Confederation of Indian Industry

Cement Manufacturers' Association

Energy Benchmarking for Cement Industry

May 2014

Disclaimer

While every care has been taken in compiling this manual CII- Godrej GBC does not accept any claim for compensation, if any entry is wrong, abbreviated, omitted or inserted incorrectly either as to the wording space or position in the Manual. The Manual is intended to be a store of information that will serve as a ready to use reference for the plant personnel involved in production, operations and energy conservation. The source bank for this manual is based on questionnaire submitted by the participating cement plants, data from CII's energy award questionnaire, case studies shared by suppliers in various CII's conferences and CII's experience from various detailed and preliminary energy audits. This manual is an attempt to bring out all the best practices adopted and best energy levels achieved by the cement Industry. While utmost care has been taken to bring out the best operating data, how ever there might have been sections and plants operating better than the results indicated, that may have missed our notice.

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R R District, Hyderabad - 500 084, India.

MESSAGE

CII-Sohrabji Godrej Green Business Centre, as part of its 'World Class Energy Efficiency initiative', has been releasing various publications/ manuals/ case study booklets, pocket guides, etc. on a regular basis to equip Indian industry with the latest trends & technologies and in the process enable them gain the much needed competitive edge.

The strategy adopted by CII is to learn from peers on their new & innovative strategies and after extensive ground work compile the learnings into a publication, which can be shared with all the stakeholders.

As part of this initiative, we have compiled this important publication- 'Energy Benchmarking for cement industry'.

This publication includes section- wise best specific energy consumption levels achieved by various Indian cement plants and the strategies adopted thereof in bringing down the consumption levels.

We are sure, this manual will provide immense opportunities in unearthing new energy saving opportunities and also enable in exploring new growth opportunities.

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.

(G. Jayaraman)
Chairman, Green Cementech 2014, CII- Godrej GBC &
Executive President, Birla Corporation Ltd.

MESSAGE

Indian cement industry is playing a very important role in the overall development of the Nation. The Sector is also in the forefront in adopting the latest and emerging technologies, which is not only bringing down the energy consumption levels but is also making good business sense. This, indeed, is a step in the right direction and augurs well for both economy and ecology.

I am pleased to record that Cement Manufacturers' Association (CMA) established in 1961, being the apex body of large cement manufacturers in India, has been acting as an effective bridge between Indian Cement Industry and the Government.

Over the years, Cement Manufacturers Association (CMA) association with CII has grown steadily and has been adding great value to the stakeholders. CMA in partnership with CII has been organising conferences on varied subjects and bringing out various technical publications/manuals.

A major step towards this direction is publishing –'Energy benchmarking for cement industry'. This Manual includes some of the best performance energy consumption data for various sections of cement plant and best practices adopted. We are sure, this Manual will enable the cement plants in achieving excellence in energy management and provide strategies for ensuring long-term competitiveness.

As we march together, we are sure, our partnership will facilitate in consolidating India as one of the global green leaders in Cement Sector.

(N.A. Viswanathan)
Secretary General
Cement Manufacturers' Association

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ACKNOWLEDGMENT

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 study, which makes this manual more useful to all stake holders.

CII-Godrej GBC acknowledges with thanks the co-operation and the support extended by all 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 entire national and international cement technical experts and associations for sparing their valuable time in offering inputs and suggestions in bringing out this manual.

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

EXECUTIVE SUMMARY

The Indian cement industry is one of the most efficient in the world and continuously adopting the latest technologies for energy conservation. Energy efficiency in the Indian cement industry is already high but still there is a scope for improvement in this area, providing the continued use of energy efficient technologies in new plants and old plants.

In an objective to further increase the transfer of knowledge among the industry CII –Godrej GBC has prepared the benchmarking manual for the Indian cement Industry. The main intention of the benchmarking study is to continue the knowledge sharing and allow all cement industries to compare their performance with the peers in India and identify their performance aspects. CII –Godrej GBC has prepared a detailed questionnaire involving all sectional parameters starting from crusher to packing plant. The questionnaire has been sent to more than 140 cement factories to fill-in the data. The majority of plants from all over India have participated in this benchmarking study and different parameters are recorded in various sections from the data provided by the plants.

The Collected data is classified in different sections and each individual section is compared with respect to section wise specific energy consumption and other parameters.

The best operating values and the outcomes of the study is as follows

- In raw material grinding vertical roller mil is consuming 13.3 kW/MT raw material compared to ball mill consumption 16.5 kW/MT raw material.
- In Pyro section with five stage preheater the best operating SEC up to clinkerisation is 16.28 kW/MT clinker where as in six stage preheaters the value is close to 23.7 kW/MT clinker.
- In cement mill section ball mill in closed circuit is operating with 27.16 kW/MT cement where as ball mill with pregrinder is operating at 23.75 kW/MT cement and vrm is operating with 21 kW/MT cement
- In over all electric SEC the best plants are standing near 67.2 kW/MT cement and in thermal SEC 6 stage preheaters are operating at 690 kcal/kg clinker whereas 5 stage preheaters are operating near 709 kcal/kg clinker.

The other important outcomes of this study are 300 best practices implemented in national and international cement plants and more than 50 performance indicators in cement industry, all recorded at one place for the benefit of the industry. Monitoring techniques with the parameter to be monitored and frequency of monitoring is also provided in each section to further aid the stake holders in achieving energy efficiency.

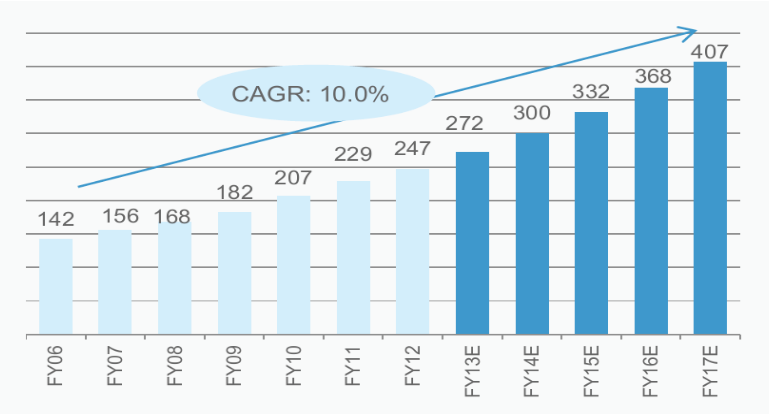
Finally the benchmarking reveals the best values at which the industry is operating each section and the best practices and technologies to be adopted to become as leader in energy efficiency.

CHAPTER-1
INTRODUCTION

1.0 Indian Cement Industry Present Scenario

India's cement industry plays a vital role in the growth and development of the nation. The cement industry has been expanding with increasing infrastructure activities and demand from residential buildings over the past many years. India's cement sector has achieved a 5.6 [1].per cent growth in 2012–13. The Indian Cement Industry has 146 integrated cement plants and 55 grinding plants accounting to a total capacity of 365.5[2] million tons.

The Indian cement sector is expected to witness positive growth in coming years, with demand set to increase at compound annual growth rate (CAGR) of more than 8 per cent during 2013–14 to 2015–16, according to report titled, 'Indian Cement Industry Outlook 2016'. In addition, cement production in India is expected to touch 407 million tonnes (MT) by 2020.



Actual and Expected Production of Indian cement Industry (million tones)

Source: *Department of Industrial Policy and Promotion, Working group for 12th Five Year Plan, Aranca Research Notes: E - Estimate, CAGR - Compound Annual Growth Rate*

1 Indian Brand Equity Foundation (IBEF) updated report on March 2014 http://www.ibef.org/download/Cement-March-2014.pdf

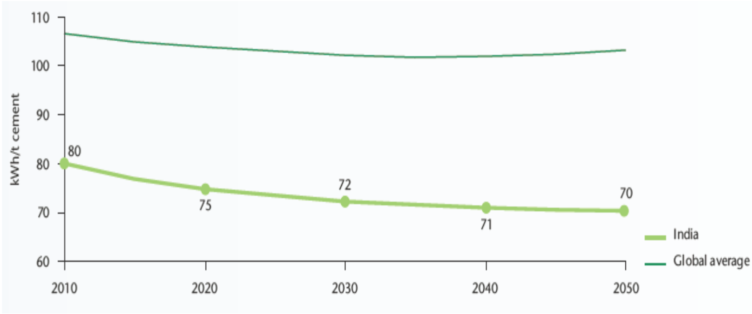
2 Global Cement Directory 2013

1.1 Major Players in Indian Cement Industry

Although the Indian cement industry has some international cement giants Holcim and Lafarge, the Indian cement industry is broadly home developed. Ultratech Cement the country's largest firm in terms of cement capacity, holds around 22% of the domestic market, with ACC Limited and Ambuja Cements Limited having 15% and 13% shares respectively. The others Indian key players (in order of market share) include Jaiprakash Associates (10%), The India Cements Ltd (7%), Shree Cements (6%), Century Textiles and Industries (5%), Madras Cements (5%), Lafarge (5%), Birla Cement (4%) and Binani Cement (4%)[3].

1.2 Energy Efficiency in Indian Cement Industry

The Indian cement industry is one of the most efficient in the world and is continuously adopting the latest technologies for energy conservation. Energy efficiency in the Indian cement industry is already high but still there is a scope for improvement in this area, provided there is a continued use of energy efficient technologies in new plants and old plants. The Indian cement industry should deploy existing state-of-the-art technologies in new cement plants and retrofit existing plants with energy efficient equipment when commercially viable. The present graph shows the current and future specific energy consumption trends in the cement industry.



Comparison of Global and Indian Electrical SEC[4]

A number of plants installed before the 1990s have been modernized to a limited extent by retrofitting with new technologies. However, they need to aim at bringing specific energy consumption levels closer to the best achieved levels in the Indian industry by further modernization and adoption of best available processes and technologies.

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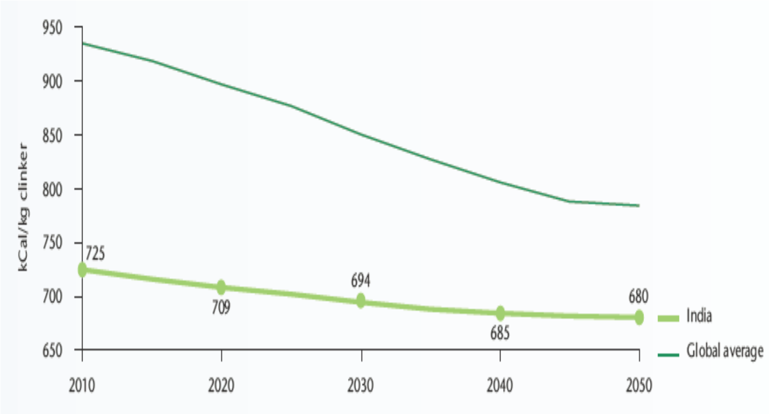
3 Global Cement Directory 2013 PRo Publications International Ltd., Epsom, UK, November 2012

4 Technology road map -Low carbon technology for the Indian cement industry



Comparison of Global and Indian Thermal SEC
Source: Low carbon technology for the Indian cement industry

1.3 Factors favoring Energy Efficiency in Indian cement Industry

Knowledge Transfer: Cement Industry is known for its technology sharing and openness in the industry. This is benefiting the Industry in replicating the best practices in their organizations without any hesitations.

Technology Upgradation: The Indian cement industry has been growing at a rapid pace during the late 20th and early 21st centuries; about 50% of Indian cement industry's capacity today is less than ten years old. While building these new cement plants, manufacturers have installed the latest, energy efficient technologies by design. As a result, recent cement plants achieve high levels of energy efficiency performance.

Increase in Energy cost: The other important aspect electricity tariffs and fuel price for industry in India being among the highest in the world, implementing such energy efficiency measures at the design stage provides significant advantage to the cement manufacturers by lowering energy and production costs. Increasing energy costs also prompted owners of older manufacturing facilities to adopt gradually the latest energy efficient technologies and improve their energy performance.

Government Initiatives: Another factor which is enabling energy efficiency movement in India is The Ministry of Power's Bureau of Energy Efficiency (BEE)-Perform achieve and trade. The key goal of the scheme is to mandate reduction in specific energy consumption for the most energy-intensive industries, and incentivize them to achieve better energy efficiency improvements that are superior to their specified specific energy consumption improvement targets. The star rating program for the equipment is also bringing revolutionary changes in the energy consumption levels.

Technology Suppliers: The most efficient global technologies have been adopted in the major Indian cement plants due to the continuous efforts in bringing the innovation and advancement in the technology. There is good interest shown by international suppliers to enter into Indian market to supply the energy efficient technologies.

Associations: Industry Associations like CII, CMA and key organisations like NCBM are continuously working for the benefit of cement industry. These associations are closely working with government in promoting the growth of the industry.

1.4 CII- Sohrabji Godrej Green Business Centre Initiatives for Cement Industry

In the efforts to promote sustainable development of cement sector and demonstrate that green makes good business sense, CII - Sohrabji Godrej Green Business Centre (CII –Godrej GBC) with the support of all the stakeholders is playing a catalytic role in promoting World Class Energy Efficiency initiative in cement industry.

Some of the initiatives from CII-Godrej GBC in Indian cement Industry include the following:

1. Development of world class energy efficient cement plants: CII-Godrej GBC have been working with all the major cement plants in the energy efficiency and sustainable front and significant benefits have been achieved and reported by these units

2. CII-Godrej GBC is also organizing national and international missions to facilitate the industry to achieve excellence in energy and environment.

3. CII –Godrej GBC is organizing an annual international conference Green Cementech to provide the latest information and technology update for the benefit of cement industry.

4. Development of a technology road map to make the Indian cement industry pursue a low carbon growth path by 2050, Three units are identified for the feasibility of implementation of these technologies and few more expressed their interest in participating in this initiative.

5. Facilitating cement plants in pursuing the PAT (Perform Achieve and Trade program of BEE) targets in a cost effective manner.

6. CII in association with Cement Manufacturers Association (CMA) is working on an initiative to facilitate development of enabling policies and framework by State and Central Pollution Control Boards, to facilitate use of urban & industrial waste as Alternate Fuel & Raw Materials (AFR) in Indian cement industry. The main objective of the project is to accelerate AFR usage in Indian Cement industry.

CHAPTER-2
BENCHMARKING IN CEMENT INDUSTRY

2.0 Objective of Benchmarking:

With the openness and knowledge sharing across the plants Indian cement industry has emerged as a leader in energy efficiency. With an objective to further increase the transfer of knowledge among the industry CII–Godrej GBC has prepared the benchmark for the Indian cement Industry. The main intention of the benchmarking study is to continue the knowledge sharing and allow all cement industries to compare their performance with the peers in India, identifying the aspects of their performance as good, bad and indifferent. This will add momentum in the Indian cement industry to perform more in energy efficient front.

Benchmarking comprises the analysis and reporting of key energy performance Indicators to foster continual energy performance improvements in industry through comparison with internal and external norms and standards. An energy benchmarking analysis generates two important perspectives; it provides an overview of how well a particular industry sector or sub-sector is doing in managing energy performance. Second, it enables company participants to perform a benchmarking exercise to compare the performance of their own plant(s) with the overall industry indicators.

2.1 Approach adopted in benchmarking study

CII –Godrej GBC has prepared a detailed questionnaire involving all sectional parameters starting from crusher to packing plant. The questionnaire has been sent to more than 140 cement factories to fill-in the data. The majority of plants from all over India have participated in this benchmarking study and different parameters are recorded in various sections from the data provided by the plants.

This study describes work with the Indian cement industry to provide a plant-level indicator of energy efficiency and equipment efficiency for plants that produce a variety of products, including ordinary Portland cement (OPC), Portland pozzolana cement (PPC), Portland slag cement (PSC) and other speciality cement products.

Benchmarking provides a more detailed comparison of a particular aspects of operations i.e., energy efficiency, equipment productivity and environmental performance.

The following specific indicators are compared in the benchmarking study.

- Specific thermal energy
- Specific electrical energy in each section
- Equipment efficiency
- Equipment productivity

- Equipment reliability
- Auxiliary power consumption in captive power plant

The cement industries who wish to have an annual or periodic comparison of key performance indicators across the range of cement industry will find this benchmarking study extremely helpful. The idea of benchmarking study is not only to identify the opportunities to improve energy efficiency but also to understand the underlying factors that impede the implementation of the energy conservation opportunities.

To address these challenges, CII-Godrej GBC has started a comprehensive benchmarking study. This benchmarking exercise will answer all typical questions which revolve in the minds of plant team:

- What is my plant's energy performance?
- How can I compare to others in the domestic industry?
- What are the reasons for the differences?
- What opportunities for improvement are available?
- What are the parameters to be monitored?
- What is the potential economic advantage that might be realized?

Finally this report describes the basic concept of benchmarking and the statistical approach employed, more recent experience gained in developing performance-based energy indicators for the Indian cement industry.

