1330 Million (1260 Million in 2010 + 70 Million in 2013) | | | | | | |
| 12 | Saving | Rs. 352.61 Million (On the basis of net generation for FY-13-14) | | | | | | |

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# ENERGY EFFICIENT TECHNOLOGY 3 :

## Installation of HT VFD/ SPRS in place of GRR for Speed control

Large slip ring induction motors are used for driving major fans (Pre-heater fan, cooler vent fan, Mill fans etc) in cement industry where they have the advantage of controlled starting characteristics and adjustable speed capability. The rotor has a 3-phase winding, with the three terminals connected to separate slip rings, which are normally connected to a liquid rheostat or resistor bank. The rheostat is used for starting, and can be disconnected once the motor is up to speed.

By changing rotor resistance with the rheostat (Grid Rotor Resistance, GRR), the motor speed can be changed. The speed control of slip ring induction motor by varying the resistance in the rotor circuit results in power loss across the rotor circuit. The amount of power lost across the GRR depends on the speed at which the fan is operating which in turn depends on the operating step of GRR.

The power dissipated in the resistances of GRR is lost as heat. However, by using a variable speed drive or by installing a Slip Power Recovery System (SPRS), the power which is lost can be avoided or recovered. In case of HT VFD's the speed of the motor is controlled by varying the frequency of the supply voltage and the speed of the motor can be controlled in the range of 0-100% of the rated speed of the motor. While installing VFD for slip ring induction motor, care has to take that the rotor terminals has to be short circuited.

Among the various options available for speed control of High Temperature (HT) p rocess fans, such as Grid Rotor Resistance (GRR) control, Slip Power Recovery Sys tems (SPRS), and so on, HT /MV Variable Frequency Drives (VFD) are found to be the most suitable speed control mechanism, considering the precise control offered and the low inherent system energy losses. Hence, for all major fans, the right selection of fan with HT VFD as a preferred speed control offers the maximum energy saving.

Wherever VFDs are installed, the elimination of control damper is preferred. However, wherever the process needs damper control, a low pressure drop damper can be installed, such as aerofoil multi-louvered damper for cooler fans, slide gate for pre-heater fan.

## Case Study No. 6

## Installation of MV VFD for PH fan at The Ramco Cements Ltd., Alathiyur

The Ramco Cements Ltd., Alathiyur is situated in Ariyalur district of Tamil Nadu. It has two kiln of 3500 TPD clinker capacity.

The Ramco Cements Ltd., Alathiyur Works has installed MV VFD for their Line-2 PH fan. This has resulted in a significant power savings in the pre-heater fan.

The details of saving and investment are as below:

| Description | Before (with GRR) | After (With VFD) |
|---|---|---|
| Average power consumption | 1862 kW (13.2 kWh/MT clk) | 1632 kW (10.9 kWh/MT clk) |
| Savings in power | 230 kW | |
| Annual Savings | Rs. 4.82 Million | |
| Investment | Rs. 13.0 Million | |
| Simple Payback period | 32.0 Months | |

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## Case Study No. 7

## Installation of MV VFD for Kiln Hybrid Bag house fan at Mangalam Cement

Mangalam Cement is situated at Morak Dist. Kota, Rajasthan. It has 2 kiln lines. Kiln-1 is of 3000 TPD clinker.

The plant has installed MV VFD in place of GRR for Line-1 Kiln hybrid bag house fan and achieved a good savings in power consumption.

The details of saving and investment are as below:

| Description | Before (with GRR) | After (With VFD) |
|---|---|---|
| Average power consumption | 290 kW | 130 kW |
| Savings in power | 160 kW | |
| Annual Savings | Rs. 6.97 Million | |
| Investment | Rs. 6.0 Million | |
| Simple Payback period | 10 Months | |

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## ENERGY EFFICIENT TECHNOLOGY 4 :

### Installation of High Efficiency Separators

Separators are used in material grinding for the purpose of separating the fine particles from the coarse material coming out from the ball mill thus increasing its grinding efficiency. The fine particles are collected as product while the coarse particles are sent back to the mill for further grinding.

