Taber International Power System Automation & Optimization

Existing Applications and Other Opportunities

***Combustion Optimization System –***

The Combustion Optimization System (COS) application performs closed-loop control of many aspects of the combustion process within the boiler. The basic COS application primarily focuses on redistributing air throughout the furnace to better balance staging and improve overall combustion relative to the desired objective (NOx, CO, heat rate, temperatures, etc.). This includes the excess O2 setpoint, windbox differential pressure setpoint, fuel air (FA) dampers, auxiliary air (AA) dampers, coupled and separated overfire air (CCOFA and SOFA) dampers, and the tilt angle of burners and SOFA dampers. Expanded COS applications can be further developed to also act on attemperator spray flows (both superheat and reheat steam), fuel flow rates, mill outlet temperatures, and forced draft (FD) / induced draft (ID) fan damper bias.

All control implemented by the COS is realized by adjusting bias settings of the unit, ensuring operation and control is always grounded in proven Distributed Control System (DCS) baselines and that all DCS safety measures remain in full effect. The COS operates using two distinct control methodologies: 1) expert logic and 2) model-based real-time optimization. The combination of these methodologies allows the COS to realize optimized operation and enhanced performance throughout unit ramping, low-load, unsteady, and steady state operation. A simplified representation of COS parallel tasks is shown below.

Diagram

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*Simplified diagram of how multiple processes are carried out and interact within   
the COS application at various frequencies*

Expert logic refers to the ability to incorporate operational best practices and unique, situational-dependent control within the overall decision making and control logic of the COS. Expert logic is beneficial for addressing unique characteristics of individual units and for realizing knowledge capture of years of experience of site operators and engineers, making those best practices automatic in control behavior and consistent across operating crews.

Model-based real-time optimization uses various types of intelligent modeling methods (e.g., neural networks, compound neural networks, regression, first-principles etc.) to generate representative models of combustion performance metrics of interest from site-specific operational data. These combustion performance metrics can be but are not limited to NOx and CO emission rates, process steam and metal temperatures, LOI (loss of ignition), heat rate, opacity, etc. It is necessary for reliable and consistent measurements of the target parameter to be available within the operational data. The developed models are interrogated numerous times to identify optimal operational settings of control parameters to realize improved performance in regards to the identified performance metrics (e.g., reduced emission rates, efficiency, etc.).

These two distinct control methodologies operate harmoniously to realize reliable and consistent operation of the unit while achieving improvements in combustion performance metrics. An example of how the system typically uses biases relevant to the existing DCS setpoints, then example of use-case results.

*Graphical user interface

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*Example of allowed operation range of COS based upon existing DCS setpoint curve*

Chart, line chart

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*Example of a Taber project’s COS application performance on NOx emission rate reduction from quarter to quarter.*

*Chart

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*Example of a Taber project’s COS application performance on NUHR during an on/off test of the system.*

***Data Collection & Processing (COS Sub-Application) –***

Data is crucial for the overall success of any optimization system, and to facilitate data access and reliability, Taber utilizes an internal application to perform real-time data collection and processing. This system functions to monitor the performance of the unit in real-time and constantly record operational data to be used for identifying key relationships and correlations between control parameters and objectives. This system is also used to intelligently filter and correct erroneous data as needed, ensuring that only the highest quality information is used by the optimization applications for making control decisions.

***Real-Time Model Retrainer (COS Sub-Application) –***

As a complex system, combustion furnaces and boilers change overtime. In response to equipment degradation, changing operating practices, and other environmental factors (both within and without the furnace), the response of the furnace changes over time. These changes can be as often as day-to-day, or seasonally or longer. Taber deploys together with its systems a real-time model retrainer, which allows the developed solution to automatically adapt itself overtime to these changing conditions. Newly collected operational data is used to retrain AI models and application methods, allowing the system to recognize changes in response behaviors and correlations between control decisions and objectives, and the system to self-adapt. This helps to ensure the system is always as representative as possible to the physical process, and that the optimal solutions and control decisions initiated are as near to reality’s optimal as possible. This is a significant advantage over systems that must be manually updated by vendor personnel or other engineers, as the transition and updates are immediate and less costly.