CHAPTER-3
BENCHMARKING IN VARIOUS SECTIONS

3.1 SINGLE STAGE CRUSHERS

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
No. of stages	-	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
Material hardness	-	soft	medium	hard	hard	medium/ hard	hard	hard	medium/ hard	medium	hard
Product size	%	+50 mm : 4	7.9	<150 mm	80	<5	5 % on 50MM	100% passing 50 mm	<5-10	0	80
Operating output	TPH	500	430	909	643	1245	900	1550	1800	1296	187
Material moisture	%	8	10-12	1	< 1	0.5-1.0	4-6	< 4	0.5-1.0	2-3	<1
Specific power con-sumption	kW / MT Limestone	0.70	0.75	0.84	0.92	1.02	1.20	1.32	1.33	1.44	1.83
Crusher MD		0.50	0.38	0.45	0.44	0.53	0.67	0.46	0.49	0.36	0.59
Bag filter Fan		-	-	-	0.1	-	-	-	-	-	-

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
0.49	0.53	0.85	0.47	1.08	0.12	-	-	-	-	-	-
Compressor	-	-	0	-	0.05	-	-	-	-	-	0.07
Total (Crusher alone)	-	-	0.38	-	0.92	1.02	1.20	-	1.33	1.44	1.83
Pre Blend-ing	-	-	0.35	-	-	-	-	-	-	-	-
Overall	-	0.70	0.73	0.84	0.92	1.02	1.20	1.32	1.33	1.44	1.83

3.2 TWO STAGE CRUSHERS

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6
No. of stages	-	two	two	two	two	two	two
Material hardness	-	soft	medium	hard	soft	hard	medium
Product size	%	15%	6.5 % retained on 75 mm screen	<90mm	Nil	<25mm	nil
Operating output	TPH	950	750	716	475	295	182
Material moisture	%	13	11 to 13	1	< 2.0	1	1
Specific power consumption	kW / MT Lime-stone	0.65	0.91	0.94	1.23	1.59	2.35
Crusher MD	-	0.45	0.65	0.60	0.87	1.20	1.70
Bag filter Fan	-	-	-	-	0.047	-	0.200
Compressor	-	-	-	-	0.037	-	0.150
Total (Crusher alone)	-	-	0.26	-	1.196	-	-
Pre Blending	-	0.20		-	0.034	-	-
Overall	-	0.65	0.91	0.94	1.23	1.59	2.35

3.3 RAW MILL-VRM

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Material hardness	-		medium	hard	soft	hard	hard		medium	medium	medium / hard
Product size	%	20	16-17	11 -12	18	11 -12	13.50	21	20-22	18	18.5-19.5
Operating output	TPH	320	225-230	290	400	330	190	403	276.5	292	285
Feed Material moisture	%		1-3	2	13	2	2	1	1	2-3	0.5-1.0
Mill DP	mmwc	740	900-930	750	600	480	680	750	480-530	500 -550	400
Mill model		L38/44	LM 30.3+3	LM 46.4	ATOX 42.5	Atox 42.5	LM32.40	UM 50.4	ATOX-45	ATOX 45, 4.5Φ and 3 Nos Rollers	AM - R–50 (TD: 5m RD: 3m -3Rollers)
Mill fan flow	km^3/hr	647	340-350	480	800	765	395	745.9	600	620 to 640	757
Cyclone pressure drop	mmwc	100	150-170	50	900	50	50	120	80	90-110	60-70
False air in the circuit	%		20-25	20	25	20	28	17	15	15-18	15-18
Sep loading	Kg/m^3	0.49			0.50			0.54	0.55	0.45	0.38
SEC											

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Mill drive		6.0	3.5-4.0	6.1	5.5	6.3	6.5	9.2	9.5	9.1	11.8
Mill fan		6.4	6.2-6.5	6.05	7.7	7.7	7.0	5.6	6.0	7.2	7.3
Aux		0.9	3.0-3.5	1.67	1.8	1.93	2.5	1.1	1.66	1.71	1.92
Overall		13.3	13-14	13.8	15.0	15.9	16.0	16.0	17.1	18.0	21.2

3.4 RAW MILL - BALL MILL/HPRG GRINDING

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Material hardness	-	hard	11-15	soft	medium	medium	11-15	13.4	hard	11-15
Product size	%	10.0	17-18	13.0 – 15.0	18.0	20-22	31-33	12.0	40.0	22-24
Operating output	TPH	160	290-300	180-185	240	129	245-255	70	80	165-175
Feed Material moisture	%	2	1-5	< 1.5	3-5	1	1-5	1	6.8	1-5
Velocity inside mill	m/sec	1.1 – 1.2	-	8.6	-	1.5	1.9	1.8	1.5	2.5-3.1
Mill spec	Dia x length	3.00 x 10.00	No ball mill	4.20 x 14.07	KPP 850/17-1500-1730 x1500-S-C	TUM 2.4 + 8.75 x 50, ID 4.6 metres, OD 5.06 m	5.0 x 9.75 2.40 (drying chamber)	R1&2: 3.4x12 & R3: 3.4x7.6	3.8 x 9.5 FKCP (Closed Circuit)	4.6x11.25 0.3 (drying chamber)
Sep fan flow	m^3/hr	-	585000	-	450000	-	125000	-	-	174000
Cyclone pressure drop	mmwc	120	70	65-75	90-110	35	-	-	350	Sep inlet to Cyclone outlet:300

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Grinding media piece wt	gm	-	-	450	-	310	-	1325	800	-
Grinding media surface area	m^2/ MT	-	-	20.31	-	-	-	20.6	26.27	-
Sep loading	Kg/ m^3	-	-		1.04	NA	3.5-4	NA	1.1	2-2.2
Circulating load			-	198%	5.25	1.9	263	2.5	212 MIC -105.81 90MIC-123.91 45MIC-164.04.	250
% sep vent volume		-	-	-	-	-	-	-	109072	-
SEC										
Mill drive		6.2	-	12.7	-	18.5	13.5	17.9	18.9	19.3
RP		7.5	8.5	-	10	-	3.8	-	-	2.1
Mill Sep fan		-	5.5	1.4	-	1.5	0.7	-	2.8	4.1
Mill vent fan		0.2	-	1.8	-	0.6	-	-	-	-

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Sept vent fan		3.1	-	-	-	-	1.9	-	-	-
Sep fan for RP		-		-	4	-	-	-	-	-
Overall		16.5	16.8 - 17.5	17.9	18.0	20.6	20.9 - 21.2	23.1	25.1	25.5 - 26.3

3.5 COAL MILL

Parameter	Unit	Plant-1	Plant-2	Plant-3	Plant-4	Plant-5	Plant-6	Plant-7	Plant-8
Mill Type		VRM	VRM	VRM	VRM	VRM	VRM	VRM	VRM
Coal Composition	%	Imported Coal 100 %	Imported Coal 30 % Indian Coal 70%	Imported Coal 100 %	Petcoke 40 %, Indian Coal 30 %, Imported coal 30 %	Imported + indian	Petcoke 100 %	Pet coke	Petcoke 100 %
Mill Output	TPH	33.75	30	33	81	35	25	25	14
SEC	kW/MT								
Mill Drive		14.5	8.8	10.7	14.5	13.3	13.1	12.4	15.1
Mill fan		5.9	8.8	12.7	11.9	10.9	11.5	19.2	18.4
Aux		3.5	9.3	3.8	2.9	5.9	5.7	6.0	7.4
Total SEC		23.9	26.9	27.2	29.3	30.2	30.3	37.6	40.9

3.6 COMPARISON OF FIVE STAGE PREHEATERS

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant-4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
KILN out-put rated	TPD	4500	4000	4000	3200	3850	3800	1200	2800	3150	2800
Kiln output operating	TPD	4670	4600	4800	3500	4400	4300	1300	2800	3250	2650
PH type	ILC / SLC	ILC	ILC	ILC	ILC	ILC	ILC	ILC	SLC	ILC	ILC
No of PH strings		Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
Calciner exit O2 / CO	%	1.8 /0.01		2.5	1.5/0.00		0.9 O2	1 O2	1.99/ 0.84	4.5/NIL	2.1
PH exit temp	Deg C	260	335	305	333	338	315	318	320	310	320-330
PH exit flow	Nm^3/kg clinker	1.39	1.46	1.53	1.58	1.50	1.43	1.78	1.61	1.65	1.48-1.51
PH exit pressure	mmwc	380	-500	520	420	-540	520	-	760	-760	640
Pressure at PH fan inlet	mmwc	395	-585	580	430	-560	590	570	780	-820	650
False air across PH	%	4	-	5	2	6	13	13	9	4	10

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant-4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Speed control for PH fan		VFD	GRR	GRR/ SPRS	VFD	VFD	GRR	GRR	GRR	SPRS	GRR
Speed control for Kiln Bag house fan		MV VFD	VFD	GRR/ SPRS	VFD	VFD	GRR	VFD	VFD	DC Drive	Damper control
Kiln Bag house fan flow	Nm^3/kg clinker	2.2	2.0	1.2	2.0	2.5	2.4	3.3	1.8	2.4	2.2
Kiln Bag house DP	mmwc	100	90-120	100-110	115	90-120	125	120	125-135	28	40-55
Kiln Bag house inlet pressure	mmwc	30	-60	50	50	-60	55	60	30-35	-102	-
Kiln Bag house type		RABH	RABH	RABH	RABH	RABH	RABH	RABH	RABH	ESP	ESP
Kiln size	Dia xlength	4.35 x 67	3.95 x 65	4.15 x 64	3.95 x 62	3.95 x 62	3.95 x 61	3.2 x 48	3.8 x 60.75	3.75 x 57	3.8 x 56
Volumetric loading	TPD/ m^3	5.6	5.8	7.0	5.0	5.7	7.0	4.3	4.5	6.5	5.2
Thermal loading	Mkcal / hr /m^2	4.2	4.0	4.9	3.3	5.8	5.0	2.6	2.2	4.6	3.1

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant-4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Phase density – PC firing	kg coal / kg air	2.4	2.0	4.2	2.7	3.1	5.5	2.5	3.3	1.4	2.9
Phase density – Kiln firing	kg coal / kg air	1.2	1.0	1.1	2.6	2.3	1.2	1.4	1.9	2.0	1.4
Type of cooler		3rd generation (SF Cross Bar Cooler 4 *5)	3rd generation	SF CROSS BAR COOLER / WITH STATIC / 3RD GENERATION	CIS/CFG GRATE COOLER	3rd generation	(3x5)SF-Cross Bar Cooler	Grate Cooler	Grate-With CIS-MFR	FLSCross Bar Cooler (10x48)	RECIPROCATING GRATE (KHD) 57.45 m2
Cooling air flow	Nm^3/kg clinker	1.7	1.7	1.7	2.2	1.9	1.8	2.2	2.1	1.9	2.2
Clinker temp	Deg C	125	165	140	120	173	180	170	120- 150	120-130	135-145
Cooler water spray	m^3/hr	1.2	5.5	-	4.5	6.0	14.0	3.7	5.0	-	5-6
Loss in PH gas	kcal / kg clinker	126	178	161	184	182	140	185	176	195	160-165

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant-4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Loss in Cooler vent	kcal / kg clinker	99	72	85	105	73	109	119	87	67	110-115
Loss in clinker	kcal / kg clinker	25	31	39	27	32	35	33	33	30	28-30
Loss in cooler water spray	kcal / kg clinker	5.0	16.0	-	-	21.0	2.2	1.7	23.2	-	5.5
Thermal SEC	kcal / kg clinker	707	709	715	732	729	710	780	772-775	737	725-735
SEC											
PH fan		3.6	6.3	6.8	6.8	8.2	7.3	8.5	11.6	10.9	9.8
RABH fan		1.6	2	3.0	3.7	3.5	3.9	3.3	2.2	2.9	-
Cooler fans		5.4	5.8	4.8	4.9	5.0	5.0	3.7	6.3	5.9	4.8
Cooler vent fan		-	0.12	0.15	-	0.20	1.10	1.35	0.40	0.24	1.02
Kiln drive		1.39	1.40	1.68	1.43	1.69	3.95	5.08	1.25	1.50	1.49
Kiln feed		1.68	2.65	1.40	-	2.97	0.65	0.57	1.29	1.00	0.72
Aux		0.39	-	3.80	5.14	-	0.83	1.82	3.01	6.09	9.00
Clinkerisa-tion		16.28	18.30	21.80	22.08	23.00	23.40	24.38	26.10	28.63	31-32
Upto clink-erisation		49.94	46.00	53.37	55.99	57.20	58.40	69.55	64.54	59.63	74-75

3.7 COMPARISON OF SIX STAGE PREHEATER

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7
KILN output rated	TPD	3800	3300	3800	5500	6500	4200	8000
Kiln output operating	TPD	5000	3700	5000	5750-6000	7810	4350	9558
PH type	ILC / SLC	ILC	ILC	ILC	ILC	SLC	ILC	Pyroclone, KHD
No of PH strings		Single	Single	Single	Double	Double	Single	Double
Calciner exit O2 / CO	%	2.0-2.1	2.8	2.0-2.1	1.5-2.5/ 0 to 0.02	1.5-2.0	2.0	1.5-2.0
PH exit temp	° C	245	290	245	270-280	290-310	285-295	255-260
PH exit flow	Nm^3/kg clinker	1.67	1.50	1.67	1.60	1.45-1.48	1.43-1.47	1.45
PH exit pressure	mmwc	560	510	560	480-550	600	450	840
Pressure at PH fan inlet	mmwc	-50	555	-50	600	670	465	950
False air across PH	%	2	10	2	15	8	8	8
Speed control for PH fan		SPRS	GRR	SPRS	VFD	SPRS	VFD	SPRS

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7
Speed control for Kiln Bag house fan		SPRS	SPRS	SPRS	VFD	SPRS	VFD	SPRS
Kiln Bag house fan flow	Nm^3/kg clinker	450000-455000	2.1	450000-455000	2.1-2.2	2.0-2.5	2.2	1.7-2.0
Kiln Bag house DP	mmwc	110-120	-120	120-140	90-130	100-120	120-150	100-120
Kiln Bag house inlet pressure	mmwc	-60 to -70	-25	-60 to -70	90-110	45	-80	45
Kiln Bag house type		RABH	RABH	RABH	PULSE JET	RABH	RABH	RABH
Kiln size		4.55 x 56L	4.15 x 64L	4.55 x 56L	4.75 x 74L	4.75 x75L	4.15 x 64L	5.8 x 85L
Volumetric loading	TPD/ m^3	7.0	5.2	7.0	5.3-5.6	7.0-7.2	5.5	5.0
Thermal loading	Mkcal / hr /m^2	4.33	3.94	4.33	4.1-4.3	3.5-4.0	4.2	3.0
Phase density – PC firing	kg coal / kg air	-	-	-	2.8-4.0	3.0	5.67	2.5
Phase density – Kiln firing	kg coal / kg air	-	-	-	1.8-2.2	2.0	2.8	1.5

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7
Type of cooler		SF Cross Bar	Grate with static	SF Cross Bar	3rd Generation	Grate	Cross- Bar Cooler	3rd Generation (Pyrofloor Cooler)
Cooling air flow	Nm^3/kg clinker	1.68-1.80	2.19	1.68-1.80	1.50 -1.70	1.72	1.95	1.75
Clinker temp	° C	165-190	120	165 - 190	120-130	130-150	120-145	130-150
Cooler water spray	m^3/hr	-	12	-	2.5-3.0	6-7	6-7	15-20
Loss in PH gas	kcal / kg clinker	135 -138	155	135 -138	140-150	130-140	145-155	125-130
Loss in Cooler vent	kcal / kg clinker	94 - 98	103	94 – 98	95-100	105-110	100-108	110-115
Loss in clinker	kcal / kg clinker	24 -25	23	24 -25	22-25	20-25	25-28	20-25
Loss in cooler water spray	kcal / kg clinker	-	13	-	6-8	-	5.0-6.5	-
Thermal SEC	kcal / kg clinker	705	705	705	716	686	700-710	695
SEC								
PH fan		7.79	9.00	7.01	3.50	3.71	5.40	4.26

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7
Calciner Fan		-	-	1.21 (Booster fan)	3.5	5.95		4.27
RABH fan		2.74	2.10	3.44	3.9	2.74	1.65	2.65
Cooler fans		13.17	6.16	13.35	3.50	5.85	5.00	9.83
Cooler vent fan		-	1.00	-	1.20	1.08	0.50	0.70
Kiln drive		-	1.32	-	1.90	2.49	1.65	2.00
Kiln feed		-	-	-	0.60	3.97	0.92	3.02
Aux		-	5.19	-	7.41	-	-	-
Clinkerisation		23.7	24.7	25.0	25.5	25.8	26-27	27.5
Upto clinkerisa-tion		-	61.3	-	66.2	70.7	54-55	74.2

3.8 COMPARISON OF SEC AND PRODUCTION

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
KILN out-put rated	TPD	8000	5500	6500	6000	5500	4000	4000	3300	3200	2800
Kiln output operating	TPD	9558	8010	7810	6700	5750-6000	4800	4600	3700	3500	2800
PH type	ILC / SLC	Pyroclone, KHD	SLC	SLC	ILC	ILC	ILC	ILC	ILC	ILC	SLC
No of PH strings		Double	Double	Double	Double	Double	Single	Single	Single	Single	Single
No of stages		Six	Five	Six	Five	Six	Five	Five	Six	Five	Five
Calciner exit O_2 / CO	%	1.5-2.0	Kiln : 3- 3.5 / 0.08 max, Calciner : 1.5- 1.8 / 0.05 max,	1.5-2.0	2.50 / 0.001	1.5-2.5 / 0.00 to 0.02	2.5	-	2.8	1.5/0.00	1.99/0.84
PH exit temp	° C	255-260	350	290-310	295	270-280	305	335	290	333	320
PH exit flow	Nm^3/kg clinker	1.45	1.52	1.45-1.48	1.55	1.60	1.53	1.46	1.50	1.58	1.61

