A Case Study on: Industry Energy Audit and Recommendations with Payback Period

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Abstract - *Industrialization is increasing daily and there's an excellent want for trade energy assessment audit in industry. To maintain and save energy from being wasted and helps in achieving highest efficiency of business. During this industry audit, assessment or audit is carried out in mechanical assessment, thermal assessment, electrical assessment, as well as chemical assessment. This paper carry rigorously ready business audit report on boiler operations and performance. There are 9 coal-based combustion centers in the plant which consume Rs.14 Lacs worth coal every day. Individual inefficiencies in these utilities need close tracking to control and optimize coal consumption. We recommend more precise coal weighing at each utility and more periodic NABL ultimate coal analysis. Waste heat recovery options for thermal boiler also carried out in this paper Assessment of all boilers, calculate their efficiencies and losses to live energy saving areas and presents them as a recommendations with their payback periods is meted out during this work program. Vane type Anemometer, Glass type Thermometer, Flue efficiency monitor, infrared thermometer, ultrasonic peak detector, these equipment are used for energy assessment of boilers and evaporator. Additionally we have measured area wise lux levels and the detail chart is enclosed in this report. This will be helpful in selecting the alternatives. 46% electricity is used in various process equipment's. Majority of process equipment are pumps. This costs around Rs.3.25Lacs per day. Energy efficiency improvement in this area will yield handsome results.*

Key Words: Audit, boiler Energy, Energy audit, Efficiency

1. INTRODUCTION.

Boiler is most energy consumable equipment as compared to any other equipment's used in industry and there is great need of energy assessment of boiler on every early[1,2].In this paper considering 12TPH Thermax boiler, 18TPH ISGEC boiler, and 18TPH FBC boiler for audit and inspection. New model is proposed for boiler industry through sincere and carefully analysis. Advanced equipment's are used In this audit during the boiler assessment and effect of this revels accurate analysis of boiler performance. [3] This paper carry an actual industry audit report on boiler performance. For assessment of boiler Thermal analysis of boilers, thermal skin heat loss of boilers, O2 percentage control in flue gases to standard values effect of coal additive, etc. test are performed on boiler.[4]

Process description:

Silicate is used as raw material. Silicate is taken into melters and predetermined quantity of steam and hot water is added to this. An exothermic reaction takes place inside the melters and slurry is formed. This is then transferred to unloading tanks in "tank farm" and further transferred to settling tanks. The vapors discharged from unloading tank are treated in a scrubber and heat exchanger to fulfil hot water requirement of melters. This heat recovery process increases energy efficiency.

The slurry remains in settling tanks for 24 hours. Once settled, it passes through a steam-based heat exchanger (if required) to take it to 55Deg C before it is fed to various reactors.

Reactors take silicate suspension, hot water and Sulphuric Acid. Quantities are determined based on predetermined recipes designed for different grades of silica to be manufactured. After reaction is over, reactor output is taken into hydraulically operated "Filter Presses" wherever condensed steam and other effluents are washed using water and compressed air. The output of filter press is termed as CAKE. The contaminated wash water is taken to ETP

These cakes are any taken in flash dryers or spray dryers. Alternative of dryer depends upon grade to be factory-made. Drying is done using hot air at 550Deg C. The drying processes output is silica of different particle size. The drier output is either packed into bags on-line or taken into storage silos.

Energy forms used: Process requires following forms of energy. a) About 6000KL of raw water every day. b) About 350 Tons of steam every day. c) About 6MW of electricity to run various process equipment and utility auxiliaries.

Plant utilities: a) Plant has a Raw water treatment plant to process raw water and prepare it for various applications. The capacity is around 6000Kl per day b) 1 x 12TPH and 1 x 20TPH coal fired FBC boilers are installed to generate steam into a common header. Use of steam is direct purging into melters and hot water generators. c) Hot water generators to generate hot water required for reactor process. d) Coal fired, FBC based Hot air generators (Water evaporation rates 7500 Ltrs x 6 and 3000Ltrs x 1) e) Two compressor farms, generating compressed air for filter presses, instrument air and air used in packaging and dust collectors. f) ETP of adequate capacity to process effluents. g) Electrical distribution system with 66KV/ 7.5 MVA source capacity, supporting average load of 5 to 6MW continuously – supporting all electrical utilities, auxiliaries of thermal utilities and process equipment's like pumps, agitators, blowers etc.

