

Energy Audit & Process Optimisation

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Abstract

Energy is one of the essential element for human development and economic growth of a country. Energy Conservation Practices have acquired top priority in present Scenario of competitive “Buyers Market” Environment Management, Economic Growth Liberalisation and Globalisation.

The Indian Cement Industry is the 2nd Largest Cement Producer in the World, with installed capacity of 112 Million Tonnes, which had undergone rapid technological Upgradation and vibrant growth in last two decades, comparable in every respect a World Class Industry. The industry is highly energy intensive and the energy bill alone costs about 60% of Cement Manufacturing Cost. There is a substantial scope for reduction in energy consumption by adopting various Energy Conservation Measures to reduce the manufacturing cost.

Energy Audit is a disciplined activity, which identifies the potential areas and equipments for improvement, where the Energy Management & Process Optimisation efforts should be concentrated for Reduction in Energy Consumption.

This paper documents the systematic, analytical approach for various Energy Conservation Measures taken by way of Energy Audit & Process Optimisation, innovative modifications to achieve the lowest Energy Consumption in Cement Plant to 77 kWh/ T of Cement and reduction in Auxiliary Equipment Energy Consumption in 15.7 MW Captive Thermal Power Plant.

Introduction

Vasavadatta Cement has 0.5 MTPA Unit-I, 0.7 MTPA Unit-II & 15.7 MW Captive Thermal Power Plant equipped with latest state-of-the-art technology comparable to World Class Industry.

Energy Audit has emerged an important tool to identify the potential areas, equipments, for Retrofitting/ Replacement/ Optimisation, Providing Cost-benefit analysis Proposals/ Recommendations for Energy Conservation Energy Audit in a Plant is generally conducted in two stages:

Preliminary Energy Audit

- Identifies the quantity and cost of Energy Forms and in the Plant.
- Energy Consumption in various Equipments/ Sections, Process Level.
- Relates Energy Input to Production & Highlights the Wastage of Energy in Equipments/ Process areas.
- Recommendations for Low Cost Energy Conservation Measures.
- Identification of Major areas/ equipments require indepth study/ analysis.

Detailed Energy Audit

- Involves Detailed Mass and Energy Balance of Major Energy Consuming Equipments.
- Evaluation of system efficiencies.
- Identification of various measures for improving the End Use of Energy Efficiently.
- Proposals for major Retrofitting/ Replacement/ Modifications providing cost benefit analysis.

An integrated approach to achieve Lowest Specific Power Consumption in Cement Manufacture has been the Prime Objective at Vasavadatta Cement, adopting methodologies such as Energy Audit & Management, Process Optimisation, Continuous Monitoring, Energy Awareness & Education for Energy Conservation.

Major modifications/ retrofittings implementation for Energy Conservation & Process Optimisation

Cement Plant (Unit I & II)

1. Retrofitting of Cooler ESP Fans, Coal Circulating Air Fan, Waste Gas Fan and provided Variable Speed Drives.
2. Conservation of V-Belt Drives to direct drives and Flat Belt Drives in Fans & Blowers.
3. Installed Belt Bucket Elevator for Kiln Feed in Unit-I

4. Star Delta Connections of lightly loaded motors.
5. Installed V.V.V.F. Drives for Cooler Fans.
6. Transformer Voltage reduced by tap changing from 410 Volts to 398 Volts.
7. Provided Capacitor Banks for MRS Bus & HT Motors to maintain Power Factor.
8. Solar lighting at Mines Magazine.
9. Installed Dense Phase Conveying System for transporting Clinker ESP Dust to Cement Mill Hopper (Unit-I)
10. Integration of Cement Transportation from Unit-II to Unit-I Cement Silo for optimal utilization of Cement Mill No. 2.
11. Retrofitting of Cooler Unit-II with Polysius Jet Stream Static Grates.
12. Installed V-Separator in Polycom Circuit Cement Mill No.-2.