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
PH exit pressure	mmwc	840	860/960 (kiln/Calciner)	600	-375	480-550	520	-500	510	420	760
Pressure at PH fan inlet	mmwc	950	960/1100 (kiln/Calciner)	670	-440	600	580	-585	555	430	780
False air across PH	%	8.0	6-8 / 5-6 (kiln/Calciner)	8.0	5.0	15.0	5.0	-	10.5	2.0	8.9
Speed control for PH fan		SPRS	-	SPRS	GRR	VFD	GRR/ SPRS	GRR	GRR	VFD	GRR
Speed control for Kiln Bag house fan		SPRS	-	SPRS	VFD	VFD	GRR/ SPRS	VFD	SPRS	VFD	VFD
Kiln Bag house fan flow	Nm^3/kg clinker	1.7-2.0	-	2.0-2.5	1.6	2.1-2.2	1.2	2.0	2.0	2.0	1.8
Kiln Bag house DP	mmwc	100-120	-	100-120	110	90-130	100-110	90-120	-120	115	125-135

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Kiln Bag house inlet pressure	mmwc	45	-	45	-60	90-110	50	-60	-25	50	30-35
Kiln Bag house type		RABH	-	RABH	RABH	Pulse jet	RABH	RABH	RABH	RABH	RABH
Kiln size	Dia xlength	5.8x85L	4.75 x 75	4.75 x 75L	4.75 x 74	4.75 x 74L	4.15 x 64	3.95 x 65	4.15 x 64L	3.95 x 62	3.8 x 60.75
Volumetric loading	TPD/ m^3	5.0	7.5	7.0-7.2	6.0	5.3-5.6	7.0	5.8	5.2	5.0	4.5
Thermal loading	Mkcal / hr / m^2	3.0	5.2	3.5-4.0	5.7	4.1-4.3	4.8	4.0	3.9	3.3	2.2
Phase density – PC firing	kg coal / kg air	2.5	3.5	3.0	3.4	2.8-4.0	4.2	2.0	-	2.7	3.3
Phase density – Kiln firing	kg coal / kg air	1.5	3.0	2.0	2.2	1.8-2.2	1.2	1.0	-	2.6	1.9

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Type of cooler		3rd Generation (Pyrofloor Cooler)	Grate cooler – Folax – (4 nos Grates)	Grate	3rd Generation – SF crossbar cooler	3rd Generation	Sf Cross Bar Cooler / with Static / 3rd Generation	3rd generation	Grate with static	CIS/CFG Grate Cooler	Grate-with CIS-MFR
Cooling air flow	Nm^3/kg clinker	1.75	1.90	1.72	1.90	1.5 -1.7	1.75	1.72	2.19	2.20	2.19
Clinker temp	$^\circ C$	130-150	180-200	130-150	145	120-130	140	165	120	120	120- 150
Cooler water spray	m^3/hr	15-20	10.0	6-7	-	2.5-3.0	-	5.5	12.0	4.5	5.0
Loss in PH gas	kcal / kg clinker	125-130	175-180	130-140	128	140-150	161.57	178	155	184	176.25
Loss in Cooler vent	kcal / kg clinker	110-115	120	105-110	22	95-100	85	72	103	105	87.10
Loss in clinker	kcal / kg clinker	20-25	38	20-25	27	22-25	39	31	23	27	33
Loss in cooler water spray	kcal / kg clinker	-	-	-	-	6-8	-	16	13	-	23

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Thermal SEC	kcal / kg clinker	695	729	686	725	716	715	709	705	732	772-775
SEC											
PH fan		4.26	3.38	3.71	5.90	3.50	6.88	6.30	9.00	6.86	11.61
Calciner Fan		4.27	7.04	5.95	-	3.50	-	-	-	-	-
RABH fan		2.65	2.81	2.74	1.50	3.90	3.05	2.00	2.10	3.72	2.24
Cooler fans		9.83	6.28	5.85	5.80	3.50	4.85	5.80	6.16	4.93	6.30
Cooler vent fan		0.70	0.54	1.08	0.20	1.20	0.15	0.12	1.00	-	0.40
Kiln drive		2.00	1.88	2.49	2.21	1.90	1.68	1.40	1.32	1.43	1.25
Kiln feed		3.02	1.40	3.97	0.45	0.60	1.40	2.65	-	-	1.29
Aux		-	3.48	-	3.60	7.41	3.80	-	5.19	5.14	3.01
Clinkerisa-tion		27.50	26.81	25.80	19.60	25.51	21.80	18.30	24.70	22.08	26.10
Upto clink-erisation		74.29	65.40	70.78	55.00	66.24	53.37	46.00	61.30	55.99	64.54

3.9 COMPARISON OF SEC (UP TO CLINKERISATION)

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
KILN out-put rated	TPD	4000	4500	4000	4200	4000	3150	5500	1200	8000	2800
Kiln output operating	TPD	4600	4670	4800	4350	4400	3250	8010	1300	9558	2650
PH type	ILC / SLC	ILC	ILC	ILC	ILC	ILC	ILC	SLC	ILC	Pyro-clone, KHD	ILC
No of PH strings		Single	Single	Single	Single	Single	Single	Double	Single	Double	Single
No of stages		Five	Five	Five	Six	Five	Five	Five	Five	Six	Five
Calciner exit O_2 / CO	%		1.8 /0.01	2.5	2.0	1.5/0.00	4.5/NIL	Kiln : 3- 3.5 / - 0.08 max, Calciner : 1.5- 1.8 / 0.05 max,	1.0	1.5-2.0	2.1
PH exit temp	°C	335	260	305	285-295	333	310	350	318	255-260	320-330
PH exit flow	Nm^3/kg clinker	1.46	1.39	1.53	1.43-1.47	1.58	1.65	1.52	1.78	1.45	1.48-1.51

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
PH exit pressure	mmwc	-500	380	520	450	420	-760	860/960	-	840	640
Pressure at PH fan inlet	mmwc	-585	395	580	465	450	-820	960/1100	570	950	650
False air across PH	%	-	4	5	8	2	4	6-8 / 5-6	13	8	10
Speed control for PH fan		GRR	VFD	GRR/ SPRS	VFD	GRR	SPRS	-	GRR	SPRS	GRR
Speed control for Kiln Bag house fan		VFD	MV VFD	GRR/ SPRS	VFD	VFD	DC Motor	-	VFD	SPRS	Damper control
Kiln Bag house fan flow	Nm^3/kg clinker	2.0	2.2	1.3	2.3	1.9	2.4	-	3.3	1.7-2.0	2.2
Kiln Bag house DP	mmwc	90-120	100	100-110	120-150	108	28	-	120	100-120	40-55
Kiln Bag house inlet pressure	mmwc	-60	30	50	-80	50	-102	-	60	45	-
Kiln Bag house type		RABH	RABH	RABH	RABH	RABH	ESP	-	RABH	RABH	ESP

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
Kiln size	Dia xlength	3.95 x 65	4.35 x 67	4.15 x 64	4.15 x 64	4.15 x 64	3.75 x 57	4.75 x 75	3.2 x 48	5.8x 85	3.8 x 56
Volumetric loading	TPD/ m^3	5.80	5.69	7.00	5.50	6.22	6.57	7.50	4.30	5.00	5.21
Thermal loading	Mkcal / hr /m^2	4.00	4.28	4.88	4.20	3.80	4.60	5.20	2.65	3.00	3.13
Phase density – PC firing	kg coal / kg air	2.00	2.48	4.27	5.67	2.73	1.47	3.50	2.50	2.50	2.97
Phase density – Kiln firing	kg coal / kg air	1.00	1.20	1.19	2.81	2.65	2.08	3.00	1.40	1.50	1.42
Type of Cooler		3rd Generation	3rd Generation (Sf Cross Bar Cooler 4 *5)	SF Cross Bar Cooler / with Static /3rd Generation	Cross- Bar Cooler (FLS) 104.5 M2	SF Cross Bar Cooler	Flscross Bar Cooler (10X48)	Grate Cooler – Folax – (4 Nos Grates)	Grate Cooler	3rd Generation (Pyro-floor Cooler)	Reciprocating Grate (KHD) 57.45 M2
Cooling air flow	Nm^3/kg clinker	1.72	1.77	1.75	1.95	2.20	1.90	1.90	2.20	1.75	2.25
Clinker temp	° C	165	125	140	120-145	120	120-130	180-200	170	130-150	135-145

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
Cooler water spray	m^3/hr	5	1	-	6-7	5	-	10	4	15-20	5-6
Loss in PH gas	kcal / kg clinker	178	126	161	145-155	177	195	175-180	185	125-130	160-165
Loss in Cooler vent	kcal / kg clinker	72	99	85	100-108	95	67	120	119	110-115	110-115
Loss in clinker	kcal / kg clinker	31	25	39	25-28	25	30	38	33	20-25	28-30
Loss in cooler water spray	kcal / kg clinker	16.0	5.0	-	5.0-6.5	-	-	-	1.7	-	5.5
Thermal SEC	kcal / kg clinker	709	707	715	700-710	728	737	729	780	695	725-735
SEC											
PH fan		6.30	3.64	6.88	5.40	7.15	10.95	3.38	8.51	4.26	9.81
Calciner Fan		-	-	-	-	-	-	7.04	-	4.27	-
RABH fan		2.00	1.68	3.05	1.65	2.05	2.93	2.81	3.30	2.65	-
Cooler fans		5.80	5.43	4.85	5.00	7.13	5.92	6.28	3.75	9.83	4.85
Cooler vent fan		0.12	-	0.15	0.50	-	0.24	0.54	1.35	0.70	1.02

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
Kiln drive		1.40	1.39	1.68	1.65	1.62	1.50	1.88	5.08	2.00	1.49
Kiln feed		2.65	1.68	1.40	0.92	-	1.00	1.40	0.57	3.02	0.72
Aux		-	0.39	3.80	-	5.04	6.09	3.48	1.82	-	9.00
Clinkerisa-tion		18.30	16.28	21.8	26-27	22.99	28.63	26.81	24.38	27.50	31-32
Upto clink-erisation		46.00	49.94	53.37	54-55	56.04	59.63	65.40	69.55	74.29	74-75

3.10 CEMENT MILL – BALL MILL CLOSE CIRCUIT

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Circuit		Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)	Ball mill (Closed circuit)
No of sep in the ciruct		One	One	-	One	One	-	One	One	One	One
Rated capacity	TPH	133	200	105	105	200	115	80 / 90	125	40	27
Operating capacity	TPH	143 / 186	225	116/122	116 /120	200	105	110	130	50 / 60	30
Ball mill dimension		4.4 x 13.5	5 x 15	4 x 11.5	4.2 x 13.5	4.81 x 15	3 x 10	3.8 x 14.65	4.4 x 16.50	3.5 x 10.90	3.05 x 14.63
Product Variety		OPC/PPC	PPC	OPC/PPC	OPC/PPC	OPC	OPC / PPC	PPC	OPC / PPC	OPC / PPC	PSC
Mill ventilation velocity	m/sec	1.0	1.0 to 1.2	-	1.2-1.4	1.0	1.10 – 1.20	0.4	6-6.2	1.0 to 1.2	1.15
Product Blaine OPC / PPC	cm^2/gm	2800 + 100 / 3800 + 100	3200	3000 / 3300	3000 / 3300	2700	300	4100	2900 - 3000 /3300 -3500	2800 / 3200	3400

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Product residue	%	OPC : 24 PPC: 22	19 - 20	<25.0	<20.0	+45 micron: 14.5%	15.6	+45 micron: 9.7%	20-25%	19 - 20	21 for Close ckt & 24 for Open ckt
Mill discharge residue	%	OPC : 55 PPC: 45	45 - 50	<35-40	<35-40	+45 micron: 40%	60.5	+45 micron; 44.3%	38-42%	45 - 50	46%
Mill discharge Blaine OPC / PPC	cm^2/ gm	240 / 305	2000	1800 to 2200 / 1800 to 2400	1800 to 2200 / 1800 to 2400	2040	130	1990	250-270	1850 / 2000	1800
Circulating load	%	1.5 - 1.8	1.0 – 1.5	1.2-1.5	1.2-1.5	1.6	-	2.8	26-29	1.5 – 2.0	2.8
Cyclone pressure drop	mmwc	150	170	200	200	90	-	130	65-75	-	70
% fly ash / % slag	%	30	30	28	28	-	26.00 / Nil	30	28-30	OPC : 5; PPC : 30	52
Sep fan flow	km^3/hr	160	275	-	145-160	248	210	140	-	67	116

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Sep reject residue	%	85-88	75 - 80	-	-	15	-	65	27-40	55-60 / 60-65	65
SEC											
Mill drive		21.61	22.63	24.50	25.00	25.10	9.00	25.40	24.0-26.0	27.11	41.41
HRGS		-	-	-	-	-	10.5	-	-	-	-
Sep fan		2.20	2.24	1.50	1.50	2.40	4.80	2.20	0.07 - 0.09	2.89	1.25
Mill vent fan		-	0.17	0.35	0.35	0.11	0.30	0.02	0.030 - 0.035	-	0.60
Sep vent fan		2.65	0.23	-	-	0.40	-	0.43	3.0-3.5	-	0.9
Dry fly ash unloading		1.00	0.07	1.95	1.95	0.50	-	0.42	0.70-0.80	0.15	2.27
Overall		27.16	27.59	28.49	28.80	30.50	31.80	29.00	32.00	33.96	45.23

3.11 CEMENT MILL - BALL MILL WITH PREGRINDER/HPRG

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Circuit		Ball mill with HRGS	Ball mill with Roller Press	Ball Mill with RP	Ball mill with HRGS	Ball mill with HRGS	Ball mill with HRGS	Ball mill with HPRGS	Ball mill with Pregrinder	Ball mill with Pregrinder
No of sep in the ciruci t		Two	Two	-	Two	Two	Two	One	One	Two
Rated capacity	TPH	225	161	170	225	225	225	270	220	165
Operating capacity	TPH	250	201	185 /210	250	250	250	265 / 300	200-220	165-175
Ball mill dimension		4.6 x 14.5	4.2x11	3.8 x 11.6	4.6 x 14.5	4.6 x14.5	4.4 x 16	4.6 x 15.0	4.2x13.8	3.8x11.5
Product Variety		OPC / PPC	OPC/PPC	OPC/PPC	OPC / PPC	OPC / PPC	OPC / PPC	OPC/PPC	OPC/PPC	OPC/PPC
Mill ventila- tion velocity	m/sec	-	8-10	0.9	-	-	-	3.5	1.2	0.6
Product Blaine OPC/ PPC	cm^2/gm	260 / 290 / 350	2850	280 /380	260 / 290 / 350	260 / 290 / 350	260 / 290 / 350	3000 / 3400	-	2750-2850 / 3150-3300
Product residue	%	2-3/0	45-50	18.2 / 16.7	2-3/0	2-3/0	2-3/0 90/212	9.5	7-8	7-8
Mill discharge residue	%	-	15-20	47 / 29	-	-	-	47.5	33-35	21-24

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Mill discharge Blaine	cm^2/ gm	210 -240	3500-3600	1682 / 1921	210-240	210-240	210 -240	1700	1600-1700	2400-2500
Circulating load	%	2.2- 2.52	1.5-2.0	300	2.2- 2.52	2.2- 2.52	2.2- 2.52	2.5	125-135	105-115
Cyclone pressure drop	mmwc	-	60-70	12	-	-	-	-	90	180
% fly ash / % slag	%	32	31	28	32	32	32	31	32	32
Sep fan flow	km^3/hr	-	251105	165565	-	-	-	464400	354190	108831 / 244022
Sep reject residue	%	-	30-40	22	-	-	-	35	41.6	61.3 / 17.6
SEC										
Mill drive		11.21	11.15	8.29	10.66	10.99	12.21	16.20	14.50	12.50
HRGS		1.53	4.92	8.95	1.58	2.19	1.47	7.00	6.30	7.50
Sep fan		1.68	2.84	1.45	1.80	1.88	1.61	3.50	3.20	2.60
Mill vent fan		4.18	5.82	0.09	5.31	6.15	5.29	0.14	0.35	0.26
Sep vent fan		-	-	0.7	-	-	-	-	0.4	0.4
Dry fly ash unloading		-	-	0.51	-	-	-	0.15	-	-
Overall		23.75	24.73	25.27	25.28	25.44	26.31	27.00	29.30	30.00

3.12 CEMENT MILL-VRM

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Mill model		LM 56.3+3	LM 56.3+3	MP5600 BC	LM 53.3.3	OK-36-4	OK 36.40	LOESCHE 56.3+3	LM 56.3+3	LM 46.2+2
Product Variety		OPC/PPC	PPC	OPC/PPC	OPC/ PPC / PSC	OPC/ PPC / PSC	OPC/ PPC/PSC	OPC/PPC	OPC/SLAG	OPC/SLAG
Rated output	TPH	250 in PPC With 4000 Blaine	250	300 @ 3600 blaine	170 / 135 / 215	185 / 190 / 150	170	270 / 305	178 at 4000 Blaine and 177 tph at 4000 Blaine in Slag	102 tph at 4000 Blaine and 101 tph at 4000 Blaine in Slag
Operating output	TPH	320 TPH in PPC with 4100 Blaine	260	305 @ 3550 blaine	215 / 179 / 177	178 / 183 / 126	160	245 / 310	190-195 tph (OPC) at 3500 Blaine and 180-185 (slag) at 4000 Blaine	104-106 (OPC) at 3500 Blaine and 100-102 (slag) at 4000 Blaine
Mill DP	mmwc	750	500	150 - 160 / 200 - 220	300	270-290	550	580	420-450 (OPC) and 360-400 (slag)	320-350
Mill fan flow	km^3/hr	680	617	900	630150	570-580	487	763	720-750 in OPC / 620-650 in slag	340-350
Bag filter DP	mmwc	130-150	80	150 to 200	100-120	110-140	150-160	100	100-120	100-120

