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DETAILED ENERGY AUDIT AND CONSERVATION IN A CEMENT PLANT

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Abstract: A Cement plant is an energy intensive industry both in terms of thermal and electrical energy and more than 40% of production cost is accounted for by the cost of energy. With intense competition in the market place on price, energy conservation offers itself as a low cost option to cut costs and create a market edge. Every effort in bringing down the thermal as well as electrical energy use would impact directly on the profitability of the company.

The energy audit and conservation project was carried out in the cement plant to assess the performance of its various sub-sections and utilities such as pyro-processes, fans, compressors for Cement Manufacturing. This project work also strives to identify potential avenues for energy and cost savings. The plant mainly relies on its 12 MW captive power plant (CPP) to meet its electricity requirements.

This project brings out in a holistic and simple fassion, the broad frame work and methodology required to be followed to conduct an energy audit and conservation study in a typical cement plant.

PROBLEM STATEMENT

Energy audit and conservation in a cement plant, involves pains taking task with enormous amount of duty parameters that need to be monitored measured and analyzed in a systematic manner to bring to maximum possible energy conservation options.

This project has attempted to address the potential energy conservation options which has a major impact on reduction of energy consumption and energy cost savings in a cement plant and with an objective to provide a frame work for instituting an energy audit in a cement plant along with evaluation methods and analysis to bring out meaningful and substantial energy conservation options, in a easy to implement manner.

This project work would serve as a reference guide to any practicing engineer to conduct with ease an energy audit, in a facility as complex as cement plant, in a professional manner.

1. INTRODUCTION

The Progressive management of this cement plant has been continuously improving its technology over the past four decades, since its establishment. It started with the wet process in three separate cement plants, and now these have been wholly converted to dry cement process and modern technology.

The management of this cement plant accords high importance to social responsibility and environmental values. This is manifest in the installation of the latest pollution control equipment in the plant.

To support the production of cement, the plant has modern vertical roller grinding mills along with tube mills both for raw meal as well as coal. Cement grinding is achieved exclusively by tube mills/horizontal ball mills.

The final products of the plant include PPC, OPC, PSG and other special cements. The major markets are Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Pudducherry etc.

2. PROCESS DESCRIPTION

The production of cement involves two major processes,

a. The Pyro-process, where lime stone the main raw material along with other additives in the form of fine ground power is converted to clinker in multi stage cyclone preheater system and a rotary kiln.
b. The grinding process, where clinker along with other additives is ground to form different grades of cement.
c. The schematic of the overall cement production flow chart is given in the Figure 2.1 Overall Flow Diagram of Cement production process.

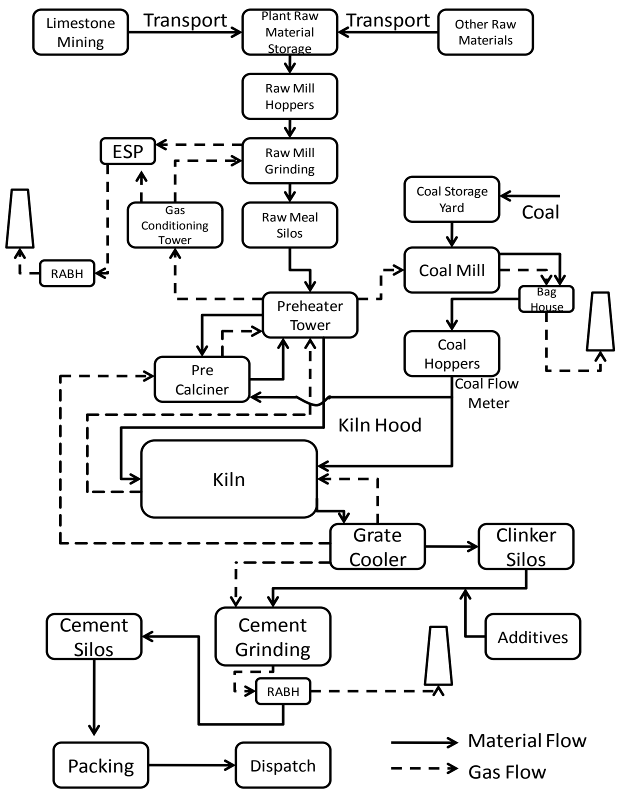
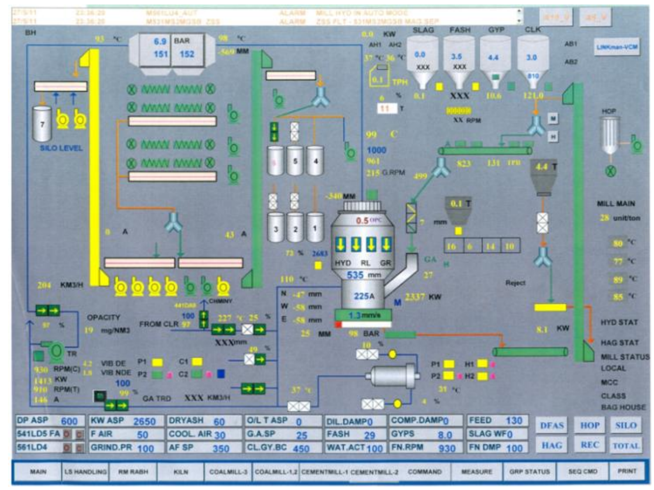


