Web Based Remote Monitoring and Management of Boilers and Cooling Water Systems

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Abstract

This paper presents a novel approach to remotely monitoring and managing boiler and cooling water systems. The Remote Manager™ core software program from iSagacity, analyzes and diagnoses water chemistry conditions in real time. Using thermodynamic analysis of the water chemistry and modeling the transport processes in the steam cycle, the software also indicates the tendency for scaling and can forecast the need for chemical cleaning of boilers and heat exchangers. Plant data is input on a routine basis then the data is analyzed by the software which provides early warning signals of abnormal conditions and that, left unattended can lead to loss of overall plant efficiency and reliability. This paper discusses the capability of the new novel software program and discusses the cost benefits of implementing this unique tool in steam and cooling water systems.

Introduction

Boiler tube failures continue to be the single largest source of forced outages in industrial type steam generators. In most cases corrosion occurs under deposits and scale which builds up on the boiler tubes. In addition to contributing to the corrosion process, the buildup of scale on the tubes by itself reduces heat transfer and therefore increases the overall fuel costs to produce a given quantity of steam. Likewise cooling towers and cooling systems also experience fouling from silt, debris and microbiological, resulting exchanger deposition and under deposit corrosion. While cooling systems are operated at lower temperatures than boilers, loss of cooling tower efficiency coupled with higher supply water temperatures and lower than design flow rates can drastically affect the efficiency and energy costs of the systems cooled.

In both boilers and cooling water systems, corrosion and scale buildup can be controlled by maintaining the proper water chemistry. Water chemistry control requires the proper selection of the water chemistry treatment program. Industry groups such as ASME and EPRI as well as the major water treatment vendors have developed water chemistry guidelines for boilers and cooling water systems. A proper water chemistry control program includes routine monitoring of various boiler, feedwater and cooling water streams. Monitoring data is analyzed to ensure that chemistry is within specifications ; additionally, the same data can be used to trouble shoot plant and equipment problems. Unfortunately, this data analysis is in many cases after the fact, and occurs due to a problem that curtails products and/or reduces system reliability. Being able to capture and

analyze data proactively, spot potentially damaging trends and take the appropriate corrective actions more quickly results in lower operating costs and increased system reliability. This paper discusses a novel approach to monitoring and analyzing water chemistry in steam plants and cooling water systems. The system has been and can be utilized in all types of industrial systems and centralized power plants.

Remote Manager

Remote Manager software is iSagacity's web based data management tool. Remote Manager software is accessed through a secure web site hosted in the iSagacity Data Center. iSage Boiler™ software module and iSage Cooling Tower™ software module are analysis modules for boiler water and cooling water systems, respectively. These programs are designed for use in monitoring boiler, steam cycle and cooling system performance in industrial or utility boiler installations. Boiler, cooling system and other steam cycle parameters can be trended and alerts can be set for key parameters (using Remote Manager software. iSage Boiler software and Cooling Tower Monitor software) that are detected to be in an abnormal condition and diagnoses the reason(s) for many common problems in steam plants and cooling water systems. An example of the System Summary page from iSage Boiler software is shown in Figure 1. Additional web pages allow the user to drill down for more detailed analysis of the data.

