Evaluation and Modifications to Improve the Fly Ash Moisture Conditioning Process at TVA’s Bull Run Fossil Plant

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ABSTRACT

Moisture control is essential for obtaining compaction and stability while maximizing volume in landfill construction. During the Intelligent Compaction (IC) project at Tennessee Valley Authority’s (TVA) Bull Run Fossil Plant (BRF), low and inconsistent moisture readings were recorded in the coal fly ash material during placement at the Fly Ash Disposal Area (FDA). As a result, areas of the landfill required additional construction effort and moisture conditioning resulting in lower outputs in production. Low moisture content also contributed to compacted lifts failing to meet the 95 percent compaction requirements and additional hours and resources to rework failed areas further reducing stacking production. In an effort to help improve the compacting and stacking process, the current fly ash moisture control process was evaluated, causes of low and inconsistent moisture readings were identified and analyzed, and solutions were developed to improve the coal fly ash moisture control process.

This paper will discuss the approach used to evaluate the existing moisture control processes used, identification and analysis of areas in the process for improvements, to develop of a new fly ash silo Standard Operating Procedure (SOP), and verification of results after implementing the new fly ash silo SOP.

Implementing the new silo SOP resulted in consistent fly ash moisture readings within the range required to achieve maximum compaction and stability during placement. The implementation of the new silo SOP also reduced the amount of moisture conditioning required during placement, decreased the number of non-compliant areas, and increased the overall production efficiency of the coal fly ash stacking procedure in the FDA.
INTRODUCTION

In support of TVA’s (IC) Program of Coal Combustion Products (CCP) being performed at BRF’s fly ash disposal area, low and inconsistent moisture readings were recorded during placement of conditioned fly ash from the dry fly ash silo. This paper summarizes the results of a fly ash moisture control monitoring program conducted at the dry fly ash silo and pug mill facility at TVA’s Bull Run Fossil (BRF) Plant near Oak Ridge, Tennessee.

The purpose of this project was to evaluate existing fly ash moisture conditioning procedures at the dry fly ash silo facility, collect and analyze data associated with fly ash moisture readings and pug mill settings, determine the causes of the moisture control problems, and develop and implement a new (SOP) for fly ash moisture conditioning at the dry fly ash silo facility. The analysis during the evaluation period found multiple factors that did contribute to low and inconsistent moisture content in the fly ash placed in the FDA. The causes of each issue were investigated with results identifying inconsistent unloading operation, non-functioning or ineffective equipment, and design flaws that contributed to consistent deficiencies in the existing fly ash moisture control process.

OBSERVATION AND EVALUATION

Initial moisture collection data took place between May 16th and May 18th, 2016. Five fly ash samples were taken from each truck during placement in the FDA. Figure 1 shows the results of the Day 1 sampling event. Twenty-two trucks were sampled with each sample tested for moisture content. Only samples from the last five trucks fell within the regulated +2/-4 percent range based on optimum moisture content.

Figure 1. Day 1 – Field Sampling Event
The next observation took place between May 23rd and June 3rd, 2016 and began by evaluating moisture content in conditioned fly ash during the dry fly ash/ pug mill unloading process. Three samples of conditioned fly ash were taken from each haul truck during the silo unloading process. The samples were immediately tested for moisture content using rapid moisture analyzers. The moisture content results were recorded along with the current silo capacity and pug mill settings during the time each sample was taken. This process continued for each haul truck, each day for the duration of the evaluation period.

Figure 2 shows moisture conditioned fly ash dropping out of the pug mill into the haul truck. The moisture samples obtained during this process were taken at the same location and dispensing time during unloading process.

Figure 2. Acquiring Fly Ash Sample from the Haul Truck

CURRENT DESIGN AND CONFIGURATION

After collection in the precipitator hoppers, fly ash is conveyed dry using a vacuum system to the silo for storage until ready to be unloaded and placed in the FDA. Fluidizers attached to the silo are used to aerate the ash and maintain high temperatures to prevent moisture from developing in the dry fly ash during storage in the silo. The fluidizers help prevent the build up of hardened and/or compacted ash in key areas of the unloading system. During the unloading process, dry fly ash is dispensed by gravity through the operator controlled fly ash feed valve into the pug mill to receive moisture conditioning. The ash feed valve can be adjusted at anytime during the mixing/unloading process.