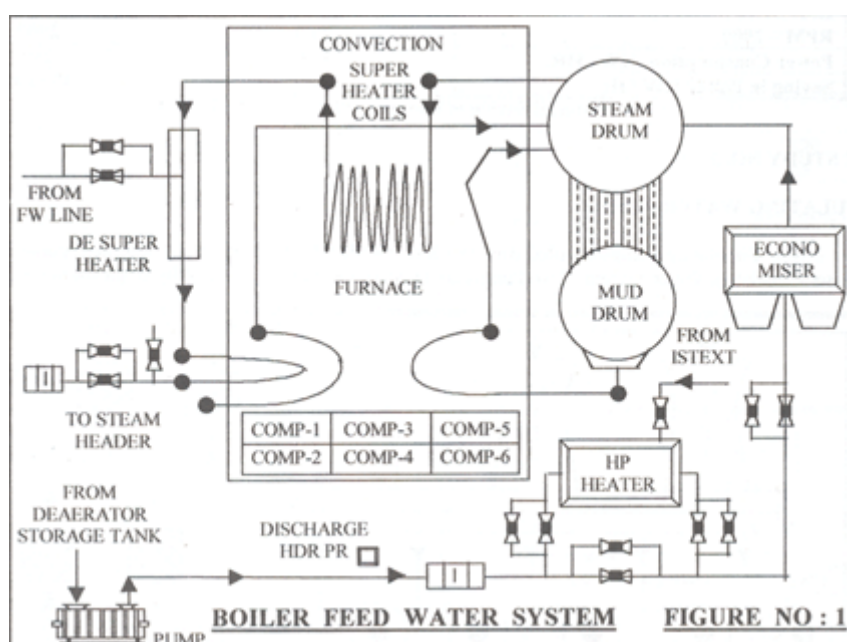
Captive Thermal Power Plant

1. Installed Dense Phase Conveying System for transporting Fly Ash from E.S.P. to Cement Mill Hopper.
2. Retrofitting of F.D. Fan, I.D. Fan, P.A. Fan and provided V.V.V.F. Drives.
3. Retrofitting of Circulating Water Pumps & provided & Cooling Tower Fans.
4. Provided V.V.V.F Drives for Condenser Extraction Pump & Cooling Tower Fans.
5. Reduction of one State in Boiler Feed Water Multistage Pump.
6. Provided Solenoid Valves in Compressors Water Cooling System for Power Saving.

Case Study No. 1

Boiler Feed Pump Modification

2 Nos. Multi Stage Feed Pumps have been provided in Feed Water System, one in Operation and the 2nd One as stand by. The function of the Boiler Feed Pump is to pressurize the deaerated water sucked in from deaerated storage tank to required Boiler Pressure. The feed water from Boiler Feed Pump passes through H.P. Heater, Economiser, and fed to Boiler Drum as shown in Fig. No. 1.



As indicated in Table -1, the Boiler Feed Pump was delivering 70 m³ / Hr. at 96 Meter Head consuming 320 kW power, whereas, the FBC Boiler has been designed for capacity of 70 TPH and Steam Outlet Pressure 64 ATA at 510 + 5° C temp.

It was observed from the Operational Parameters that the Boiler Feed Pump discharge pressure 96 Meter Head is much higher than the required Boiler Pressure of 80 Kg/Cm² and Wastage of Electric Energy in Pump HT Drive Motor. To optimize the Feed Water System, it was decided to modify the Pump HT Drive Motor. To optimize the Feed Water System, it was decided to modify the Pump Rotor 10 Stages to 9 Stages by eliminating one stage to reduce the Pressure Head. This modification was implemented in consultation with OEM M/s KSB Pumps and the Boiler Feed Pump was commissioned.

It can be seen from the Table No. 1 that, after this modification the Boiler Feed Pump is delivering 70 m³/ Hr. at 86 Meter Head to meet the boiler feed system requirement and achieved substantial saving in power 35 to 40 KW/ Hr. Considering the significant saving, the stand by Boiler Feed Pump has also been modified.

