Fleet-Wide Optimization For SO_2 Cap Compliance

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Keywords: Efficiency, Enterprise Automation, Expert Systems, Modeling, Neural Networks, Optimization, Scrubbers

Abstract: Today's power generation facilities need to operate more cost-effectively while still achieving environmental compliance and meeting the increasing demand for electricity. These factors have caused power producers to look for ways to help older plants do what may seem impossible -- to simultaneously produce more power, increase profitability, and become more environmentally friendly.

The use of optimization software as part of an overall pollution abatement plan has been shown to improve environmental compliance. Additionally, such software has exhibited a number of financial benefits for users, making an emission reduction strategy agreeable to both power producers and environmental interests.

This manuscript will discuss new methods of using optimization to help power producers plan for SO_2 cap compliance, while decreasing overall operating costs, increasing equipment life span, and making valuable air pollution trading credits available to other power generation assets.

Introduction:

The ability to manage emissions over an entire fleet of operating units is now a possibility. The goal of a Fleet Emissions Optimizer is to determine the optimum SO_2 emission rate for each of the plant so that the total amount of SO_2 produced does not exceed the yearly cap and that the flue gas is scrubbed in the most cost effective manner.

The optimization software can reside on a computer or server located in a central location and should receive key parameters from each of the plants. These key parameters should facilitate the calculations for cost of a scrubbed MW and provide FGD system(s) set points that can be sent from the central computer to each of the plants control systems to provide operational advice or even closed loop control.

The amount of SO_2 being produced from each plant can be continuously integrated at the central machine and the predicted yearly SO_2 amount will be continuously updated so that the difference between the maximum allowed and the predicted amount can be calculated. This difference is the error that must be continuously compensated for by the optimization software.

The integration of data from dissimilar sources is a key element of this application. The need to account for operating labor costs, additional operating heat rate penalties, and maintenance cost factors have a large impact on the ease of integration for fleet wide emissions strategies.

There are numerous potential benefits of this fleet wide emissions strategy. The potential to provide data redundancy of key variables, replicate or provide diversity in calculations used for business decisions, and provide a reporting mechanism for this information are valuable aspects of this integration and optimization system.

FGD Removal Systems:

In a Dry Sodium Injection (DSI) system, dry reagent is injected into the upper part of the furnace to react with SO_2 in the flue gas. The finely grained reagent is distributed quickly and evenly over the entire cross section in the upper part of the furnace in a location where the temperature is in the range of 750-1250 ^oC. Commercially available limestone ($CaCO_3$) or hydrated lime ($Ca(OH)_2$) is used as sorbent. While the flue gas flows through the connective pass, where the temperature remains above 750^oC, the reagent reacts with the SO_2 and O_2 to form $CaSO_4$. These units have a maximum removal efficiency of 50%.

The wet scrubber systems using Lime Spray Dryers (LSD), require the use of an efficient particulate control device such as a fabric filter. The Reagent that is used is typically lime or calcium oxide. The lime slurry, also called lime milk, is atomized and sprayed into a reactor vessel in a cloud of fine droplets. The heat of the flue gas evaporates the water vapor. The residence time (about 10 seconds) in the reactor is sufficient to allow for the SO_2 and the other acid gases such as SO_3 and HCl to react simultaneously with the hydrated lime to form a dry mixture of calcium sulfate/sulfite. Wastewater treatment is not required in spray dry scrubbers because the water is completely evaporated in the spray dry absorber. The by-product also contains un-reacted lime that may be recycled and mixed with fresh lime slurry to enhance reagent utilization. Factors affecting the absorption chemistry include flue gas temperature, SO_2 concentration in the flue gas and the size of the atomized or sprayed slurry droplets. These systems have a maximum removal efficiency of 90%.

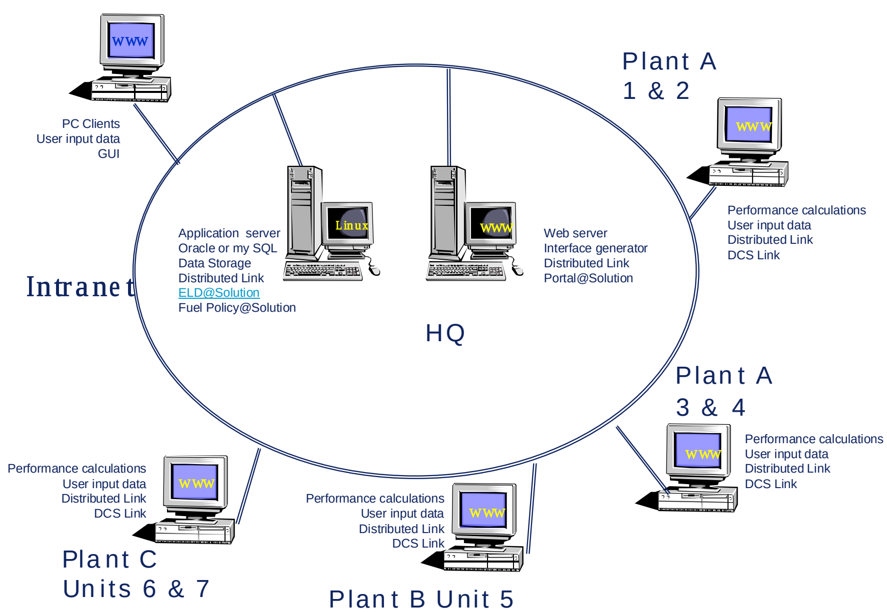
Whether it is a DSI or LSD system the only item that can be manipulated is the removal efficiency setpoint.

