Power Plant Performance Improvement

Opportunity Identification Report

Executive Summary and Opportunity Summary

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1. EXECUTIVE SUMMARY

This document summarizes the findings of the Opportunity Identification Study which was conducted by ABB for UTCL Vikram Cement Works power plant.

1.1. The objectives of the assessment were as follows

1. To identify opportunities to measure the current performance of the power plant and identify the deviations from the design performance level. Baseline the current plant performance to measure the actual improvements after implementation of suggested improvements
2. To identify opportunities to directly improve the control & operation of the plant process and subsequently improve the performance of the plant such as efficiency, heat rate etc.

Throughout, the process was collaborative and open, with an emphasis on the enhancement of existing systems for overall improvement in the plant performance.

1.2. General feedback

Various controls especially Boiler Steam Pressure, Temperature and O2 are some of the major areas, which need attention. Though average value of critical process parameters is maintained near design set point, we observe large variations from the set point thereby exposing the plant equipment/components to excessive thermal stress like creep and fatigue.

In order to get increased Boiler Efficiency, increased Boiler Life & Unit Stability, the performance of related control loops must be improved for tight control of parameters at the respective set points under steady state conditions and fast recovery under disturbance conditions such as tripping of any major equipment like Cement Mill / Turbine / Boiler without operator intervention.

While going through the existing Control Logics, we noted that some of the major control logic need to be enhanced for improved performance / to get the desired parameter controllability, stability and disturbance rejection capability.

1) We used actual control logic S/W to track and find out how controls were prepared and configured. Combustion control loops were not tuned or in few cases no configured. Feeder controls were directly used to control Main Steam Pressure (Boiler Outlet) without cross limiting from Total Air Flow.
2) Real Time Trend of some critical parameter under Steady State condition shows no problem in Control Performance. Critical Parameters of Boiler were quite steady. This behavior is the result of grid connected operations even when actual load in cement plant is varying.
3) In absence of 02 Hour Real Time Trend of Critical Parameters of Boiler under disturbance condition, we infer/presume that excepting Combustion Control, other control loops are working fine.
4) It is learned that coal mixing is done on common DCF and then delivered to boiler.

Status of Existing Major Boiler Control Loops

ABB further looked into the existing design / engineering of Control Loops with specific attention to Combustion Control. Following are the observations:

Sl. No.	Control Loop	Status
		Unit # 1- 2
1.	Combustion Control : a) Boiler Master Control (M.S. Pressure) b) Fuel Flow Control c) SA Flow Control + O2 Trim	Manual
2.	PA Flow Control	Auto
3.	Main Steam Temp. Control	Auto
4.	Furnace Draft Control	Auto
5.	Drum Level 3-E Control	Auto
6.	DP @ FRS Control	Auto
7.	Bed Temp. Control	Manual
8.	Dump Control	Manual

1. **Plant Master Control**
   Does not exist, which is a must for header connected units for proper control of Plant Load, Common Header Steam Pressure (UTCL to provide common header pressure measurement signal) and Load Sharing between two Boilers

2. **Boiler Master Control :**
   It is designed around a simple PID controller having no proper Feed forward action and adaptive tuning. A Fluidized Bed Combustion Boiler normally exhibit a very high Boiler Inertia to the tune of 10 to 15 minutes for a response to a change in Boiler Firing Rate, which an ordinary PID cannot handle. Further with different type of fuel, boiler has different response, viz, faster response with Pet Coke or high GCV Coal as compared to that of Low GCV Coal with large amount of ash content. This changing response time with fuel is not optimally taken care in the existing logic.

3. **Fuel Flow Control :**
   a. The quality of Fuel, i.e. heating Value or GCV of Fuel is never consistent. Today it has some value, the next day, even in hours, it will have some different value. This change in GCV of Fuel has great impact on Combustion Control. Continuous correction of Heating Value changes in Fuel are not seen in the logic.
   b. Automatic Gain Control of Fuel Master is also not seen.
   c. Load sharing / biasing among Coal Feeders is not seen in the logic.

4. **Total Air Flow Control :**
   The Boiler Master Demand signal Cross Limited by Fuel Flow is used to calculate basic PA and SA Flow Demand. No compensation for changing fuel GCV is seen in the logic.

   a. PA Flow Control :
   PA Demand signal calculated as aforesaid is used for PA Flow Control. No compensation / trimming for high / low Bed Temp. is seen in the logic.

   a. SA Flow Control :
   Standard SA Flow Control with O2 Trimming logic is used.