A good separator should ensure that the stream of coarse material generally referred to as reject should contain very little fine particles as possible (less than 10-15% retained over 45 micron sieve) and the stream of fine material should contain very low quantities of coarse material. An efficient separator improves the mill performance by avoiding the over grinding of the material and thereby reduces the grinding power consumption. By efficiently separating the coarse particles from the fine particles, it maintains the required product fineness, avoids over-grinding, thereby saving mill power consumption.

High-efficiency separator / classifier improve the grain size distribution of the finished cement and reduce grinding power requirements. The high separation efficiency results in higher proportion of classifier fines which results in decline of the number of circulations of the mill feed and hence the throughput rises by up to 10 -15%. This result in reduction of the specific energy demand compared to grinding circuits with standard separators. High efficiency separators contribute to the energy demand for grinding with about 5 to 8%.

## Case Study No. 8

## Upgradation of Raw mill & Coal mill classifier with energy efficient classifier & vortex rectifier at The Ramco Cements Ltd., Alathiyur

The Ramco Cements Ltd., Alathiyur is situated in Ariyalur district of Tamil Nadu. It has two kiln of 3500 TPD clinker capacity. The plant has installed Loesche mills for raw material and coal grinding.

The plant has upgraded the raw mill & coal mill classifier with energy efficient classifier & vortex rectifier and has achieved significant savings in power consumption.

Raw mill-1 was commissioned with rated capacity of 180 TPH at 17% residue on 90 mic and Raw mill-II was commissioned with rated capacity of 215 TPH at 17% residue on 90 mic. Raw mill-1 was successfully upgraded by replacing classifier from LJKS65 to LSKS52 and bigger roller in 2000/2001. Both the raw mills were in smooth operation at output of 215-220 TPH at 17% residue on 90 mic.

The plant details are as below:

| | Line 1 | Line 2 |
|---|---|---|
| Commissioned year | 1997 | 2001 |
| Kiln | FLS-3500 TPD | FLS-3500 TPD |
| Raw Mill | Loesche LM 38.3 | Loesche LM 38.3 |
| Coal Mill | Loesche LM 20.2D | Loesche LM 20.2D |
| Cement mill | OK 33.4 | Loesche LM 56.2+2C |

The raw mill was designed for a feed moisture of 5% normal % 10% maximum. Over a period of time the normal feed moisture increased to more than 10% causing the reduced raw mill output to 205-210 tph from 215-220 tph. During monsoon mill output was further reduced to 190 tph. Hot gas generator (HGG) has to be operated to get the output of 210 tph to meet clinker production. HGG consuming about 2 tph of fine coal. Since more heat was required for drying the gas volume was to be increased in mill and thereby causing higher product residue.

To overcome this problem raw mill classifier was changed from LSKS 52 to LSKS 57.

