Heartland

Case Study

Heartland Water Technology's LM-HT® Concentrator Provides ZLD Treatment of FGD Purge Water Using Flue Gas as Thermal Energy Source

Location

Georgia Power Company's Bowen Plant
Cartersville, GA

Key Takeaways

- ZLD treatment of Flue Gas Desulfurization (FGD) blowdown
- Utilization of flue gas waste heat as thermal energy source
- Solidification and Stabilization of residuals passing TCLP for toxic metals.

Background

To demonstrate compliance options with pending wastewater discharge regulations, Heartland Water Technology teamed with the Electric Power Research Institute, Southern Company, and Georgia Power's Plant Bowen to conduct a 14 day demonstration project evaluating the capability of a Heartland LM-HT Concentrator system to concentrate and treat FGD wastewater to Zero Liquid Discharge (ZLD). The project was novel in that the Heartland Concentrator utilized flue gas from Plant Bowen's Unit 4 as the exclusive thermal energy source for evaporative treatment of the wastewater.

At A Glance

- Use of on-site flue gas reduces need for external energy source
- Prevent residuals from entering the environment

Figure 1. A view of the pilot Heartland Concentrator in operation at Georgia Power's Plant Bowen.

Challenge

In 2015, the U.S. Environmental Protection Agency (EPA) published revised effluent limitation guidelines (ELGs) for electric power generating units (EGUs). While the guidelines are under review for potential revision, the discharge limits as currently written for the discharge of FGD wastewater generated by any EGUs with capacity greater than 50 MW are shown in Table 1 below.

Constituent	Discharge Limit	
	30-Day Average	Daily Max
Arsenic (As)	8 µg/L	11 µg/L
Mercury (Hg)	356 ng/L	788 ng/L
Nitrate/Nitrite (as N)	4.4 mg/L	17 mg/L
Selenium (Se)	12 µg/L	23 µg/L

Table 1. ELG Discharge Limits for Existing Coal-Fired EGUs of greater than 50 MW capacity.

To transition EGUs toward future com pliance, the power industry has evaluated many technologies in recent years. Many of these technologies were found to be cost prohibitive, resource intensive, or excessively challenging to operate due to:

- Scaling of heat exchanger surfaces and other process equipment resulting in excessive downtime and cleaning.
- Chemical pretreatment requirements resulting in additional process com plexity, waste disposal, and prohibitive operating costs
- Operational hypersensitivity to changes in water chemistry requiring significant monitoring technology and laboratory resources to mitigate process upsets and resulting downtime.

Clearly, effective and efficient treatment of coal-fired power plant FGD wastewater poses a significant challenge for meeting existing and future compliance standards. Any treatment solution must demonstrate:

- Ability to process high total dissolved solids (TDS) water.
- Flexibility to various levels of suspended particulate concentrations.
- Resistance to surface scaling of processing equipment.
- Resistance to corrosion and erosion of equipment.
- Simple, cost-effective integration with existing power plant operations.
- Flexible processing capability up to zero liquid discharge (ZLD).

Figure 2. Flue gas ductwork from Bowen's Unit 3 feeding the Heartland Concentrator

Figure 3. Progression of FGD purge water in the Heartland Concentrator from raw feed to solidified and stabilized residual.

Solution

Heartland Water Technology's LM-HT® Concentrator provides an evaporative wastewater treatment solution, including:

- A direct-contact method of evaporation that eliminates the potential for scaling of heat exchange surfaces and other challenges faced by other evaporative technologies.
- A simple process to minimize routine maintenance and improve operations.
- A low-cost, corrosion resistant construction that utilizes materials such as fiberglass and CPVC.
- An innovative flexible design using various waste heat sources such as flue gas for thermal energy to significantly reduce operating costs.

Having demonstrated prior operational success using thermal energy sources at different capacities in multiple industries; Heartland's LM-HT Concentrator attracted interest in the power industry as a potential long-term solution to the wastewater challenges of the coal-fired power industry. Accordingly, Heartland and the Electric Power Research Institute (EPRI) started a demonstration project at Georgia Power's Plant Bowen utilizing the Heartland Concentrator to process FGD purge water was initiated. Heartland developed an integrated design utilizing flue gas from an EGU's air quality control system (AQCS) as the sole thermal energy source for evaporation. This configuration is attractive for many reasons:

- Flue gas is a viable waste-heat energy source, providing favorable economics for evaporative wastewater treatment compared to other energy sources.
- Integration as a closed-loop vapor system would allow for concentrator operation without effect on current air emissions or permitting.
- Entrained fly ash in the flue gas provides suspended particulates that may aid in solidification and stabilization of residuals as part of a (ZLD) process.