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9
Mill fan head	mmwc	1000	700	600	810	650-670	800	780	-650 to -700	-500 to -550
% Fly ash / % slag	%	30-33	35	32	31/42	28 % fly ash and 40 % slag	26.00 / 45.00	31	100% slag	100% slag
SEC										
Mill drive		13.0	13.9	16.3	16.0	16.0	16.5	16.5	21-2	22-2
Mill fan		7.0	8.7	6.8	6.3	8.0	8.5	8.6	11-12	8-9
Aux		1.0	2.4	2.8	5.7	5.0	4.2	4.6	6-7	10-12
Total		21.0	25.0	25.9	28.0	29.0	29.2	29.8	39-4	40-42

3.13 PACKING PLANT

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Rated output		180	240	80	90	3x180	320	2x120	265	220 / 180 / 120 / 90 / 220 / 180	2x240
Operating output		-	140	80	89	200	200		250	200 /140 / 110 / 60 / 200 / 140	
No of spouts		12	16	6	6	12	8	12	26	16 / 12 / 8 / 6/ 16 /12	12
Bag filter fan volume (m3/hr)		18100	44,000	16717	19500	34592, / 34654 / 33603	12000	-	38400	-	-
SEC		0.65	1.15	1.19	1.20	1.27	1.40	1.72	1.90	1.97	3.87
BF fan kW / spout		-	4.69	1.70	3.00	3.67	-	2.40	1.50	Included in SEC	4.00
Compressor pressure	bar	-	6.0	6.7	6.0	6.7	5.0	5.5-6	5.0	Included in SEC	5.5-6

3.14 UTILITIES

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Kiln capacity	TPD	4000	9558	7810	3800	1200	3250	2800	2800	3600	11250
Grinding capacity	TPH	270	565	402	200	40	185 / 210		-	-	510
Upto clinkerisation		0.40	0.99	1.24	1.30	1.31	1.94	2.05	2.15	2.19	2.70
Cement grinding & pacKing		0.47	-	-	1.00	1.13	0.69	1.40	-	0.78	1.04
Avg op pressure for HP compr	Bar	6	6	6	6.7	6.7	6	-	-	6.7	5.5-6.5
Comp pr for fly ash unloading	Bar	2		2.5	Root blower is used	Root blower is used	3.5	-	-	3	2-3
Fly ash unloading SEC		-	-	-	0.07	0.15	0.51	-	-	-	3.5-4.0

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Cooling water flow pyro section		400	600	700	180	60	Air Cooled	-	-	-	-
Cooling water flow cement section		-	-	600	30	19	Air Cooled	-	-	-	-
Aux BF – pyro section	Nos	5	11	9	27	11	10	6	4	6	-
Aux BF – cement section	Nos	14	32	22	16	5	12	10	10	9	-
Aux BF – pyro section	kW / MT	0.38	-	-	1.52	2.22	0.51	0.75	0.17	0.33	-
Aux BF – cement section		0.74	-	-	1.02	1.64	1.2	1.23	0.55	0.6	-

3.15 CAPTIVE POWER PLANT

Parameter	unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
Installed capacity	MW	15	30	9	17.5	12.5	15	17.5	17.5	25	3x25
Type		AFBC	AFBC	AFBC	AFBC	AFBC	AFBC	AFBC	AFBC	AFBC	CFBC
PLF	%	82.3	68.5	88.5	84	88	64	77.8	85	67.21	85
Heat rate	Kcal /kWh	3250.36	3327	3040	3018	3490	3495	3035	3074	3426	3007
Coal CV	Kcal / kg	5268.83	5503	3204	3213	4940	4981	3175	3205	3538	3096
LOI – Bed ash	%	20.1	19.4	<1	<1	0.4-0.5	14.2	<1	<1	7.5	2.3
Inst header pressure	Bar	5.5	5.5	6	6	6	5.5	6	6	6.8	6.5
Fly ash tpt pressure	Bar	4.5	4.0	5	5	4.5	4.0	5	5	3.2	4.5
APC	%	7.97	8.53	8.96	9.30	9.50	9.56	9.56	9.69	12.59	13.51

ELECTRICAL SEC UP TO CLINKERISATION

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
Plant Capacity	MTPA	1.9	3.0	5.5	3.1	1.0	1.4	1.3	1.7	7.2	3.1
Upto clinkeri-sation	kW/MT Clinker	46.00	49.94	53.37	54-55	56.04	59.63	65.40	69.55	74.29	74-75

OVERALL ELECTRICAL SEC

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8	Plant-9	Plant 10
Plant Capacity	MTPA	1.5	3.3	3.0	1.4	5.5	1.9	1.7	3.1	1.0	7.2
Over all SEC	kW/MT Clinker	65.55	68.00	68.24	70.95	73.44	73.56	78.67	78.90	85.00	87.82

FIVE STAGE PREHEATERS HEAT BALANCE

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant-9	Plant 10
Plant Capac-ity	MTPA	3.1	3.0	1.7	8.6	5.5	2.1	1.3	1.0	4.6	1.0
Thermal Sec	kcal/kg clinker	705	707	710	711	715	725	729	732	761	772

SIX STAGE PREHEATERS HEAT BALANCE

Parameter	Unit	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant7	Plant 8
Plant Capacity	MTPA	7.2	3.1	7.2	3.3	3.07	3.4	4.2	3.4
Thermal Sec	kcal/kg clinker	686	690	695	697	705	716	720	722

CHAPTER-4
EXTRACT & OUTCOME OF THE STUDY

The ultimate objective of the study is to identify the best specific energy consumption levels where the best plants are operating and the same was compared in the earlier sessions. The outcomes of the study are recorded in the tabular column

S. No	Section	kW/MT Material
1	Single stage crusher	0.70
2	Double stage crusher	0.65
3	Raw Mill-VRM	13.30
4	Raw Mill-Ball Mill	16.50
5	Coal Mill	23.90
6	Five stage Preheater up to clinkerisation	16.28
7	Six stage Preheater up to clinkerisation	23.7
8	Cement Mill –Ball Mill Close circuit	27.16
9	Cement Mill-Ball mill with HPRG	23.75
10	Cement Mill-VRM	21.00
11	Packing	0.65
12	Total Plant	65.55

These are the best figures which are operating in different sections in different plants .If any of the single plant is operating with all these best figures by adopting all possible latest technology in all sections then the typical energy levels will be at par compared to the peers in the industry.

The estimated energy levels with best sec in each sections are tabulated as below:

	If all the best numbers are put together for operation			
Section	5 stage		6 stage	
	Best numbers kW/Ton of material		Best numbers kW/Ton of material	
Crusher	0.7	0.8	0.7	0.8
Raw mill-VRM	13.3	19.9	13.3	19.9
Coal mill-VRM	23.9	3.1	23.9	3.1
Pyro	16.2	16.2	23.7	23.7

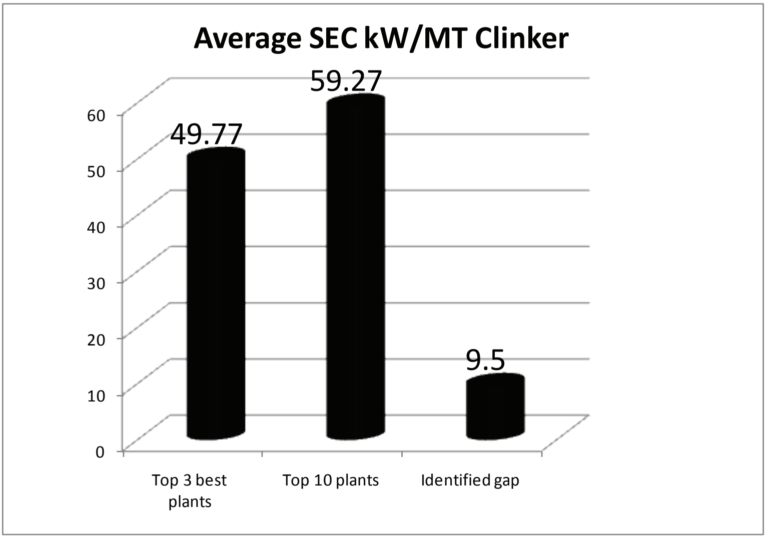
Up to clinkerisation (kW/MT of Clinker)		40.1		47.5
Cement - VRM	21	21	21	21
Up to clinker	40.1	29.3	47.5	34.7
Up to cement (kW/MT of cement)		50.3		55.7

Assumptions for the above calculations: Clinker Capacity-4500 TPD, Raw meal to clinker factor-1.5

Comparative analysis between top 3 plants and the remaining plants:

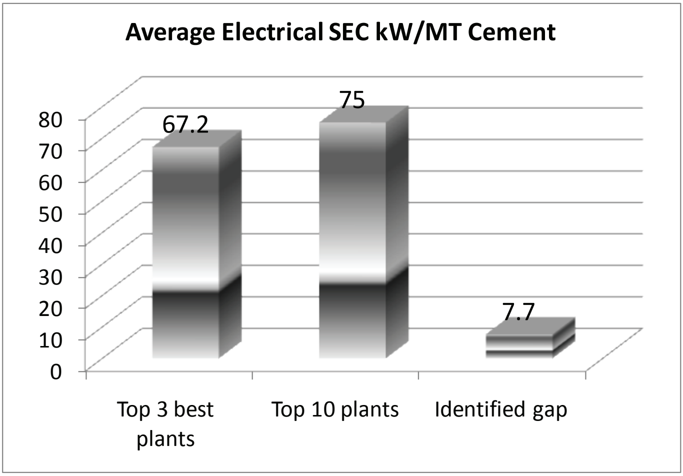
Electrical SEC Analysis up to clinkerisation

Plant composition	Average SEC kW/MT Clinker
Top 3 best plants	49.77
Top 10 plants	59.27
Identified gap	9.50



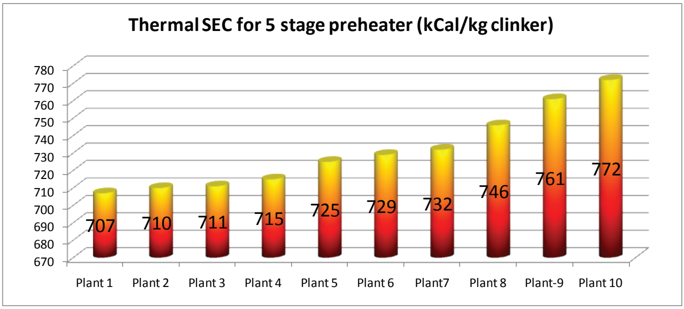
Overall Electrical SEC Analysis

Plant composition	Average SEC kW/MT Cement
Top 3 best plants	67.2
Top 10 plants	75.0
Identified gap	7.7
Country's best (Source: Low carbon technology road map)	80



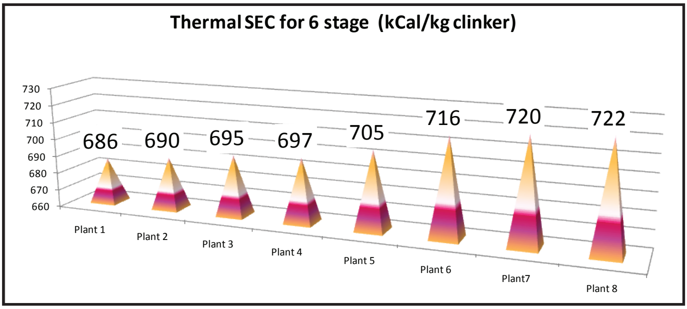
Thermal SEC analysis for 5 Stage preheater

Plant composition	Average SEC kCal/kg Clinker
Top 3 best plants	709
Top 10 plants	731
Identified gap	12



Thermal SEC analysis for 6 Stage preheater

Plant composition	Average SEC kCal/kg Clinker
Top 3 best plants	690
Top 8 plants	704
Identified gap	14
Country's best (Source: Low carbon technology road map)	725



The Identified Best Top Ten Technologies for Achieving Best Specific Energy Consumption levels:

With reference to the best sec achieved in different sections the implementation of following technologies will operate the typical cement plant at the best operating sec

1. **MV VFD:** 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. 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 loss due to GRR can be avoided by Installing VFD.

Savings potential	100	kW
Annual Savings	36.00	Rs. Lakhs/annum
Investment	96.00	Rs. Lakhs
Payback period	32	Months

2. **Roller Press:** Material grinding is the largest electrical energy consumer in cement manufacture. By design ball mills are efficient in fine grinding than coarse grinding. Installation of Roller press in the upstream of ball mill can

avoid the inefficient coarse grinding from ball mill, reduce and maintain the feed size to mill hence the system more efficient. Roller press can produce the product with size less a micron. Reduced feed size of the material to the ball mill results in reduced power consumption for grinding needs.

Savings potential	7	kW/MT cement
Annual Savings	630.00	Rs. Lakhs/annum
Investment	30.00	Rs. Crores
Payback period	57	Months

3. **Cooler:** The Indian cement industry, over the last several years, has increasingly adopted reciprocating grate coolers with great success. The reciprocating cooler has under gone significant design development and the latest generation cooler has better clinker properties with significantly lower exit gas and clinker temperatures. The total heat loss of latest generation clinker coolers is less than 100kCal/kg of clinker and has a recuperation efficiency of 75-80%.

Savings potential	20	kcal/kg clk
Annual Savings	300.00	Rs. Lakhs/annum
Investment	20.00	Rs. Crores
Payback period	80	Months

4. **Automation:** An effective advanced automation and control system can bring substantial improvements in overall performance of the kiln, increased material throughput, better heat recovery and reliable control of free lime content in clinker. Furthering the scope of automation in process control, quality is also maintained by continuous monitoring of the raw mix composition with the help of x-ray analyzer and automatic proportioning of raw mix components. The analyzer quickly analyzes the entire flow online providing real time results. Automation and control systems can significantly improve the performance of grinding systems by reducing the Variations, maintaining precise particle size distribution and increasing throughput.

Savings potential	1	kWh/MT cement
Annual Savings	90.00	Rs. Lakhs/annum
Investment	100.00	Rs. Lakhs
Payback period	13	Months

5. **Fly ash Drier:** Increase in manufacture of blended cement and quantity of addition of fly ash in cement results in reduced energy consumption and lowers carbon emission intensity. This increase has resulted in a short fall of availability of dry fly ash in some of the cement manufacturing clusters. The fly ash can be dried either by taking the hot gases from the cooler exit (or

from the pre-heater exit) installing fly ash drier.

Savings potential	0.5	kWh/MT cement
Annual Savings	45.00	Rs. Lakhs/annum
Investment	200.00	Rs. Lakhs
Payback period	53	Months

6. **High Efficiency Separator:** 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. An efficient separator improves the mill performance by avoiding the over grinding of the material and thereby reduces the grinding power consumption. 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%.

Savings potential	1.5	kWh/MT cement
Annual Savings	135.00	Rs. Lakhs/annum
Investment	200.00	Rs. Lakhs
Payback period	18	Months

7. **WHR:**. The technologies available for waste heat recovery include Rankine Cycle, Organic Rankine Cycle and Kalina Cycle. 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 gas if the moisture content in the raw material is low and only little hot gas/air for drying. In total up to 22 kWh/t clinker or about 20% of the power consumption of a cement plant can be met by using currently available waste heat recovery technologies without significant changes in kiln operation.

Savings potential	30	kWh/MT clinker
Annual Savings	1575	Rs. Lakhs/annum
Investment	60.00	Rs. Crores
Payback period	46	Months

8. **Cross belt analyzer:** Sampling of crushed limestone or raw meal (input to the kiln) is essential to maintain stockpile quality and control chemistry of raw mix, thereby maintaining homogeneous clinker composition to meet quality requirements. Cross belt analyzers analyze the chemical properties of the materials instantaneously and direct corrective actions much quicker compared to conventional sampling and quality control methods. Cross Belt Analyzers (CBA) can be installed either in upstream of the stock pile or before the raw mill.

Savings potential	5	kcal/kg clk
Annual Savings	75	Rs. Lakhs/annum
Investment	200.00	Rs. Lakhs
Payback period	32	Months

9. **AFR:** 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). With extensive national and global expertise available, the Indian cement industry today is technically ready for adopting higher TSR rates. The increase in substitution rate will help in saving conventional energy by utilizing the waste and alternative fuels available near to the plant.