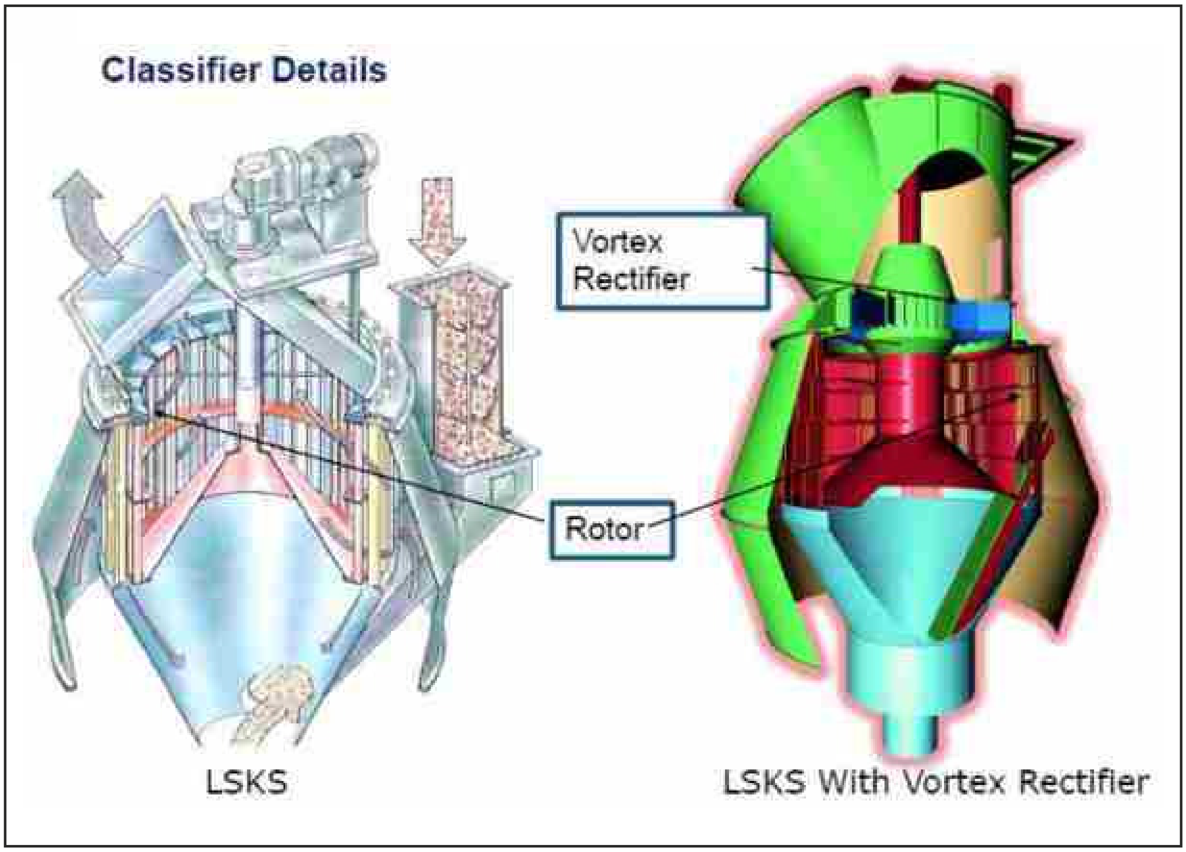
Comparative operating data of Raw Mill-1:

| Description | Before Modification | After Modification |
|---|---|---|
| Classifier size | LSKS 52 | LSKS 57 |
| Feed Moisture (%) | >=10 | >=10 |
| Mill output (TPH) dry | 207 | 231 |
| Product residue (212 mic) % | 2.3-3.0 | 1.5-2.0 |
| Product residue (90 mic) % | 19-20 | 16-17 |
| Specific power: kWh/Mt | | |
| Mill | 5.56 | 4.55 |
| Fan | 6.33 | 6.28 |
| Total specific power | 11.89 | 10.83 |

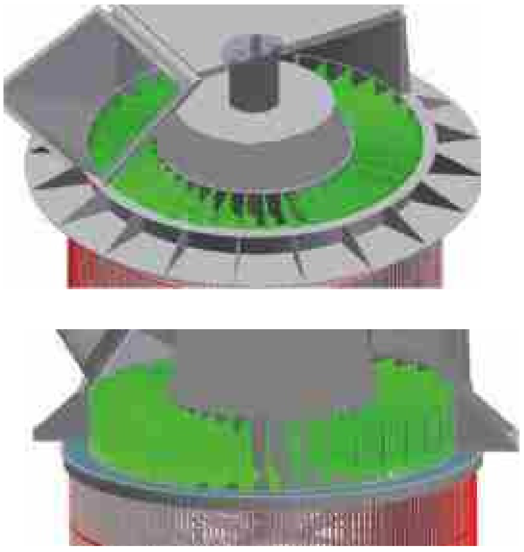
Comparative operating data of Raw Mill-2:

| Description | Before Modification | After Modification |
|---|---|---|
| Classifier size | LSKS 52 | LSKS 57 |
| Feed Moisture (%) | >=10 | >=10 |
| Mill output (TPH) dry | 210 | 233 |
| Product residue (212 mic) % | 2.3-3.0 | 1.5-2.0 |
| Product residue (90 mic) % | 19-20 | 15-16 |
| Specific power: kWh/Mt | | |
| Mill | 5.57 | 4.42 |
| Fan | 7.29 | 6.52 |
| Total specific power | 12.86 | 10.94 |