Figure 3. Fly Ash Feed System into the Pug Mill
While inside the pug mill, water is injected via three nozzles and mixed with two, paddle type agitators before continuing into the haul truck for transport to the FDA (Figure 4). The flow rate of water into the pug mill is controlled by the operator and can also be changed at any time during the mixing/unloading process.

Figure 4. Pug Mill Agitator and Moisture Conditioning in the Pug Mill

ANALYSIS AND FINDINGS

SILO CAPACITY VS FLY ASH FEED

Figure 5 shows a plot of silo capacity (percent remaining), fly ash feed and water valve position (percent open), each time a sample was taken, and the corresponding moisture content of each sample. The initial results indicated an increase in moisture content as the silo capacity approached 35 percent remaining. Moisture content continued to increase as ash level lowered, with the highest moisture contents being produced at levels below 10 percent remaining. The indirect relationship between silo capacity and moisture content indicated one area where moisture content would change if settings were not adjusted. The type of adjustment and amount also indicated an area of inconsistency from operator to operator. It was determined that the gravity fed design is the major contributor to the increase in moisture content during low levels of capacity. As the silo capacity decreased, the weight forcing the fly ash through the fly ash feed valve also decreased. The smaller amounts of dry fly ash increased the water/dry fly ash ratio resulting in higher moisture contents. The problem would compound as levels in the silo dropped resulting in difficulty in maintaining consistent moisture at silo levels below 10 percent. Figure 5 shows increases made to the fly ash feed valve beginning around noon and the adjustments there after to maintain constant moisture control as the fly ash leaves the pug mill.
WATER PRESSURE LOSS

During the mixing/unloading process, water flow rate into the pug mill is achieved using an operator controlled water control valve. The water control valve position is an indication of the percent open controlling water flow to the pug mill. During mixing operations multiple observations were made of an unexpected loss in pressure supplying water to the water control valve. Further investigations revealed the system providing water to the pug mill is shared between multiple operations within the power plant. As additional plant operations requiring water would come online water pressure throughout the system would drop resulting in an unexpected loss in pressure to the pug mill. The pressure loss would decrease the amount of water flow through the water control valve decreasing the water/dry fly ash ratio resulting in dryer moisture contents during those conditions. These conditions provided another problem related to inconsistent moisture control discovered in the conditioned fly ash.

OPERATIONS CONTROL PROCESS

The dry fly ash silo is operated individually by six different operators on rotating shifts. During the monitoring phase, four operators were observed; with each operator having slightly different methods of maintaining fly ash moisture control during the silo
unloading process. Changes to the fly ash feed valve, shown in Figure 5, were made as soon as a variance in moisture contents were observed; however these changes sometimes can be delayed due to the variation of different moisture analysis techniques typically used. The existing process allows the silo operator to make pug mill adjustments based on visual and/or physical characteristic changes to the fly ash or as notified by the fly ash stacking contractor in the land fill or FDA. Furthermore, these adjustments varied dependent on the operator in control. Discussions were conducted with each operator to address concerns and ideas to develop an improvement in the fly ash moisture control process. Two common concerns were procedure inconsistencies between operators as related to timing and type of adjustments needed and the unexpected loss of water pressure during the unloading process. Figure 6 shows the monitors available to the silo operator during the mixing/unloading process. The monitors show the conditioned fly ash as it leaves the pug mill and is loaded into the haul truck.