5. **Furnace Pressure Control :**
   Feed forward logic for anticipatory control on changes in total air flow is not seen.

6. **Main Steam Temp. Control :**
   Although standard Cascade Control is implemented, yet it is lacking anticipatory Feedforward action and adaptive tuning of PID parameters.

7. **Dump Control :**
   No logic for Dump Control is found in Control Schematic. Due to grid connected operations, power plant is stabilized during disturbance/load variations by either operating dump valve or evacuating excess power to grid.

Actual plant performance based upon the plant data collected during site visit

Actual plant performance is calculated using ABB's performance calculation software module with 100% Pet Coke of calorific value of 8182 kcal/kg and mixed with 30-40% limestone as a boiler feed.

The baseline performance is calculated as values of the key performance parameters (KPIs) at full load are recorded below:

Unit #1 Baseline Performance:

SI ID	Performance Parameter	Unit	Actual (Baseline)	Design	Remark
1.	Gross MW generated	MW	23	23	
2.	Gross turbine heat rate	Kcal/kwh	2409*	2510.27	Scope for improvement
3.	Gross unit heat rate	Kcal/kwh	2967.67 ▲	2898.7	Scope for improvement
4.	Boiler efficiency	%	81.17 ▼	86.6	Scope for improvement

NOTE: * requires discussion & review with plant efficiency team. We presume data quality issues in the process parameter data.

Unit #2 Baseline Performance:

SI ID	Performance Parameter	Unit	Actual (Baseline)	Design	Remark
5.	Gross MW generated	MW	20.29	20.29	
6.	Gross turbine heat rate	Kcal/kwh	2731.75 ▲	2528.9	Scope for improvement
7.	Gross unit heat rate	Kcal/kwh	3323 ▲	2922.58	Scope for improvement
8.	Boiler efficiency	%	82.2 ▼	87	Scope for improvement

1.3. Summary of opportunities

The assessment identified more than a dozen opportunities in UTCL Vikram Cement Works power plant.

1.4. Conclusions

This study has identified a number of opportunities with significant savings for relatively low expenditure. In particular, the Quick Win opportunities could be implemented immediately with assistance from ABB. These projects can be implemented for a reasonable cost and will allow Customer to start saving immediately, building credibility for the performance improvement initiative and allowing the resultant savings to be channeled into more capital intensive improvement projects.

Major benefits from implementing the proposed solution. These are listed below,

- Improve unit reliability by reducing control variability
- Improve heat rate by reducing fuel consumption per unit of energy
- Improve boiler efficiency through combustion optimization
- Improve (faster) equipment response to load disturbances
- Reduce excess O2 and improved emission
- Reduce energy consumption by electrical equipment like ACC fans
- Improve operator efficiency

Sr. No.	Process Parameter	Expected Deviation under steady state
1.	Common header steam pressure	± 3 kg/cm2
2.	Furnace draft	±10 mmwc
3.	O2 in flue gas	±1 %
4.	Boiler outlet steam temperature	±5 degC
5.	RH outlet steam temperature	±5 degC

Sr. No.	Performance Parameter	Expected improvement over baseline
6.	Boiler Efficiency	Up to 0.2%
7.	Heat rate[1]	0.6% (19kcal)

NOTE:
1: Total Heat Rate improvement is result of improvement in boiler efficiency, combustion control, LOI and reduction in dump steam/export MW

2. PLANT OVERVIEW

CPP of Vikram Cement Works has Grid connected 02 TG sets with export no limit & 5 MW import limitations per 15 min. block. Plant has Load Management System. Load of Turbine is increased / decreased using Raise / Lower Push Buttons from DCS. The CPP Boilers are connected via a Common Header, but measurement of Common Header Steam Pressure does not exist. The details of main equipment and DCS are given below:

Sr No.	Description	Make	Type	MCR Value
1	Boiler #1	DONGFANG	CFBC	130 TPH at 100 Kg/cm2 and 535 deg. C
2	Boiler #2	DONGFANG	CFBC	130 TPH at 100 Kg/cm2 and 535 deg. C
3	Turbine #1	HTC (HNK40/56/60)	Woodward 505 Governor	23 MW at 90 Kg/cm2 and 535 deg. C (Steam Flow = 102 TPH),
4	Turbine #2	HTC (HNK40/56/60)	Woodward 505 Governor	23 MW at 90 Kg/cm2 and 535 deg. C (Steam Flow = 102 TPH),
5	DCS	ABB	Symphony Plus	

Main equipment of each boiler:

Sl. No.	Main Equipment	Unit # 1		
		Qty.	Duty	Operation.
1.	ID Fan	1 No.	100%	VFD
2.	SA Fan	1 No.	100%	VFD
3.	PA Fan	1 Nos.	100%	VFD
4.	Drag Chain Feeder	4 Nos.	100%	VFD
5.	Lime Stone Screw Feeder	1No.	100%	VFD
6.	Bed Material Screw Feeder	1No.	100%	
7.	CEP	2 Nos.	100%	
8.	CW	5 Nos.	100%	
9.	ACC Fan	6 Nos.	100%	
10.	BFP	3 Nos.	100%	

Fuel being used: Combination of Pet Coke, Indian Coal, Imported Coal and Lignite with following designed heating values (GCVs) & composition are being used. Measurement of Coal Flow is Volumetric Type. Mixing of Coal is done on common DCF delivering fuel to boiler.

Sl. No.	Fuel	Flow	GCV	C	H2	O2	S	N2	H2O	Ash
		TPH	Kcal/Kg	%	%	%	%	%	%	%
1	Pet Coke Reliance		8182	82.58	4.65	4.74	6.07	1.61	0.43	0.74

Sl. No.	**Fuel**	**Flow**	**GCV**	**C**	**H2**	**O2**	**S**	**N2**	**H2O**	**Ash**
		TPH	Kcal/Kg	%	%	%	%	%	%	%
2	Pet Coke Saudi		7930	83.87	4.01	1.63	8.78	1.20	0.62	1.65
5	Indian Coal		3468	24.69	3.46	11.76	0.35	0.83	2.42	45.67

3. ABB'S PERFORMANCE IMPROVEMENT METHODOLOGY

ABB's approach to Performance Improvement consists of a phased methodology, with accompanying tools and techniques that have been developed over several years of working with clients on sites having a wide and varying range of energy generation and consuming processes.

Each step of the Energy Efficiency Improvement methodology aims to deliver precisely the information needed to enable the customer to move forward with confidence and eventually complete a program of improvements that will deliver real and sustainable energy savings.

Opportunity Identification (this study) – The Opportunity Identification Study aims to identify specific opportunities to deliver improvements, by confirming how, where and why energy is used, identifying areas of inefficiency, and comparing current performance with established industry best practices.

Project Specification, Bid, Contract (current phase) – The decided opportunities follow the usual technical and commercial process. The project specification is included into the request for proposal. Bids are negotiated and a supplier is contracted.

Implementation (later phase) – The projects are implemented and completed. The savings verification method described in the opportunity summary will document the achieved savings.

the opportunities are subject to a ranking process including the criteria
FEASIBLE
Confidence, that the opportunity can be implemented and will perform as defined.
SIMPLE
Impact of the opportunity implementation on running business (e.g. shut down).
Number of parties involved to install the opportunity.
QUICK
Dependence on other site schedules.
Development time until the opportunity feasible implementation.
Implementation time.

4. OPPORTUNITIES OVERVIEW

Since units are Grid connected, following Advanced Model Predictive & Adaptive OPTIMAX Control with suitable Feed forward are proposed along with Coordination among Boilers & Turbines for enhanced unit stability, availability and efficiency.
Similar to UTCL Rajshri Cement Works, we propose to implement Advance Optimax Controls consisting of Model Based Predictive Feedforward Controller with Adaptive Tuning in the below mentioned control loops in order to get following benefits immediately:

1. Operation of Units nearer to rated Main Steam Pressure and Temperature resulting into increased efficiency & life of Turbine & Boiler thick metal parts.
2. Significantly reduced Dump Steam Flow and thereby reduced Fuel Consumption in boilers and reduced Power Consumption by ACC Fan Motors & other auxiliary equipment, resulting into significant cost saving on fuel & electrical energy.
3. Operators get strain free / relaxed time to do other value added work.
4. Improved and consistent Combustion by maintaining O2 % near the desired value by ensuring an Air rich environment in the furnace under all conditions resulting into increased efficiency, reduced CO / CO2 generation and reduced LOI