10. **Energy Efficient Blowers** – Normal PD blowers are operating at lower efficiency the latest trend to install energy efficient blowers which are saving more than 30% energy compared to normal standard blowers

Savings potential	0.5	kWh/MT cement
Annual Savings	45	Rs. Lakhs/annum
Investment	100.00	Rs. Lakhs
Payback period	27	Months

Assumptions For the analysis:

Clinker Capacity - 4500 TPD

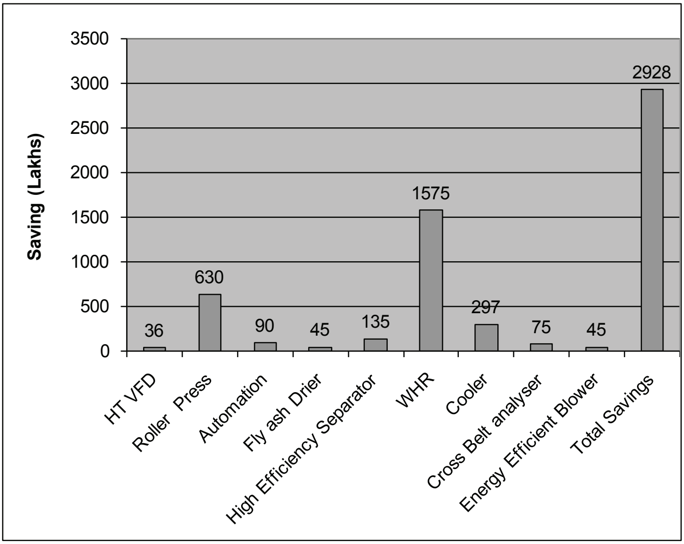
Clinker to Cement Factor - 0.73

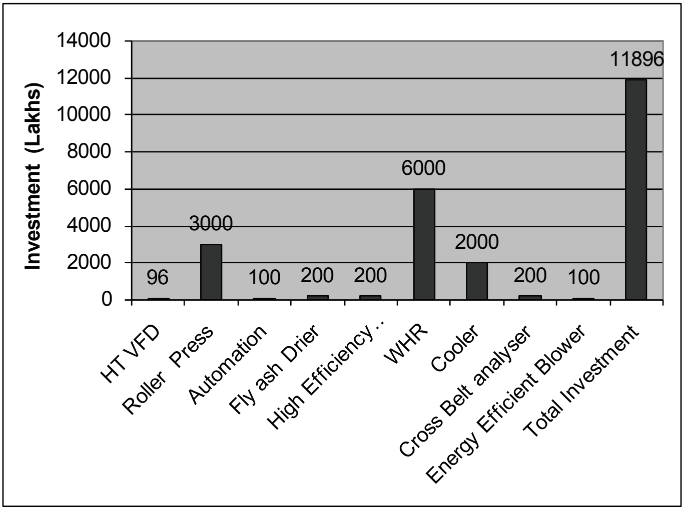
Cement Capacity - 2 MTPA

Power Cost - Rs. 4.5/kwh

Coal Cost - Rs. 1000 /Million Kcal

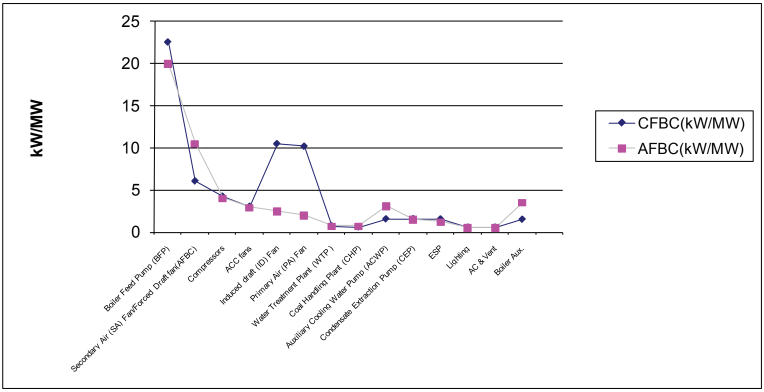
Operating days - 330


Saving (Lakhs)
3500
3000
2500
2000
1500
1000
500
0
36
630
90
45
135
1575
297
75
45
2928
HT VFD
Roller Press
Automation
Fly ash Drier
High Efficiency Separator
WHR
Cooler
Cross Belt analyser
Energy Efficient Blower
Total Savings


Investment (Lakhs)
14000
12000
10000
8000
6000
4000
2000
0
96
3000
100
200
200
6000
2000
200
100
11896
HT VFD
Roller Press
Automation
Fly ash Drier
High Efficiency ..
WHR
Cooler
Cross Belt analyser
Energy Efficient Blower
Total Investment

ANALYSIS OF CAPTIVE POWER PLANTS

S.No	Area/Equipment	CFBC(kW/MW)	AFBC(kW/MW)
1	Boiler Feed Pump (BFP)	22.60	20.00
2	Secondary Air (SA) Fan/Forced Draft fan(AFBC)	6.07	10.50
3	Compressors	4.26	4.00
4	ACC fans	3.05	2.90
5	Induced draft (ID) Fan	10.50	2.50
6	Primary Air (PA) Fan	10.20	2.00
7	Water Treatment Plant (WTP)	0.74	0.70
8	Coal Handling Plant (CHP)	0.61	0.70
9	Auxiliary Cooling Water Pump (ACWP)	1.56	3.10
10	Condensate Extraction Pump (CEP)	1.59	1.50
11	ESP	1.55	1.20
12	Lighting	0.58	0.50
13	AC & Vent	0.58	0.50
14	Boiler Aux.	1.51	3.50
15	Over all Auxiliary Consumption (%)	6.53	5.36



CASE STUDIES

Optimization of RABH Fan power consumption.

RABH fan capacity is affected by

1. False air across circuit (% of false air directly indicates % of higher SEC)
2. Moisture content in the Raw Material (Higher the moisture content higher is the water vapour formation and higher the fan volume)
3. Water spray in mills for bed formation (High water spray implies higher water vapour formation and higher fan volume)
4. Presence of GCT (Applicable to older plants – High water spray indicating higher water vapour formation higher fan volume)

RABH fan head is affected by

5. RABH pressure drop (Directly effects the fan power consumption)
6. Fan inlet pressure (Higher the pressure drop in circuit higher is the fan power consumption)

Other factors

7. Fan efficiency itself (To be always aimed at over 80 % especially for compound mode conditions where operating hours are higher)

The comparison among three plants are given below as an indication of the effect of each of these parameters on the RABH fan power:

Parameter	Plant 1 5200 TPD	Plant 2 9300 TPD	Plant 3 4600 TPD
Bag house fan power during compound mode operation	197 KW (Operating with VFD)	670 KW (With VFD)	330 KW (With GRR)
Clinker production	195 TPH	385.5 TPH	190
BH fan specific power during compound mode	1.01 KW/MT of Clinker	1.74 KW/MT of Clinker	1.74 KW/MT of clinker
Gas temperature	100 Deg C (Due to dilution air at bag house inlet)	150 Deg C	106 Deg C (Due to dilution air at bag house inlet)
BH fan specific flow rate	1.96 Nm3/Kg clinker	1.73 Nm3/kg clinker	2.12 Nm3/kg of clinker
BH fan inlet pressure	-112 mm WC	-219 mm WC	-102 (at damper inlet) *-175 mm WC at fan inlet but this value of need to be used for benchmarking as this only indicates the fan parameters
BH fan outlet pressure	-20 mm WC	- 13 mm WC	-15 mm WC
False air across RM	7.2 %	11 %	29.8 %
BH fan efficiency	74 %	94 %	80 %
PH exit specific volume	1.37 Nm3/kg clinker at 265 Deg C	1.37 Nm3/kg clinker at 279 Deg C	1.66 Nm3/kg clinker

Parameter	Plant 1 5200 TPD	Plant 2 9300 TPD	Plant 3 4600 TPD
Reasons for higher power	Reference RM False air less then 10 % which is good operating number Unavoidable Fan efficiency compared to other plants is lower if increased to 80 %: 0.07 KW/MT Avoidable with change in new fan Fresh air intake which is unavoidable to maintain bag fabric requirement (Considering 5 % of total volume: 0.05 KW/MT) Avoidable with change in new type of bags So equivalent SEC all these changes would be: 0.89 KW/MT of clinker	High BH fan inlet pressure (almost higher by 100 mm WC compared to reference plant leading to higher power consumption) Increase in power due to higher fan inlet pressure = (219-120) = 99 mm WC = 48 % of fan power So equivalent SEC with 120 mm WC bag house fan inlet suction would be: 0.90 KW/MT of clinker	High moisture in raw material leading to increased air quantity (8 % Moisture : 26 TPH water. 26*1240 = 33240 Nm3 of water vapour accounting to 8 % of volume : 0.134 KW/MT) Unavoidable High false air across raw mill (Considering 10 % of the false air reduction: 0.174 KW/MT) Avoidable Fresh air intake which is unavoidable to maintain bag fabric requirement (Considering 5 % of total volume: 0.085 KW/MT) Avoidable with change in new type of bags Damper operation increasing fan power (0.14 KW/MT loss) Avoidable with installation of new drives So equivalent power with all these reduction would be: 1.74-0.134-0.174-0.85-0.14 = 1.2 KW/MT

Optimization of the Preheater fan power consumption:

PH fan capacity is affected by

1. Raw material composition itself but almost same composition is used in Indian Plants. * cannot be altered much
2. False air across preheater (% of false air directly indicates % of higher SEC)
3. Fine coal moisture content (High moisture content means higher water vapour formation and higher fan volume) * not a very major criteria
4. Raw meal moisture content (High moisture content means higher water vapour formation and higher fan volume) * not a very major criteria
5. Excess air maintained in case of AFR firing in calciner (Applicable only to plants using higher thermal substitution rates) * not a very major criteria

PH fan head is affected by

1. Number of stages
2. Type of cyclones (LP or HP)
3. Some plants have very high Preheater height for achieving higher thermal efficiency, here the savings achieved through thermal efficiency is much higher then the loss associated with the pressure drop
4. Downcomer duct velocity (Higher velocity leads to higher pressure drop thereby higher fan head) * Some plants have very high PH height for achieving higher thermal efficiency can simultaneously effect back in higher pressure drop

PH Exit returns dust quantity

1. Lower top cyclone efficiency can lead to higher return dust which affects the exit gas density. Higher the return dust higher is the gas density resulting in- higher power consumption of PH fan to handle the gas. It additionally causes higher pressure drop across downcomer duct.
2. Higher top cyclone efficiency gives more benefits in case of thermal energy consumption.
3. Fan efficiency itself (To be always aimed at over 80 %)

The comparison among three plants are given below as an indication of the effect of each of these parameters on the PH fan power:

Parameter	Plant 1 5200 TPD	Plant 2 9300 TPD	Plant 3 4500 TPD
PH fan power during compound mode operation	1040 KW (Operating with VFD)	2189 KW (With VFD)	1195 KW
Clinker production	195 TPH	385.5 TPH	188.7
PH specific power	4.77 KW/MT of Clinker	5.67 KW/MT of Clinker	6.33 KW/MT of clinker
Number of Stages	6 stage ILC	6 stage SLC	5 Stage ILC (5 Stage due to high limestone moisture drying requirement in raw mill)
Gas temperature	265 Deg C	279 Deg C	339 Deg C
PH specific flow rate	1.36 Nm3/Kg clinker	1.37 Nm3/kg clinker	1.46 Nm3/kg of clinker
PH Fan inlet pressure	-506 mm WC	- 580 mm WC	-535 (at damper inlet) *-585 mm WC at fan inlet but this value of need to be used for benchmarking as this only indi-cates the fan parameters
PH fan outlet pressure	-18 mm WC	- 30 mm WC	-40 mm WC
False air across PH	2.58 %	Exact number not available	Exact number not available
PH fan efficiency	85.4 %	87.7 %	90 %

Parameter	Plant 1 5200 TPD	Plant 2 9300 TPD	Plant 3 4500 TPD
Reasons for higher power	Reference PH height in excess of 150 m best known number for medium capacity kiln	Downcomer duct velocity: 17.5 m/s High PH fan inlet pressure (almost higher by 74 mm WC compared to reference plant leading to higher power consumption) Increase in power due to higher fan inlet pressure = (580-506) = 74 mm WC = 13 % of fan power = 0.74 KW/MT So equivalent SEC with lower pressure drop across preheater would be: 5.67 – 0.74= 4.93 KW/MT of clinker	Downcomer duct velocity: 18.8 m/s High false air across raw mill preheater resulting in higher specific exit gas volume If compared with 1.37 Nm3/kg clinker the excess gas volume accounts to (1.46-1.37)= 0.09 Nm3/kg clinker false air/excess air anyone SEC effect: 0.39 KW/MT Avoidable Damper loss is 50 mm WC. Damper operation increasing fan power (0.51 KW/MT loss) Avoidable with installation of new drives So equivalent power with all these reduction would be: 6.33-0.39-0.51 = 5.43 KW/MT of clinker

RAW MILL SEC ANALYSIS

Plant Name		Plant -1	Plant -2	Plant -3	Plant -4	Plant -5	Plant -6	Plant -7	Plant -8	Plant -9
Mill Type		LM 46.4	LM 30.3	Atox 45	LM 36.4	Polysius	Polysius	Atox 47.5	Chinese make	Atox 55
Mill output	TPH	304	205	285	230	330	225	325	155	410
Limestone moisture	%	11	11	1		1	10	1	1	1
Mill fan SEC		7.15	9.67	5.26	5.65	9.14	10.64	8.44	8.22	9.94
Mill Drive SEC		4.62	3.4	9.3	9.15	7.55	6.49	9.36	10.34	10.78
Aux (Booster fan + classifier)		0.43	0.26	0.12	0.08	0.35	0.53	0.21	0.21	0.20
Total SEC		12.20	13.33	14.68	14.88	17.04	17.66	18.01	18.77	20.92
Fan inlet flow	m3/hr	734276	391699	615933	405129	836725	644656	854245	416926	1106904
Fan inlet flow	Nm3/hr	503300	266624	434565	278614	516441	415079	564933	273172	773081
False air (mill inlet to fan inlet)	%	21.4	27	24.4	39.2	15.4	52	23.5	23.4	
Separator loading	gms mtrl/ m3 air	414	523	463	568	394	349	380	372	370
Nozzle ring velocity	m/s	54.5	49.6	35.26	30	68	26.5	51.46	43.5	51.01

Plant Name		Plant -1	Plant -2	Plant -3	Plant -4	Plant -5	Plant -6	Plant -7	Plant -8	Plant -9
Mill DP	mmWc	740	900	540	670	730	800	600	450	740
Pressure drop from mill outlet to fan inlet	mmWc	155 (140 mmWc across cyclone)	220 (140 mmWc across cyclone)	133 (80 mmWc across cyclone)	190 (140 mmWc across the cyclone)	220 (170 mmWc across cyclone)	150 (ESP in the circuit in place of cyclones)	280 (250 mmWc across cyclone)	125	220 (143 mmWc across cyclone & 60 mmWc across Venturi)
Raw mill Fan efficiency	%	89.8	76.7	93	95	84.5	89.1	93	70.96	81.8
Speed control in fan		VFD	SPRS	LRC	GRR	GRR	GRR	GRR	SPRS	VFD
Damper loss across fan	%	Nil	4.6	10	2	nil	2	7	5.5	nil

The major power consumption in VRM is Mill main drive & Mill fan. As can be seen in the above case studies of different plants, Raw mill (VRM) power consumption depends on the following parameters

1) Limestone hardness: As seen in above data, the plants with soft limestone has lower specific power consumption of mill main drive, the range varies from 3.4 kWh/MT to 6.5 kWh/MT where as the plants which has hard limestone the SEC of mill drive is in the range of 7.5 to 10.5 kWh/MT

2) Power consumption of mill fan depends on the following parameters:

   a) Volume handled by the fan

   b) Nozzle ring velocity

   c) Separator loading

   d) Pressure drop across the mill and cyclones

   e) False air in the circuit

   f) Speed control type in the fan

3) Volume handled by the fan: The air volume in the mill circuit depends on

   a) Nozzle ring velocity

   b) Drying requirement

   c) Separator loading

4) The optimum nozzle ring velocity to be maintained in the mill is 45-55 m/s. Maintaining low velocity will affect the separation in the mill and increase the rejects at mill bottom. On the other hand maintaining high velocity will increase the DP which in turn increase the fan power. Pressure drop across the mill increases with the increase in the nozzle ring velocity which is also indicated in the above table. As seen in the above table two plants are maintaining the nozzle ring velocity in the range of 30-35 m/s and so the mill fan SEC is in the range of 5.3 to 5.7 kWh/MT clinker where as the mill drive SEC is high in the range of 9.15-9.3 kWh/MT due to increase in the rejects.

5) Separator performance will also affect the SEC of mill fan. The high efficiency separator will operate with separator loading of >500 gms/m^3. As seen in the above table the plants which is having separtor loading in the range of 460-560 gms/m^3 is operating with low SEC in mill fan. One of the plant is having separator loading of 523 gms/m^3 but the fan SEC is on the higher side due to high pressure drop from mill outlet to fan inlet.

6) The plants which have high moisture in the limestone has to maintain the required volume at mill inlet to remove the moisture in the feed. Limestone with high moisture needs more heat at the mill inlet. Though the volume of gas will remain the same for mills with more and less moisture the gas composition will be only PH gas for high moisture and more recirculation and less PH gas for mills with less moisture.

7) False air in the circuit will affect the separator only if the false air is after mill outlet. Reducing false air will not change mill fan power as the volume is controlled by 3 factors mentioned earlier and the total volume remains constant however mill output can get affected. False air in raw mill circuit will increase the Kiln/Bag house fan power. If the drying requirement is the main criteria then false air in the circuit should be as low as possible. As seen in the above table one of the plant is maintaining the lowest false air of only 15% across the circuit. The false air % as indicated in the above table does not include the fresh air at mill inlet.

8) The pressure drop in the mill circuit will also affect the fan SEC. The pressure drop in the circuit will depends on the cyclone pressure and duct pressure. The pressure drop across the cyclone should be in the range of 80-90 mmWc. As seen in the above table one of the plant is having pressure drop of only 80 mmWc across cyclone. CFD study could be useful to optimize the pressure drop in the ducts, cyclone and separator. Use of low pressure drop cyclone and efficient separator can optimize the mill fan power.