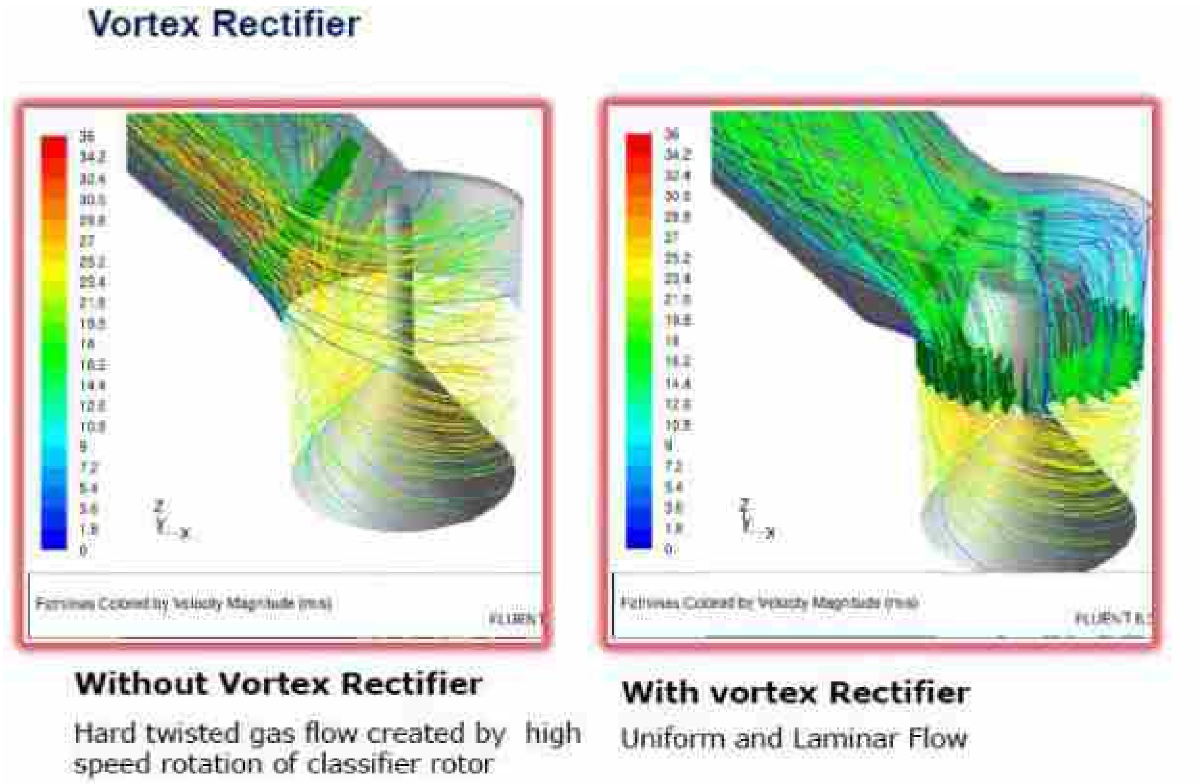
This has resulted in saving of about 1.2 kWh/MT in specific power drawn by mill & fan.




**Raw mill 38.3 Classifier upgradation:**



The installation of vortex rectifier for the classifier has resulted in restoring a linear flow in the ductwork & maintaining homogeneous velocity distribution thus resulting in a low dp and leading to a reduced specific energy consumption.

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## Case Study No. 9

## Cement mill Separator performance of best operating plant

During the plant energy audit, CII-GBC has observed separator performance for few of the best operating plants and the observed parameters are summarized in below table.

A good separator should ensure that the stream of coarse material generally referred to as reject should contain very little fine particles as possible (less than 10-15% retained over 45 micron sieve) and the stream of fine material should contain very low quantities of coarse material. An efficient separator improves the mill performance by avoiding the over grinding of the material and thereby reduces the grinding power consumption. By efficiently separating the coarse particles from the fine particles, it maintains the required product fineness, avoids over-grinding, thereby saving mill power consumption.

| Parameters | Unit | Plant A | Plant B |
|---|---|---|---|
| Production | TPH | 210 | 152 |
| Separator reject at -45 mic | % | 15 | 21 |
| Sep loading | $kg/m^3$ | 0.86 | 0.70 |
| Sep fan power | kWh/MT | 1.55 | 1.18 |
| Sep vent fan flow | % of separator fan flow | 10 | 4 |

# ENERGY EFFICIENT TECHNOLOGY 5 :

## Increasing the Thermal Substitution Rates in Cement Plants

Alternative fuel use in the Indian cement industry is at very low levels; the country's average stands at less than 1% of Thermal Substitution Rate (TSR). Several nations globally have utilized cement kilns as an effective option for their country's industrial, municipal and hazardous waste disposal. This creates a win-win situation for both the local administration and the cement plants: the administration utilizes the infrastructure already available at cement kilns, thereby spending less on waste management, and the cement kilns are paid by the polluter for safe waste disposal, as well as having their fuel requirements partly met.