The primary aim of this pilot study was to evaluate the efficacy of an integrated LM-HT Concentrator® system in utilizing flue-gas waste heat as the exclusive thermal energy source for evaporative treatment of FGD wastewater. This included evaluating:

- Wastewater processing capabilities of the integrated system, including net volume reduction, extent of concentration, and residuals properties.
- Consequences, both physical and chemical, of introducing flue gas containing entrained fly ash into operations.
- Impact of variations in EGU plant operations on concentrator performance.
- Feasibility of ZLD treatment of FGD wastewater residuals to achieve environmentally acceptable disposal.
- Commercial scalability of this technology for treating FGD blowdown and/or other difficult power plant wastewaters.

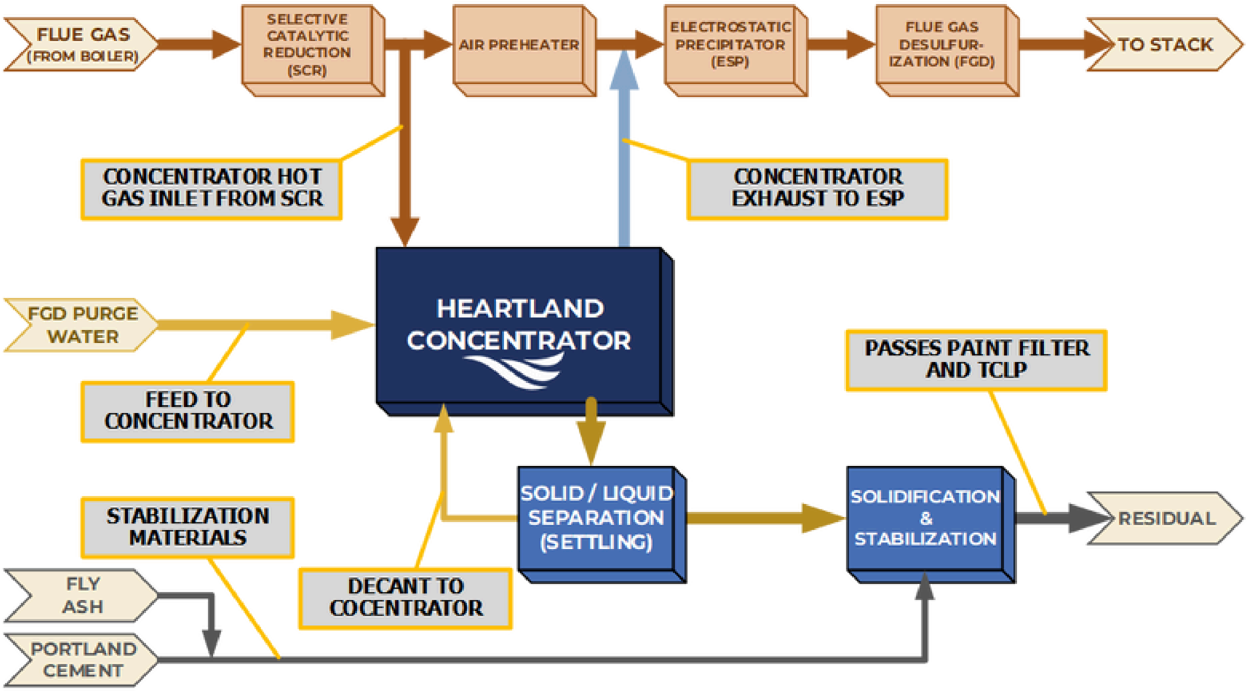

Figure 4. Process Flow Diagram showing the integration of the Heartland Concentrator with Plant Bowen's Unit 3.

Solution

Figure 2 illustrates the process flow and integration of the Heartland Concentrator with the Plant Bowen described as follows:

- A hot flue gas slipstream from the selective catalytic reduction (SCR) output feeds the Concentrator.
- FGD purge wastewater is introduced to the concentrator for processing and mixed with the flue gas
- Evaporates a portion of the wastewater, yielding a concentrator exhaust of cooled gas saturated with water.
- Exhaust is reintroduced downstream of the air preheater and upstream of the electro¬static precipitator (ESP).
- Additional gravity settling stages aid in recovering free liquid for further processing in the concentrator.
- After 90-95% volume reduction, the resulting effluent residual slurry consists of primarily precipitated solids and a small amount of saturated liquid.
- The residual slurry is then further solidified and stabilized for final disposal.