Energy Audit methodology:

Electrical: 1) Collecting electrical energy consumption data for previous 12 months along with production data for same months. 2) Physical measurement and pie charting electrical energy consumption among various plant processes and utilities. Verification of consumption with average figures. 3) Recording transformer wise loading, power quality parameters and assessing % utilization. Assessing effects of deteriorated power quality. 4) Assessing Reactive power compensation, and current – voltage harmonic levels, experience-based estimation of extra distribution loss – Recommending solutions for reducing distribution loss. 5) Recommending solutions for harmonic compliance as per national and international standards. 6) Feasibility of demand optimization. 7) Illumination audit. 8) Feasibility of use of renewable energy.

Thermal: 1) Collecting data on coal consumption for 2 boilers and 7 hot air generators.

2) Performance analysis of both the boilers and recommending energy saving measures with required investments and paybacks.

3) Performance analysis of 7 (or all working) hot air generators and recommending energy saving measures with required investments and paybacks.

4) Assessing feasibility of heat recovery from flue gases and process exhausts.

5) Assessing measurement of quantity of coal used for different utilities.

6) Comparative study of different thermal utilities serving similar loads and comparison of their performance.

Mechanical: 1) Performance study of compressors and study of use of compressed air. 2) Performance and efficiency study of sample pumps.

Observations:

1) Plant receives electrical energy at 66KV, and average consumption is 4516KW while maximum is 5236KW. 2) The load varies between 4MW to 5.3MW. With offered reactive power correction at LT side of various transformers, the reactive power requirement varies between 600KVAR capacitive to 1000KVR inductive, 355KVAR being average inductive requirement. 3) 66KV side voltage harmonic distortion is well within limit – between 1 to 2.1%, however current harmonic distortion varies between 18 to 24% which is on much higher side. 4) Majority of the loads are NONLINEAR – VFD type, and current harmonic distortion handled by the plant is very much on higher side. Added to this most of the transformers have only capacitors for power factor correction and as such current harmonics are amplified. This has resulted into 7 to 14% voltage harmonic distortion. 5) 750KVA and 3500KVA transformers are used beyond 90% of their rated capacity. This is not advisable as almost entire load is nonlinear.

KWh per day from measurements

Area	**KWh/day**	**Rs./day**
Boiler	5786	40505
Coal handling system	622	4351
CFHAG	26184	183288
ETP	2957	20698
RWTP	5083	35582
Compressor	6930	48510
ADMIN building	686	4805
Capacitor	633	4430
Lighting	633	4430
Process	46430	325011
Total	**98335**	**688348**

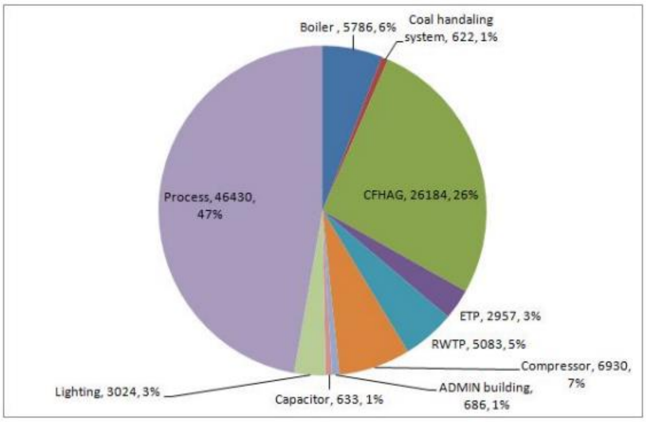

Chart-1: Electrical Energy Pie charting

Observations:

1) Plant load is around 4.5MW to 5MW and remains within this band 24 x 7. 2) 47% Load is process load – which mainly comprises of various pumps, blowers etc. Cost of this energy is around Rs.3.25 Lacs per day. 3) 26% Load is auxiliaries of coal fired hot air generators. Cost of this energy is around Rs.1.85 Lacs per day. 4) RWTP, Compressors and boiler auxiliaries put together the load is 18%. 5) Distribution loss within plant would be around 1% more than usual due to higher levels of current and voltage harmonic levels. 6) 750KVA and 3500KVA transformers are loaded beyond maximum efficiency loading. These are ordinary distribution transformers and are not designed to handle heavy harmonics. This is resulting into huge voltage distortion and associated resonance. 7) Reactive power compensation at present is manual and not automatic. Overcompensation results into harmonic amplification and under compensation does not offer unity power factor. 8) Transformer utilization. 9) Existing APFC panels are mostly working in manual mode. Except for part correction in case of 3500KVA transformer, all other panels use only capacitors. The most upstream (at 66KV) recorded data shows that the power factor is not maintained at unity and the reactive power requirement varies from average 355 KVAR to 1000KVAR. 10) Electrical, instrumentation cable lying, HT, LT panel rooms were in reasonably good condition and adequately maintained. 11) If plant is facing issues like frequent or abnormal motor burning, electronic card failures, VFD failures, the same could be due to excessively high harmonic levels within plant distribution. The available 66KV supply power quality parameters are well within compliance requirements as such there is no problem in available supply. The harmonic levels are increased within the plant primarily due to nonlinear nature of load and resonance created by use of "Only Capacitors" for power factor correction. This needs to be reduced at the earliest to a) Reduce distribution loss, which could be 1% extra at present. b) Improve power quality within the plant – which will result into increased life of electrical equipment's, curtail electronic failures and motor burning. c) Achieve statutory compliance at point of common coupling at 66 KV for harmonic levels. 12) As regards other electrical utilities like compressors, illumination, pumps etc. we have enclosed separate sample studies highlighting energy saving opportunities elsewhere in this report. 13) Specific Energy consumption – Electrical – based on data for the period Jan 2016 to Sept 2016. 14) As a first step towards energy saving, plant can plan to match internal BEST PERFORMANCE every month. One can see that an effort towards achieving this, can ideally result into saving of about 4.54Lacs per month or around 1% of total savings.