***Knowledge-based Sootblowing (KSB)***

The Knowledge-based Sootblowing (KSB) application is an intelligent sootblowing program that effectively incorporates system knowledge from years of experience of site operators and engineers into a rule-based unit-wide sootblowing strategy. Together with site knowledge, available sensor data from the unit is used to estimate the effects of soot blowing activity on heat transfer and efficiency throughout the furnace. Depending on the resolution of available data, this may be unique to each individual tube section within the boiler at intermediate steps within the steam cycle, or it may be generalized to the final measurements. The combination of knowledge-based operation and quantitative information allows for the system to effectively manage soot build-up throughout the individual sections of the furnace where existing sootblowers are located to better control steam temperatures, fouling and slagging, and tube erosion. KSB operation provides uniform and consistent soot management across the furnace leading to improved operation.

Analysis of operational data is used to inform initial relationships between individual blowers and operating metrics of interest. This identifies quantitative conditions used to guide boiler cleaning practices, rather than traditional time-based and manual activations. This data analysis is then complemented by discussion with site personnel with ample experience and understanding of the operating tendencies of the unit, which informs individual rule adaptation and development. The end result is a highly interconnected and complex system that is capable of inferring current system states and responding by cleaning only the necessary surfaces within the boiler, increasing operating efficiency, decreasing tube erosion, and overall benefiting unit consistency and operation. Consistently operating units further benefit from combustion optimization and advanced steam temperature control by the reduction of disturbances from disparate sources and varied operating practices.

Chart, histogram

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*Data analysis results indicate optimal sootblower activation times for individual blowers*

***Slagging and Fouling Inference System***

Understanding of real-time slagging and fouling conditions within a boiler are crucial for proper maintenance and management of the unit. When sufficient instrumentation (e.g., temperature measurement) is available, local conditions at individual walls and panel surfaces within the boiler can be inferred, and the relative amount of fouling and slag currently present can be indicated. These representations are effective in guiding the self-adaptation of all of Taber’s applications, as the decisions of these applications can be correlated to the unit’s surface fouling and slag, and action taken to ensure a sufficient level of cleanliness within the unit that balances tube and metal life with optimal heat transfer for steam and power generation.

***Steam Temperature Controller (STC)***

Steam temperature control within coal-fired boilers is subject to many factors, which makes the temperature response to different control actions highly variable. Traditional control is often PID based, which equates to using only a single indication, or crudely constructed combination of several indications, to control spray attemperator flow rates and burner tilt positioning (where available). When units operate under variable loads and demands, this approach generally results in sub-optimal control and stability, which affects the remainder of the unit through a compounding series of swings (e.g. drum level, throttle pressure, turbine valves, fuel feed rate, feedwater flow rate, MW output). These instabilities are harmful in numerous ways.

Taber’s STC system uses a combination of many control and estimation approaches (first-principles modeling, data-driven modeling, and rate forecasting) to combine the numerous factors which influence steam temperature and the resulting unit effects to more accurately predict the unit-wide effects of control decisions to regulate steam temperature, and make decisions which minimize unit variability while achieving desired temperature setpoints. This system not only controls spray attemperator flow rate, but also recognizes the effects of combustion air injection, burner tilt movements, sootblowing activities, and other contributing factors to stabilize unit operation and more completely control steam temperature. The result is enhanced unit flexibility and efficiency.

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*Demonstrated improvement in steam temperature setpoint realization and decreased attemperation flow rates during system on/off test resulting in greater operating efficiency.*

***Cooling Tower Optimization (CTopt Application) –***

Many power generators utilize evaporative cooling towers to aid in reducing backpressure on the low pressure (LP) turbine, as well as to provide other cooling needs to the process. The bulk of these cooling towers consist of multiple cells, where each cell promotes water evaporation which results in cooling by forcing (pushing) or inducing (pulling) air across the hot water. Although the design of each cell is usually identical, performance and effectiveness often varies due to numerous subtleties, from differences in fouling rates of cell media to tower water flow and localized stratification. Beyond differences from cell to cell, changing ambient conditions also affect tower performance, where changing wind speeds and directions, temperature, and humidity directly impact tower behavior.

Taber’s CTopt application uses process data collected directly from the relevant tower to learn the varied effectiveness of individual cells within the tower as outside conditions and load demands on the tower change in order to maximize the cooling ability of the tower while minimizing power usage. Depending on the hardware available for control of the tower, this is accomplished by optimally activating and deactivating individual cells when appropriate, or by adjusting motor speeds from cell to cell using VFDs. This practice has been shown to decrease tower power usage as much as 5% - 10% while maintaining cooling capacity. Control of other parameters, such as water flow between cells, would enable additional improvements such as water usage, to be achieved.