Cement kilns can theoretically operate with 100% TSR, thereby completely off-setting the need for primary fossil fuels. However, several other enabling factors, such as the installation of adequate pre-processing and blending facilities, and the availability of alternative fuels without technical limitations (heat content, larger proportion of detrimental trace elements, chlorine, sulfur and so on) should be considered.

Cement kilns can exhibit significantly varying behaviour depending on the type of alternative fuel substituted, and hence the technical competence of the industry should be adequate to face these challenges which come alongside a TSR increase. With extensive national and global expertise available, the Indian cement industry today is technically ready for adopting higher TSR rates.

Increased TSR in the cement industry would be possible if the waste legislation in the country progresses in line with the industry's increased need for alternative fuels. Following steps are needed for accelerating the use of AFR.

1. First and foremost, a change in perspective amongst policy makers is required to explore cement kiln utilization of waste disposal.
2. Stringent waste legislation is needed which will enable high heat content waste to be co-processed in cement kilns rather than in incinerators where the heat content goes largely unutilized. It is important that the legislation related to cement kilns is as stringent as for dedicated waste facilities.
3. To ensure availability and consistency of alternative fuel quantity and quality, waste legislation in the country should enable effective waste collection, treatment and processing by introducing a new service sector which works as an effective intermediary between waste generators and the cement industry.
4. The pricing of waste is also a key factor to ensure waste minimization at source (to reduce disposal costs for waste generators) and to ensure zero or negative cost to cement manufacturers (encouraging them to install the expensive handling, storage and firing facilities at their premises) for increased TSR.
5. The social acceptance of using wastes as alternative fuels in cement kilns by the society and consumers.

## Case Study No. 10

## Alternative Fuel utilization at Ultratech Cement, Reddipalayam Cement Works, TamilNadu

UltraTech Cement Limited, Reddipalayam unit is located at Reddiapalayam village of Ariyalur District in Tamilnadu. It has one kiln of 3250 TPD clinker production capacity.

Ultratech Cement, Reddipalayam Cement Works had taken innovative initiatives of utilization of waste fuels such as DORB, tyre chips, paint sludge etc. The focus was on these waste high calorific material which has potential to reduce the fuel cost substantially. Though the concept of alternate fuel was prevalent in the developed countries, where the government was very supportive, it was totally a new concept in Indian Industry.

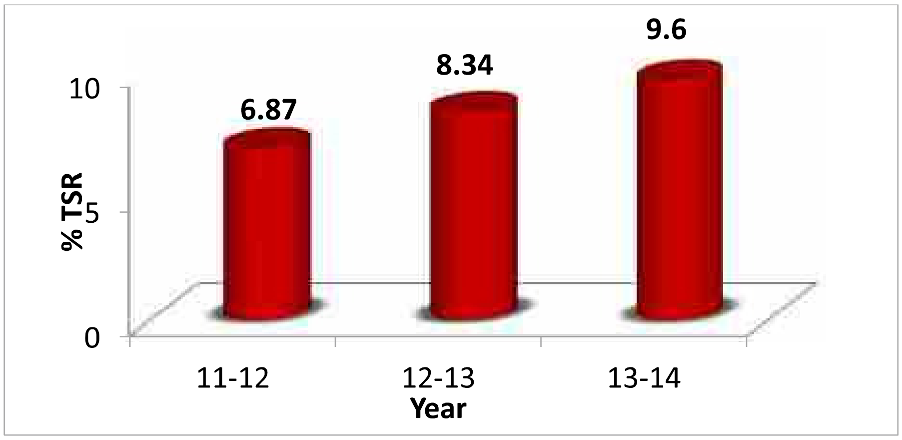
Reddipalayam Cement Works had been the pioneer in this regard in the cement industry by taking a lead as to how economically it could use the alternative fuels which had immense potential that too without affecting the product quality. Major initiatives were undertaken for implementing this project were: finalizing the technology, exploring the availability of different types of alternate fuels, their trial runs and subsequently plant scale trials, obtaining clearance from State & Central Pollution Control Boards and other regulatory agencies for usage of the waste fuels.

