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Application Solution

Summary

Use Dynamic Simulation to minimize incidents of boiler implosion and develop better designs to improve the controllability and safety of the boiler and FGD system.

Business Value

Avoid unnecessary boiler stiffing for conversion of forced draft to balanced draft operation, which can cost in excess of several million dollars. In addition, MFT control logic can be designed which helps prevent implosion damage to a boiler.

SimSci™

Dynamic Simulation Example:

Boiler Draft Analysis for FGD Projects

INTRODUCTION

A Flue Gas Desulfurization (FGD) retrofit will affect a power plant's controllability and may expose it to an unplanned shutdown or mechanical damage during upset conditions. Dynamic simulation is a valuable design tool for FGD retrofit process and control design. In particular, Dynamic simulation can assess the possibility of boiler implosion due to continued operation of an induced draft fan seconds after a master fuel trip. Dynamic simulation can also assess controllability issues associated with parallel units using a shared FGD system. Dynamic simulation provides the required information to make important design decisions that can significantly improve the controllability and safety of the boiler and FGD system.

As a result, customers can avoid unnecessary boiler stiffing for conversion of forced draft to balanced draft operation costing in excess of several million US dollars. The customer can evaluate axial versus centrifugal ID Fan selection. In addition, MFT control logic can be designed which helps prevents implosion damage to a boiler.

TWO APPROACHES

SimSci-Esscor™ has two approaches to performing FGD retrofit draft studies.

1. Use an existing Power plant OTS model developed with DYNSIM® Power. The positive aspect of this approach is that the model is rigorous, validated by operators, and is a near exact duplication of the control system. The negative aspect is that it is difficult to modify the process model and controls to evaluate alternative process and control designs. It is also difficult to determine the impact on parallel boilers when multiple boilers share a common FGD system.

2. Develop a specialized DYNSIM model specifically for boiler draft study. This model includes only the air and flue gas system and simplified controls. The model is rigorous from a thermodynamic basis. The process and controls are easily modified to evaluate alternative process and control designs. The negative aspect is that it may not have the actual control system. However, this limitation is mitigated by the assumption that for safety studies controls should be simulated and not respond if the control response is beneficial.

This document describes approach two, the development of a specialized DYNSIM model specifically for boiler draft analysis.

DYNAMIC SIMULATION MODEL

Figure 1 illustrates the dynamic model of a typical boiler.

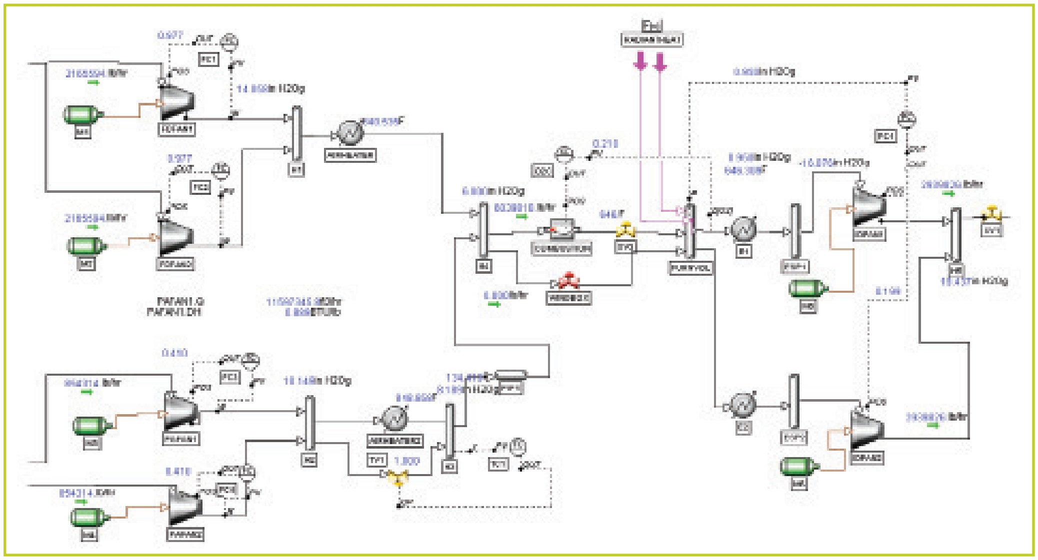

Figure 1: Typical Boiler Air and Flue Gas System

The following assumptions were made in the development of this model:

- DYNSIM compressors are used to model the primary air, secondary air, and induced draft fans.
- A DYNSIM Combustor is used to model the combustion and temperature increase of the air.
- The furnace is modeled with a very large volume header. The header is customized to simulate radiant heat transfer from the gas to the waterwalls. Waterwalls are modeled at near constant temperature and the furnace pressure flow solution is set to “Explicit” to improve accuracy.
- A valve XV1 models the pressure drop through the FGD system.
- Controls include flow control on the secondary air fans, pressure control on the furnace, and oxygen control on fuel. Since the controls are frozen for the MFT, the actual control configuration is simplified.

CASE EXECUTION AND RESULTS

A DYNSIM Scenario was created to easily run the simulation cases repeatedly while doing initial trial runs.

1) Stop addition of fuel to combustion over 1 second
2) Place furnace pressure control on manual

Figure 2 shows the rapid decay in pressure as fuel is discontinued and hot gas in the furnace continues to radiate heat to the walls of the furnace. Pressure falls to -17.5 in. H_2O g in this hypothetical boiler with very powerful ID fans designed to overcome the pressure drop in the FGD system.

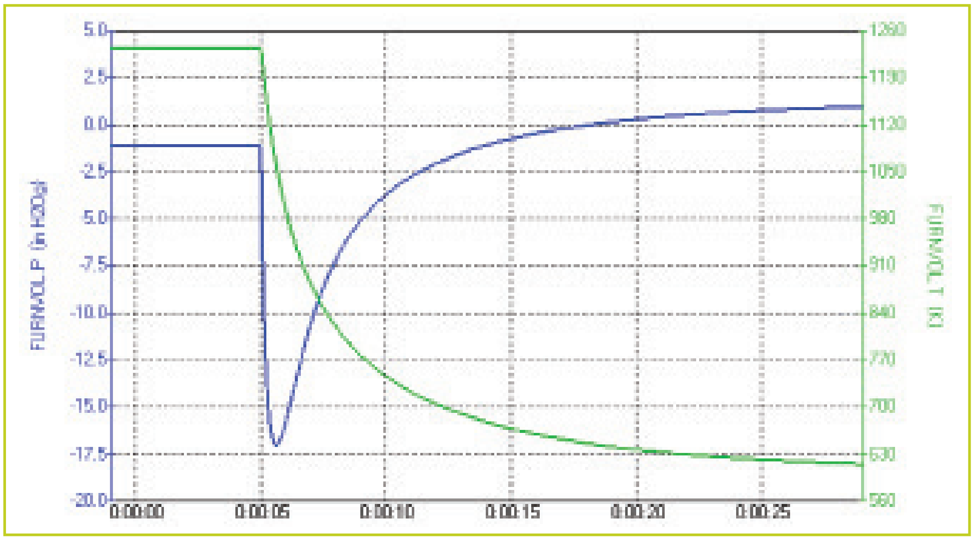

Figure 2: Furnace Pressure and Temperature Dynamic Response

Future Work

This simulation was a relatively simple evaluation. The following is a list of model and scenario improvements required in an actual boiler draft analysis.

- Use actual fan curves converted from head in meters to polytropic head in kJ/kg by dividing by the fan curve reference fluid density.
- Include actual damper characteristics such as opening time and conductance as a position of open position.
- Expand model of back pass to calculate heat transfer to economizers and air heaters.
- Evaluate fuel volume from slide dampers to furnace to determine inventory of fuel supply after closing fuel flow dampers
- Expand model of combustion to simulate windbox dampers and proper control response.
- Determine a comprehensive scenario that reproduces the actions of the actual plant controls. This includes moving windbox dampers to purge positions and tripping the appropriate motors.

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