Table No. 1 Boiler Feed Pump Modification

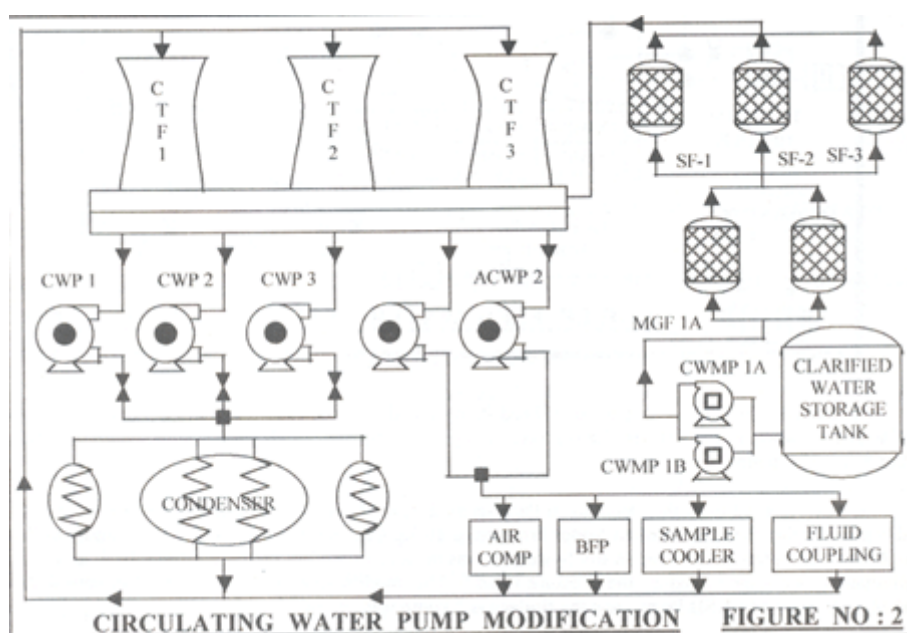
Sl. No.	Design Parameter	Operating Parameter	
		Before Modification	After Modification
1	Make – KSB HAD 100/10	Pump Rotor 10 Stages	9 Stages
2	Capacity – 76 m ³ / Hr.	70	70
3	Head in Meters – 96.4	96	86
4	H.T. Drive Motor, 350 kW, 6.6 KV RPM – 2900	2900	2900
5	Power Consumption KW/ Hr.	320	280
6	Saving in Power kW/ Hr.	-	35 to 40

Annual Saving in Power = 40 x 24 330 x Rs. 2.50
= Rs. 7.92 Lacs

Case Study No. 2

Circulating Water Pumps

3 Nos. circulating Pumps coupled with 180 KW, 990 RPM LT Motors have been incorporated in Turbine Condenser Circulating Water System. Two Pumps are in operation and one as stand by as shown in Fig. No. 2.



As shown in Table No. 2 the Pumps are designed to deliver 1650 m³/ Hr. at 27 Meter Head. It was observed from the Operational Parameters that, Delta T across the Condenser is 8-10 °C as against the operational requirement of Delta T 12 °C, indicating that the Circulating Pumps are delivering much more quantity of water than system requirement resulting in to pressure drop in valves and wastage of Electrical Energy in the Pump.

In order to optimize the Process Control and Energy Conservation, the modified Impeller of Revised Specifications were installed in same casing and VVVF Drives were also installed for better regulation. It can be seen from Table No. 2 that, after retrofitting of 2 Nos. Circulating Pumps there is substantial reduction in Power Consumption from 130 KW/ Hr. to 95 KW/ Hr. in each pump. The

Process Control is much better and at reduced load on Turbine one Pump is sufficient to meet System Requirement.