Chart

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Fan ID

*Varied power needs of “identical” cooling tower cells in a single tower,   
demonstrating opportunity for optimized power usage cell-to-cell*

A close up of a map

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*Reduced tower power consumption through individual cooling cell fan speed optimization*

***Hg & PAC Injection Optimization (HgPACopt Application) –***

The process of PAC injection is often controlled using only rudimentary methods, and these don’t usually employ methods which capitalize on the characteristics of the process – namely that a larger period of time rolling average of Hg is of interest and the variable reduction effect of different PAC feedrates due to changing load and system conditions.

Taber’s HgPACopt system uses rule-based and model-based methods as applicable to identify PAC effectiveness and expected effects on the average Hg value that is regulated or monitored (e.g., 24-hour average, 30-day average, etc.), and adjusts PAC injection rates as this understanding dictates. This results in the opportunity for using less PAC (decreasing operating costs) while achieving better control of the Hg average. Existing systems have demonstrated a 15% reduction in PAC usage, with improved Hg emission rates and improved management of downstream effects (i.e., minimized opacity spikes due to PAC injection, LOI measurements, etc.).

Chart

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*Comparison of HgPACopt performance (engaged) vs. base DCS control (disengaged),   
showing reduced PAC usage and improved Hg emission and opacity rates*

***Real-time Coal Quality Estimation* –**

Coal quality has a pronounced effect on the operation of coal-fired boilers. Fluctuations and variations in coal quality over time, which can occur even when fuel is obtained from a single source, can impact the way the unit should be controlled and operated to maximize efficiency and maintain appropriate unit cleanliness. Unfortunately, measuring coal quality in real-time is very difficult, and available measurements are at best taken off the feed belt to the units, 2 – 12 hours before combustion of that fuel, or more often only available from manually collected samples off the pile or from the supplying mine, with results of these samples becoming available days later, often after that particular fuel represented by the sample has been combusted by the boiler.

Using historical data, Taber generates a model that relates real-time operating conditions (e.g., pulverizer amps, total fuel flow and steam flow, hot air damper positions, etc.) to coal quality and characteristics, providing a real-time indication of currently combusting coal in the boiler. Through a concerted effort, Taber works closely with the site to collect any available coal sampling results (from both proximate and ultimate analyses) and to estimate the delay time between sample collection and combustion. This information is used to correlate past operational data to coal sampling results and is then used to train representative models of characteristics such as energy content, ash fusion temperature, ash percentage, and others. These model predictions can then be used in a variety of ways, and in the context of the KSB application, are used to inform rule and hold operation to properly clean the heat transfer surfaces in the unit. This added information made available to the Taber’s other performance optimization applications enhances the adaptability of the system in responding to varying fuel characteristics, realizing further operational improvements.

Chart

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*Comparison of including coal quality classification label in model input on prediction capability. Model prediction performance correlates closely with optimization performance improvement.*

***Generator H2 Sliding Pressure Optimization (H2opt) –***

Many power generators employ hydrogen for cooling, as well as to reduce rotor drag. Intelligently controlling hydrogen pressure within the casing in response to varied cooling demand represents an opportunity for improving generator efficiency as well as increasing temperature consistency which helps prolong material life. Taber’s H2opt system is a proposed opportunity which will draw upon data collection and analysis of the opportunity for H2 sliding pressure optimization within the generator. This process will involve working closely with operators and engineers to make small changes to the H2 pressure setpoint and recording the effects. After performing this testing at a number of conditions, the results will be analyzed and the opportunity for optimization ascertained. After generating this response database, Taber’s H2opt system will be able to improve temperature consistency while improving operating efficiency by learning the cooling demand of the generator in response to varying load and other system states and determining the optimal hydrogen pressure for each state. By decreasing hydrogen pressure 30 psig, more than 1.8 MW can be recovered, decreasing net unit heat rate. This also represents a decreased need for hydrogen, reducing material costs.