SI No	Area	Present Situation	Suggested Improvement	Benefit
Quick Win Opportunities				
1.	Control System	Common header pressure control does not exist	When the boilers are connected to a common header, there should have been a common header pressure controller to work as supervisory level master controller and the Boiler Master Controllers working as slave controllers	Better control of header pressure and load sharing between boilers as per Operator's discretion.
2.	Control System	Basic PID control for air & fuel feed without taking care of large boiler inertia and multiple fuel types such as Pet coke, Indian Coal, Imported Coal & Lignite.	Model Predictive Advanced Controller with suitable Feedforward & Adaptive Tuning is required for the purpose.	Improved & stable response to air & fuel feed as well as change in the fuel type. Reduce control variability resulting in cost saving.
3.	Control System	Using Boiler Steam Flow as Feedforward to Pressure Controller. Such a control is resulting into uncontrollability of Boiler Pressure.	Modify the feed forward using the feedback from turbine load demand.	Improved control and increased Set Point limits for pressure controller
4.	Control System	Change in the fuel quality (i.e. heating value changes in fuel) has not	Automatic calorific value correction of fuel in the control loops.	Less variability & better functioning of loops. Avoid / minimize the

Sl No	Area	Present Situation	Suggested Improvement	Benefit
		been taken care off into any control scheme.		need of frequent etuning to manual mode.
5.	Control System	Low performance of cross limiting of fuel & air demand	Make use of GCV corrected fuel flow in cross limiting of air & fuel	Better combustion control and furnace draft
6.	Control System	Basic PID control resulting into overshoots & undershoots, thereby de-stabilizing new cross limited fuel demand	Advanced controller with feed forward with auto gain adjustment	Minimize overshoot & undershoot in the control performance
7.	Control System	High Bed Temp. / High U-Beam Temp Run Back	Advanced controller with Pri. Air to Sec. Air flow ratio control.	Achieve desired Bed/U-Beam temperature. No fuel change / load change may be necessary.
8.	Control System	PA flow control based on cross limited total air demand is not optimum	Advanced control to take care of fuel type, ignition temp. and heating value of fuel used.	Provide proper Bed Fluidization and minimum ignition temperature for each type of fuel being used
9.	Control System	SA flow control & O2 trim control is not optimum	Advanced controller for improved & economical IGV mode of FD fan control and furnace safety feature	Electrical energy saving, additional furnace safety and also improvement in boiler efficiency
10.	Control System	Furnace pressure control is not optimum	Advanced controller with feedforward for improved & economical IGV mode of control	Electrical energy saving
11.	Control System	Steam temp. control in attemperator 1 & 2 is not optimum	Model predictive / PI-PI Cascade control logic with suitable Feed Forward & Derivative actions and adaptive PI tuning.	Faster anticipatory control under boiler disturbances like change in load demand / fuel flow etc. with improved safety action and stable control parameters
12.	Control System	Dump valve control is not used properly for stability of boiler parameters	Implement advanced dump valve control scheme to arrest the pressure rise under various unit disturbances	Avoid / minimize tripping under all possible disturbance conditions : § Both Boilers running with both TG and one of the TG trips § Islanding of Turbine take place.

SI No	Area	Present Situation	Suggested Improvement	Benefit
				§ Load Throw Off takes place (for example any Cement Mill trips etc.)
13.	Control System	Online continuous performance monitoring of power plant is not available. So operator's do not know the deviation between current and the design performance like heat rate, efficiency, boiler efficiency etc. and not aware of need to take any corrective actions	Implement performance calculation for online performance monitoring & reporting. Know process deviation in comparison with the design performance	Continuous feedback on the plant performance - HMI and system guided actions to improve operations
14.	Control System	No control coordination between Boiler & Turbine[1]	Boiler & Turbine operate in coordinated mode of operation during On Grid condition	Run back operations for unit stability under disturbance conditions or at the time of islanding from grid

NOTE:
1: Coordinated operation is applicable only when Turbine set point adjustment is possible remotely from Boiler DCS