9) SEC depends on the fan performance: Parameters to be observed seen are the fan efficiency (>85%), damper loss, fan inlet velocity and type of speed control installed in the fan. In majority of the cases the fan efficiency is in the range of 80% and above. Damper loss in the fan operating with Louvre type damper should not be more than 10-15 mmWc. Although raw mill fan generally operates with full volume but in some cases the type of speed control installed in the fan will also affect the fan SEC. Fan operating with GRR speed control could be replaced with VFD control

CEMENT MILL -BALL MILL SEPARATOR FAN ANALYSIS

Parameter		Plant-1	Plant-2	Plant-3	Plant-4	Plant-5	Plant-6	Plant-7	Plant-8	Plant-9	Plant-10
Operating capacity	TPH	105	75	80	90	80	140	152	164	95	260
Separator fan flow	m3/hr	211016	144717	134091	141598	138206	235098	221511	260814	111371	496225
Specific loading	Kg material/ m3	0.50	0.52	0.60	0.64	0.58	0.60	0.68	0.62	0.853	0.524
Operating Fan power	kW	382	272	223.16	224.20	252.00	326.89	179.00	301.00	134	943
Sp.Energy consumptionSeparator fan	KW/MT	3.64	3.63	2.79	2.49	3.00	2.33	1.2	1.8	1.4	3.6
Fan inlet pressure	mmwg	-524.00	-555.00	-484.00	-462.00	-458.00	-340.00	-248.00	-342.00	-425	-670
Fan Efficiency	%	76.66	84.01	78.99	87.28	72.00	65.00	84.25	83.41	95	93
Fan speed control		Damper	Damper	GRR	GRR	GRR		GRR	GRR	GRR	GRR
Velcoity in fan inlet duct	m/s	13.00	13.00	18	18	20	15	14	17	20	20
Loss across damper on fan head	%	34	32	-	-	-	-	-	-	4	3
Percentage of Separator reject passing on 45 micron	%	38	20	37	33	34	30	21	40	20	15
Circulation load		3.4	1.2	2.7	2.5	2.3	2.1	3	2.7	1.5	1.4

Reasons for higher power consumption in fan

1. Type of speed control for fan
2. Velocity of gas in the fan inlet duct
3. Higher fan inlet suction(Due to system resistance)
4. Operating efficiency of the fan
5. Low specific loading (Specific loading should in the range of 0.6 kg material/m3)
6. False air after classifier

Mill performance affected by

1. Velocity inside mill(Std 1.2 m/s) - Maintaining the correct velocity will lead to Reduction in <3 microns fraction in mill out put,increase mill output rate and improve overall mill performance
2. Sp surface area of grindng media in second chamber (40 m2/Ton)
3. % filling of GM - 28-30% is the ideal mill filling level

Performance of classifier

1. Separtor performance residue on -45 Mic
2. Circulation load (separator feed/separator product)
3. Lesser specific loading (kg of material/m3) 0.6 kg material/m3 is the standard for specific loading
4. False air after mill

CHAPTER-5
ENERGY INDICATORS IN CEMENT INDUSTRY

S. No	Parameter	Unit	Indicator
1	WHR least pressure drop	mm WC	32
2	WHR least false air	%	6.4
3	Lowest Preheater pressure drop	mm WC	-506
4	Lowest Preheater exit O_2	%	2.58
5	Lowest Preheater exit CO	ppm	50.6
6	Fine coal conveying phase density in PC string	Coal/Kg of air	5.5
7	Fine coal conveying phase density in Kiln string	Coal/Kg of air	5.2
8	Specific surface area Cement mill 1st chamber and 2nd chamber:		
	1.6 Piece weight Chamber -1	m^2/Ton	10.24
	1.6 Piece weight Chamber -2	m^2/Ton	40.24
9	TAD temperature drop	^{0}C	30
10	Highest cooler bed height	mm WC	650
11	Lowest lime stone size from crusher	mm	<40
12	Lowest raw mill cyclone pressure drop	mm WC	50
13	Highest dust concentration separator loading	gm/m3	548
14	Lowest DP across RABH	mm WC	80
15	Lowest CA fan power	kW/MT	1.2
16	Highest AFR Substitution	%	9
17	Lowest Raw mill silo top fan power for 3300 TPD kiln	kW	6
18	Lowest cooler loss	Kcal/kg clinker	98.4
19	Lowest cooling air with respect to cooler loss	Nm^2/kg clinker	1.62 @ 98.4 kcal/kg
20	Highest cooler loading	TPD/m^2	63
21	Highest kiln Thermal loading	kcal /hr / m^2	5.7
22	Highest kiln volumetric loading	TPD /m^3	7.0
23	Highest draught at chimney bottom	mmwc	-60
24	Preheater fan highest efficiency	%	90.5

S. No	Parameter	Unit	Indicator
25	Raw Mill fan highest efficiency	%	87.4
26	Cement Mill fan highest efficiency	%	88.0
27	Highest Fly Ash addition	%	33
28	Highest slag addition	%	55
29	Best top cyclone efficiency	%	97.05
30	Lowest VRM false air		
	Subtracting feed moisture evaporation, water spray evaporation, seal air fan	%	7.21
	Raw Mill VRM	%	13.04
	Cement Mill VRM	%	13.20
31	Lowest Preheater fan specific power	kW/MT Clinker	3.64
32	Lowest electric distribution losses	%	3.2
33	Lowest Capacitor power loss	w/KVAR	3
34	Optimum voltage for lamps	V	210
35	Lowest frequency maintained for CPP operating in island mode	Hz	48.8
36	Best efficiency of motors in LT & HT	%	97.1
37	Lowest VFD loss and SPRS loss	%	3/4
38	Lowest lighting load (kW) or SEC	Kw/MT cement	0.5
39	Lowest harmonic distortion in Cooler fans (V/I)	%	2/8
40	Highest capacity of Renewable energy in onsite installation	MW	5.75
41	Highest power factor in CPP in Island mode	-	0.97
42	Lowest compressor air generation pressure	bar	5.5
43	Lowest pressure drop in compressed air distribution system	bar	0.1
44	Lowest pressure drop across dryer	bar	0.1
45	Lowest CPP auxiliary power consumption		
	AFBC	%	5.36
	CFBC	%	6.53
46	Lowest Cooling water flow in Pyro, cement mill and compressors	m^3/MT of clinker	1.5

S. No	Parameter	Unit	Indicator
47	Lowest fly ash unloading power both reciprocating and Screw	kW/MT	0.7
48	Lowest Conveying pressure from Esp hopper to bunker in cpp	bar	3
49	Lowest SEC for blower @1 bar	kW/MT coal	1.1
50	Lowest compressor air load Cement mill, CPP and Pyro for 4200 TPD plant	CFM	2450
51	Lowest excess air in CPP		
	Indian Coal	%	2.5
	Pet Coke	%	2.8
52	Lowest heat rate in CPP < 30 MW	kcal/Mwh	3007
53	Lowest primary air		
	Indian Coal	%	19.74
	Pet Coke	%	12.94
54	Lowest pressure drop between BFP and drum pressure	Bar	10
55	Lowest pressure drop in flue gas path	mm WC	64
56	Lowest Cooling water circulation SEC	m^3/MW	239
57	Lowest auxiliary cooling water circulation	m^3/MW	10.5

CHAPTER-6
BEST PRACTICES IN CEMENT INDUSTRY

MINES

1. Using CAP for reducing the fly rock and improving Powder factor
2. Using automation for improving the truck performance
3. Using software to enhance mines life
4. Using mines land for RE installation
5. Using mines land for Energy Plantation
6. By changing blasting technology from top initiation system to bottom initiation system through Nonel shock tubes, crusher input size reduced and output increased from 7ton to 10ton per kg of blasting.
7. By the compaction of the floor of the benches diesel consumption of the transport equipment had been reduced from 22ltr/hr to 18ltr/hr.
8. Surface Mining by use of Surface Miner for soft and medium hard materials
9. Use of Mega Rock Breaker
10. Reducing Moisture content of materials by trench cutting and de watering

CRUSHER & PRE BLENDING

11. Utilizing beneficiation plant for processing low grade limestone
12. Using wobbler for to by pass under size through the crusher
13. Using VFD for crusher bag filter fan
14. Installing VFD for crusher compressor
15. Installating Cross Belt Analyzer for optimizing the mines life
16. Interlocking Crusher fan speed with crusher feed belt RPM
17. Crusher output size reduction to get benefit in VRM & Crusher
18. Interlocking crusher feeder rpm with crusher load to optimize loading
19. Installation of Material starvation switch in belt conveyors to avoid idle running
20. Installation of Light pipe for Stacker
21. Installation of Cross Belt analyzer for Coal
22. Power saved by pile changeover in online (without stopping the crusher). Due to this avoided idle run hours during stop seq.+ idle run hours of stacker during pile change over + idle run hours of stacker & transport during start up.
23. Power saved by Stacker hydraulic pump through logic modification.
24. P&V motor switching off after the end of “B” shift due to no “C “shift operation at Crusher-1 & 2.
25. Providing heating system and hydraulic scrapper at wobblers to increase crusher productivity.
26. To operate Limestone crusher from Central control room to facilitate people

development-

Earlier there was local control for crusher operation and one operator per shift was required for the same. High levels of noise was common in the area. To carry out proposed improvements/changes a team was formed, which carried out all the concerned activities in house without the support of any consultant. First an optical fiber cable from LS crusher to CCR was laid and HMI of Control system and the weighbridge was given to CCR. IP cameras were installed at all the three locations to monitor Apron feeder, Dump hopper and weighbridge from CCR.

BENEFITS:

a. The LS crusher operator's who were operating the crusher in high sound area were shifted to CCR and now they have learnt other operations of the main plant and improved their knowledge.

b. The LS crusher operators are now able to operate Cement mills and Raw mills independently.

c. Operation of complete plant from a single location.

d. Availability of the data at a single location.

27. Automation of Mines weighbridge by installation of RF ID card reader system.
28. Installation of Radar level monitoring system in Crusher Dump Hopper
29. Installation of VFD to reclaimer.
30. All additives belts are covered with GI sheets to feed moisture free material in rainy season.
31. Crusher Productivity has been improved by maintaining the constant bed level, an interlock is provided to stop the crusher apron feeder based on the apron feeder current
32. Ensuring sufficient amount of material availability before starting the crusher for continuous operation
33. Use of Compound Impactor (Two Stage Crushing) to achieve lowest power consumption with best size reduction ratio suitable for Vertical Roller Mill for Raw grinding.
34. Use of Sizer type Crushers for Soft and medium Hard materials

RAW MILL-BALL MILL

35. Installation of Tertiary crusher for increasing the mill output
36. Installation of Cross Belt Analyzer for on line quality control
37. Installation of Boltless Classifying liner
38. Mill level control system based on vibrations instead of acoustic control
39. Shorter length of drying chamber to increase output
40. Mono chamber for mills with HPRG
41. HPRG in finishing mode
42. High separator loading
43. Bucket type belt conveyor in place of metallic conveyor

44. VFD for Raw meal silo top bag filter fan
45. Adaptive predictive control system for mill operation
46. VFD for Separator fan, mill vent fan, sept vent fan
47. Air slide fans with pressure less than 250 mmwg for fine material air slide and 350 mmwg for separator reject air slide
48. Low pressure drop cyclones
49. Rotary Air Lock for mill feed to reduce false air
50. Reject sample analysis on 90 micron daily basis to optimize sep performance
51. The plant stopped Nib trap blower and air is taken from air slide blower and thus we saved 2 kW power per hour in raw mill.
52. Optimized the silo dust collector by introducing VFD for bag filter fan
53. Use of filter bags with moisture and Oil repellent finish

RAW MILL - VRM

54. Mill Louvre velocity in the optimum range 45 -55 m/sec
55. Maximum Sep Loading gm / m^3 of air
56. Low pressure drop cyclones
57. Rotary Air Valve for mill feed to reduce false air
58. Blocking the louvre below the rollers and optimizing the flow
59. Vera bar for flow measurement in place of orifice and venturi
60. VFD for raw mill fan
61. Cross belt analyzer at mill feed belt for online quality control
62. Low false air across mill circuit
63. Reducing feed size in line with crusher for total power reduction
64. Adaptive Predictive control system for mill
65. Minimum continuous recirculation in Mill rejects (10 – 30%)
66. Vortex rectifier for reducing the pressure drop across the classifier
67. Carrying out CFD for optimum pressure drop in the ducts
68. Interlock has been made Seal air fan STOP with 1 hr delay after mill stop of Raw mill
69. Air slide blowers 12 No optimized in phase II raw meal transport system.
70. Process optimization done by reducing raw mill dam ring height & mill feed size.
71. In belt discharge chutes provided self cleaning spring loaded plates provided to avoid coating/jamming
72. Reduction in false air by 3% by replacing of rubber dampers in VRM circuit.
73. Installation of air blasters, SS chute, polymer liners in limestone hopper and reclaimer discharge chute to avoid jamming
74. Usage of Feldspar in raw mix grinding to mitigate the effect of sulfur from pet coke
75. Installation of Sinter cast liners for Table & Roller to increase the life and to

reduce the Downtime hours.

76. Mill Reject system running based on Reject Chute Level & Timer switch instead of continuous operation.
77. Expert Optimizer had been installed to reduce the standard deviation in the product results and for consistency in output.
78. Low pressure off line Pulse jet cleaning – especially suitable for Glass fibre bags(bag specific weight 750gms/m2) to get lower pres-sure drop & longer life without loss in performance
79. Fully welded cast steel table liner and roller tyres for low wear rate and longer mill availability

COAL MILL

80. Installation of additional crusher for reducing the size
81. Vibration based control system for mill filling
82. Optimum drying chamber for reducing the output
83. VFD for Mill fan and booster fan
84. Rotary Air Lock for mill feed to reduce the pressure drop
85. Optimum phase density in fine coal conveying
86. Energy efficient blower instead of PD blower
87. Reject sample analysis on 90 micron daily basis to optimize sep performance
88. Vera bar in place of venturi and orifice
89. High residue for calciner firing compared with kiln firing
90. GRR introduced for Coal Mill-drive to control speed to grind Pet coke
91. High efficiency dynamic classifier in place of Static Vane Grit Separator (for ball mill circuit)

PYRO PROCESSING

92. Optimum excess air at preheater outlet
93. Reduce false air across pre heater circuit
94. VFD for preheater fan, Cooler vent fan and cooler fans
95. Low pressure drop cyclones
96. Low pressure drop across down comer duct
97. High efficiency cyclone in the top stage
98. Low thermal conductivity bricks in the kiln inlet and calcining zone
99. High momentum burner with AFR usage
100. Low suction loss in cooler fans
101. Optimum clinker bed height for improved cooler efficiency
102. Optimum charge ratio for ESP for better emission control
103. Chimney draught for reducing the cooler vent fan power consumption
104. Adaptive Predictive control system to improve efficiency
105. Installation of WHR for utilizing waste heat

106. Installation of VFD for shell cooling fan and auto control with shell temperature
107. Installation of Graphite sealing system for kiln inlet and outlet seal
108. Installation of slide gate instead of multi Louvre damper in pre heater fans with SPRS / GRR
109. CFD analysis of cyclones to improve heat transfer, cyclone efficiency
110. Optimum feeder box height for better heat transfer in riser ducts
111. Low temperature drop in Tertiary Air Duct
112. Better sealing arrangement for camera, pyrometer in kiln hood
113. Timer based operation for Screw conveyors below Cooler ESP, RABH
114. Increasing chimney height to reduce power consumption
115. Optimizing RA fan with VFD for reducing RABH fan power consumption
116. Use of Effluent water for cooler spray
117. Low capacity pump for GCT and cooler to avoid recirculation
118. Low pressure drop and false air across WHR boiler
119. Low pressure drop across cooler fans silencer
120. Installed VFD for kiln feed aeration blower to operate in required pressure & speed.
121. Coal conveying pipe size reduced to getting required velocity
122. 5th Cyclone inlet area reduced (at bottom entrance) for both strings to increase inlet velocity and to avoid material surges from this cyclone.
123. To reduce the pressure drop across PH down comer, installed baffle plates at PH top of DC duct.
124. Substitution of Industrial waste as Alternate fuel. (Highest consumption in TSR basis in India)
125. Provided C3 clearance Bearings in F.K Pump for avoiding abnormal sound and vibration
126. Grease distributer is provided for uniform grease spray throughout the width of the gear/pinion and proximity is provided at distributor plunger to sense its operation. If there is no flow proximity will sense thereby avoid girth gear running without grease
127. Cooler Mid hot air connected to raw mill to dry limestone.
128. Addition of Horicon (cyclone) in top stage to reduce pressure drop and minimize dust loss.
129. Kiln feed LSF standard deviation has been achieved up to 1.4 through optimization of blending silo extraction cycle
130. Used the un burnt fly ash as fuel
131. Silo extraction standard deviation of Cao is <0.15.
132. Installed with a Knock out chamber in TAD take off to reduce the Clinker fine dust re entrainment into the Preheater
133. Belt Bucket Elevator with Steel chord
134. PH down comer duct sizing : Duct inside gas velocity can be kept at <10 m/sec to minimize the pressure drop and to save PH fan power(applicable

where the power cost is > 10 US Cents per kwh

135. Use of Natural Pozzolana like Riyolite, Pumice and Basaltic Scoria as Silica Substitute in Raw mix for Clinkerisation to reduce the energy consumption and increase production

CEMENT MILL

136. HPRG for pre grinding
137. Separator for HPRG for overall performance
138. Diverting HPRG sep reject for another mill to optimize overall circuit
139. VFD For separator , mill vent and sep vent fans
140. Dry fly ash bin at 20 m near mill for optimizing power and use of energy efficient blower for fly ash unloading
141. Fly ash feeding at mill outlet
142. Air seal / felt seal in separator to reduce fines in reject
143. Sep vent in the range of 10 -15 % of separator fan flow
144. Low pressure drop across separator circuit (cyclone, separator, duct)
145. CFD for ducts and cyclones for optimizing pressure drop
146. Adaptive predictive control system
147. Lower size grinding media in second chamber
148. Mill fill control system using vibration measurement
149. Residue control instead of Blaine control
150. Hydraulic pressure of roller press reduced from L1-130 to 90 & L2-140-100bar to avoiding initial trippings
151. Interlock has been made RP motor cooling fans stop 1hr time delay after RP stop.
152. Interlock has been made Bag house heaters automatically stop 1hr delay after the mill stops.
153. Cement VRM support to run without hot gas by replacement of hydro-pneumatic spring type HSLM in place of conventional hydraulic type HSLM. Thermal Energy saving achieved.
154. Mill de-dusting discharge material directly goes with mill fresh feed in CM3. It has been observed that mill running with unstable and tripping 2-3 times in a day. Redirected de-dusting discharge material to classifier. Benefits,(i) Mill tripping avoided (ii) Initial startup & Aux power saving.
155. Provided auto skewing adjustment arrangement for Roller Press.
156. Cement Mill slide shoe bearing interlock modification. If any LP Pump trip, automatically HP Pump should run to avoid tripping of Mill.
157. Use of problem solving tools (six sigma, RCM etc) for elimination of chronic problems.
158. Elevator installed in place of pneumatic conveying system for fly ash unloading.
159. Every 45 days roller profiling is done for both rollers of Roller press in CM-1 & 2 circuits.

