OPERATIONAL AUDIT : AN EFFECTIVE WAY FOR ENHANCEMENT OF PLANT PRODUCTIVITY AND SAVINGS IN ENERGY CONSUMPTION

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ABSTRACT

The most advanced cement manufacturing technology does not, on its own, guarantee profitable operations. The cement manufacturing operation for maximum cost efficiency not only requires the advanced technological design but also sound operational practices.

Operational Audit is an effective way for enhancing the productivity and minimising energy consumption. The objectives of a comprehensive operational audit of a plant should include:

- Optimisation of the output
- Reduction in Specific Energy Consumption
- Trouble shooting in electrical, mechanical and process systems
- Dust abatement
- Quality assurance

This paper describes with the help of a case study, a typical methodology adopted for such an audit and the various measures suggested for optimising the operations of a cement plant. The studies have identified the potentials for increasing production & reduction in energy consumption and in planning their investment priorities for their plants modernisation.

1. INTRODUCTION

In the past three decades, extensive developments in the cement manufacturing process and technology have taken place in cement industry. Most of these developments have primary focus on energy efficiency and quality assurance. Now a days modern energy efficient equipment are available in the market by which cement industry is able to achieve the specific thermal energy in the range of 680-700 Kcal/Kg clinker and electrical energy in the range of 85-90 KWh/t cement. Besides adoption of such energy efficient technologies, number of potential areas can be identified for reduction in the energy consumption, through a comprehensive and carefully planned audit.

The most important of these areas are process control and process optimisation. Other potential areas could include dust emission reduction, preventive maintenance etc. In this paper, authors have specifically dealt with process optimisation for enhancement of plant productivity and savings in energy consumption through Plant Operational Audit.

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2. OPERATIONAL AUDIT

In simple terminology 'Operational Audit' can be defined as "A systematic approach to examine the effectiveness of facilities and efficiency of the operations". The approach can be broadly classified in following steps:

- Compilation of historical data
- Identification of bottlenecks and constraints
- Study and Analysis
- Recommendations
- Implementation of suggested measures

The methodology for Plant Operational Audit is shown in Figure 1.

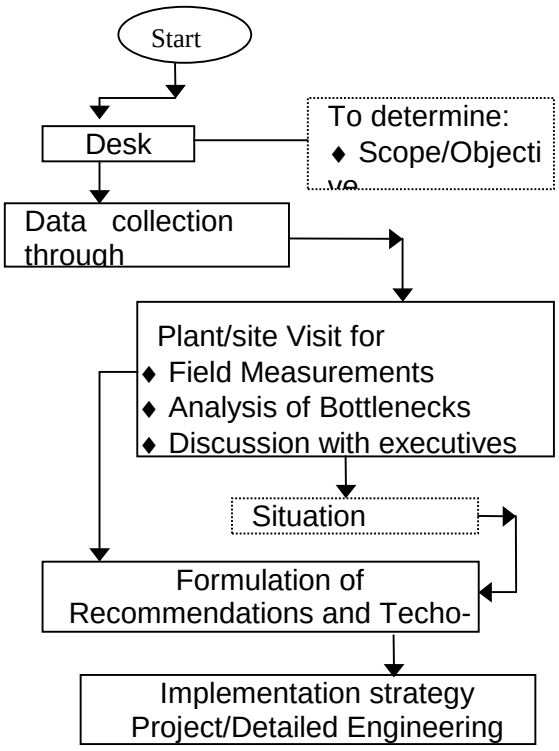

Figure 1

The purpose of Plant Operational Audit is manifold. It includes :

- To formulate strategies for increasing production and minimising the energy consumption which results in increased profitability.
- To create awareness towards the adoption of new technology.
- To develop a positive attitude towards energy conservation.
- To inculcate the habit of regular audit of operations to identify areas for improvements.