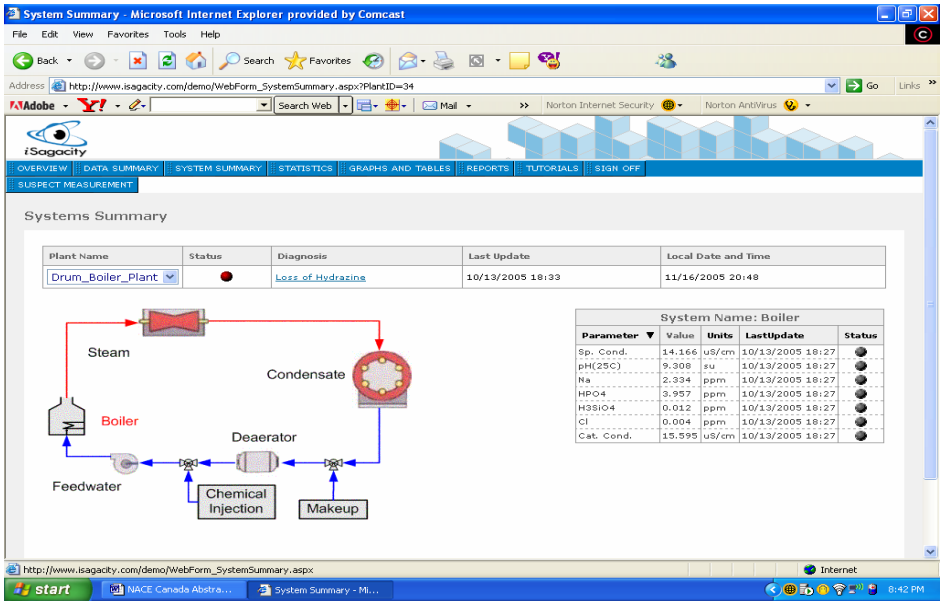

Figure 1 Remote Manager System Summary

Data can be entered directly into Remote Manager software via a web page interface or automatically from SCADA, DCS, ODBC Compliant Databases, Data Historians, or PDAs via the Internet, or company intranet/LAN system.. All data undergo analysis by a series of algorithms. First, the data are screened for their timeliness. Key pieces of data are reviewed to ensure that the system is in a condition to be analyzed. Remote Manager has the ability to suspend diagnosis if conditions exist where performing a diagnosis is inappropriate or not possible. For example, if the unit is off line, diagnosis is suspended.

There are seven layers of screening applied to each data channel to determine its integrity and individual impact on the overall system. This screening process is the precursor to identifying suspect measurements and abnormal conditions.

Water Chemistry Diagnostics

The iSage modules evaluate the chemistry data in real time by comparing the measured data to a custom library of scenarios. Each scenario represents a different system condition as will be described later. A pattern recognition algorithm is used to determine which scenario best matches the data. The diagnostic algorithm first identifies if an abnormal condition exists. Then the diagnosis determines if the abnormal condition is known or unknown. Finally, the diagnosis is revealed on a secure web page for the user. In addition, abnormal conditions can be alerted directly to the users e-mail, text pager, cell phone, or PDA for immediate attention and response. The routine lists all suspect measurements in a separate area for the user to investigate. A suspect measurement is either an invalid instrument result or a leading indicator of a developing event. Suspect measurements require customer interaction and attention. Finally, all data and results are reported on a secure web page for visualization, corrective action statements, and consequences to long-term operation in the diagnosed condition. Individual alerts can also be established for individual measurements as specified by the customer. All information is stored remotely on a Microsoft SQL® database and is accessible through the web interface.

System Library for Diagnostics

The diagnostic engine uses a library of conditions or scenarios which are continuously compared to the current set of system data. A standard library is available for both boilers and cooling water systems. The specific features of each scenario are customized for each customer. The scenarios are created using iSagacity's chemical thermodynamic and transport models (1). A partial list of some scenarios for both the iSage Cooling Tower and Boiler software application at a power station follows. The plant is a two unit station with HRSG's located in Oregon. They have used iSage Boiler and Cooling Tower software since December of 2003 (2). It is important to recognize that sufficient plant data must be supplied to evaluate these conditions. Where data is not available, other custom scenarios can be developed for each application.

<u>Typical Cooling System Scenarios</u>

Normal Chemistry
This scenario specifies what is required for normal chemistry conditions.

Cooling Water Scaling Conditions
The scaling conditions are indicated by the Scaling Index, total alkalinity, and the cooling tower pH.

Reduced Condenser Performance
The scenario uses condenser performance issues to determine when potential actions are needed to improve condenser performance. The algorithm focuses on condenser back pressure and cleanliness factor.

Verify Cooling Tower pH Meter
This scenario can be used to safeguard against an isolated cooling tower pH meter which could lead to excessive fouling of the condenser without proper indication. The scenario uses cleanliness factor, terminal temperature difference, total alkalinity, and the acid pump delivery to determine elevated pH conditions without a pH measurement.

High Biological Demand
This scenario uses the calculated Bio Index and the measured free chlorine in the water to determine the biological demand in the system.

Condenser Cleanliness Factor
The overall heat transfer coefficient is calculated in real time for the main condensers. This value is compared to design data to give a condenser cleanliness factor. This factor is useful in determining the overall fouling conditions of the condenser.

Condenser Terminal Temperature Difference (TTD)
The TTD of the main condensers is calculated in real time. This value is useful in trending the performance of the condensers and is based on the calculated steam temperature and the outlet cooling water temperature of the main condensers.

Cooling Tower Scaling Index
A scaling index was developed from the calculated hold time index and the cooling tower pH. The scaling index is calculated in real time and is useful in determining scaling conditions due to extensive clean up half lives in the cooling tower. These conditions stress the chemical inhibition properties and potentially allow for scaling to occur.

Cooling Water Delta Temperature
The condenser cooling water delta T is calculated for trending purposes as a performance parameter. Elevated delta T's can indicate low cooling water flowrates. Minimized delta T's can indicate fouling.