Energy Analysis of Thermal utilities.

1) During audit we have recorded output and input parameters of both boilers and 6 hot air generators. Our thermal experts undertook physical inspection of all these utilities along with discussions about performance with respective operating staff. We have done flue gas analysis of all these utilities to know quality of combustion. We used recorded flue gas parameters and standard ultimate coal analysis for efficiency calculations and then to locate losses.

2) The analysis shown on next page covers all thermal utilities in the plant and compares their performance. We have used following methodology for this analysis.

a) We have used "model Ultimate coal analysis for Indonesian coal" for these calculations. b) Moisture % in coal is corrected (Sr No 1) in table on next page to 30% based on our observation at site and experience. c) Heat loss due to un - burnt and radiation etc. is taken as 7% (Sr No 26) and 2% (Sr No 27) respectively. d) Flue gas outlet temperature (Sr No 9) and O2% (Sr No 16) in flue gas is taken from flue gas analyzer readings. e) Rest of the parameters are calculated using basic stoichiometric equations. We have attached soft copy of excel sheet giving these calculations.

3) The O2 %, Excess air and stack temperature in almost all cases is on higher side indicating inefficient combustion and lot of scope for improvement in overall efficiency. Active control over these parameters will result in direct reduction in coal consumption.

4) We have considered o2 % as 10% for boilers and 13% for CFHAGs (to be on conservative side) to quantify savings by improving combustion. The results are shown on page 15.

5) Overall thermal efficiency and efficiency by indirect method, matches within +/- 15% except for FD 1. We have done calculations using both methods to cross check the results.

6) These boilers are presently used with 15 to 18% blow down. The raw water is fed to boilers after softening. The process uses of steam being direct purging, the condensate recovery is nil. The boilers accept fresh feed water at

ambient temperature continuously. This increases TDS levels at high values necessitating high blow down percentage.

7) At present feed water is not preheated. If chemical dosing is done to remove the dissolved O2, there will be increase in the boiler water TDS. In view of increasing boiler life, reducing chemical consumption and also reducing TDS caused due to chemicals, we propose a feed water tank preheater using steam purging. This will also reduce blow down. It is very difficult to quantify end results due to this.

Recommendations for combustion efficiency improvement (Common for boilers and CFHAGs)

1) O2 analyzer may be provided in outlet duct, for monitoring purpose, if not for any control. 2) Automation of furnace draught control by measuring the furnace pressure (transmitter) and controlling the ID fan by VFD. Presently, this is left in one position, with no control. 3) Wherever dilution fans are used, they should work in close loop by accepting feedback from "Critical tube skin temperatures. Above steps may be executed in the same sequence stated above and in steps, confirming no disturbance in steam / hot air parameters as required by process. For 1 and 2 above the VFDs are already in place, so they can be effectively used. Post commissioning standard SOPs may be generated for operators to follow. 4) Due to part load operation, steam boilers currently might be running on single bed, as such there is possibility of leakages happening through the idle bed. It is possible to distribute the steam load on the two boilers such that one boiler runs most of the time on close to full load, with both beds in operation, while the 2nd boiler runs mostly on 1 bed only (1 bed at its full load, with the other bed system made fairly leak proof). 5) There is a possibility of introducing TDS measurement based automatic blow down operation, which will avoid present open loop operator dependent loss in every shift. This can result into almost 7% fuel saving in case of boilers. 6) We very strongly recommend a much-sophisticated coal weighing system at each combustion point and a weekly periodic audit confirming purchase stock and consumption. We also recommend NABL testing of coal once a week and a conditional rate agreement with the coal supplier for quality commitment. 7) In case of hot air generators, flue gas temperatures are high, they will remain high even after combustion efficiency improvement. So, there is a fair possibility to recover heat from these gases. 8) Stack outlet and air inlet ducts in case of hot air generators are very close to each other in present design, so it is feasible to implement this heat recovery.

