Paste Thickening in Waste Ash Applications

Brett Housley, P.E.¹, Jerold Johnson, P.E.¹

¹WesTech Engineering, Inc., 3665 S. West Temple, Salt Lake City; UT 84115

CONFERENCE: 2015 World of Coal Ash – (www.worldofcoalash.org)

KEYWORDS: coal ash, pond replacement, paste thickening, surface stack, subaqueous deposition, ash pond remediation, thickened tailings.

ABSTRACT

With tighter regulations on ash pond development and expansion, it has become necessary to explore methods for ash disposal that eliminate the need for ponds. In addition to eliminating new ponds it is more and more critical to renovate or remediate existing impoundments to reduce risk. Paste thickening is a new and innovative way to increase waste material rheology and yield strength, making impoundments safer and more sustainable. This paper will explore the fundamentals of paste thickening and its application in waste ash surface stacking and subaqueous deposition for pond reclalm.

INTRODUCTION

Paste has become an increasingly important method to address many of the environmental problems facing the power industry. Ash pond life, improved water recovery, ash pond dam safety and environmental sustainability have been drivers for many utilities to investigate paste disposal. Conventional slurry ponds are the most familiar ash disposal method and use high rate thickeners to recover water at the plant. Slurry pumps are used to transport the waste ash to the pond. To manage the volume of water, this method uses water retaining dams that can have a significant risk of disastrous failure. Many coal fired power facilities are removing and decommissioning their ash ponds due to recent pond failures and increasing political pressure. This is a monumental task that will have a large economic impact to the utilities and their clientele. Paste thickening is an important and viable option to solve the pond closure problem.

Paste technology has proven itself in many mineral applications around the world. The benefits of a paste/thickened tailings (P/TT) system may include significant increase in water recovery, increased deposition stability, elimination of water retaining dams, increased ash storage capacity, reduced operating cost, and ease of site closure and remediation. Design of a P/TT system requires a holistic approach to properly connect the process steps of thickening, transportation, and deposition with proper consideration of the material rheology [1].
PASTE QUALITIES

A major difference between slurry and paste is that slurry exhibits Newtonian fluid properties, while P/TT acts as a non-Newtonian suspension even exhibiting a yield stress. Newtonian type slurry characteristics are well understood including the fact that suspended particulates will settle and segregate when velocities are not maintained. This phenomena is the cause of sanding in pipes and segregation in ponds. In contrast P/TT has a network of bonded (gelled), closely packed fine particles, which acts like a net to hold coarser particles in suspension. This phenomena account for the non-settling and non-segregating nature of pastes which is important for surface stacking and sub-aqueous deposition.

Yield stress is fundamental parameter defining paste material. It is measured in units of pressure and is related to the force required to initiate movement of the paste. The ability of the paste material to resist movement or have a yield stress, is what enables paste to be stacked; ie. the force of gravity cannot overcome the internal strength of paste. The higher the strength or yield stress of the paste, the greater the slope of the resulting paste stack or angle of repose.

Another very important trait of P/TT is rapid drying. The uniform distribution of particles within a deposition layer creates uniform capillary-like channels that draw water up to the surface where evaporation occurs and increased concentration gradient is developed. This wicking action accelerates drying and helps the deposition layer to achieve greater load supporting consistency within weeks. Most P/TT surface stacks will be built in layers from 200 – 500 mm thick. Once a lift is in place, flow is diverted to another part of the deposit allowing the freshly layered material to dry and crack before the next layer is overlaid. This construction method builds a self-supporting, free draining stack without the need for slurry retaining dams.

Clearly P/TT is exceptional for surface deposition, but it can also be most practical in subaqueous deposition as well. Since paste material has the inherent ability to resist mechanical deformation (yield stress), it also has the ability to resist diffusion of the surrounding liquid. Figure 1 show the difference between a Newtonian slurry and a paste being sub-aqueously deposited. Paste deposited under water does not break up and mix with the water, but stays consolidated and intact. Essentially paste allows for the formation of an underwater surface stack.