Figure 6. Monitors Available to the Silo Operator

EQUIPMENT AND MAINTENANCE

Additional factors determined to contribute to fly ash moisture control inconsistencies included maintenance and operation of the heater, fan, and fluidizers. The fluidizers are responsible for maintaining dry and fluffed conditions of the dry fly ash during storage in the silo. The heater used to drive the fluidizer was found to not be maintaining proper temperatures of the dry fly ash during storage. The lower temperatures resulted in small amounts of condensation to form inside the silo. The increased moisture allowed the fly ash to build up and bridge in and around the fly ash feed valve. The build up of ash produced inconsistent feeding problems due to clogging through the fly ash feed valve. The clogging also resulted in the fly ash feed valve becoming inoperable and shutting down the silo unloading process until repairs could be implemented.
RECOMMENDATIONS

The observations and analysis along with operator comments and concerns concluded a list of problems including equipment, design, and operations were contributing to inconsistencies in the existing moisture control process. A new Standard Operating Procedure (SOP) including new check lists, protocols and a control chart would be needed to help address the issues found while providing a consistent procedure for the moisture control process.

The SOP developed contains pre-mixing/unloading protocols, check lists, and a fly ash feed valve control chart. The pre-mixing/unloading check lists include equipment checks to ensure all supporting equipment is running correctly, followed by a pug mill wash out procedure including a minimum 30 second cleanout to be completed at the beginning of each day.

To help address the issue of unexpected loss in water pressure, the plant has been advised to minimize operations involving the use water of during silo unloading operations. An additional investigation, not covered by this paper, is being conducted to look for ways to isolate the silo water system from the rest of the plant.

The operators are now instructed to maintain water pressure in place of focusing on the water control valve. If water pressure drops below a predetermined value for a period of 30 seconds or more, adjustments are made to the fly ash feed valve until normal water pressure returns. A fly ash feed valve control chart (Figure 7) has been developed to address the issue of increased moisture content as silo levels drop below 35 percent. The control chart has been calibrated with the moisture contents recorded during the observation phase and provides fly ash feed valve settings as related to silo capacity levels. The control chart also provides instruction to stop operations once silo levels drop below 10 percent followed by a minimum 30 second clean out of the pug mill.

| Bull Run Fly Ash Pug Mill Settings for Alpha “A” and Bravo “B” Silos |
| Begin each operation with a clean-out of at least 30 seconds |
| Set water flow rate between 235 – 245 gallons per min. |
| Silo % Capacity > 100% - 50%: Ash Feed Valve setting at 44% |
| Silo % Capacity > 50% - 30%: Ash Feed Valve setting at 47% |
| Silo % Capacity > 30% - 20%: Ash Feed Valve setting at 50% |
| Silo % Capacity > 20% - 15%: Ash Feed Valve setting at 54% |
| Silo % Capacity > 15% - 10%: Ash Feed Valve setting at 56% |
| Stop hauling when silo is at 10% remaining. |
| Empty silo at least 2 times per week with a minimum of two days in between. |

Figure 7. Pug Mill Settings Chart for Silo Dumping Procedures
CONCLUSION

The new SOP was introduced to the silo operators for their review and comments. After comments and concerns were addressed the new SOP was implemented. Moisture contents at the FDA improved during the first day of use. Moisture contents were verified from samples taken from each haul truck during placement in the FDA. Minor adjustments and clarifications were addressed as the silo dropped below 35 percent. The stacking contractor was able to place and compact a lift with minimal conditioning. Tests required for compaction verification, concluded results at or above the compaction requirements with moisture contents within the regulated range of +2/-4 percent of optimum moisture content for each test point. Figure 8 below shows moisture content readings collected on June 6th, 2016 the first day of implementing the new silo SOP.

SUMMARY OF LESSONS LEARNED

Following are key lessons learned from the fly ash silo moisture monitoring event:

- The use of a standardized SOP provides a consistent operating procedure while defining specific protocols as conditions change while emptying the dry fly ash silo.
Following pre-mixing check lists and procedures ensures that all equipment is working properly and all piping and mixing areas are clean and clear of built-up ash material.

Moisture content increases during the unloading procedure as silo capacity levels drop. This is due to the design feeding dry fly ash through the fly ash feed valve. The fly ash feed valve control chart developed as a result of this project will assist the operator in maintaining consistent moisture using fly ash feed valve adjustments as silo levels are lowered.

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