Chart, line chart

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*Representation of windage loss reduction due to sliding H2 pressure for similar H2 purity*

***Real-Time Heat Rate Monitoring Dashboard* –**

Unit heat rate indicates overall operational efficiency, however accurate measurements of heat rate in real-time are often elusive. Further, making effective decisions based on operating efficiency is not possible when this indication is not available or is unreliable. Using a combination of first-principles methods and artificial intelligence, Taber can provide an effective representation of immediate heat rate and operating efficiency suitable for informing real-time control and decision making. The individual components that make up unit heat rate, including boiler efficiency, turbine efficiency, and various steam and water circuits, are all broken down into a live dashboard such that engineers can see at a glance the most important indications of how their unit is performing and quickly identify anything that is out of place or could be improved. Additionally, the results of the heat rate determination process and the contributing factors can be utilized by the COS and KSB systems to inform logic generation and activation to optimize combustion control as well as the soot blowing process to maximize heat transfer efficiency while maintaining tube metal health and longevity. The figure below shows one potential dashboard member, a representation of the calculated Net Unit Heat Rate (NUHR) relative to load, total fuel, final steam temperatures, and RH spray flow and the current culmination of operating parameters affecting heat rate gain/loss.

Chart

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*Real-time displays of contributing factors to unit operating heat rate.   
Displays can be customized according to site requests and specific interests*

***SCR / SO2 Scrubber / Other Process Optimization –***

Similarly to the applications described above, other ancillary systems present opportunities for improved operation through adaptive control, automation, and optimization. Potential candidates for applications are SCR ammonia injection (avoiding ammonia slip and decreasing additive usage), SO2 scrubber performance (improving SO2 removal efficiency, decreasing rotary atomizer power usage, decreasing lime/limestone/chemical costs, etc.), pulverizer start/stop automation, halide injection at pulverizers, and other systems across and beyond the power plant process.

***Predictive Maintenance & Anomaly Detection –***

Simple and effective maintenance strategies are critical for lowering costs across industries, Condition-based maintenance can replace time-interval or gut-feel based approaches, detecting problems before they cause process upsets or secondary damage. This reduces the overall maintenance burden as well as costs from unexpected downtime.

Detecting departures from expected values is an essential element of condition-based maintenance. Users first create a reference dataset of “normal” operating conditions. Current vibration, power consumption, or other data can then be trended on top of the expected values, as shown below. The images below show examples of this type of monitoring and detection. on the left is data from a wind turbine prior to a failure event. The image to the right shows a departure from expected fuel flow for a gas burner, indicating a maintenance need. With Griffin, this type of display can be created in seconds, based on existing data and without the addition of new sensors.

Chart, line chart

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*Examples of real-time monitoring and detection of equipment failures. On the left is data from a wind turbine prior to a failure event, to the right live monitoring shows a departure from expected fuel flow for a gas burner, indicating a maintenance need*

With the proliferation of equipment monitoring hardware that includes onboard diagnostics and alarm generation (MSET and similar), false positives have become a serious issue. Alarm filtering applications can be deployed by Taber that can be easily updated in real-time based on experience and best practices. This adds crucial flexibility to DCS systems and black-box solutions provided by other vendors.

More sophisticated fault detection relies on creating a model to predict the value of a given output across operating conditions. These models can be statistical, such as with MSET, based clustering algorithms, or regression algorithms like a neural network. Once the data-driven model is trained to predict the process value (using user-curated “good” data), it can be used to predict the current value. When a significant deviation is observed, users can be alerted to either a malfunctioning sensor, maintenance issue, or some other type of process problem. This method can be applied to any type of output generated by a plant, including entire groups of outputs simultaneously.

Predictive maintenance and anomaly detection can drastically improve process reliability and operating costs. Utilizing intelligent systems for this purpose takes the strain away from maintenance personnel doing manual monitoring and can be more effective and accurate.

A picture containing graphical user interface

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*Intelligent processing of multiple real-time data signals to detect pending failure*

***Engineer Workflow Automation –***

Automation of repetitive, mundane, data-related tasks can liberate your and your engineers’ time to be spent on making impactful decisions and initiating system improvements. Using real-time process data connections, Taber’s custom-built automation applications do all the data analysis, report compilation, and optimization of resources in a single click. View system performance and explore deeper insights in real-time on a personalized dashboard. By pinpointing what is really going on with your system, you have the capability to significantly improve every aspect of your workflow and ultimately save countless hours and likely significant dollars through better understanding of unit and equipment conditions.

Each engineer’s day-to-day and responsibilities are unique, so Taber works directly with you to develop workflow automation that’s completely customized to your interests, needs, and objectives. In less than one week, your personalized dashboard and automated reports can be developed and ready to use, saving you countless hours and effort on your next report preparation and meeting discussion material.

Graphical user interface, application, Excel

Description automatically generated

*Example of engineering dashboard with personalized content*