160. Grinding media makeup charge as per requirement (Blaine /residue graphs).
161. Auto reversal of mill feed rotary air lock to avoid stoppage due to rotary air lock stalling
162. No Preheating before start up of mill (No Hot gas generator used)
163. Online monitoring of Nitrogen pressure in accumulators
164. Separate grinding and Blending of additive materials

PACKING HOUSE

165. Air slide fans for silo extraction instead of compressed air / blower
166. Blower for packing machine feed bin (surge hopper) extraction instead of compressed air
167. Packer fan volume 2000m3/ hr / spout consuming 1.9 kW/ spout /hr
168. Low false air across packer bag filter
169. VFD for packer fan and interlock with machine operation
170. Material starvation switch in belt conveyors to avoid idle running
171. Open wagon loading
172. All 10 no. packers are upgraded with EEL packers to reduce the weight variation.
173. Truck loading de-dusting system interlock is provided whenever truck loading is stop.
174. Auto flushing system provided for bag printing machine.
175. Zero velocity chute provided in Packing Plant vibrating screen to increase the life.
176. Cleaning compressor, 18.5 kW stopped in packing plant & 2.2 kW blower arranged for cleaning purposes and saved Rs. 8.39 Lakhs annually.
177. Online branding system to reduce man power.
178. Installation of VFD for compressors & an interlock is provided with no. of packers running for reduction of Specific power consumption
179. All discharge chutes are lined with ceramic pad to reduce the bag burstage
180. Conversion of truck loader inclined belt from rough top to fish bone type belt to reduce bag burstage
181. Regular cleaning of spouts in every shift.
182. Installation of electronic bag counting mechanism before truck loading machine.
183. Use of small capacity compressor for single plant operation.
184. Floor Sweeper for Spillage Cement collection
185. Vacuum Cleaning System for Spillage Recovery

COMPRESSOR

186. Generation pressure at 5.5 bar irrespective of the section
187. VFD for compressor

188. LP compressor for fly ash unloading
189. Dedicated compressor operating at 4.0 bar for Pulse jet kiln bag house
190. Red tag system for minimizing and reducing leakages
191. Level based drain valve instead of timer
192. Demand side / supply side controller to optimize power
193. Centrifugal compressor for base load in multiple kiln in single location
194. HOC dryer instead of refrigerant dryer
195. Energy efficient blower at 0.8 bar for fly ash unloading
196. Optimized the ideal running of ELGI compressor's dryer through interlock and saved 3kW per hour.
197. Reduced the pressure drop across filter and optimized the pressure setting of compressors and saved 25 kW per hour.
198. Screw Compressor in place of Reciprocating compressor for sustained volumetric efficiency and energy saving
199. Decentralized Compressed air generation according to consumer capacity

PUMPS

200. Level based auto control instead of manual control
201. Booster pump for high head low volume users like separator Gear box
202. Sand filter recirculation based on online turbidity measurement
203. High Energy efficient pumps
204. Online water flow meter
205. Submersible pumps for mines dewatering
206. Optimized the operation of cooling tower during winter and stoppages of cement mill and saved 2 kW power per hour.
207. Installed smaller water pump (18 kW) for usage during plant shutdown instead of 60 kW water pump (during kiln running)
208. Gas conditioning in Cooler & Raw mill is being done with the Treated STP water.
209. Water treatment plant's rejects, Boiler Blow down & cooling tower blow down water is being used for Gas conditioning in Cooler, Raw mill & Dust Suppression
210. Reducing the specific water consumption from the level of 0.22 m3 per ton of cement to 0.18 m3 per ton of cement

ELECTRICAL DISTRIBUTION

211. Installation of lighting transformer and maintaining optimum lighting voltage
212. Install Auto power factor controller and maintain unity power factor
213. Optimize the frequency of turbo generator (In island mode only)
214. Install LED lamps with Solar PV for colony and remote street lighting
215. Replace the old rewound motors with Energy Efficient IE3 motors

216. Install Intelligent MCC Controls
217. Speed control through GRR with 20 – 100% speed variation where VFD is not available
218. Interlock the GRR cooling fans operation with GRR panel temperature
219. Replace the T12 or T8 lamps with T5 lamps
220. Install Magnetic induction lamps for high bay areas in place of HPMV lamps
221. Replace the Mercury vapor lamps with Metal halide/Sodium vapor lamps/ CFL/Magnetic Induction Lamps
222. Convert Delta to permanent Star connection for lightly loaded motors (<35%)
223. Install auto star delta converter for lightly loaded motors (variable loads)
224. Minimize unbalance in Voltage by equally loading the transformer
225. Using Soft Starters to avoid higher initial currents to larger size motors
226. Replace Cooler vent fan and Kiln main drive motors with AC drives
227. Install Harmonic filters
228. Installation of Energy Monitoring system
229. Installation of Light pipe in place of high discharge lamps for day lighting
230. Replace 85W incandescent lampsd with 45W CFL lamp.
231. Replace 70 W Sodium vapor lamps replaced with 45W CFL
232. Interlock the transformer cooling with temperature of the winding
233. Optimize ESP heaters operation from 110 to 80 degC.
234. Commissioning of Energy monitoring system to control the power consumption
235. In-house overhauling of all HT motors rating from 250kw to 5300kw.
236. Plant lights ON&OFF optimization through PLC timer
237. Use Astronomical switches/ LDR's for lighting controls
238. Install maximum demand controller to avoid demand charges
239. Conducting Thermography survey on electrical system to avoid breakdowns
240. Power distribution at 11KV for to minimize distribution losses
241. Selected white metal bearing motors with forced lubrication to minimize breakdowns on bearings failures
242. Upgrading of old SPSR with IGBT based SPRS to increase availability of SPRS
243. Upgrading old SPRS controllers (Bin card system) with New controller to increase availability of SPRS.
244. Replacement of reciprocating chiller with high efficiency screw chiller for air condition
245. Scheduling of mill operation to reduce TOD consumption resulting in cost saving
246. Use of Passive infrared sensors for lighting system

247. Intelligent relay for reducing the LT motor failures
248. Optimization of distribution Transformer losses by loading the transformer between (40 %-60 %)
249. Isolate the primary of transformer also to avoid no load losses
250. Increase the radiators size of Power transformers to improve cooling
251. Reduce the tap setting of Power/Distribution transformer to optimize the system voltage
252. Install energy efficient amorphous transformer for new installations
253. Optimize the Charge Ratio of ESP Transformer
254. Install Medium Voltage VFD in place of GRR/LRR
255. Install magna drive for variable speed applications
256. Replace the Panel incandescent indication lamps with LED lamps
257. Replace halogen lamps with metal halide lamps
258. Optimize the operation of lighting in MCC rooms with door interlock/ entrance switch/movement sensors
259. Install neutral Compensator in lighting circuit to compensate neutral current
260. Provide more transparent sheet instead of asbestos sheets to use natural light
261. Replace the turbine hall exhaust fans with turbo ventilators
262. Providing of Insulated Wall Panels for the MCC Rooms to reduce Air conditioning load

CAPTIVE POWER PLANT

263. VFD for Pumps (BFP, CEP, CWP,ACWP) and fans
264. Optimum pressure drop across condenser and HE
265. Optimum frequency and power factor
266. IGBT control system for furnace control
267. Optimum excess air
268. Optimum false air in flue gas circuit
269. Desulphurization & Gypsum production for reducing flue gas loss
270. Low pressure compressed air for fly ash and bed ash transport
271. VFD for instrument and fly ash compressor
272. Low pressure drop in FD fan
273. Multi stage drag reduction valve in place of ARC
274. Turbo ventilator for turbine hall
275. Low pressure drop in flue gas circuit
276. VFD for cooling tower fans
277. Vacuum pump in place of ejector
278. Adaptive Predictive control system for operation
279. Low compressed air leakage
280. Sep lubrication oil pump for generator cooling and governor

281. Optimum charge ratio for better ESP performance
282. Changing Evaporator coils once in every two years to achieve maximum performance
283. Monitoring tube thickness in every shutdown
284. Introduction primary screen in coal belt to avoid fines
285. Predictive and Preventive Maintenance Practice
    a. *Tripping Analysis.*
    b. *Thickness checking of Acid tanks & Chimneys.*
    c. *Committee for steam leakage detection.*
    d. *Ultrasonic leak detection for vacuum.*
    e. *Wear Debris Analysis for TG oil.*
    f. *Checking of thermal insulation.*
    g. *Condition monitoring of all equipment.*
    h. *Maintenance is being done through EAM system.*
    i. *Coal sieve analysis.*
    j. *Chemicals are being used on first come, first out basis.*
    k. *Half yearly checking of compressed air vessels.*
    l. *Yearly checking of slings, chain blocks, D-shackles & EOT Crane*
    m. *Replacement of Boiler Bed coils, once in Two years.*
    n. *Chemical followed by bullet shot Cleaning of condenser tubes once in two years.*
    o. *Monitoring the condition of major equipments as per check list.*
    p. *Over-hauling of TG sets – once in 5 years*
286. Dual speed for Cooling Tower fan.
287. Installed Energy efficient Air Conditioners in plant.
288. TPP ACC-1 chamber lighting circuit modified with ON/OFF switch.
289. TPP ESP top lighting circuit modified with ON/OFF switch
290. Installation of steam heaters to maintain Lube oil temperature of DG, thereby stop use of electric heater and save energy.
291. Utilization of waste hot gases from TPP to reduce moisture content in lignite.
292. Modification of fluidizing & pushing air line in air slide to opti-mize & control high bed temperature to increase Boiler efficiency.
293. Modification in ACC condensate drain line resulting in improved vacuum, reduced heat rate & auxiliary consumption of 0.48%.
294. Avoiding steam dumping
295. Mist/Sprinkler cooling for Air Cooled Condenser Operation.
296. Optimization of Ash conveying time and eliminate empty line purging.
297. Installation of mechanical transport system in place of pneumatic transport for flyash handling

GENERAL

298. Compressed air purging based on DP across bag filter
299. VFD for bag filter fans and interlocking speed with suction
300. Cooling tower fans speed reduction in stead of on /OFF control
301. Optimum delta T across heat exchangers
302. Installation of Evaporative condenser for improving AC plant performance
303. Installation of Vapor Absorption Refrigeration system
304. Installation of Building Management system for reducing AC load
305. Construction / Retro fit to Green Building to reduce power consumption
306. Installation of Hybrid (Solar / Wind) power generation systems
307. Installation of Solar thermal systems for steam generation for canteen
308. Daily monitoring and analysis of key parameters
309. Daily power consumption report sent all management cadre employees for their information and control action
310. Celebration of National Energy conservation week celebrations to educate all persons
311. Rain water harvesting done for every individual bore well to recharge ground water table.
312. Installation of Transparent sheet at workshop to avoid lighting during day time.
313. Replacement of tube type heat exchanger with plate type heat exchanger to improve efficiency.
314. LOTO for all energy isolation.
315. Carrying out energy audits at regular intervals and adopting necessary energy conservation activities through Zero / Low / high cost investments
316. Robo Lab
317. Torn out switch introduced for Belt Conveyors to identify the belt cut
318. Performing Root Cause Analysis of any failures / breakdowns to avoid recurrence.
319. Formation of energy circle team.
320. Selection of equipments for saving on energy.
321. Implementation of ISO 50001 for effective energy conservation and management
322. Scheduling and Operation of production plants having spare capacities to reduce the peak load requirement.

CHAPTER-7
MONITORING PARAMETERS FOR ACHIEVING ENERGY EFFICIENCY

Monitoring system is an integral part of any cement plant; Energy Monitoring is the process of establishing the existing pattern of energy consumption and explaining deviations from the expected values, if any.

The following parameters can be used by Energy Manger and the Process engineer for optimizing the output and power consumption in each section:

CRUSHER:

S. No	Parameter	Purpose	Preferred monitoring frequency
1	Crusher output size	To ensure crusher and raw mill output	Weekly
2	Crusher feeder speed(rpm) and running hours	To ensure optimum crusher output and loading	Online Daily
3	Crusher output , TPH, BDP and actual	BDP and actual	Daily
4	SEC, BDP and actual	Deviation and improvement	Daily
5	Main Bag filter DP	Optimum venting and power	Online continuous
6	BF venting Specific air flow, m^3 / TPH	Identify excess air flow	Monthly
7	Moisture content of material	Too high wet material adds up to energy consumption. Monitoring and controlling moisture at Crusher product shall be more effective to control energy conservation in mining, transportation & raw grinding sections. To control by mine dewatering program/plan the mine block operation/surface drying	Daily average sample or Online continuous

RAW MILL -VRM

S. No	Parameter	Purpose	Preferred monitoring frequency
1	False air from mill inlet to mill fan outlet	Optimizing fresh air in RABH / Kiln bag house fan and its power	Monthly
2	Mill fan Inlet pressure	Pressure drop across circuit	Online continuous
3	Mill outlet dust loading gm /m^3	Optimize flow accordance with output	Monthly
4	Cyclone pressure drop	Achieve lowest SEC	Online continuous
5	Pressure drop across Mill fan inlet damper	Damper condition	Monthly
6	Louvre velocity	Optimize Mill DP	Monthly
7	Mill reject %	To optimize Mill fan SEC	Online continuous
8	Mill load (avg kW) to allowable kW	Optimize output	Monthly
	SEC		
9	Mill drive	Monitor and maintain SEC	Online continuous , Daily
10	Mill fan	Monitor and maintain SEC	Online continuous, Daily
11	Mill fan Efficiency	To achieve best tech possible, monitor and maintain	Monthly
12	Mill feed size	Optimize output	Weekly
13	Mill product residue Target and actual	Optimize mill and kiln operation	Hourly
14	Feed moisture	For Mill Efficiency monitoring	Daily average
15	Mill Internal Water Spray rate	For Mill Efficiency monitoring	Daily average

RAW MILL- BALL MILL

S. No	Parameter	Purpose	Preferred monitoring frequency
1	False air from mill inlet to mill fan outlet	Optimizing fresh air RABH / Kiln bag house fan	Monthly
2	Mill fan Inlet pressure	Pressure drop across circuit	Online continuous
3	Sep dust loading gm /m^3	Optimize flow accordance with output	Monthly / Online
4	Cyclone pressure drop	Achieve lowest SEC	Online continuous
5	Pressure drop across Mill fan inlet damper	Damper condition	Monthly
6	Mill Grinding media filling level	To achieve optimum grindability in mill	Online continuous
7	Circulation load	Ensure better separator efficiency	Online Continuous
8	Mill Reject < 90 micron sieve	Monitor separator performance	Shift wise
	SEC		
9	Mill drive	Monitor and maintain SEC	Online continuous, Daily
10	Mill fan	Monitor and maintain SEC	Online continuous, Daily
11	Mill fan Efficiency	To achieve best tech possible, monitor and maintain	Monthly
12	Mill feed size	Optimize output	Weekly
13	Mill product residue Target and actual	Optimize mill and kiln operation	Hourly
14	Mill load (avg kW) to allowable kW	Optimize output and decide on grinding media make up charge	Daily
15	Piece weight in first chamber	To achieve optimum grindability in mill	Monthly

S. No	Parameter	Purpose	Preferred monitoring frequency
16	Grinding media surface area in second chamber	To achieve optimum grindability in mill	Monthly
17	Size of Slot Opening in the partition wall grates / cleanliness	To achieve optimum material and gas/air flow through mill	Fortnightly
18	Pressure drop across mill	To monitor the material and air/gas flow and identify the blockages if any in the grates (partition and discharge diaphragm)	On line continuous