Fig.2.1: Overall flow diagram

3. RAW MEAL PREPARATION

Limestone is obtained directly from the mines, which are located around 50 km away from the plant. The limestone boulders are crushed in primary and secondary Crusher at the mine site itself and transported to the factory. The lime-stone at the factory storage yard after unloading, is tested for quality standards after which it is segregated as high grade, medium grade and low grade lime stone by the Stacker and Reclaimer. Clinker Preparation. The finely ground and blended raw meal is sent to the Kiln via a five stage Pre-heater string and pre-calciner. The first stage of the Preheater is a double cyclone. Depending upon the various types of cements manufactured, appropriate additives are added to the clinker and are ground in the cement VRM.

Figure 3.1: Typical Mimic sample of the Raw Mill Section



4. ENERGY SCENARIO

4.1 Electrical Energy System

The cement plant receives electricity supply from the Captive Power Plant (CPP) (12 MW) and DG sets. It is distributed to various sections of the plant. An energy meter is installed on 110 kV feeder incomer, which records import and export values of power to the grid.

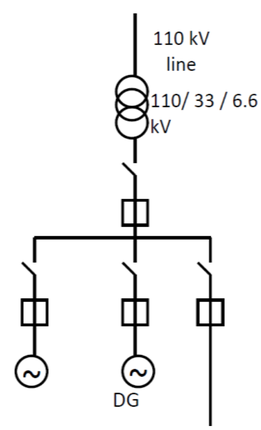


Table 4.1: Details of Sources of Electricity

Source	Annual power consumption in lakh kWh
TNEB (Grid)	27.105
CPP	37.67
DG Set	930.55

The same is presented as a pie chart in the Figure 4.2, which gives the pictorial view of percentage of contribution of energy from each source.

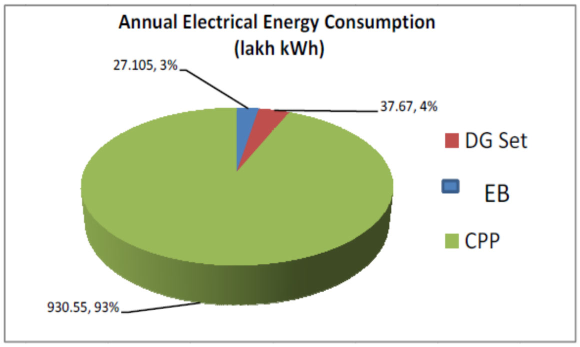


Figure 4.2 Break-up of Electrical Energy Sources

From the above graph, it is clear that the CPP contributes about 93%(930.55 lakh kwh) of total cement plant electrical energy requirements followed by the DG set accounting for 4% (37.67 lakh kWh) and rest 3% (27.105 lakh kWh) from the EB grid supply.

4.2 Utilization of Electrical Energy

Electrical energy is being utilized in all the sections of the plant. The section wise specific power consumption per tonne of cement is presented table 4.2 below:

Table 4.2: Section wise Break-up of Electrical Energy consumption

S. No.	Section	Specific power Consumption per tonne of cement YTD
1	Lime Stone Transport	0.49
2	Raw Mill-1& 2	17.35
3	Kiln	20.43
4	Coal Mill -3	3.77
5	Coal Mill - 1&2	0.49
6	Total Cement Mill	29.25
7	Packing House	1.65
8	Miscellaneous	4.06
9	Quarry	1.17
10	Plant Stoppage Units	0.25
	Total	78.91

The above break up of SEC is represented as a pie chart in Figure 4.3

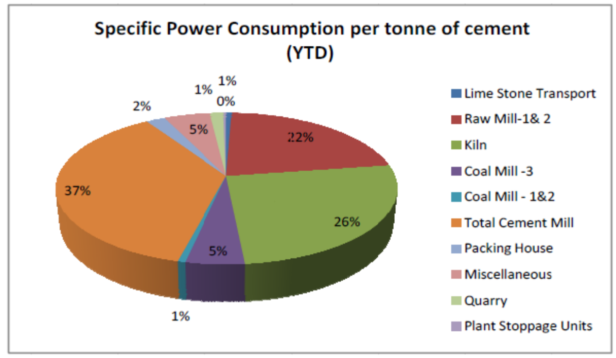


Figure 4.3 Specific power consumption section wise break-up

From the above pie chart, it is evident that the cement mill section (37%) is the major contributor to overall SEC, followed by kiln section (26%) and then by Raw mill section (22%), while all the other sections of the plant including miscellaneous, account for only 15% of total SEC.