Projected energy saving in Illumination.

Most of the area in MSPL plant has task-based illumination. The present luminaries are all conventional and are fed by a step-down transformer. The total load is around 192 kw and is ON for around 10 hrs. a day. Plant has an option to use Induction lighting for all High bay and outdoor lighting. Office and low height lighting can be replaced by LEDS. Induction lights offer very low glass cover temperatures which may be helpful in avoiding accumulation of dust and Harding of the same. (This may reduce available light output).

These advanced lighting technologies will reduce energy consumption by about 40% if deployed with proper design. While matched with required investments, the payback may not be attractive but if executed as a part of total energy conservation program. The same be offset in reasonable time and the saving can be materialized. The savings are estimated at 40 x 10 X 30 x 7 = Rs 84000 per month.

We have measured area wise lux levels and the detail chart is enclosed in this report. This will be helpful in selecting the alternatives.

Conclusion.

1) 46% electricity is used in various process equipment's. Majority of process equipment are pumps. This costs MSPL around Rs.3.25Lacs per day. Energy efficiency improvement in this area will yield handsome results. Computerized energy management system would help in automatic data collection and would allow operating staff to use the data and work on energy saving.

2) There are 9 coal-based combustion centers in the plant which consume Rs.14 Lacs worth coal every day. Individual inefficiencies in these utilities need close tracking to control and optimize coal consumption. We recommend more precise coal weighing at each utility and more periodic NABL ultimate coal analysis. MSPL can also think about "Conditional rate contract" for coal supply if the same is not in place.

3) Almost 70% of plant load is NONLINEAR and demands harmonic currents. Plant electrical infrastructure is over stressed due to these harmonics and must be resulting into excessive distribution loss. Reactive power compensation at present is done using capacitors and not detuned filters. This is causing voltage distortion. This is slow poisoning for all electrical equipment's in plant. These harmonic levels can cause abnormal motor burning, electronic failures, nuisance tripping.

4) Coal combustion at all stations is open loop. The combustion parameters are adjusted manually to get required steam and hot air parameters. Inspection of combustion parameters revels inconsistent performance and excess O2 and excess air in flue gas. This indicates inefficient combustion.

5) Both the boilers use about 15 to 18% blow down. This can be reduced to half by opting for TDS (conductivity) sensing based automatic blow down. This will result into significant saving in coal combustion.

6) The flue gas temperature and excess air% is on higher side in case of all hot air generators. The heat recovery is possible here. The recovered heat can be used for preheating input air to these hot air generators. The stack output and air input are physically close to each other, so this is technically feasible.

7) The process uses hot water. This is generated in plant using direct steam purging into hot water tanks. The required hot water temperature is 80 Deg C and daily quantity requirement is 2000KL. We have checked feasibility of using heat pumps or concentric solar water heating. The present fuel used being coal, both these technologies do not offer convincing pay back periods and as such are ruled out for saving energy cost.

8) At present about 185 Tons of steam is consumed for generating hot water. This requires about 37 tons of coal every day. A separate coal based "HOT WATER GENERATOR" will operate at about 85% overall efficiency and would require 25 Tons of coal per day and will save 12Tons per day. Such hot water generators give consistent and efficient performance for longer time with comparatively less maintenance. This is a strategic decision as it would attract capital expenditure, space etc.

9) The hot water generated as above is taken to respective reactor floors using bare pipes. In most of the cases they are not insulated. At present the pipe outer temperature at HOT WATER GENERTOR END is 75 Deg C, while at point of use the same is 55 Deg C. Insulating these pipes would lead to energy saving.

10) Plant and admin block has about 350000 sq ft roof top. Another 35000 sq ft area is occupied by tank farms, which is open from top. Plant can think about up to 1.5 MWp roof top PV solar power system. This can be installed on capital investment basis or BOOT (Built operate own and transfer) basis. This can generate about 1500 x 0.7 x 8 x 300 = 2520000 KWh in year, which can be used by plant at about Rs. 1 less than tariff (with BOOT option). This will save 25.2 Lacs annually. With capex option this will save about Rs.176Lacs annually. (all these figures are rough estimates and may vary after detail feasibility study.)

11) MSPL may think about implementing ISO 50001 – energy management ISO standard and expect continual improvement in energy performance.

12) Savings due to solar PV and illumination improvement are not shown in main table as they are dependent on MSPL choice.

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