Not all material in slurry can become paste. To demonstrate paste qualities, a portion of the particles need to be smaller in size. A general rule of thumb is for twenty percent of the particles to be less than 20 microns in size. A particle size distribution on the solids is the first step to determine if there are enough fines to generate a paste. The next step beyond the particle analysis is to continue with batch and continuous laboratory or on-site testing.
ADVANTAGES OF PASTE

P/TT can be leveraged to provide significant advantages for ash disposal [2]:
- Eliminate ash storage ponds: The greatest single benefit of using paste for ash disposal is containing the waste in a stack as opposed to a pond. Ponds, dikes and dams are significantly higher risk than surface stacks. Paste can be an effective way of reclaiming an existing pond due to its ability to be sub-aqueously deposited.
- Reduce ground water contamination: Paste has very low permeability making it an ideal barrier to fluid migration into the ground.
- Increase overall ash storage capacity: Ponds store both solids and liquids whereas paste storage in the same volume will contain considerably less liquid and thus more solids. Paste stacks also have additional volume found in the conical stack dome.
- Conserve more water for reuse: With P/TT more water is extracted prior to disposal. This recovered water is available for beneficial reuse.

TEST RESULTS: COAL ASH

The feasibility of P/TT produced from coal ash was recently demonstrated in a continuous test at a Midwestern power plant. The continuous testing cylinder is shown in Figure 2. The objective of this testing was to determine if this material could produce a paste, and if it could, what properties that material might have. With the determination of paste rheological properties a production and deposition system could be designed.
Ultimately the objective for this plant was to eliminate an existing ash disposal pond.

The plant has several tailings streams which are combined in their ash pond, including gypsum, fly ash and bottom ash. On site batch and continuous testing confirmed that paste could be produced, but that each composition or blend of the waste streams gave different paste characteristics. A common misconception is that paste rheology properties and concentration are synonymous. As can be seen in Figure 3, different materials can have the same yield stress, but very different concentrations. Paste production and deposition are concerned only with the yield stress achieved by a material and not the concentration.

For this project it was interesting to note that the results of the paste production testing gave yield stress values quite similar to those seen in coal wash plant refuse (50-80 Pa yield stress). However underflow wt% solids were highly dependent on the blend of the streams, particularly with respect to the quantity of gypsum in the stream.

![Figure 3: Yield stress curve for fly ash and combined streams](image)

The paste thickener for this application was designed for a reasonable yield stress of 50-80 Pa, which could be achieved with any combination of waste streams, but with an understanding that the underflow concentration would vary as a function of the feed composition.

**CASE STUDY: SUB-AQUEOUS DEPOSITION**

As noted above, paste deposited sub-aqueously allows the conversion of conventional slurry ponds to a surface stack. As paste is deposited under water on one side of a pond, the displaced pond volume is collected on the opposite shore. As the deposition
grows, it will eventually displace all of the overhead water and rise above water level and begin to dry.

This process was successfully used at a coal refuse pond dredging operation in West Virginia. A new process was developed in which fine coal previously lost to refuse in the wash plant could now be captured. It was determined that significant fine coal values existed in the refuse pond and a dredging operation begun for recovery of that material. Since most of the fine coal collected near the pond dam, dredging was commenced at that end of the pond. The opposite end of the pond where refuse tailing were fed contained mostly coarse material and little valuable coal and so the reprocessed tailing slurry was re-deposited. Unfortunately the returning slurry easily resuspended upon re-entry to the pond and the fines were carried again to the dam end of the pond. Significant recirculating fines loads shut the process down.

The solution to the problem was to use P/TT in the tailing reprocess. The re-processed tailings were consolidated and made into a paste material which was then delivered to a location near the feed end of the pond where it was sub-aqueously deposited back into the pond. Paste then settles to the bottom of the pond without resuspending. This prevented any recirculation back to the dredging location near the dam. This project could not have been accomplished without the unique properties of paste.

Figure 4 shows a picture of the deposition site. The paste is forming a delta as it is deposited sub-aqueously into the existing pond. The pile does not resuspend in the liquid, but rather it displaces the water as it is deposited. The aerial photo in the upper right corner of the picture shows same delta taken some time after the main photograph. The delta is larger and has dried over time as it has been deposited.
CASE STUDY: ARCH COAL

Paste provides a method to concentrate fine particle and to remove any ponds by surface stacking. Material with a large number of fine particles can be turned into a paste to utilize its unique prosperities. Coal washing facilities wash a number of different sizes of particles from very coarse to ultra fine. The Lone Mountain Plant owned by Arch Coal located in Virginia is no different.