Achievements

- Manufacturing cost reduction of Clinker by using alternate fuels
- Safe disposal of Hazards waste, agro waste, paint sludge from automobile industry
- Conservation of resources – Reduced use of fossil / non-renewable fuels.
- Fossil fuel (coal, lignite) is non-renewable source of heat energy. By way of co incineration of high calorific waste material (Agro waste and industrial generation the plant is able to replace as high as 10% to 15% of fossil fuel.
- Reduction of Green Gas Emission
- Protect environment and controlling emissions

This innovative project has been registered as CDM (Clean Development Mechanism) project. This is a very significant occurrence in any cement industry and by reducing $CO_2$ emission, this project is going to benefit the unit by around 32 Cr over the years.

Alternative Fuel consumption on TSR basis:

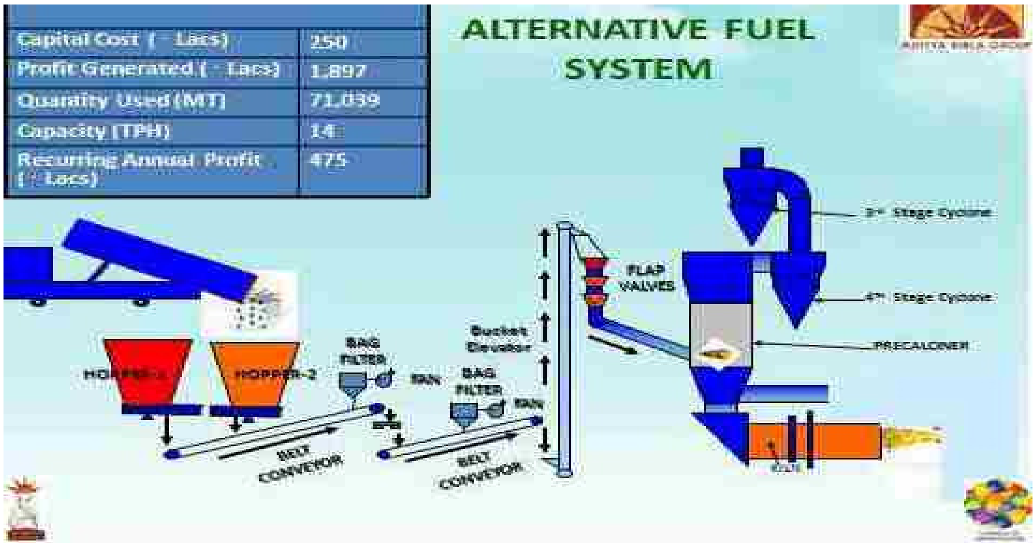



The various alternative fuels used at Reddipalayam Cement Works are:

DORB, Cashew nuts shells, Plastic Waste, Bio-compost, Municipal Solid Waste, Coir Waste/dust, Coffee husk, Palm seed shell, Wood strips, Shredded tyres, Wooden dust, Paint sludge, Carbon powder etc.

**Issues faced during implementation**

Since various alternate fuels have different chemical compassion and characteristics like ash %, alkalis content and harmful metals / chemicals etc., it was required to adjust the chemistry of other inputs to maintain consistent quality in the output. It was a challenge to Quality Control team, which they could deliver with their in-house research. Since there was no impact on the quality, the customers were not affected.




<u>**Alternative Fuel Feeding System at Site**</u>

The unit had modified the process to handle multiple fuel in pre-calciner as shown below

**1. Installation of plastic Shredding machine (Capacity 400 Kg/Hr):** Hazardous plastic materials are shredded to small pieces and dispose in calciner for combustion process.

**2. Wood Cutting machine (Capacity 300Kg/Hr):** Wood cutting machine scrap woods cut down to small pieces and fed to calciner for combustion.

**3. Shredder Machine:** Plastic shredder machine 10 TPH with mechanised system .This helps to reduce the size of solid AFR less than 50 mm; however for plastic material the size is not reduced below 300 mm therefore a screening arrangement is planned underneath the discharge of new shredder, which will collect the bigger size plastic material and recirculation back into shredding machine for rethreading.

