TECHNICAL PUBLICATION

SO_2 Removal Enhancement to the Vectren, Culley Generating Station Units 2 & 3 Wet Flue Gas Desulfurization System

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ABSTRACT

Babcock Power Environmental Inc. (BPEI), a subsidiary of Babcock Power Inc., was commissioned to design and implement modifications to Vectren's Culley Generating Station Units 2 & 3 Wet Flue Gas Desulfurization (WFGD) System to ensure that the effluent SO_2 emissions were in compliance with Environmental Protection Agency (EPA) requirements. The objective of the modifications was to ensure that the WFGD system achieves greater than or equal to 95.5% SO_2 removal efficiency based on a 30 Day rolling average for all fuels fired.

Culley Generating Station Units 2 & 3 WFGD system, originally designed and constructed by BPI, started commercial operation in 1994 and was originally designed to handle boiler loads of 365 MWg at a maximum SO_2 loading of 6.7 lb/MBtu. Today the system is required to treat flue gas resulting from boiler loads and SO_2 loadings of up to 392 MWg and 8.0 lb/MBtu respectively.

Absorber baffles were retrofitted in the Culley WFGD System's absorber tower during the March 2004 outage to enhance the overall SO_2 removal. The baffles serve to better distribute the incoming flue gas over the entire absorber cross-sectional area as well as eliminate "gas laning" along the absorber walls. Improving the absorber flow distribution and liquid-to-gas contact increases the absorbers effectiveness to remove SO_2 from the flue gas, thus achieving higher overall SO_2 removal efficiencies.

The installation of absorber baffles resulted in an average SO_2 removal efficiency enhancement of 4.1%. This paper reviews the baffle design and presents data from before and after absorber modifications.

INTRODUCTION

On June 6, 2002, the U.S. Environmental Protection Agency (EPA) and the Department of Justice announced a Clean Air Act (CAA) settlement with the Southern Indiana Gas and Electric Company, Inc. (SIGECO), now Vectren Power Supply, for the F. B. Culley coal-fired power plant (Culley Station).

As part of the settlement, Vectren was required to improve the existing Wet Flue Gas Desulfurization (WFGD) system serving Culley Station's Units 2 and 3 coal-fired boilers so as to achieve and maintain a 30 Day Rolling Average SO_2 removal efficiency of greater than or equal to 95.0% by June 30, 2004.

Culley's WFGD operation has changed several times since it started commercial operation in 1994. Gross boiler load was increased from 365 MWg to 392 MWg and the SO_2 loading was increased from 6.7 lb/mmBtu to up to 10.0 lb/mmBtu.

Babcock Power Environmental Inc. (BPEI) was commissioned to design and implement modifications to the existing WFGD system to meet or exceed SO_2 performance parameters as listed below:

* The primary objective was to achieve greater than or equal to 95.5% SO_2 removal efficiency based on a 30 day rolling average for various fuels fired at the Culley Station

* Also, while fulfilling the primary objective, the system was to maintain a high degree of availability. A minimum of one of the six recirculation pumps was to be treated as a spare

Modifications selected/implemented for the existing Culley WFGD system were the addition of new recirculation pump gear reducers, absorber sump suction line screens, and absorber baffles. This paper focuses on the implementation of the absorber baffles only; no recirculation pump modifications have been made.

BACKGROUND

Vectren's F. B. Culley Station is located on the Ohio River near Newburgh, Indiana. Culley Units 2 and 3 are rated for 105 MWg and 287 MWg respectively.

Unit 2 is an upgraded balanced draft furnace. It consists of one Babcock and Wilcox pulverized coal-fired steam generator, two FD fans, one electrostatic precipitator (ESP) with two chambers, and two ID Fans with variable speed drives.

Unit 3 is also an upgraded balanced draft furnace. It consists of one Babcock and Wilcox pulverized coal-fired steam generator, two FD fans, two ESP's, two air heaters, a Selective Catalytic Reactor (SCR) system, and two constant speed ID Fans.

The WFGD System was designed and supplied by BPEI, formerly Riley Inc. The system is limestone based and utilizes a counter/co-current open spray tower with in-situ forced oxidation. The flue gas exits Unit 2 and 3 ID fans and flows through a single absorber tower to a common wet stack.

