Unique Approaches of Coal Ash Management Using Geotextile Tubes

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ABSTRACT

Recently the Environmental Protection Agency (EPA) established national regulations for the safe disposal of coal combustion residuals (CCRs) from coal-fired power plants. These CCR byproducts, such as fly ash and bottom ash, can be a real challenge for both small and large facilities to remove and manage. The EPA’s comprehensive set of requirements addresses the risks from coal ash disposal like leaking of contaminants into ground water, blowing of contaminants into the air as dust, and the catastrophic failure of coal ash surface impoundments.

Geotextile tube dewatering technology can provide a unique approach for the management of coal combustion residuals. By incorporating geotextile tube technology, coal-fired facilities can dewater and contain CCRs. This technology can be utilized in the operation of existing surface impoundments, efforts to beneficially use consolidated ash, and the continued operation of coal-fired operations by direct sluicing the daily flows from the plant into geotextile tubes.

This paper will discuss several unique approaches involving the remediation or clean closure of surface impoundments, beneficial use of dewatered CCRs, and direct sluicing operations incorporating geotextile tube technology for the safe disposal of by-products from coal-fired power plants.

INTRODUCTION

Since the late 1800’s, coal has played a major role in U.S. production of electrical energy. Coal-fired power plants have provided reliable electrical power from the earliest days when power plants were run with hand fed coal to heat boilers to produce steam. The introduction of pulverized coal led to improvements in the electrical generation process...
by providing higher combustion temperatures, improved thermal efficiency, and lower requirement for excess air for combustion.

In a typical coal-fired process, water is turned into steam, which then drives turbine generators to produce electricity. This process starts when pulverized coal is burned to produce steam, then the pressure of the steam drives the turbine shaft blades of a generator to produce electricity. The steam is pulled into a condenser where steam is converted back into water to be used repetitively in the facility.

The waste by-products created have presented a challenge. In response, utility companies have continuously worked on process innovations to uncover methods to burn coal more cleanly. The by-products are in various forms like fly ash, bottom ash, boiler slag, and flue gas desulfurization (FGD) material. The combination of these waste-by-products have caused coal ash to be one of the largest industrial wastes generated in this country.

Fly ash is mostly silica produced during the burning of pulverized coal and has a very fine, powdery consistency. Bottom ash forms in the furnace bottom and is a coarse particle which is too large to be carried up into the smoke stacks. Boiler slag is molten bottom ash and FGD is leftover material from the process of reducing sulfur dioxide emissions.

The environmental concern of coal ash waste by-products is that the ash contains many different types of contaminants which could pollute the environment. As a result, a lot of effort is placed in the ability to reuse coal ash to reduce greenhouse gas emissions, landfill space, and reduce virgin material costs. The federal government has implemented national regulations to ensure safe disposal of CCRs. There have been several well-noted environmental disasters involving ash releases into the environment. In 2008, over 5.4 million cubic yards of coal ash was released in the Kingston, TN during the Fossil plant incident. It is estimated that 39,000 tons of ash was released into a river at the Dan River, NC plant in 2014.

The EPA’s comprehensive set of requirements addresses the risks from coal ash disposal such as leaking of contaminants into ground water, blowing of contaminants into the air as dust, and the catastrophic failure of coal ash surface impoundments. In April 2015 the Final Rule for Disposal of Coal Combustion Residuals from Electric Utilities was published under 40 CFR Part 257. This rule was followed by the publication of the Effluent Limitations Guidelines under 40 CFR 423 in November 2015.
GEOTEXTILE TUBE DEWATERING TECHNOLOGY

Geotextile containers have been used since the 1960’s as shoreline protection in marine and river structures such as breakwaters, dikes, artificial islands, and jetties. Over the years, this technology has transferred into the dewatering of wastewater with the aid of chemical conditioning. There are three basic stages to dewatering with geotextile containers: confinement, dewatering, and consolidation (see Figure 1). The specially engineered textile from which the geotextile containers are fabricated from provides confinement of the fine solids inside the container while allowing water to permeate through the textile. As the water drains, the solids continue to densify inside the geotextile container and the volume inside the container continues to consolidate over time.