PYRO SECTION

S. No	Parameter	Purpose	Preferred monitoring frequency
1	Kiln feed LSF SD	Kiln stability, optimum heat of reaction, clinker grindability	Daily
2	Preheater outlet oxygen	To maintain optimum excess air	Online Continuous
3	Preheater outlet CO	To maintain optimum excess air	Online Continuous
4	Preheater outlet pressure and temperature	Maintain and monitor preheater thermal loss	Online Continuous
5	Preheater fan inlet damper pressure drop	Damper condition	Monthly
6	False air across preheater (from kiln inlet to preheater fan outlet)	Optimize electrical and thermal sec	Monthly
7	Kiln inlet No_x level	Burning Zone excess air level	Online Continuous
8	Each cyclone Δ P and Δ T (BDP and actual)	Optimize electrical and thermal sec	Monthly
9	Dust concentration in down comer duct (BDP and actual)	Optimize electrical and thermal sec	Yearly

S. No	Parameter	Purpose	Preferred monitoring frequency
10	RABH DP	Optimize bag life and fan power	Online Continuous
	Fan efficiency		
11	Preheater fan	To achieve best tech possible, monitor and maintain	Monthly
12	RABH Fan	To achieve best tech possible, monitor and maintain	Monthly
13	Cooler vent fan	To achieve best tech possible, monitor and maintain	Monthly
14	Cooler fans	To achieve best tech possible, monitor and maintain	Monthly
15	Temp drop across TAD	Reduce radiation loss and false air entry	Monthly
16	Cooler fans suction pressure	Optimize fan power	Monthly
17	Pressure drop across silencer in cooler fans	Ensure optimum power	Monthly
18	Damper pressure drop (if any)		Monthly
19	Preheater fan	Damper condition	Monthly
20	Cooler vent fan	Damper condition	Monthly
22	SEC		
	Preheater fan	Monitor and maintain SEC	Online continuous and daily
	Cooler fans	Monitor and maintain SEC	Online continuous and daily
	Cooler vent fan	Monitor and maintain SEC	Online continuous and daily
	RABH fan	Monitor and maintain SEC	Online continuous and daily
	Coal conveying blower	Monitor and maintain SEC	Online continuous and daily

S. No	Parameter	Purpose	Preferred monitoring frequency
23	Specific air flow		
	Cooling air	Monitor and maintain thermal & Electrical SEC	Monthly
	Cooler vent air	Monitor and maintain thermal & Electrical SEC	Monthly
	Preheater fan flow	Monitor and maintain thermal & Electrical SEC	Monthly
	RABH fan flow	Monitor and maintain thermal & Electrical SEC	Monthly
	Tertiary air flow	Monitor and maintain thermal & Electrical SEC	Monthly
24	Coal phase density		
	Kiln	Optimise blower power and sp heat consumption	Monthly
	PC	Optimise blower power and sp heat consumption	Monthly
25	Primary air %		Monthly
26	Cooler bed height	To achieve cooler recuperation efficiency	Online Continuous
27	Temperatures		BDP and actual
	Cooler vent	Monitor and maintain specific heat consumption	Online Continuous
	Clinker	Monitor and maintain specific heat consumption	Online Continuous
	Preheater outlet	Monitor and maintain specific heat consumption	Online Continuous
	Tertiary Air	Monitor and maintain specific heat consumption	Online Continuous
	Secondary air	Monitor and maintain specific heat consumption	Online Continuous
	Kiln Exit gas	Monitor and maintain specific heat consumption/Volatile circulation phenomena	Online Continuous
28	Water spray quantity		

S. No	Parameter	Purpose	Preferred monitoring frequency
	Cooler	Water, energy conservation, specific heat consumption	Online Continuous
	Down comer / Top cyclone	Water, energy conservation, specific heat consumption	Online Continuous
29	Free silica (Quartz) in kiln feed %	Kiln stability, optimum heat of reaction, clinker grindability	Hourly
30	Free lime in clinker %	Kiln stability, optimum heat of reaction, clinker grindability	Hourly
31	Kiln Feed Fineness – Residue on 212 micron sieve	Control of Free Lime and optimize energy consumption	Hourly

CEMENT MILL -BALL MILL

S. No	Parameter	Purpose	Preferred monitoring frequency
1	Circulation Load	Optimize separator performance	Online continuous
2	Separator loading(gm/m^3)	Optimize fan power	Online continuous/ monthly / variety wise
3	Velocity inside mill	Avoid over grinding	Mill vent volume can be alternative
4	Specific grinding media weight for first chamber	Optimize grindability	Monthly / regarding half yearly
5	Specific GM surface area for second chamber	Optimize grindability	Monthly / regarding half yearly
6	% filling level	Optimum output	Online continuous
7	Residue on 45 micron in the reject	Monitor separator performance	Shift wise
8	Roller press BDP KW and actual loading	Optimum grinding	Online continuous

S. No	Parameter	Purpose	Preferred monitoring frequency
9	Product residue or Blaine Target and actual	Optimum output and power	Hourly
10	Separator vent flow as % of circulating air flow	Control false air in the circuit, cooling of cement and optimize power	Monthly
11	Pressure drop across cyclone	Optimize fan power	Online continuous
	SEC		
12	Mill , HPRG Drives	Monitor and maintain SEC	Online continuous, Daily
13	CA fan	Monitor and maintain SEC	Online continuous, Daily
14	Mill vent	Monitor and maintain SEC	Online continuous, Daily
15	Sept Vent	Monitor and maintain SEC	Online continuous, Daily
16	Bag filter DP		
	Sept vent	Optimize bag life and fan power	Online Continuous
	Sept fan inlet	Optimize bag life and fan power	Online Continuous
	Mill vent	Optimize bag life and fan power	Online Continuous
17	Fan Efficiency		
	CA fan	To achieve best tech possible, monitor and maintain	Monthly
	Mill vent	To achieve best tech possible, monitor and maintain	Monthly
	Sept Vent	To achieve best tech possible, monitor and maintain	Monthly
18	Feed Composition/Recipe	To monitor consumption of additives and extenders	Online / Continuous

S. No	Parameter	Purpose	Preferred monitoring frequency
19	Feed moisture	To monitor SEC	Daily
20	Pressure Drop across Mill	To monitor SEC	Online / Continuous
21	Size of Slot Opening in the partition/end wall grates / cleanliness	To achieve optimum material and gas/air flow through mill	Fortnightly

UTILITIES

S. No	Parameter	Purpose	Preferred monitoring frequency
1	Compressor (HP) SEC	Monitor and maintain power	Daily
2	Up to clinkerisation		
3	Cement grinding		
4	Compressed air generation pressure	Optimize power and indication of leakage and pressure drop	Online continuous
5	Compressor loading %	Ensure optimum utilization	Monthly
6	Compressed air leakages %	Unproductive power	During every shutdown
7	Compressor SEC	Condition of compressor	Monthly where stand by is available other wise during stoppages
	Compressor discharge air temperature	Monitor and maintain efficiency of compressor / Cooling system/ FAD Capacity	Daily
	Screw Compressor – Oil Pressure	Monitor and optimize no load power	Periodical
8	Cooling water circulating flow		
	Pyro section	Water consumption and power saving	Monthly

S. No	Parameter	Purpose	Preferred monitoring frequency
	Cement mill	Water consumption and power saving	Monthly
9	Cooling water inlet and return temp	Effectiveness of heat exchangers ,process heat load and cooling tower effectiveness	Online continuous
10	COC	Water consumption	Monthly
11	Pump efficiency	Optimum power	Monthly
12	Pump discharge pressure	Line condition, requirement and valve throttling	Online continuous in case of common header or monthly
13	Fly ash unloading pressure	Optimize compressor power	daily
14	Air Conditioning SEC (kW/TR)	Optimize air cooler performance	Daily

CAPTIVE POWER PLANT

S. No	Parameter	Purpose	Preferred monitoring frequency
1	Boiler exit oxygen	Monitor and maintain excess air	Online continuous
2	Id fan inlet oxygen	Monitor and maintain false air	Monthly
3	DP across BFP Flow control valve	BFP power	Online continuous
4	Efficiency		
	BFP	To achieve best tech possible, monitor and maintain	Monthly
	CEP	To achieve best tech possible, monitor and maintain	Monthly
	CWP	To achieve best tech possible, monitor and maintain	Monthly
	ACW	To achieve best tech possible, monitor and maintain	Monthly

S. No	Parameter	Purpose	Preferred monitoring frequency
5	Compressor SEC	Monitor and maintain power	Daily
6	Inst compressor pressure	Optimize power and indication of leakage and pressure drop	Online continuous
7	Ash conveying pressure	Optimize power and indication of leakage and pressure drop	Online continuous
8	Compressor loading	Ensure optimum utilization	Monthly
9	Cooling tower inlet and outlet temp	Effectiveness of heat exchangers ,process heat load and cooling tower effectiveness	Online continuous
	Approach to Wet bulb temperature	Monitor the efficiency of Cooling tower	Monthly
10	Temp in ARC line (after valve)	Optimize BFP power, identify ARC valve life	Online continuous
11	Id fan inlet pressure	Optimize fan power	Online continuous
12	FD fan suction pressure	Optimize fan power	Online continuous
13	Fan efficiency		
	FD fan	To achieve best tech possible, monitor and maintain	Monthly
	Id fan	To achieve best tech possible, monitor and maintain	Monthly
14	SEC kW / MW (BDP and actual)		
	Pumps	Monitor and maintain SEC	Online continuous, Daily
	Fans	Monitor and maintain SEC	Online continuous, Daily
	compressor	Monitor and maintain SEC	Online continuous, Daily

S. No	Parameter	Purpose	Preferred monitoring frequency
15	Coal - Moisture	Monitor and Control Parasite consumption	Daily
16	Heat Rate	Monitor the boiler efficiency	Daily
17	Coal – Proximate analysis	Monitor the boiler efficiency	Periodical/ Shipmentwise
18	Gas Turbine inlet air temperature	Monitor the Turbine efficiency	Hourly

ELECTRICAL

S. No	Parameter	Purpose	Preferred monitoring frequency
1	Transformer Losses	To calculate efficiency	Monthly
2	Transformer winding temperatures	To eliminate or interlock with winding temperature	Online continuous, Daily
3	Transformer Incoming voltage	TO minimize the operation of OLTC by manual/auto mode	Online continuous, Daily
4	Transformer Tap position	To optimize distribution voltage	Monthly
5	Motor Loading	To Improve the efficiency	Monthly
6	Motor Voltage	To reduce the voltage loss and for maintain optimum voltage	Online continuous, Daily
7	Power factor	To reduce the distribution losses and increase the capcity(KVA)	Online continuous, Daily
8	Capacitor Power	To reduce the loss	Monthly
9	Captive Power plant –Frequency in Island Mode	To minimize the frequency and saving power in centrifugal loads	Online continuous, Daily
10	Captive Power plant – Power factor in Island Mode	To improve turbo generator efficiency	Online continuous, Daily
11	Lighting Voltage (210 V)	To save power and increase lamp life	Online continuous, Daily

S. No	Parameter	Purpose	Preferred monitoring frequency
12	Distribution Losses	To reduce cable losses	Online continuous, Daily
13	Maximum demand	To avoid any penalties	Online continuous, Daily
14	Temperature of major feeders	To avoid any shut downs (using thermograph)	Monthly
15	Voltage drop	To minimize distribution losses	Monthly

ABBREVIATIONS:

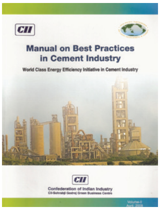
AC	- Alternating Current
ACC	- Air Cooled Condensor
ACWP	- Auxiliary Cooling Water Pump
AFBC	- Atmospheric Fluidized Bed Combustion
AFR	- Alternate fuel & Raw Material
BDP	- Best Demonstrated Practice
BEE	- Bureau of Energy Efficiency
BF	- Bag Filter
BFP	- Boiler Feed water Pump
BH	- Bag House
CA	- Circulating Air
CAGR	- Compound Annual Growth Rate
CAP	- Capacity
CCR	- Central Control Room
CEP	- Condensate Extraction pump
CFC	- Chlorofluorocarbon
CFD	- Computational Fluid Dynamics
Ckt	- Circuit
CMA	- Cement Manufacturers' Association
CO	- Carbon monoxide
COC	- Cycle Of concentration
CWP	- Cooling Water Pump
DP	- Differential Pressure
EOT	- Electric Overhead Travelling
ESP	- Electostatic Precipitator
FA	- False Air
FD	- Forced Draft
GCT	- Gas Conditioning Tiwer
GI	- Galvanized iron
GRR	- Grid Rotor Resistance
HMI	- Human Machine Interface
HP	- High Pressure
HPMV	- High Pressure Mercury Vapor Lamp
HPRG	- High Pressure Roller Grinding
IGBT	- Insulated Gate Bypolar Transistor
ILC	- In Line Calciner
LDR	- Light Dependent Resistor

LED	- Light Emitting Diode
LOI	- Loss on Ignition
LOTO	- Lock Out Tag Out
LRR	- Liquid Rotor Resistance
LS	- Lime stone or Linear Stacker
LSF	- Lime Saturation Factor
MCC	- Motor Control Center
MTPA	- Million Tons per Annum
MV VFD	- Medium Voltage Variable Frequency Drive
NCBM	- National Council for Cement and Building Materials
NCV	- Net Calorific Value
OPC	- Ordinary Portland cement
P&V	- Pressureisation & Ventilation
PAT	- Perform Achieve and Trade
PH	- Pre Heater
PLC	- Programmable Logic Controller
PLF	- Plant load factor
PPC	- Portland Pozzolona Cement
PPM	- Parts Per Million
PSC	- Portland Slag Cement
RABH	- Reverse Air Bag House
RE	- Renewable Energy
RP	- Roller Press
RPM	- Revolutions per Minute
SEC	- Specific Energy Consumption
SLC	- Separate Line Calciner
SPRS	- Slip Power Recovery System
STP	- Sewage Treatment Plant
TAD	- Tertiary Air Duct
TG	- Turbo Generator
TOD	- Time of Day
TPH	- Tonnes per Hour
TSR	- Thermal Substitution Rate
VFD	- Variable Frequency Drive
VRM	- Vertical Roller Mill
WC	- Water Column
WHR	- Waste Heat Recovery

Publications by CII-GBC as part of World Class Energy Efficiency in Cement Plants

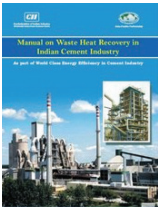
Manual on Best Practices in Cement Industry

The publication details the best practices followed by the Indian plants in the areas of energy efficiency, quality and productivity improvement.



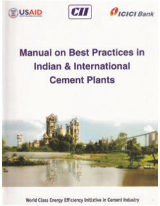
Manual on Waste Heat Recovery in Indian Cement Industry

The manual focuses on description of technologies available for Waste Heat Recovery Potential and installations in the Indian Cement Plants. This also discusses the advantages and also the barriers towards the deployment of WHR Technologies.



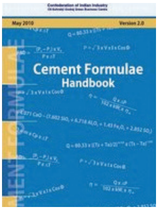
Manual on Best Practices in Indian & International Cement Plants

The publication was brought out as part of world class energy efficiency which covers the energy conservation measures carried out in the six cement plants as part of the mission and the experience and learning on Waste Heat Recovery from international mission carried out in Germany, Belgium, UK, Switzerland and Japan cement plants.



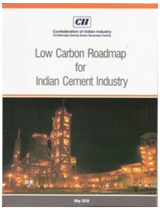
Cement Formulae Handbook

The formula book is a compilation of useful formulas, norms available at various sources, intended as a store of information which acts as a quick reference for the plant personnel. This was very well accepted by the Indian cement plants and subsequently the second edition was released during the annual conference in 2010.



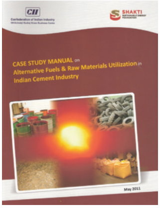
Low Carbon Roadmap for Indian Cement Industry

The report is an effort to create a road map for Indian Cement Industry to achieve the reduction in its Green House gas emission intensity. This is meant for due contemplation, reflection and necessary action from the Indian cement industry in its road map towards a low carbon growth.



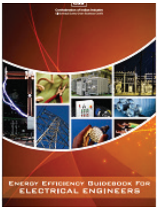
Case study Manual on Alternative Fuels & Raw Materials Utilization in Indian Cement Industry

The purpose of this manual is to act as catalyst for promoting increased use of alternate fuel & raw materials in Indian Cement Industry through co processing of wastes and reducing cost of clinker production, thereby improving performance competitiveness of individual cement plants. The objective also is to promote a much needed ecologically sustaining solution to the waste management problem in the country through co processing in cement kiln.



Energy Efficiency Guidebook for Electrical Engineers

The guidebook is a quick reference for electrical engineers that covers the fundamental theory of basic electrical equipments and provides the latest information on electrical systems such as motors and its control, transformers, lighting systems etc. It also throws light on the possible energy saving opportunities and newest trends in electrical and lighting systems.

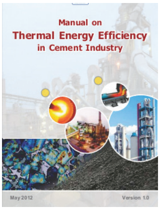


Low Carbon Technology Roadmap for the Indian Cement Industry

The report is a set of technical papers focusing on technologies, policy factors and financing needs for carbon emissions reduction and resource efficiency enhancement in Indian cement Industry. The technology papers are developed by Confederation of Indian Industry (CII) & NCCBM in partnership with International Energy Agency (IEA) and WBCSD's Cement Sustainability Initiative (CSI).

Manual on Thermal Energy Efficiency in Cement Industry

The Government of India in consultation with Bureau of Energy Efficiency (BEE) has released the PAT targets for the period from 2012-13 to 2014-15 in relation to their current level of energy consumption. Cement industry needs to focus more on Thermal Energy Efficiency in its endeavour to achieve the PAT targets. This manual serves as a ready reckoner on thermal energy efficiency including latest norms and best practices to reduce thermal Specific Energy Consumption.



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