State of the Art Application:

The deployment of Distributed Control (DCS) system architectures designed for power plant use has many tangible and intangible benefits. The ability to link these DCS systems to the various island of automation can be leveraged for fleet-wide information exchange. The use of “open” interfaces can facilitate this data exchange. This may pose a challenge for older vintage DCS products, but is seamless in more modern renditions of DCS technology.

The preferred open interfaces like OPC, NetDDE and Modbus transmitted over an Ethernet data network can be supplanted by dedicated links if data sources are less open or if reductions in network traffic are an issue. The network architecture can be illustrated conceptually as follows in Figure 1:

Figure 1: Fleet-wide conceptual network architecture



The fleet-wide application must gather the plant data, track various costs and calculate the economic trade off between the many relationships and the cost functions. The heat rate penalty of additional parasitic load from scrubbers must be factored for many measured and unmeasured variables. The coal type and impact on the need for reagent is a relationship for consideration in the optimization strategy. The increased volume of dry and wet ash removal from the increase in scrubber lime usage ratios applies as a minor cost issue while the water usage and cost relationship for wet scrubbers has an additional impact. The non-linear functions of these costs are all challenges for the optimization application. The ability to capture a dynamic real-time heat rate curve for the units and deploy that as the basis for the optimization solution are novel ideas for a fleet emissions optimizer. Linear models can be developed for unmeasured flows and related cost functions that have relationships that follow the generation profile of the plant.

The need to integrate data sources and date collection elements from the business networks down to the control networks and local area plant networks is also considerable challenge. The Information Technology (IT) departments at the corporate and plant locations need to be appraised on how this fleet strategy may affect them. Considerations for fixed or floating (dynamic) IP addressing schemes and the type of LAN and WAN connections are important decisions. The need to add hubs, network switches, ports and connections to existing network devices and equipment must be anticipated to insure the connectivity adds to the hardware and software aspects of a fleet integration project.

Business systems are not always the easiest integration components. Using a common global database can assist in solving the problem of meshing business and operational networks data. The use of centralized operations and maintenance programs can present a unique set of challenges of their own when integration of cost factor data is desired. Security policies are a key element when the business network is linked to a functional part of the generation assets. The need for firewalls, and secure data connections can protect the enterprise from intrusions or 'hacking'. Certain operating systems can also discourage a majority of efforts to disrupt the network services. Deployment of these less common operating systems may require additional training and set up, but in some cases can improve network and computer performance while enhancing security.

The plant automation systems and the various programmable logic controllers (PLC) used by sub system vendors are an additional integration consideration. Upgrade to or development of custom interfaces to these systems to permit communication to a central data server or main automation system can be important accurate plant models. In some situations hard wiring sensors to an easily integrated system may prove more cost effective that upgrading older balance of plant automation systems.

Some legacy systems or pneumatic control components in the plant can make integration and coordinated automation an interesting challenge. For example, the use of a common gas regulator and flow meter for an plant ignition gas supply makes calculating the additional start-up time related to warming the SO2 scrubber to operating temperature more of a logical guess than a division problem.

Project Components:

The fleet wide optimization system has a number of scaleable main components. The central data base server is a key headquarters component. The model server and home for the dynamic models and optimization strategy is another component server of the fleet optimizer. These devices collate the data from the various plants; provide displays and trend visualization, charts and decision support screens that can be used throughout the enterprise. Additional features can be added such as a web-based server for the corporate intranet or client server administration functions as well hosting engineering tool sets. Reporting functions can be implemented at the headquarters location, which provides a point for replication of the plant data server information. The interface to the business network occurs with one of these main data servers. Firewall functions can be configured at these machines to support corporate security policies.

The key component for the various plant locations is the data server (s) -- common connection point where the main plant automation systems are integrated. These remote data server can display the DCS graphics, back up of the DCS historical data, and serve as a host for some of the plant specific models. They can also provide a network address translator if there are duplicated local network addresses or names on various units within a plant. The data server is the point of integration for the plant control system, CEMS system, and various PLC systems that provide data for the fleet optimizer models and optimization. Local reporting and historical trends as well as near real time data is available throughout the plant LAN from this point. The remote display of alarms, DCS graphics and multiple unit data can aid troubleshooting. These features can be accessed from any PC on the LAN equipped with client software. The ability for personnel to view multiple unit data on a common display, in real-time can provide significant decision support in a flexible generation pool.

Engineering the hardware and software to work within the existing networks configurations is a critical project component. Experience with high speed networks, network architectures, and the best methods and practices to get a functional connection without down time or related equipment outages is also a piece of the project that that can't be overlooked. The project management skill necessary to get the many hardware, software and engineering aspects completed in the proper sequence is the catalyst that enables a successful fleet emissions optimization project.

Summary:

The technology exists for dynamic plant models to be used in fleet wide optimization utilizing corporate network infrastructures. The wide area and local area network connectivity challenge can be met with solutions that will satisfy security and open communication goals. The incorporation of the various cost functions can be directly integrated, or in the case where there is insufficient instrumentation, can be closely approximated through various modeling means. The use of linear and non-linear technologies enables a fleet wide optimization solution that will predict emission cap compliance based on load forecasts. The solution can actively optimize the plant settings, in real-time, to achieve the desired compliance target margins.