4.3 Thermal Energy System

Various fuels are being used the cement plant, for process kiln. The various fuels used and annual consumption quantities are detailed in the table 4.3 below-:

Table 4.3: Annual Thermal Energy consumption in a cement plant and their share

S. No.	Name of Fuel	Annual consumption in tonnes	Calorific Value Kcal/kg	Energy Equivalent Million kcals
	Solid Fuels			
1	Coal (Indian)	111200	3263	362.85
2	Coal (Imported)	10580	5961	63.06
	Liquid Fuels			
3	Furnace oil(F.O)	1243.47	10000	3.71
4	High Speed Diesel (HSD) *(including consumption by material handling of 241 tonnes)*	248.73	10399	2.59

The share of various thermal energy sources in terms of quantity is clearly represented in a pie chart in Figure 4.4

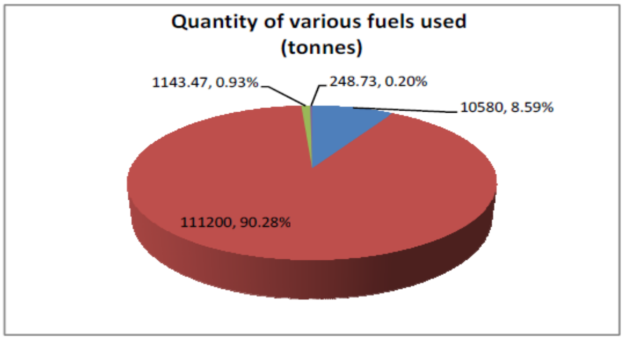


Figure 4.4 Share of Thermal Energy Sources

From the above chart, it is evident that Indian coal constitutes the single largest thermal energy sources (90.28%) followed by Imported coal (8.59%) for pyro processing. The remaining 1.1% of Furnace oil and HSD are used for start-up and DG set operations.

The equivalent thermal energy contribution of each of the fuels towards cement production is depicted in the pie chart in Figure 4.5.

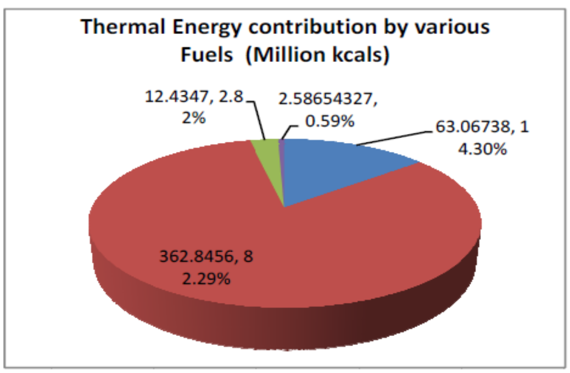


Fig 4.5Share of Thermal Energy use by different fuels

From the above pie chart, it is clear that the indian coal has a maximum share (82.29%; 362.85 Mkcals)in the overall cement plant's total thermal energy use and Imported coal constitutes 14.30% (63.06Mkcals)followed by minimum contribution by both the liquid fuels.

4.4 Share of type of Energy in cement production

From the piechart in Figure 4.6, it is clear that in the production of cement in this plant 67.75% of total energy is contibuted by Thermal Energy and 32.25% by Electrical energy from the grid and CPP together.(heat rate of CPP is considered).

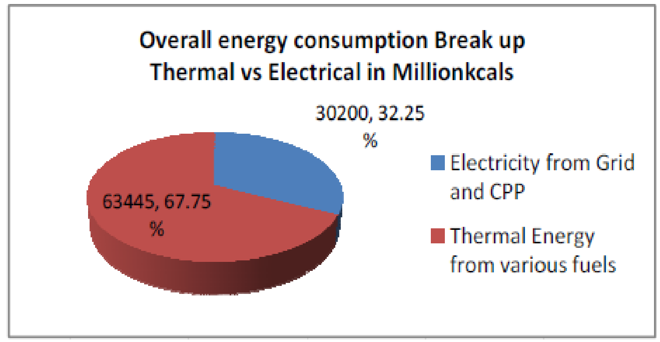


Figure 4.6: Share of Enegry type in cement production

4.5 Heat Rate of CPP/DG

Even though the cement plant receives supply from the EB and DG sets, it primarily depends on its own 12MW captive power plant for its electricity requirements. The heat rates of CPP and DG set are summarised in table 4.4:

Table 4.4 Heat rates of CPP and DG set

Description	Units	
Avg. Gross Heat rate of DG Set	kCal/kWh	2337.51
Average Gross Heat Rate of CPP	kCal/ kWh	3245.36

4.6 SEC consumption

The Specific Energy consumption breakup as reported by the plant are as given in table 4.5:

Table 4.5: Specific Energy Consumption of Plant

Description	Units	Value
Thermal SEC	kCal/kg Clinker	730
Electrical SEC (up to Clinkerization)	kWh/Tonne Clinker	59.74
Electrical SEC (Cement Grinding)	kWh/Tonne Cement	29.43

5. FIELD OBSERVATIONS AND FINDINGS

Table 5.1: Total Surface Heat losses (Radiation & Convention)

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S.no	Section Ref.	Surface Temp. (Ts)	Surface area	Radiation heat losses	Convection heat losses	Total Surface heat Losses
		°C	Sq.m	Kcal/hr	Kcal / hr	Kcal / hr
1	Grate Cooler	140	89.56	69433.96	48083.38	117517
2	Cooler take off	183	105.73	140348.08	86580.72	226929
3	Kiln chamber	154	42.64	39962.63	26744.88	66708
	TAD (dist. frm PC end in m) 2	212	13.31	23958.78	13504.98	37464
	TAD (dist. frm PC end in m) 4	219	13.31	25655.38	14138.12	39794
	TAD (dist. frm PC end in m) 6	223	13.31	26531.29	14455.23	40987
	TAD (dist. frm PC end in m) 8	216	13.31	24919.33	13866.59	38786
	TAD (dist. frm PC end in m) 10	222	13.31	26279.13	14364.59	40644
	TAD (dist. frm PC end in m) 12	200	13.31	21216.44	12423.53	33640
	TAD (dist. frm PC end in m) 14	223	13.31	26531.29	14455.23	40987
	TAD (dist. frm PC end in m) 16	220	13.31	25903.74	14228.69	40132
	TAD (dist. frm PC end in m) 18	172	13.31	15581.81	9927.26	25509
	TAD (dist. frm PC end in m) 20	217	13.31	25163.18	13957.07	39120
	TAD (dist. frm PC end in m) 22	212	13.31	23958.78	13504.98	37464
	TAD (dist. frm PC end in m) 24	213	13.31	24196.70	13595.33	37792
	TAD (dist. frm PC end in m) 26	105	13.31	5811.28	4265.22	10076
	TAD (dist. frm PC end in m) 28	88	13.31	4027.31	2962.38	6990
	TAD (dist. frm PC end in m) 30	77	13.31	2999.57	2170.25	5170
	TAD (dist. frm PC end in m) 32	86	13.31	3785.31	2778.32	6564
	TAD (dist. frm PC end in m) 34	92	13.31	4374.66	3223.62	7598
	TAD (dist. frm PC end in m) 36	101	13.31	5369.20	3951.46	9321
	TAD (dist. frm PC end in m) 38	96	13.31	4836.19	3565.16	8401
	TAD (dist. frm PC end in m) 40	85	13.31	3689.92	2705.32	6395
	TAD (dist. frm PC end in m) 42	90	13.31	4224.56	3111.16	7336
	TAD (dist. frm PC end in m) 44	88	13.31	3978.50	2925.39	6904
	TAD (dist. frm PC end in m) 46	107	13.31	5980.72	4383.89	10365
	TAD (dist. frm PC end in m) 48	130	13.31	8841.59	6261.40	15103
	TAD (dist. frm PC end in m) 50	123	13.31	7981.50	5720.94	13702
	TAD (dist. frm PC end in m) 52	98	13.31	4993.84	3680.32	8674
	TAD (dist. frm PC end in m) 54	83	13.31	3501.52	2560.44	6062
	TAD (dist. frm PC end in m) 56	90	13.31	4174.94	3073.84	7249
	TAD (dist. frm PC end in m) 58	85	13.31	3737.51	2741.77	6479
	TAD (dist. frm PC end in m) 60	99	13.31	5100.00	3757.45	8857
4	Klin (dist. frm burner end in m) 1	75	12.9	2739.60	1971.69	4711
	Klin (dist. frm burner end in m) 2	183	12.9	17152.05	10581.10	27733