PROBLEM

Inherent in open spray tower absorbers utilizing spray nozzles to introduce reagent slurry to the inlet flue gas is a region of lower spray density near the absorber walls. Nozzle arrangements are designed to produce a given amount of spray overlap. This ensures optimal coverage of the bulk absorber vessel cross-sectional area. However, absorber geometry and spray nozzle symmetry does not allow for the same degree of spray overlap near the vessel wall. In order to provide uniform spray coverage across the entire vessel cross-sectional area, designs would have to implement additional nozzles located closer to the wall. Apart from being uneconomical, locating nozzles too close to the vessel wall can lead to rapid wear and as a result require constant maintenance.

Lower spray densities and inadequate spray coverage can lead to the inlet flue gas bypassing the main reagent slurry spray zone. This can be generally termed as “wall sneakage” or “gas laning.” Typically areas where wall sneakage is present are less efficient at removing SO_2 from the flue gas and in turn have higher SO_2 concentrations at the absorber outlet resulting in lower overall absorber removal efficiencies.

BPEI designed absorber baffles for the Culley WFGD absorber vessel to reduce the presence of wall sneakage. The baffles fill in areas of minimal reagent spray coverage forcing the flue gas to pass through the existing effective spray zones.

Baffles were installed at the level 2 and level 4 spray header supports during the 2004 outage.

DATA EVALUATION

Digital Control System (DCS) data was provided to BPEI by Culley in Microsoft Excel format representing the actual operating and performance parameters for the Culley WFGD system before and after the recent modifications. Each data set represents approximately one week’s worth of data taken directly after a scheduled outage for the respected year. Data was obtained to directly compare the pre and post retrofit time periods. Utilizing data recorded immediately after the 2003 and 2004 outages allows for the comparison of the system's operation on an equal basis.

DATA ANALYSIS

Examining the effect of the installed absorber baffles in the Culley WFGD absorber was performed in two ways.

First, raw data from 2003 was directly compared to raw data from 2004.

Secondly, data from both the 2003 and 2004 time periods was normalized to the design conditions as defined below in table 1. The average of the corrected 2003 data was directly compared to the average of the corrected 2004 data to produce an estimated percent enhancement due to the addition of absorber baffles.

Table 1

WFGD Engineering Study Design Basis

Description	Units	Value
Maximum Outlet Flue Gas Flow*	[afcm]	1,301,571
Maximum Outlet Flue Gas Temperature*	[oF]	132
Maximum Outlet Flue Gas Pressure*	[iwg]	0
Maximum Inlet SO_2 Concentration	[lb/mmBtu]	8.0
Recirculation Pump Flow	[gpm]	36,102
No. of Recirculation Pumps in Operation	[# of #]	5 of 6
ID of Recirculation Pumps in Operation	[--]	D, F, A, E, B
SO_2 Removal Efficiency	[%]	95.5

*Predicted value based on actual data.

RESULTS AND DISCUSSION

Figures 1 and 2 display raw data taken directly from the Culley WFGD system DCS for the time period immediately following the March 2003 outage.

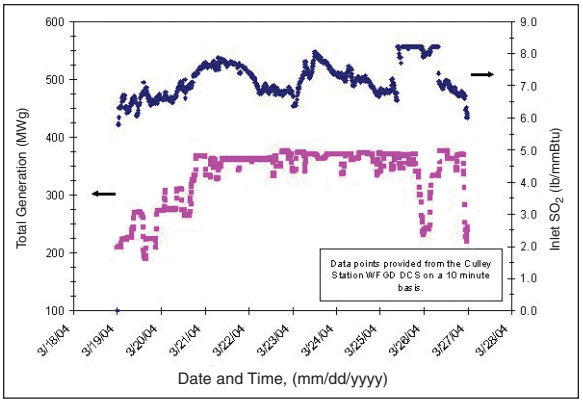

Figure 1. Total Station Generation and SO_2 Inlet Loading versus Time

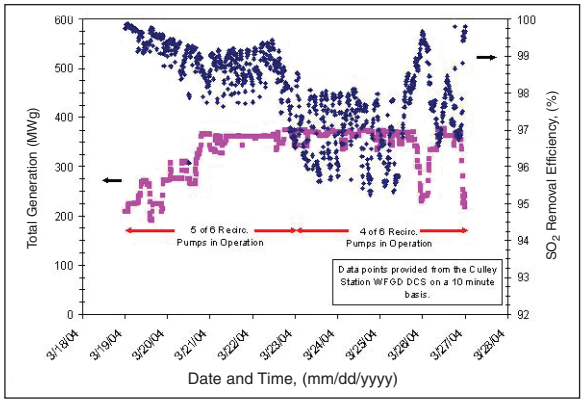

Figure 2. Total Station Generation and SO_2 Removal Efficiency versus Time

The figures represent a wide range of operating parameters such as unit load, inlet SO_2 concentration, number of operating recirculation pumps, and SO_2 removal efficiency. The information contained in the Figures 1 and 2 is summarized below:

* Data was available for four and five pumps in operation
* In general the inlet SO_2 exceeded the original design value of 6.7 lb/mmBtu
* Unit 2 and Unit 3 combined full load data is available
* SO_2 removal efficiency was always greater than or equal to 95.0% over the entire range of conditions listed above, even when operating only four recirculation pumps
* Removal efficiencies of 98.0% and greater are obtained for five pump operation with inlet sulfur loading of up to 8.0 lb SO_2/mmBtu

The installation of absorber baffles at the 2nd and 4th spray levels of the Culley WFGD absorber improved the overall system SO_2 removal efficiency well beyond the target value of 95.5% with five pumps in operation.

Both raw and normalized data was used to quantify the magnitude of enhancement that can be attributed to the addition of the absorber baffles. A summary of the raw data points, both before and after the installation of the absorber baffles shows that the absorber baffles enhanced the overall SO_2 removal efficiency of the Culley WFGD system by an average of 4.11% when four of the six pumps were in operation.

Normalizing the raw data to reflect the design conditions previously defined in Table 1 allowed for the evaluation of the overall SO_2 removal enhancement for a wider range of operating parameters, such as the number of operating recirculation pumps. As shown below in Figure 3, for normalized data with four pumps in operation, the WFGD system increased from an average SO_2 removal efficiency of 87.80% to 93.80%. This represents an average enhancement of 6.83%. For the same design conditions with five pumps in operation the WFGD system experienced an average SO_2 removal efficiency increase from 92.69% to 96.41%. This represents an average enhancement of 4.01%.

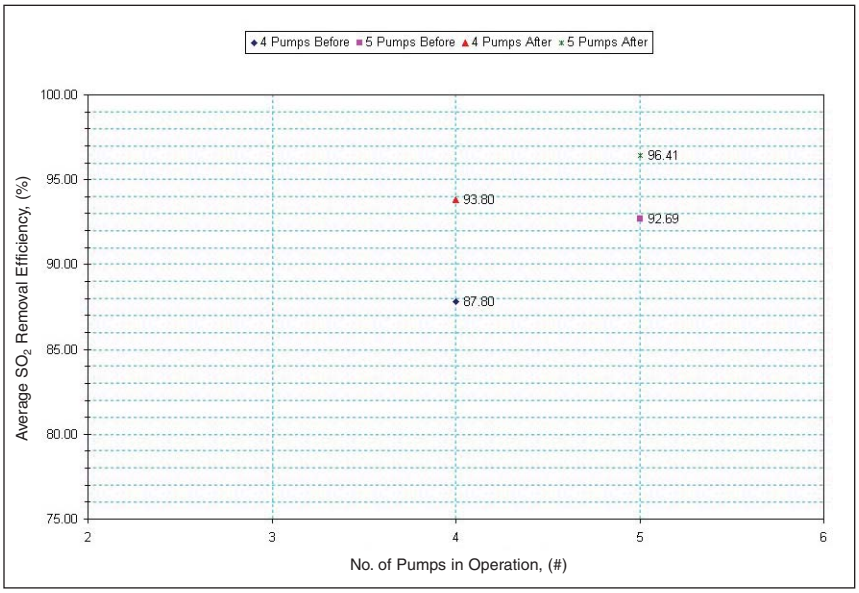

Figure 3. SO_2 Removal Efficiency (Before and After System Modifications)

CONCLUSIONS

As indicated by the results highlighted throughout this document the absorber baffles proved to be a very successful and economical solution to the problem of "gas laning" in open spray tower absorbers utilizing spray nozzles.

The absorber baffles installed at the Vectren, F.B Culley Generating Station accomplished the following:

* Allowed for the successful treatment of increased flue gas flows and inlet SO_2 loading
* Eliminated the need to purchase or modify process equipment
* Experienced negligible added pressure drop

The Culley Station WFGD system is currently exceeding the guarantee value of 95.5% SO_2 removal efficiency for the maximum unit 2 and 3 load with five pumps in operation for a SO_2 loading of 8.0 lb/mmBtu and four pumps in operation for a SO_2 loading of 6.7 lb/mmBtu. Further, the modifications at the Culley Station WFGD system demonstrate the ability for greater than 98.0% removal with high sulfur coal.