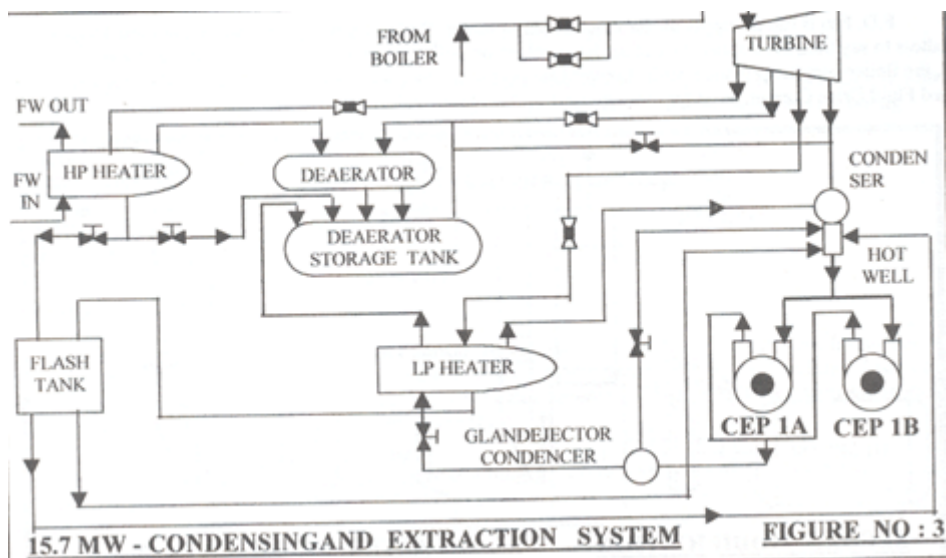
Table No. 2 Circulating Water Pumps

SI. No.	Design Parameter	Operating Parameter	
		Before Modification	After Modification
1	Make – KBL	-	-
2	Capacity – 1650 m ³ / Hr.	1600	1100
3	Head in Meters – 27	25	25
4	L. T. Drive Motor 180 KW RPM-980	960	833 (85%)
5	Power Consumption KW/ Hr.	130	95
6	Saving in Power KW/ Hr.	-	35

Annual Saving in Power = 35 x 2 x 24 x 330 x Rs. 2.50
= Rs. 13.86 Lacs

Case Study No. 3

Condensate Extraction Pump Modification



Condensate Extraction Pump of STG Set, discharge Steam-condensate to Deaerator for reuse in Boiler Feed Water System, maintaining a constant level of condensate in the hot well of the Condenser of the Turbine through a set of 2 Nos. Control Valves as shown in Fig. No. 3. There are 2 No. of Pumps, one running and one standby. The Pumps were supplied by the Turbine supplier M/s. Toyo Denki, Japan.

On studying the complete Steam Condensate Recycling System, it was observed that, the total pressure drop in the system from discharge neck of the pump to final delivery point a Deaerator Inlet Nozzel was around 4 to 4.5 Kg/Cm², which seemed to be very high and an area of energy loss. To minimize this loss, we changed the Pump Discharge line from 100 NB to 150 NB to enable the Pump to run at lower Head and incorporated V.V.V.F. Drive to run the motor at lower speed in consistent with T.G. Load, maintaining a constant condensate level in the Condenser Hot-well.

Table No. 3 Indicates the power saving achieved after modification of condensate extraction pump modification

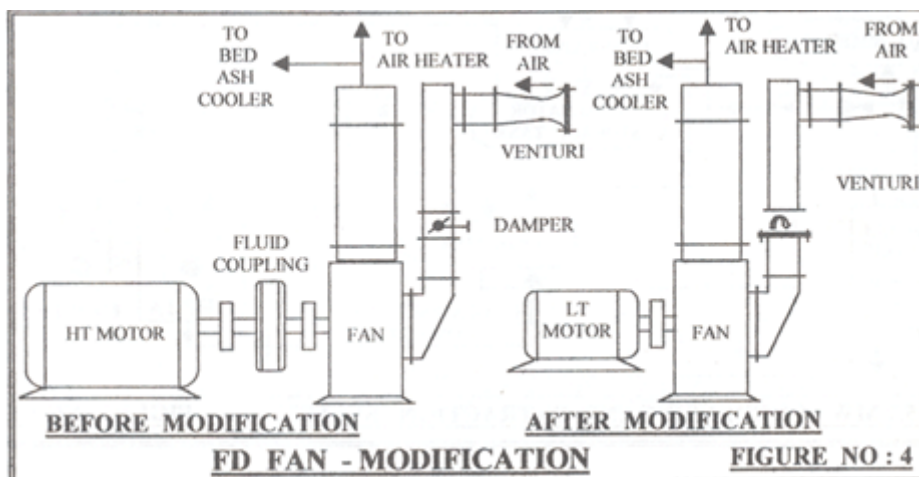
Sl. No.	Design Parameter	Before Modification	After Modification
1	Capacity 70 M ³ / Hr.	58	58
2	Head in Mtrs. – 109	95	70
3	Speed in RPM – 2940	2940	2350
4	Drive Motor Power – 55 KW	35	24
5	Saving in Power KW/ Hr.	-	11