	Klin (dist. frm burner end in m) 3	197	12.9	19956.44	11795.76	31752
	Klin (dist. frm burner end in m) 4	219	12.9	24899.03	13721.31	38620
	Klin (dist. frm burner end in m) 5	255	12.9	34398.42	16853.99	51252
	Klin (dist. frm burner end in m) 6	245	12.9	31519.91	15969.56	47489
	Klin (dist. frm burner end in m) 7	239	12.9	29871.02	15439.49	45311
	Klin (dist. frm burner end in m) 8	211	12.9	23022.96	13019.17	36042
	Klin (dist. frm burner end in m) 9	210	12.9	22794.90	12931.55	35726
	Klin (dist. frm burner end in m) 10	192	12.9	18925.59	11360.82	30286
	Klin (dist. frm burner end in m) 11	176	12.9	15843.32	9977.86	25821
	Klin (dist. frm burner end in m) 12	179	12.9	16303.76	10192.95	26497
	Klin (dist. frm burner end in m) 13	199	12.9	20272.19	11926.47	32199
	Klin (dist. frm burner end in m) 14	187	12.9	17829.42	10883.80	28713
	Klin (dist. frm burner end in m) 15	229	12.9	27376.35	14601.42	41978
	Klin (dist. frm burner end in m) 16	185	12.9	17537.21	10753.99	28291
	Klin (dist. frm burner end in m) 17	254	12.9	34250.54	16809.75	51060
	Klin (dist. frm burner end in m) 18	271	12.9	39519.28	18314.90	57834
	Klin (dist. frm burner end in m) 19	249	12.9	32651.50	16323.21	48975
	Klin (dist. frm burner end in m) 20	178	12.9	16211.06	10149.90	26361
	Klin (dist. frm burner end in m) 21	182	12.9	16961.35	10494.74	27456
	Klin (dist. frm burner end in m) 22	182	12.9	16866.48	10451.58	27318
	Klin (dist. frm burner end in m) 23	172	12.9	15122.44	9634.59	24757
	Klin (dist. frm burner end in m) 24	182	12.9	16866.48	10451.58	27318
	Klin (dist. frm burner end in m) 25	148	12.9	11188.05	7601.97	18790
	Klin (dist. frm burner end in m) 26	172	12.9	15033.69	9591.76	24625
	Klin (dist. frm burner end in m) 27	183	12.9	17152.05	10581.10	27733
	Klin (dist. frm burner end in m) 28	216	12.9	24184.68	13457.79	37642
	Klin (dist. frm burner end in m) 29	289	12.9	45484.17	19864.83	65349
	Klin (dist. frm burner end in m) 30	307	12.9	52229.71	21457.76	73687
	Klin (dist. frm burner end in m) 31	310	12.9	53616.56	21767.21	75384
	Klin (dist. frm burner end in m) 32	297	12.9	48590.06	20617.31	69207
	Klin (dist. frm burner end in m) 33	299	12.9	49152.79	20750.06	69903
	Klin (dist. frm burner end in m) 34	295	12.9	47846.63	20440.29	68287
	Klin (dist. frm burner end in m) 35	283	12.9	43548.21	19377.77	62926
	Klin (dist. frm burner end in m) 36	275	12.9	40833.03	18669.19	59502
	Klin (dist. frm burner end in m) 37	277	12.9	41333.16	18802.05	60135
	Klin (dist. frm burner end in m) 38	270	12.9	39195.33	18226.33	57422
	Klin (dist. frm burner end in m) 39	281	12.9	42687.01	19156.35	61843
	Klin (dist. frm burner end in m) 40	239	12.9	29871.02	15439.49	45311
	Klin (dist. frm burner end in m) 41	210	12.9	22681.40	12887.75	35569
	Klin (dist. frm burner end in m) 42	186	12.9	17731.70	10840.52	28572
	Klin (dist. frm burner end in m) 43	182	12.9	16961.35	10494.74	27456
	Klin (dist. frm burner end in m) 44	195	12.9	19540.13	11621.65	31162
	Klin (dist. frm burner end in m) 45	184	12.9	17247.86	10624.30	27872