A dewatering cell, as shown in Figure 2, must be constructed to hold the geotextile containers. In most cases the available area for construction of a dewatering cell is limited but geotextile containers can be manufactured in many configurations and sizes to maximize the available footprint. Creating a slight grade with the slope in the length direction of the geotextile containers promotes drainage of the filtrate for better collection. An advantage of geotextile containers is that they can be stacked in a pyramid configuration several layers high depending on the consolidated characteristics of the dewatered solids.
Generally, this cell has an impermeable membrane installed to help control the volume of effluent which drains through the containers. Typically, the effluent is returned back into a body of water, and in some instances can be directly discharged if the filtrate quality meets reporting limits. The CCR slurry can be dredged or pumped directly into geotextile containers.

If the flow of CCR slurry is extremely high, a manifold system can be installed which allows multiple containers to be filled at one time to maximize dredging output. The primary feature of a geotextile container is to retain solids and contaminants while permitting effluent to drain through the pores of the woven engineered filtration textile. During all phases of the dewatering process (filling, dewatering and consolidation), the filtration textile must provide excellent tensile properties, efficient effluent drainage, and effective retention of solids to guarantee optimum slurry dewatering.

The filtration properties of the engineered textile permit the containers to capture the solids, while water drains out. The moisture will continue to filter out and solids will continue to dry over time promoting more volume consolidation. Using the appropriate polymer for chemical conditioning will allow for the solids in the wastewater stream to create an agglomeration and release free water for drainage. Figure 3 shows typical results of geotextile container dewatering with a depiction of in-situ slurry, conditioned slurry, and filtered effluent.

![Figure 3. Results of dewatering](image)

Chemical conditioning optimizes the dewatering performance of geotextile containers, increasing the dewatering rate, improving effluent quality, and achieving higher dry mass. The chemical conditioning of the wastewater occurs before the slurry is pumped into geotextile containers to accelerate dewatering.

Once the solids are fully consolidated or have met minimum requirements for transport, several options are available for disposal. Typically, after consolidation, the geotextile
containers can be cut open and solids transported to landfill or land applied. In some applications, the containers can be buried in place allowing the dewatering area to be reclaimed.

COAL ASH MANAGEMENT

By incorporating geotextile tube technology, coal-fired facilities can dewater and contain CCRs using specially engineered textile that retain the solids inside geotextile tubes, while releasing the clear water through the fabric pores. This technology can be utilized in the operation of existing surface impoundments, efforts to beneficially use consolidated ash, and the continued operation of coal-fired operations by direct sluicing the daily flows from the plant into geotextile tubes.

In particular, geotextile tube technology can provide an alternative to applications involving remediation and clean closure of impoundments, beneficial use of dewatered CCRs, direct sluicing, and providing structural containment for paste.

Projects involving the remediation and clean closure of surface impoundments require the hydraulic removal of CCRs to geotextile tubes, where the solids are retained inside the tube and effluent flows through the pores of textile fabric as shown in Figure 4.

Figure 4. Dewatering of CCRs from Surface Impoundment

Removing the ash from the surface impoundments helps to protect groundwater and protects the impoundment from external events like flooding, erosion of ash piles, and seismic events. Another advantage of geotextile tubes is offered by containment of the ash to mitigate dust issues, which can help limit these effects to nearby communities.

The CCR material found in surface impoundments could range from fly ash, bottom ash, slag, and other by-products. If the material requiring removal has coarse properties, then typically these types of CCRs can be dewatered without the aid of chemical flocculants.
If the material composition is comprised of very small fines, the addition of chemical flocculants or combination could be needed to improve the overall utility of geotextile tubes. These chemical flocculants help bind the small fines to become larger particles to be retained inside the geotextile tubes, they also help the particles release chemically bound water.

Extensive polymer bench testing must be conducted during the initial design phase to evaluate the proper chemical flocculants and dosage rates required. In Figure 5, the funnel on the left is insitu CCR slurry and on the right, is a properly chemically conditioned CCR slurry. The beaker below the funnel provides insight to the clarity of the effluent water, and the consolidated CCR solids are shown contained on the top side of the engineered textile.

![Figure 5. Cone Test Demonstration Without and With Polymer](image1)

These small-scale bench tests, like pillow bag test (ASTM D7880), in Figure 6 help predict the achievable dewatered solids attainable over time. Not only can the achievable dry cake solids be predicted, but this test also allows for testing of the effluent water to determine if discharge criteria can be met.