Traditionally, the Lone Mountain facility used two conventional high rate thickeners to separate the very fine solids from the liquid. The underflow slurry would reach 21% solids by weight in the thickeners. It was then pumped into an underground tunnel system and then into an impoundment. Storage ponds are a common treatment method for waste sludge, very similar to ash ponds in the power industry. The impoundment was closed for dredging maintenance and dyke repair when Arch Coal elected to modify their system for paste disposal. This provided added safety and environmental sustainability.

The Lone Mountain facility added belt filter presses to the underflow of the conventional thickeners. Four belt presses were required to meet the demands of the plant. The presses were capable of producing 50% solids by weight paste. As the paste was produced from the belt presses, it was then discharged into dumpsters. The paste was then hauled to a landfill half a mile away by truck. This operation ran for 9 years before Arch Coal decided to review their operation to determine if they could improve their process. Paste thickener bench and pilot scale testing showed that a continuous paste thickener could produce underflow similar in density to the belt press filters discharge.

Table 1 shows the cost comparison between the existing belt presses and the new paste thickener. Four main points were considered for evaluation between the two paste systems as outlined below:

- Operating cost: This is the largest ongoing expense of the facility. Large capital projects can often be advantageous if they save on the continual operating costs of a facility. The largest operating cost the facility sees is chemical consumption, specifically polymer. This cost also includes power costs from pumps and motors.
- Maintenance cost: During normal operation of a paste system, equipment will be required to be maintained to reach its expected life. This cost can be extensive for large mechanical pieces of equipment.
- Transportation cost: The paste needs to be transported to the disposal or stack site. Current operation is to truck the paste to a landfill located ½ mile away from the coal washing facility.
- Capital cost: This is all inclusive of equipment, erection, civil and electrical work.
Table 1: Comparison of the belt press paste system and paste thickener system [3]

<table>
<thead>
<tr>
<th></th>
<th>Belt Press Paste System</th>
<th>Paste Thickener Paste System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating cost</strong></td>
<td>Cationic =&gt; 200 g/t</td>
<td>Cationic = 30 g/t</td>
</tr>
<tr>
<td></td>
<td>Anionic =&gt; 200 g/t</td>
<td>Anionic = 25 g/t</td>
</tr>
<tr>
<td><strong>Maintenance cost</strong></td>
<td>Belt life, down time</td>
<td>Low maintenance</td>
</tr>
<tr>
<td><strong>Transportation cost</strong></td>
<td>Trucking paste</td>
<td>Pump plant underflow to paste thickener</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gravity return of water to plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gravity/pumped discharge paste</td>
</tr>
<tr>
<td><strong>Capital cost</strong></td>
<td>Additional belt press(es)</td>
<td>Paste thickener, flocculant plant, slurry pumps to feed thickener, underflow paste pumps</td>
</tr>
</tbody>
</table>

The largest contrast in the comparison between each system was shown in the operating costs. The existing belt press system required 10x the polymer than the paste thickener. Yearly savings in chemical consumption is $1.1 million based on the chemical consumption shown in Table 1. Transportation cost accounted for an additional $0.5 million per year based on trucking costs and road maintenance. Due to the operating and transportation cost advantages of the paste thickener system, the decision was made by Arch Coal to design and install a WesTech Deep Bed paste thickener replacing all existing belt filter presses.

The paste thickener has successfully been constructed and commissioned which has resulted in payback of less than two years [3]. Figure 5 shows the thickener installed at the Arch Coal facility [4].

Figure 5: Arch Coal paste thickener
CONCLUSION

Pond replacement and remediation is becoming increasingly important due to potential environmental catastrophes and political pressure. Pastes distinctive properties such as high yield stress and non-segregating particles make it an ideal alternative to ash ponds. Impoundments can be dredged and turned into paste then deposited back into the same pond it was taken from. This allows for a unique opportunity in pond replacement. P/TT benefits have become increasingly important to address many of the environmental and political problems facing the power industry today.

REFERENCES