Annual Saving in Power = 11 x 24 x 330 x Rs. 2.50
= Rs. 2.18 Lacs

Case Study No. 4

Modification of Boiler F.D. Fan

F. D. Fan is run to supply air for combustion of fuel in Boiler Furnace as shown in the Flow Diagram No. 4. Needless to say that the requirement of air for combustion will vary with respect to load on the Boiler. To achieve this, the Boiler supplier provided Multi-Louver Dampers in the Fan suction with constant speed motor with Variable Speed Fluid Drive Coupling and for measurement of Air Flow – A Venturi arrangement.



On studying the system, it was observed that, the total pressure drop across the Damper was around 25 MMWG and across the Venturi around 90 MMWG, so the total system pressure drop, beside the ducts was around 110 to 115 MMWG and hence an area of heavy energy loss. In order to optimize the system and Energy Conservation, the following modifications were done.

1. Removed the Air Flow measuring Device "Venturi" and Air Flow calibration was done from the Fan Characteristic Curve-Pressure Vs. Flow at different speed levels.
2. H.T. Motor was replaced with a 250 KW Rating L.T. (415 V) Motor, incorporating V.V.V.F Drive to enable the Fan to run at different speeds with respect to Boiler Load to get the desired Air Flow.
3. Fan Suction Damper was made in operative to keep it always wide open as its function would be taken care by the V.V.V.F. Drive of the motor.

Table No. 4 Indicates the achievement after modification

SI. No.	Design Parameter	Before Modification	After Modification
1	Capacity Flow – 27.24 M ³ / Sec.	23	23
2	Pressure – 700 MMWG	620	620
3	Speed in RPM – 1435	1410	1339
4	Drive Motor Power – 260 KW, 6.6 KV (H.T. Motor)	260 KW, 6.6 KV (H.T. Motor)	250KW, 415V (L.T. Motor)
5	Power Consumption KW/ HR	210	190
6	Saving in Power KW/ Hr.	-	20

Annual Saving in Power = 20 x 24 x 330 x Rs. 2.50
= Rs. 3.96 Lacs

Case Study NO. 5

Retrofitting of Clinker Cooler Expansion Unit – II

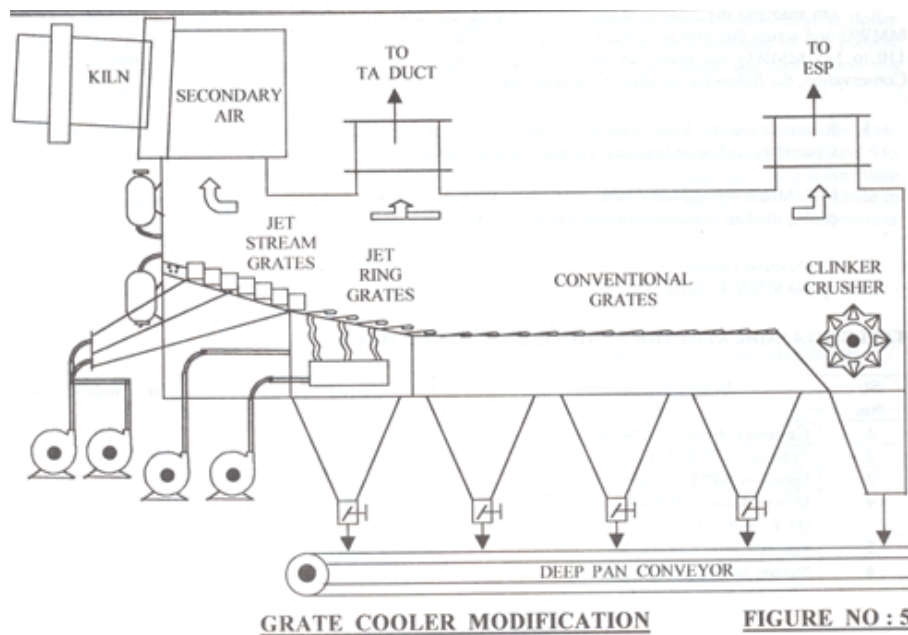
In 2000 TPD Capacity Expansion Unit – II Polysius Design Reciprocating Grate Cooler SR 3121/ II with 13 Rows of Jet Ring Plates having total Cooler Grate Area 65 M² has been provided for Clinker Cooling. The Expansion Unit-II was commissioned in March, 1997.