![Figure 6. Predictive Small-scale Bench Testing (ASTM D7780)](image2)
The material nature of the CCRs will determine the repetitive cycles of filling and dewatering required to consolidate the volume of material hydraulically removed from the surface impoundment, see Figure 7. A complex environment exists consisting of suspension, settling and settled zones within the structure; with the extent of these zones changing per the nature of the dewatering phase and the time over which the dewatering process occurs.

![Figure 7. Typical Geotextile Tube Dewatering Process](image)

The dewatered CCR content could exceed 75% solids/25% water ratio by weight when coarse CCRs are involved, whereas finer lighter material could reach 50% solids/50% water ratio by weight upon consolidation. Once consolidated, the dewatered material can be excavated from the geotextile tubes for disposal, see Figure 8.

![Figure 8. Removal of Dewatered CCR Material](image)

In typical applications, material is hydraulically pumped to geotextile tubes where the wet volume is consolidated over time and the dewatered solids are disposed of. With beneficial use applications, disposal is not required and the dewatered material may be
benefically used, which eliminates the need to landfill or incenerate. One option to avoid excavation and disposal of dewatered ash from geotextile tubes is land reclamation. Once the geotextile tubes are dewatered, the tubes become the final method of disposal and the dewatering cell can be capped as shown in Figure 9.

![Figure 9. Beneficial Use as Land Reclammation](image)

Another beneficial use application of CCR material can be building of containment structures using the geotextile tube as a construction form. The CCR material must have a nature that provides shear strength when dewatered. Typically the material would be hydraulically dredged, but also can be used transported to geotextile tubes in a paste form. No matter the method of filling, the geotextile tubes in their final dewatered form could be used to construct embankments, raise levees around an impoundment, or act as revetments. Filled geotextile containers can easily be installed to fit contours of a designated area as shown in Figure 10.

![Figure 10. Beneficial Use as Containment Structures](image)

Direct sluicing applications involving geotextile tubes provide an advantage to the coal-fired plants to minimize and eliminate CCR material from surface impoundments. In direct sluicing, the coal slurry is sluced directly to geotextile tubes where the CCRs are retained inside the tube and only effluent will be directed into the impoundments. Direct sluicing involves large volumes of ash slurry and require a large area to construct the dewatering cell to house the geotextile tubes.
Typically these applications have large flows, possibly over 24-hr period, and this flow must be manifolded to multiple tubes to manage the dewatering as shown in Figure 11. As with typical dewatering applications involving geotextile tubes, bench testing must be conducted in the early stages of project development based on the nature of the flow sluiced from the power plant.

Figure 11. Direct Sluicing Dewatering Cells

Due to the potential large volume of daily flows of a continuous operation, direct sluicing projects may require stacking of geotextile tubes to maximize any space limitations. If the laydown area for the dewatering cell is over low to moderate strength cohesive subgrades, an evaluation for bearing capacity and settlement should be conducted. The analyses enable the engineer to forecast any potential total settlement below the geotextile structures.

CONCLUSION

Coal-fired industrial byproducts such as fly ash, bottom ash, slag, and FGD materials can be a real challenge for both small and large power facilities to remove and manage. With geotextile tube dewatering technology, facilities can easily consolidate waste materials across a wide spectrum of applications. With remediation and clean closure of surface impoundments, geotextile tube dewatering technology is an economical and sustainable water management option with many advantages such as maintaining key water quality discharge parameters and sufficient free board for continuous operation. Another unique advantage of geotextile tube dewatering involves the ability to safely contain fly ash, and prevent airborne particle contamination from windblown ash piles.

Geotextile tube technology can allow beneficial use of consolidated ash residuals to reclaim land, create structures, use as road base, or increase the height of berms around an impoundment to increase its capacity. Reuse of these CCR materials preserves limited landfill space that would otherwise be consumed by normal disposal.
Direct sluicing into geotextile tubes allows coal-fired plants to retain CCR solids inside tubes, while only sending effluent water into impoundments. This benefit from use of geotextile tubes greatly reduces, and essentially eliminates the placement of CCR solids into surface impoundments.

Geotextile tubes are a flexible technology that provide high volume, low cost dewatering and containment. This technology offers an alternative to coal-fired plants to handle coal ash with the implementation of newly established federal regulations for ash disposal.

REFERENCES