3. CASE STUDY

Holtec has recently carried out Operational Audit in a cement plant having a kiln of 3300 t/d clinker capacity with Precalciner system, with a view to:

- Study the plant operations
- Assess the present systems energy utilisation effectiveness and identify the areas and causes for high energy consumption and
- Suggest measures for increasing the production and reducing the energy consumption.

Plant Details :

Plant capacity	:	1.00 mio t clinker per annum
Lime stone crusher	:	850 t/h, Impactor crusher, 1024 kW
Coal Crusher	:	750 t/h, Roller Crusher, 200 kW
Raw Mill	:	290 t/h, VRM, 3400 kW
Kiln	:	3300 t/d, Six stage Preheater and Precalciner strings, Separate line calciner, Conventional grate cooler
Coal Mill	:	40 t/h, Vertical roller mill, 600 kW
Cement Mill	:	230 t/h, Roll Press, 2x1000 kW +Ball mill, 2x 2200 kW

3.1 Diagnosis

The plant operation was studied in detail during the plant visit. Prior to the plant visit a comprehensive questionnaire was developed for collection of relevant data and information. Details of plant machinery and operational data to the extent possible were collected through this questionnaire prior to the visit to ensure proper desk study. The audit team comprising of Process, Mechanical, Electrical and Instrumentation specialists had extensive discussions with plant executives and collected additional relevant information on operational bottlenecks, parameters and energy consumption pattern. During the study various measurements of process parameters, energy and dust concentration, etc. were taken in raw mill, clinkerisation, coal mill and cement mill sections. Heat, Gas and Mass balance of pyro-processing sections were carried out with ultimate objectives of identifying the potential areas for production optimisation as well as energy savings.

To study the existing level of energy consumption and operational bottlenecks, process measurements were carried out when system was operating at stabilised production level. The process measurements and heat consumption details are given at Annexure I.

After analysing the system bottlenecks, following recommendations were made to achieve higher output and energy savings. The recommendations are divided into two categories

- ➲ Without Investment i.e. Operational Improvements
- ➲ With Investment i.e. Technological Upgradations

3.2 Observations and recommendations (without investment)

Observations	Recommendations
♦ High dust nuisance in crusher section	♦ Provide some more vent points and relocating some of the existing points in existing bag filters ♦ Provide water spray arrangement at unloading hopper
♦ High raw mill inlet pressure i.e. 62 mmwg	♦ Maintain around 25-35 mmwg by adjusting the inlet damper
♦ Preheater exhaust gas volume was 1.68 Nm3/Kg of clinker with 5-7% Oxygen content.	♦ Reduce Preheater exhaust gas volume from 1.68 to 1.50 Nm^3/Kg clinker by arresting the leakages and optimising the kiln operation. ♦ Reduce high oxygen percentage (5-7%) at preheater strings outlet by arresting the leakages
♦ Differential outlet temperature in the two strings of Preheaters (268C and 299^oC).	♦ Adjust material dispersion box and plate in preheater cyclones. ♦ Readjust air sealing flaps for proper functioning.
♦ Kiln hood (outlet) draft was in the range of 8-10 mmwg.	♦ Maintain the kiln hood draft in the range of 2-3 mmwg.
♦ Cooling air - 2.15 Nm^3/Kg of clinker. ♦ Clinker outlet temperature - more than 125^OC ♦ Variation in secondary and tertiary air temperature	♦ Synchronise Cooling air and grate speed to obtain maximum and stable secondary and tertiary air temperature.
♦ Dust nuisance at material transfer points and material conveying was high	♦ Modify operation of dedusting bag filters in terms of purging sequence, cleaning air cycle and compressed air quality

By implementing the above recommendations, the following improvements have been envisaged*:*

Increase in output	=	12.00 %
Reduction in Thermal Energy	=	5.00 %
Reduction in Electrical Energy	=	5.00 %