The primary challenges with this configuration are:

- Managing variability of flue gas operating temperatures and pressures resulting from upstream process dynamics such as plant load shifts or outages.
- Coordinating operations to ensure safe, robust, and successful performance.
- Managing any impacts of introducing flue gas containing fly ash within the concentrator system on equipment, operation, and/or physical properties of concentrated residuals.

These challenges were investigated with an EPRI sponsored operational study at Georgia Power Company's Plant Bowen, involving operation of a pilot-scale Heartland Water Technologies LM-HT Concentrator integrated into the site's 950 MW Unit 3 coal-fired EGU.

Over 14 days of continual operation, Heartland treated more than 10,000 gallons of FGD wastewater with the following sections describing key project highlights.

Wastewater Processing

The concentrator achieved a net volume reduction of approximately 90-95%, approaching 15 cycles of concentration of chemical species within the FGD wastewater. Figure 3 illustrates this progression with results summarized in Table 2. FGD waste-water, initially at 3.5% solids (by weight), was concentrated to 40% solids within the concentrator. Additional gravity settling of suspended and precipitated solids yielded residual slurry that approached 80% solids. Concentrator operations demonstrated consistent performance during the pilot study, requiring minimal operator inter-vention for cleaning or maintenance activities. As a result, the concentrator achieved 98% equipment availability.

Integration with EGU

Commercial integration was demonstrated in two key areas throughout the study:

- Successful and reliable wastewater treatment during daily cycling of EGU from minimum to maximum electrical output.
- Successful coordination with plant operations and consolidation of necessary safety protocols such as lock-out/tag-out procedures for activities involving equipment from both processes.

Regarding impact of flue gas variability on concentrator operations, a correlation be-tween EGU power output and evaporation rate was noted. This behavior is due to the reduced energy available in the flue gas stream at low EGU loads to drive the evaporation process. Despite daily swings in flue gas energy temperature, and pressure, the concentrator demonstrated remarkable flexibility, operating flawlessly over inlet flue gas temperatures ranging from 375°F to 500°F, well below the anticipated 650°F design temperature.

Fly ash introduced to the system within the flue gas was primarily captured in the circulating liquid within the concentrator and found to provide a net benefit in facilitating solids precipitation and management. No notable detriment to operations was noted, and simple periodic cleaning using a power washer easily removed build-up without the need for additional cleaning chemicals.

ZLD Processing

Concentrated residuals from the Heartland Concentrator were combined with coal fly ash (CFA), Portland cement (PC), and/or ferrous sulfate (FS) in various relative quantities to form a matrix of solidified samples.

These samples were allowed to cure and then evaluated for toxicity characteristic leaching procedure (TCLP) performance to determine if immobilization of the Resource Conservation and Recovery Act (RCRA) metals within the sample was sufficient for the material to qualify as class D (non-hazardous) waste for disposal. All TCLP concentrations, including selenium, for every mixture tested were found to be below the TCLP limits; therefore, the Heartland Concentrator shows promise as a viable method for an integrated process compliant with ZLD standards.

	Infeed FGD Purge Water	Process Circulation	Settling Tank Discharge	Secondary Settling
Total Solids	3.5%	30-40%	50-60%	70-80%
Total Diss. Solids	3.5%	30-35%	10%	<10%
Specific Gravity	1.0	1.2	1.5	>1.5
Calcium (mg/L)	6,500	55,000	55,000	55,000
Sodium (mg/L)	120	30,000	20,000	25,000
Chlorides (mg/L)	15,000	210,000	230,000	250,000
Sulfates (mg/L)	1,000	350	~300	~300
				

Table 2. Results Summary

Results

With the results of this pilot study, Heartland Water Technologies LM-HT® Concentrator demonstrated commercial viability for FGD wastewater treatment and the capability to process to environmentally acceptable ZLD. Integration within existing EGU operations optimized concentrator efficiency and operability. The integrated concentrator system excelled in operability, achieving less than 2% unplanned downtime during the trial. Integrated operation of the concentrator required minimal operator intervention for processing, cleaning, or maintenance activities.

Heartland's LM-HT Concentrator is poised to become an integral part of EGU operations as regulatory standards become increasing stringent