During the operation of the Plant, the following problems were experienced:

1. Red River in the Cooler.
2. Oxidation & Cracks on the Jet Stream Plates.
3. Failure of Flexible Hose of the Jet Ring Plates.
4. Higher Clinker temperature at Outlet.

To overcome these problems and to optimize the system, the Jet Ring Cooler Retrofitting has been implemented in the month of May, 2000 during the Kiln Annual Maintenance Shut Down. The First 7 rows of Jet Ring Grate Plates has been replaced with Jet Stream Static Grates, retaining 6 rows of Jet Ring Plates and modifying the Ductings of Existing Cooler Fans as shown in Figure No. 5.

To reduce the actual Shut Down period for Retrofitting the ducting of the Fans were fabricated and erected to the maximum possible extent while the Cooler was in operation. The complete Retrofitting was completed during the period of Kiln Brick Lining and the system was commissioned on 29th May, 2000.



It may be seen from Table No. 5 that the Secondary Air & Tertiary Air Temperature has increased resulting in to lower fuel consumption, power in Fans, stable Kiln condition and good quality Clinker, High reliability etc.

Table No. 5 Retrofitting clinker cooler with jet stream static grates

Sl. No.	Design Parameter	Before Modification	After Modification
1	Clinker Cooler	SR 3121/ II with 13 Rows of Jet String Plates. Grate Area 65 M ² .	First 7 Rows retrofitted with Jet Stream Static Grates.
2	Specific Cooling Air Volume NM ³ / Kg. of Clinker	2.0 – 2.2	1.85 – 1.92
3	Secondary Air Temp. °C	1050 – 1080	1080 – 1120
4	Tertiary Air Temp. °C	725 – 750	750 – 800
5	Cooler Vent Air Volume NM ³ /Kg.	1.4 – 1.5	1.25 – 1.30
6	Cooler Vent Fan RPM	530 – 580	450 – 550
7	Cooler Exhaust Gas Temp. °C	300 – 330	280 – 310
8	Clinker Temp. °C	180 – 220	170 – 190
9	Power Saving in Kw/Hr	-	71
10	Heat recuperation at Operating Condition:	65%	72%

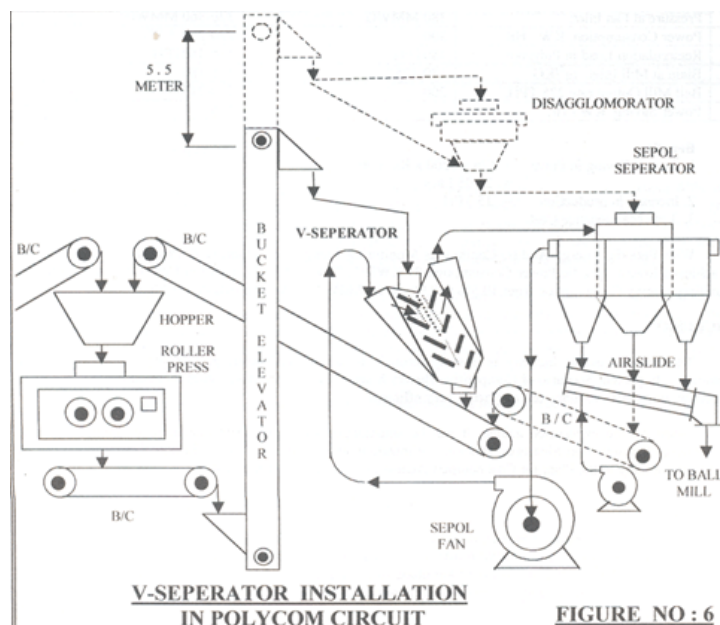
1. Annual Saving in Power = 71 x 24 x 330 x Rs. 2.50 = 14.06 Lacs
2. Thermal Energy = 16 kCal / Kg of Clinker