Overall Plant Efficiency
The overall efficiency of the power plant is calculated from the measured load and the calculated heat loss in the main condenser. This indicator is useful for trending general performance.

Condenser Steam Temperature at Saturation (Tsat)
The saturated steam temperature is calculated from the condenser back pressure. This value is used in the calculation of the TTD.

Cooling Tower Cycles of Concentration
The cycles of concentration in the cooling towers is calculated from the cooling tower blowdown flowrate and the total make up flowrate. The cycles of concentration are directly related to the cooling tower hold time index.

Cooling Tower Hold Time Index (HTI)
The HTI is the cooling tower clean up half life. This is the time that it takes to remove half of the concentration of impurities from the cooling tower. The HTI is dependent on the cooling tower volume, blowdown flowrate, and the make up flowrate.

Cooling Tower Biological Index (Bio Index)
The microbiological demand on the cooling tower is related to the free chlorine concentration and the delivery of the chlorine to the system. The higher the Bio Index, the higher the microbiological demand is for a given chemical federate.

Typical Boiler Scenarios

Normal Chemistry
The scenario specifies the requirements for normal operating chemistry.

Small Condenser Leak
This scenario is designed based on the cooling water and normal steam cycle chemistry. A small condenser leak that is near the alarm levels is modeled to help alert the plant personnel to conditions before they become a threat to unit availability.

Large Condenser Leak
This scenario is also based on the cooling water and normal steam cycle chemistry. A large condenser leak is diagnosed for conditions that are near or above the level where power reduction actions may be necessary.

Amine Overfeed
This scenario maintains the proper relationship between amine concentrations and various system chemistry parameters such as pH, conductivity, and cation conductivity. Amine overfeed is diagnosed when the amine concentrations are maintained outside the normal operating range.

Amine Underfeed
This scenario also maintains the proper relationship between amine concentrations, pH, conductivity and cation conductivity. The scenario alerts plant personnel when low amine conditions threaten the general corrosion rate in the pre-boiler systems and potentially increases the corrosion product (iron/copper) transport to the boilers.

Deaerator Malfunction
This scenario evaluates the removal of oxygen and volatile constituents around the deaerator and alerts plant personnel to degrading equipment conditions.

Air In-Leakage
This scenario evaluates the relationship between oxygen and cation conductivity in the steam cycle to alert plant personnel to excessive air in leakage before condenser performance issues arise.

Feedwater/Condensate Dissolved Oxygen Meter Malfunction
A site specific requested scenario that evaluates the performance specifically of the dissolved oxygen meter that is used for both feedwater and condensate analysis. Malfunctioning of this instrument can falsely indicate a problem with the deaerator operation. This scenario allows distinguishability between these two events.

Predictive Algorithms

In addition to the diagnostic engine supplied with the Remote Manager software, predictive algorithms have also been deployed with the platform. iSagacity working with Baker Petrolite, have implemented an algorithm for predicting flow accelerated corrosion tendencies (FAC) in steam plants (3). The algorithm uses the measured oxygen concentration, the local pH calculated at temperature using EPRI's MULTEQ code (4) and the local flow conditions. The MULTEQ code allows the pH to be calculated for several organic amines used in industrial steam systems. This algorithm can be used to alert operators that conditions leading to FAC exist at specific locations in the steam plant. The MULTEQ code has also been used with Remote Manager software to predict the tendency for acid and caustic conditions to form under deposits in boilers as well the potential for hardness scale formation in boiler and cooling water systems. The FAC and scaling algorithms are currently be used in both refinery and large scale gas processing plants.

The most recent algorithm developed for Remote Manager software is a real time prediction of the boiler tube temperature in industrial boilers. The algorithm first predicts scale buildup based on a boiling deposition model that is fit to deposit scale density measurements made for the plant. The insulating capacity of the scale is used in conjunction with a heat transfer model to calculate the temperature rise of the boiler tubes. This algorithm is being deployed with Baker Petrolite to project the need for chemical cleaning of refinery boilers. This program is currently undergoing testing in a major mid-western refinery.

Cost Benefit

The iSage Cooling Tower and Boiler modules with Remote Manager software provide a complete solution to water chemistry program management. Direct cost savings include; reduction of shift chemistry support, elimination of selected grab sample requirements, and optimization of chemical treatment. Indirect savings include; improved responsiveness to abnormal chemistry events resulting in reduced equipment maintenance costs and tighter environmental compliance. The predictive algorithms can be used to guide inspections and plan maintenance activities such as chemical cleaning.

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