**4. Apron feeder:** Apron feeder width 1200 mm is installed and commissioned to avoid hopper


discharge chute jamming thereby improve flow ability.

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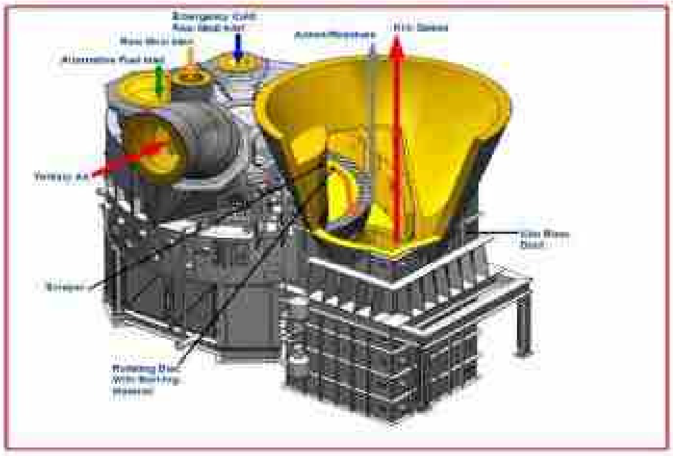
## Case Study No. 11

## Installation of HOTDISC for increasing thermal substitution rate at Kesoram Industries Ltd., Unit Vasavadatta Cement, Sedam, Karnataka.

Vasavadatta Cement is a division of Kesoram Industries Ltd., situated at Sedam, Karnataka. It has 4 kiln lines of operating capacity 2400 TPD, 3600 TPD, 4500 TPD & 4500 TPD.

For increasing the thermal substitution rate and to feed different types of alternative fuels Vasavadatta Cement has installed HOTDISC. The HOTDISC is a safe, simple and effective combustion device that maximizes the substitution of fossil fuels by alternative fuels in a controlled and environmentally sound manner. The hotdisc is installed at pyro-processing unit-3 in September'12.

This State of art technology is first of its kind in India, for cement industry to utilize Refused Derived waste & Tyres in cement rotary kiln as alternative fuel in efficient way with compliance with all the environmental regulations. The Hotdisc is supplied by FLSmidth.



The Hot Disc is a simple combustion device, integrated with the pre-heater and calciner systems. The HOTDISC gives the flexibility to burn a wide variety of solid waste in sizes up to 1.2 m – from sludge or grains to whole truck tyres.

Features of HOTDISC Technology:

- Combustion of Alternative Fuels takes place in Oxygen rich atmosphere.
- Variable retention time based on the type of Alternative Fuel is possible to ensure complete combustion.
- Can accept lumpy materials – Whole truck Tyre, baled material, etc, apart from the small size materials.
- Longer retention time, 10-45 minutes
- Calciner TSR of upto 60 % can be achieved.

Working principle:

As an integrated part of the kiln system, the HOTDISC is added onto the calciner and functions as a moving hearth furnace. The waste fuels are introduced via the tertiary air duct to the slowly rotating disc where they start to burn in fully oxidising conditions when meeting the hot tertiary air. When alternative fuel, preheated raw meal and tertiary air are fed into the HOTDISC, it produces combustion gases, partly calcined meal and combustion residues. These are then processed in the calciner along with the other streams that go into the calciner. The result is calcined meal ready for the kiln and well-controlled emissions.

Fig: Hot disc reactor at Vasavadatta Cement.


Benefits of Hotdisc:

- Reduction in Calciner coal firing ~ 7 TPH (TSR >30% based on AF availability)
- Reduction in laterite consumption (0.4% ) due to steel wires in tyres
- Nox reduction (PPM) at main stack from base line test: 35%

Alternative fuel feeding rate & other parameters with Hotdisc at Vasavadatta Cement:

- Feed rate of shredded tyres: 3.5 TPD
- Feed rate of RDF: 10 TPH
- Speed of Hot disc:-4-5 RPH
- Temp level inside hot disc: 1150 $^{o}$C
- Preheater meal diversion towards hotdisc: 20%

Fig: RDF & waste tyre handling system

Fig: Whole tyre feeding system

Alternative fuel consumption at Vasavadatta Cement:

<table>
<tr><th>Different Types of AFR Consumed (in MT)</th><th>2012-13</th><th>2013-14</th><th>Coal Saved Indian</th><th>Coal Saved Imported</th><th>% Share of AFR</th><th>Rs.in lac Saved</th></tr>
<tr><td>Benzo Feron</td><td>359.26</td><td>640.81</td><td rowspan="9">14876</td><td rowspan="9">2484</td><td rowspan="9">2.576</td><td rowspan="9">415.48</td></tr>
<tr><td>Tyre Chips</td><td>1,980.06</td><td>251.00</td></tr>
<tr><td>Carbon Black (Cement Plant)</td><td>572.94</td><td>9434.73</td></tr>
<tr><td>PU Waste</td><td>19.13</td><td>17.46</td></tr>
<tr><td>Rubber Chips</td><td>0</td><td>875.55</td></tr>
<tr><td>Plastic Waste</td><td>0</td><td>1047.66</td></tr>
<tr><td>Stalk (Agricultural Waste)</td><td>0</td><td>1263.78</td></tr>
<tr><td>N-butonol</td><td>0</td><td>33.51</td></tr>
<tr><td>Muncipal Waste</td><td>85.68</td><td>36.93</td></tr>
</table>

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## ENERGY EFFICIENT TECHNOLOGY 6 :

### Increase the PPC Production / % addition of Fly Ash in PPC Manufacturing

The increased use of fly ash in Portland Pozzolona Cement (PPC) directly impacts the reduction of clinker factor in cement thereby reducing fuel combustion and reduced limestone calcinations.

Fly ash conforming to standard IS: 3812 (1) 2003 can be used (up to 35% maximum) in the manufacture of PPC as per IS: 1489 (part 1) 1991. The role of fly ash in PPC is attributed to the pozzolanic action leading to a contribution to strength development. Studies carried out on the Indian fly ash samples have indicated that the range of glass content varies between 15 and 45% and the Lime Reactivity (LR) between 2.0 and 7.0 mpa.

The fine fraction of fly ash below 45 micron is a major portion, and contributes predominantly to the performance of PPC. This particular aspect of fly ash is very important with a view to enhance the % of use of fly ash in PPC and concrete and needs further thorough and systematic investigations to arrive at adoptable methodologies of using finer fly ash at higher levels. The quality of the clinker and suitable and adequate admixture addition will improve the fly ash absorption. The addition of plasticizers will help in fly ash absorption in concrete applications.

The average fly ash % utilisation in Indian cement industry is around 27%.

## Case Study No. 12

## Increasing fly ash addition in PPC by superfine fly ash grinding-Ambuja Cement Rabriyawas, Rajasthan

Ambuja Cement, Rabriyawas is situated in Rabriyawas village in Pali district in Rajasthan. It has one kiln with capacity 6000 TPD upgraded in Sept 2007. It has 2 cement mills. One is ball mill with 120 TPH capacity and other mill is ball mill with roller press as pre-grinder of 250 TPH capacity.

Ambuja Cement Ltd., Rabriyawas has increased the fly ash consumption by 2% from 26.62% to 28.48% by adding 2% superfine fly ash in PPC. This leads to reduction of clinker factor to 62.5%. The details of the projects is as below:

Objective:

- To produce activated superfine fly ash from Cement mill-2
- Enhancement of fly ash addition percentage with minimum investment cost
- To create data base & practical approach prior to install roller press in CM-1 & continuous grinding of fly ash in CM-2 with proper blending system.

Concept:

- Raw fly ash was grounded in CM-2 to produce superfine fly ash (5% R on 45 µ).
- Installation of superfine fly ash dozing system to PPC product air slide to enhance fly ash doses.

**Modification in Cement Mill-2 prior to grinding of fly ash:**

- Cement mill-2 was selected for the trial run
- Modification in the mill feeding system to feed the raw fly ash into the mill inlet from 80 MT bin on consistent basis
- Grinding media of Chamber-I was changed from existing 90,80,70 & 60 mm to 25 mm approx 65 MT
- Diverter mounting at ESP & product air slide for taking material towards fly ash elevator instead of product air slide
- Modification in mill product transport air side to store superfine fly ash in 3000 MT silo
- Addition of Superfine fly ash into PPC product air slide with in-house air slide blender arrangement before the final mixing into silo feed bucket elevator.

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