Case Study No. 6

Installation of V – Separator in Polycom Circuit

In expansion Unit – II for Cement Grinding Polycom size – 17/ 10 – 7 with Sepol and Close Circuit Ball Mill 4.6 Dia. X 14.5 ML of 225 TPH Capacity has been provided in System Engineering.

After commissioning the Cement Grinding Unit in June, 1997, it was observed during operation that, the Polycom output in Powder form ad the operation of Disagglomerator having twin drive motor each of 160 KW is not required. The Disaggolometer was bypassed for Energy Saving two years back and provided direct ducting from Bucket Elevator discharge to Sepol Separator. Refer Fig No. 6.



To further optimize the system for Energy Conservation, the following modifications have been implemented:

1. Reduced the height of Polycor Bucket Elevator by 5.5 Mtr.
2. Removed the Sepol Drive, Sepol Rotor, Static Grates.
3. Eliminated 1000 mm width Belt Conveyor from the Circuit.
4. Installed V-Separator in the Circuit and modified ductings.

Table No. 6 V-Separator installation in Polycor circuit

Sl. No.	Design Specifications	Before Modification	After Modification
1	Polycor Bucket Elevator Drive Motor – 160 KW – 1450 RPM.	45 Meter C/ C	Reduced height by 5.5 Mtrs.
2	Sepol with D.C. Motor 300 KW 250 – 1500 RPM.	Operational in Polycor Circuit.	Removed Rotor, Gear Box Drive with Motor
3	1000 mm Wide B. C. with Gear box & Motor 6 KW, 1450 RPM	Operational in Polycor Circuit.	Eliminated complete B.C. with Drive.
4	V-Separator installed in Circuit, Sepol Fan duct modified.	-	Installed before Sepol in Circuit.
5	Sepol Fn RPM Pressure at Fan Inlet.	990-990 380 MMWG	700-990 320-360 MMWG
6	Power Consumption. KW/ HR	300	220-250 TPH
7	Recirculation Load in Polycor.	480 TPH	450-480 TPH
8	Blain at Mill Inlet. M ² /KG	170-175	175-180
9	Ball Mill Output rate 225 TPH.	200	210-215
10	Power Saving KW/ Hr.	-	126

Benefits

1. Annual Saving in Power = 126 x 5200 x Rs. 3.06
= 20.05 Lacs
2. Increase in production = 15 TPH
3. Low Maintenance Cost.

With Periodic Energy Audits, Continuous Monitoring Energy Conservation & Process Optimisation, we have achieved lowest Specific Power Consumption 81 KWH/ T, 77 KWH/ T of Cement in Unit-I & II and reduction in Auxiliary Energy Consumption from 10.5% to 9.0% in 15.7 MW Captive Thermal Power plant.

Conclusion

The Indian Cement Industry is passing through an era of Restructuring, Merging, Consolidation and Acquisition. In present Scenario of Competitive Byers Market, Energy crisis and steep increase in Energy cost, it as become imperative to make use of Energy very efficiently.

Based on the experience gained, it can be summarized that, with implementation of Periodic Energy Audits, Energy Conservation Measures, Process Optimization and Diagnostic Studies, Energy Consumption can be reduced substantially in the Plant for Cost competitiveness and increase in Profitability.

Reference book:

7th NCB International Seminar on
Cement and Building Materials
New Delhi, 21-24 November 2000