S.no	Section Ref.	Surface Temp. (Ts)	Surface area	Radiation heat losses	Convection heat losses	Total Surface heat Losses
		°C	Sq.m	Kcal/hr	Kcal / hr	Kcal / hr
	Klin (dist. frm burner end in m) 46	180	12.9	16490.09	10279.10	26769
	Klin (dist. frm burner end in m) 47	181	12.9	16677.66	10365.31	27043
	Klin (dist. frm burner end in m) 48	183	12.9	17152.05	10581.10	27733
	Klin (dist. frm burner end in m) 49	201	12.9	20805.16	12144.52	32950
	Klin (dist. frm burner end in m) 50	166	12.9	13991.77	9079.24	23071
	Klin (dist. frm burner end in m) 51	155	12.9	12189.60	8147.30	20337
	Klin (dist. frm burner end in m) 52	168	12.9	14420.75	9292.46	23713
	Klin (dist. frm burner end in m) 53	189	12.9	18223.51	11057.08	29281
	Klin (dist. frm burner end in m) 54	198	12.9	20061.36	11839.32	31901
	Klin (dist. frm burner end in m) 55	199	12.9	20378.10	11970.06	32348
	Klin (dist. frm burner end in m) 56	202	12.9	20912.77	12188.17	33101
	Klin (dist. frm burner end in m) 57	214	12.9	23599.34	13238.38	36838
5	5th cyclone cylinder	130	174.53	116796.02	82630.25	199426
6	5th cyclone cone	119	76.55	42967.08	31002.24	73969
7	5th cyclone material chute	153	64.65	59812.14	40132.38	99945
8	5th cyclone gas outlet	94	101.68	35353.51	26063.63	61417
9	Precalciner	110	492.69	236249.72	172555.35	408805
10	4th cyclone cylinder	111	167.12	81608.14	59537.56	141146
11	4th cyclone cone	121	75.47	43791.60	31495.37	75287
12	4th cyclone material chute	127	33.61	21475.36	15281.82	36757
13	4th cyclone gas outlet	127	45.04	28774.58	20475.93	49251
14	PC o/l duct	192	173.40	253973.87	152457.67	406432
15	3rd cyclone cylinder	109	171.57	80771.06	59059.24	139830
16	3rd cyclone cone	95	75.83	26953.91	19871.50	46825
17	3rd cyclone material chute	132	21.17	14603.70	10290.10	24894
18	3rd cyclone gas outlet	80	104.40	25646.31	18675.56	44322
19	2nd cyclone cylinder	82	142.22	36905.40	26966.32	63872
20	2nd cyclone cone	70	74.04	13314.68	9417.59	22732
21	2nd cyclone material chute	132	12.23	8438.29	5945.81	14384
22	2nd cyclone gas outlet	65	80.16	11943.33	8239.78	20183
23	1A cyclone cylinder	66	137.45	21311.94	14787.42	36099
24	1A cyclone cone	119	37.45	21018.79	15165.78	36185
25	1A cyclone material chute	130	8.54	5712.32	4041.32	9754
26	1B cyclone cylinder	71	137.45	25586.38	18170.08	43756
27	1B cyclone cone	110	57.44	27542.88	20117.15	47660
28	1B cyclone material chute	120	8.54	4871.81	3509.59	8381
Total surface heat loss rate		$q_{loss-radiation}$	Kcal/hr	3312373.45	2010621.79	5322995
Total specific surface heat loss		$q_{loss-conv.}$	$kCal/kg_{cli}$	27.41	16.64	

Overall Kiln Heat Balance

The kiln and grate cooler heat balance is based on the above input baseline parameters presented in table 5.1 and the overall heat input and output balance for the kiln are encapsulated in the tables 5.3 and 5.4The output heat balance presents the magnitude of loss (kcals/kg clinker) as well as percentage of total loss.

5.2 Electrical system

Besides the thermal energy consumed in the pyro-process, good deal of electrical energy is also consumed in the process of production of cement. Fans account for a major portion of the electrical energy consumption apart from pumps, air compressors, lighting and material handling.

5.2.1 FANS

Methodology:

Towards analyzing the as run performance of all the major Process fans, the average operational duty parameters were collected during the period of study by way of field measurement, design values and also from the Central Control Room (CCR).In order to identify the potential gaps in performance that could be bridged all the relevant fan operational duty parameters were compared with the designed and PG test values. All these were analyzed in depth and accordingly all the fan operating efficiencies were calculated. In addition, respective energy conservation options were identified and presented along simple payback periods which are discussed in ENCON chapter.