3.3 Recommendations : with investment

- Incorporation of mechanical conveying for raw meal transport to silo to save electrical energy
- Incorporation of mechanical conveying for kiln feed transport to Preheater strings to save electrical and thermal energy
- Incorporation of mechanical conveying for cement transport to silo to save electrical energy
- Incorporation of dip tube in lower most cyclone to save thermal energy
- Incorporation of variable speed drives in cement mill ESP fan to save electrical energy
- Modification in cooler Ist grate with new generation CFG plates to increase production and save thermal energy
- Vent points location and material transport hood arrangements to be modified for suppressing the dust generation and emission

An investment of Rs. 76 mio is envisaged in implementing of above recommendations which is expected to yield increase in production and reduction in energy consumption as follows:

Increase in output	=	13.50 %
Reduction in Thermal Energy	=	4.00 %
Reduction in Electrical Energy	=	7.00 %

Based on the above savings, the pay-back period of investment of Rs. 76 mio worked out to 1.80 years.

After implementation of recommendations suggested in plant operational audit (with & without investments), reduction in thermal energy, fuel and electrical energy consumption envisaged are summarised in Table 1, Table 2 and Table 3 respectively.

Table 1 : Saving in Thermal Energy

	Before Modifications	**After Modifications**	
		Without investment	**With investment**
Heat Input	**Kcal/Kg clinker**	**Kcal/Kg clinker**	**Kcal/Kg clinker**
Fuel-Kiln comb.heat	263.00	249.00	240.00
Fuel-Cal. comb.heat	489.00	463.00	445.00
Total from Fuel	**752.00**	**712.00**	**685.00**
Free Heat from feed	17.68	17.68	17.68
Others (Prim. air + rest air)	5.46	5.25	4.26
Cooling air	7.71	7.71	6.54
Total	782.85	742.64	713.48

Heat Output	**Kcal/Kg clinker**	**Kcal/Kg clinker**	**Kcal/Kg clinker**
Exhaust Gas incl. dust	158.46	137.51	136.68
Waste air	124.05	110.85	84.10
Clinker	19.38	13.90	13.90
Heat of formation	393.92	393.92	393.92
Water evaporation	4.64	4.64	4.64
Radiation (kiln+Preheater string+	82.4	81.82	80.24

	Before Modifications	After Modifications	
		Without investment	With investment
Precalciner string+ Cooler+Ter. Air Duct)			
Total Output	782.85	742.64	713.48

Table 2 : Saving in Fuel Consumption

	Before Modifications	After Modifications	
		Without investment	With investment
Fuel Consumption % @ 5200 Kcal/kg coal	14.46	13.69	13.17

Table 3: saving in Electrical Energy (KWh/t OPC)

	Before Modifications	After Modifications	
		Without investment	With investment
Lime stone Crushing	2.85	2.57	2.56
Raw mill	31.96	30.81	28.86
Clinkerisation	26.76	23.50	19.94
Coal Mill	5.53	4.90	4.70
Cement Mill	27.86	27.86	26.99
Packing Plant	1.96	1.96	1.85
Miscellaneous(lighting etc.)	3.37	3.37	3.37
Total	100.29	94.97	88.27

4. CONCLUSIONS :

In the product like cement which is primarily a low value product, with high incidence of taxes and duties, high energy costs, the avenues available to a plant for reducing its costs are limited. In the present environment due to energy crisis and steep increase in the cost of energy and other input materials, it has become imperative to give serious thought on how to make operations and equipment efficient towards use of energy and adoption of latest technology equipment to retain the requisite competitive edge in the market.

Based on the several studies in the field of operational audit, it has been observed and proven that by

- Doing continuous process diagnostics investigations / monitoring,
- Process optimisation,
- Maintaining the preheater and precalciner strings, dedusting system, ducting and
- Providing quality utility services in terms of compressed air quality, water quality, etc.

production level can be improved and energy consumption can be reduced.

In the Case Study discussed in this paper about 27% increase in production, 12.00 % saving in electrical energy and 9.00 % saving in thermal energy consumption could be identified through a properly planned and executed Operational Audit.

Annexure I

Process Measurements And Heat, Gas & Mass Balance