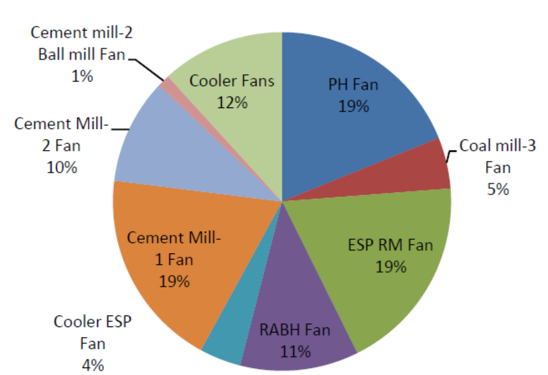

Fig5.2.1(a) Connected load of Major fans

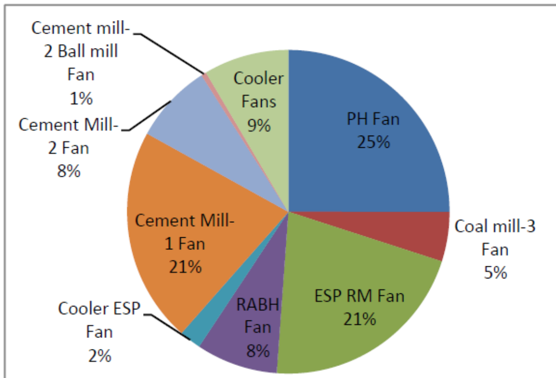

Fig 5.2.1(b) Operating Load of Major Fans

a) Energy Performance of Pre-heater fan

The energy performance of the pre-heater fan was assessed based on as-run field measurement data, CCR data and design data as shown in Table 5.2.1

Table 5.2.1: Energy Performance of PH fan

S.No	Parameter reference	Units	Rated Value	As run trial value
1	Kiln Load	TPH (*1)	3000	2900
2	Fan Speed	RPM	1000	980
3	Fluid		Pre-heater gas	Pre-heater gas
4	Fluid Temp	°C	336	321
5	Site Barometric Pressure	$mmWC_G$	10187	10187
6	Fluid density	kg/m^3	0.637	0.594
7	Flow at Fan inlet	m3/hr	425000	485831
		TPH	270.53	288.74
8	Suction Pressure	$mmWC_G$	-	-777
9	Discharge pressure	$mmWC_G$	-	-89.0
10	Head developed	$mmWC_G$	1040	688.0
11	Motor Efficiency (assumed)	%	92	92
12	Fan motor rated power	kW	1500	1500
13	Motor input Power	kW	1742.4	1545.0
14	AirKW *(Fan hydraulic power)*	kW	1202.24	909.16
15	Power absorbed by Fan	kW	1603.0	1421
16	combined Efficiency	%	69	58.85
17	Fan Efficiency	%(*2)	75.00	63.96
18	Specific Energy Consumption (rated parameter vs. operating parameters)	$kWh/1000m^3$	3.77	2.93
		kWh/ton	5.93	4.92
19	Sp. Energy Consumption (rated flow and as-run head vs. as run parameters)	$kWh/1000m^3$	2.50	2.93
		kWh/ton	3.92	4.92
20	% margin on flow	%	reference	-14.3
21	% margin on Head	%	reference	33.8
22	% margin on Power	%	reference	5.2

(*1) Originally the PH fan was designed for 1700 TPD kiln load and which has now been enhanced to 3000TPD and further enhancement to 3500TPD is being contemplated which is presently not possible due to PH fan capacity limitations.

(*2) Fan design efficiency is an assumed value, in the absence of actual data.

6. RESULTS AND DISCUSSIONS (ENCON Options)

6.1 Energy Conservation in Thermal Areas:

The following energy conservation options have been identified.

- Stray/false air ingress reduction.
- Pressure drop reduction.
- Grate cooler efficiency improvements.
- Reduction of radiation heat loss in cyclones &TAD
- The pre-heater exit gas heat is been utilized in rest-Raw mill and rest-coal mill. However there appears to be enough heat in the PH gas existing the GCT as the bypass line to RABH. This could be used to operate a VAM to mitigate electricity consumption in vapour compression system.

Table 6.1.1 ENCON Option1: Stray/false air ingress reduction

False Air Measurements And Saving Calculations

Location	O2	False Air	False Air in Total Circuit (%)			Fan Flow	DP	Fan Efficiency	Power Saving	Annual Saving	Monitory Savings
	%	%	Observed	Allowable	Avoidable	m3/hr	mmWC	%	kW	Lakh kWh	
Preheater Fan											
Preheater Outlet (6 Floor)	2.7	7.6	7.6	5.0	2.6	485831	688.0	62.7	40.4	3.2	16.5
PH Fan Inlet	4										
Coal Mill Circuit											
Coal Mill Inlet	6.6	23.4	50.0	25.0	25.0	68644	768.0	49.8	75.8	6.1	30.9
Coal Mill Outlet	9.3										
Coal Mill BH outlet	11.2	19.4									
Coal Mill BH Fan outlet	11.4	1.0									
Raw Mill Fan Circuit											
Raw Mill Inlet	8.6	26.5	61.0	25.0	36.0	393322	740.0	70.6	425.4	29.6	150.8
Raw Mill Outlet	11.2										
Raw Mill ESP outlet	13.1	24.1									
Raw Mill ESP fan outlet	13.3	27.3									
RABH Fan											
GCT outlet	6.2	41.2	60.9	25.0	35.9	488462	249.5	71.3	175.5	12.2	62.2
RABH inlet	10.5										
RABH outlet	11.5	10.3									
RABH fan outlet	11.8	3.3									
Cement Mill-1											
Saving by Avoiding False air ingress considering 15% is acceptable inleak in the cement mill section		27.9	27.9	15	12.9	260924	859.0	76.5	108.2	8.7	44.2
Total Savings by arresting False Air									**717.1**	**51.1**	**304.6**
Investment *(procuring 2 no. air locks , one for raw mill section and one for Cement mill section .and one additional rotary feeder puls modification in other area including arresting leakage air.)*										Rs. Lakhs	200
Simple payback period										years	0.66
Note:	For PH fan and Coal mill circuit, the savings are calculated based on 8000hrs of operation per year where as for raw mill and RABH savings are calculated based on 21hrs of operation per day with 331 day of operation per year.										

7. RECOMMEDATIONS AND CONCLUSIONS

Pyroprocess

Heat Balance: A detailed heat balance was conducted for the pyro-process of the cement plant, The heat balance was conducted for the system consisting of Grate Cooler, Kiln, Pre-calciner and the pre-heaters. It was found from the heat balance that the total heat input into the system was 815.25kCal/kg clinker. Whereas, on the heat output side, around 51% of the energy input was used for the useful clinkerization process and the total heat loss from the system was 49%. That is, around 25% of the input energy was lost along with the pre-heater gases, 13% of the input energy was lost along with cooler exhaust air and 2.56% along with the hot exiting clinker from the grate cooler. The radiation and convective losses account for 5.3% of the total heat input.

Cooler Recuperation Efficiency: The Cooler recuperation efficiency is calculated based on indirect (heat loss) method and was evaluated to be 64.64%. The grate cooler efficiency can be improved by 2.8% by reducing the heat loss in, (a) exit clinker (exit clinker temp reduction from

130^{0}C to 100^{0}C) and (b) in exhaust air (by reducing temperature of exhaust air from 275^{0}C to 255^{0}C).

Gas Balance: The gas balance of the system was drawn starting from the pre heater fan outlet to the RABH fan exhaust, which gives a snapshot of the gas flows, temperatures, static pressures, O_2% and corresponding stray air in-leakage across concerned equipment (like the Vertical Raw mill, Vertical Coal Mill (VCM), electrostatic precipitator (ESP), RABH, Cement Mills etc. A table has also been prepared and presented, which encapsulates the equipment wise values of all the relevant parameters.

Stray air in-leakage reduction: It is found from the field measurement that the false air in- leak across the raw-mill circuit is around 61%, Coal mill circuit is 50%, pre-heater RABH fan circuit is 61% and the cement mill1 circuit is 28% of individual input flows. It must be noted here that the major stray air in leaks through the feeding mechanism of the VRM, VCM and the Cement mill (hopper feeding), can be avoided by replacing the old and inefficient triple feed gates with modern rotary feeders. The detailed quantification of savings has been dealt with in the subsequent ENCON sections.

Pressure drop reduction in Ducts: The velocities of the gas in each duct connecting all the major cement equipment is calculated and related with the corresponding pressure drops in the ducts. It was found the gas velocities in the pre-heater down-comer duct, Raw mill ESP to ESP fan duct and the Cooler ESP to the Cement mill, are more than 18m/s, against the recommended duct gas velocity of 16m/s.The equivalent energy reduction projections, alongside energy and associated cost benefit savings, have been calculated.

Fan Efficiencies: The performance of the major process fans were analyzed based on the average operational duty parameters collected during the period of study, by way of field measurement, design values and also from the Central Control Room (CCR).The performance of the fans such as Raw mill ESP fan, RABH fan and the cement mill 1 fan are good and are operating at efficiencies more than 70%. Where-as, the other major fans, namely, pre-heater fan which is operating at 64% efficiency, coal mill fan and the cooler ESP fans which are operating at efficiencies less than 50% and the cement mill 2 Bag house fan is operating at an efficiency of 67%. As regards the performance of the cooler fans, except P1, 2L and CIS fans , all other fans are performing at efficiencies less than 60% and will yield sizable energy savings if replaced with energy efficient fans, which can perform with efficiencies of 80% and more.

8. FUTURE SCOPE OF WORK

This thesis report details the methodology for conducting and evaluating energy conservation and audit for a cement plant. Being a very complex in nature, it is observed that they are many other energy conservation options that can be tapped in future like having latest technologies like high pressure roller mills before raw mills and coal mills which reduces grinding energy by 15-25%,variable frequency drives for all grate cooler fans which reduces grate cooler fan energy consumption, waste heat recovery from preheater and grate cooler exhaust gases, from which about 70% of the existing power consumption can be generated, use of alternate fuels and raw materials etc.

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