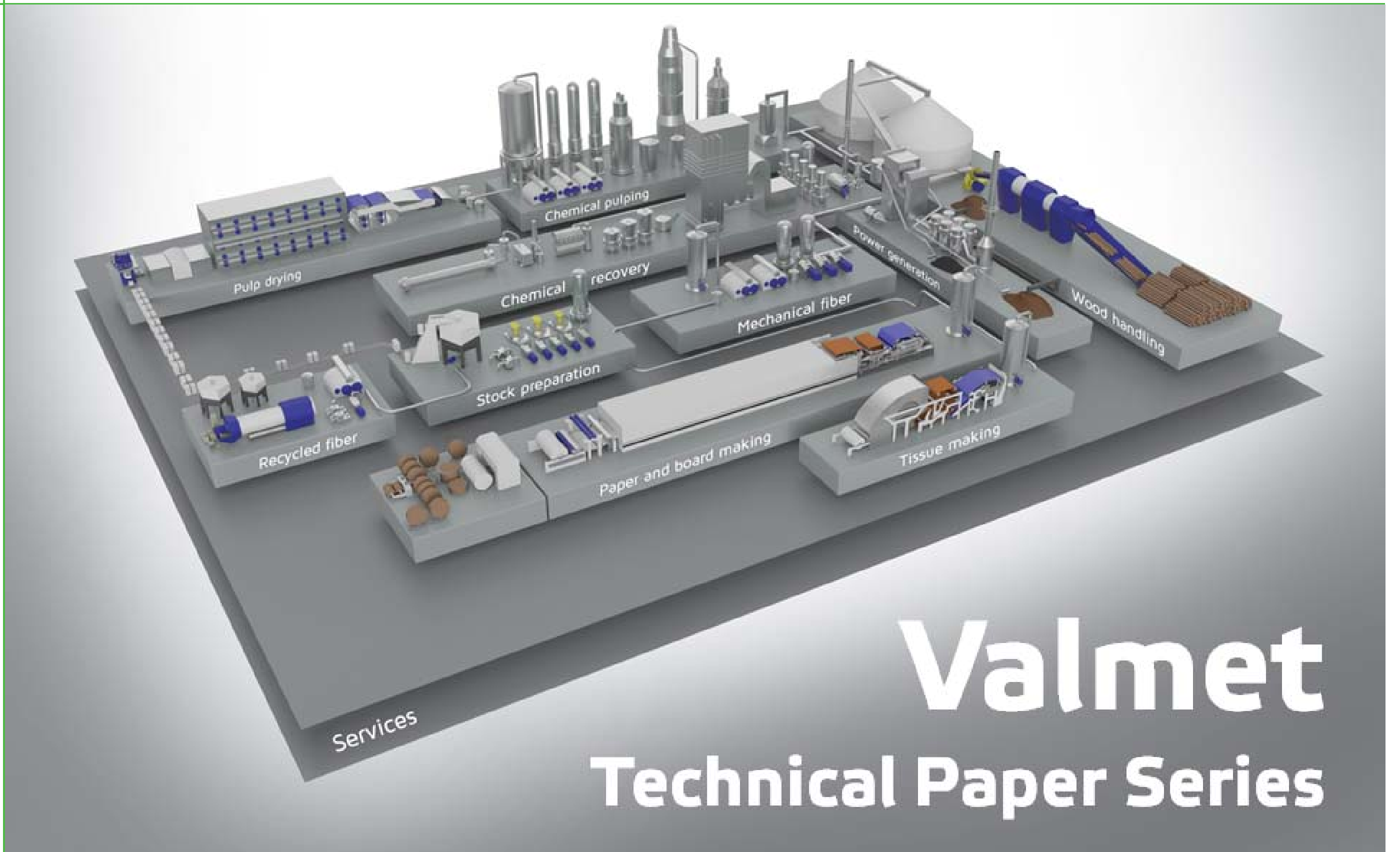

Disposing of Secondary Sludge (Biosludge) in the Recovery Boiler

Executive Summary

Secondary sludge (biosludge) is the most problematic residue of the effluent treatment process when it comes to disposal due to the difficulty in dewatering it to an acceptable level. The high moisture content (often more than 80%) makes it difficult and costly to landfill or to incinerate in a power boiler. Several mills in Europe, going as far back as 1994, have elected instead to hydrolyze the secondary sludge and mix it in the black liquor at the evaporators to burn it in the recovery boiler. For a typical integrated mill, secondary sludge dry solids are equivalent to about 1% of the black liquor solids.

This paper will provide an overview of the secondary sludge hydrolysis process, why it is required to prevent scaling in the evaporators and how it is introduced into the black liquor. It will review the benefits that can be achieved by hydrolyzing and disposing of the sludge in the recovery boiler as opposed to landfilling or incineration in the power boiler and discuss the impact of non-process elements (NPE) that can be present in the secondary sludge. It will also discuss the experience of several mills that have elected to use this method for disposal of the secondary sludge, where no significant negative impacts have been experienced in mills that have adopted incineration of the secondary sludge in the recovery boiler, as well as the means used to control the NPE in the liquor cycle.

Introduction

Secondary, or biosludge, from effluent treatment systems present specific problems for disposal due to its high water content and the nature of the solids it contains. It normally comes out of the basin or reactor with a very low solids content, in the range of 0.5% to 2% solids. It is hard to dewater to a level higher than 10% to 20% solids, making transportation and disposal problematic. Traditional disposal methods such as landfill and incineration in the power boiler offer challenges with water leaching, odor or a loss of thermal efficiency and high energy cost. A different approach taken by several mills in Europe has been to hydrolyze the secondary sludge by mixing it with black liquor and to send it to the concentrator for disposal in the recovery boiler. For a typical integrated mill, secondary sludge dry solids are equivalent to about 1% of the black liquor solids. This paper will review the process for hydrolyzing the secondary sludge, its impact on the evaporators and recovery boiler, and the impact on the non-process elements (NPE) in the liquor cycle of this disposal method. Several mills where this process was implemented will be discussed.

Secondary sludge (biosludge)

Typically, two types of sludge are produced in the effluent treatment systems of pulp and paper mills. They are commonly referred to as primary sludge, which comes from the separation of suspended solids from the effluent stream in the primary treatment system (clarifier), and secondary sludge (also referred to as biosludge) which consists of the micro-organisms that are used to capture and decompose the dissolved solids in the secondary treatment system (**Figures 1 & 2**).

Figure 1. Aerated basin secondary effluent treatment

Figure 2. Typical micro-organisms from secondary sludge

Traditional disposal methods for secondary sludge

Dewatering secondary sludge is a significant challenge as the micro-organisms are small, of a similar density to water with a significant amount of water contained within their cell membrane walls. The high moisture content of the sludge makes it difficult to dispose with traditional methods such as landfill (now banned in Europe), composting or incineration in a power boiler. Secondary sludge typically requires a special landfill to deal with the potential for leaching and odors (H_2S and other odorous compounds released during decomposition), composting and land spreading requires treatment of the sludge to reduce odors and tends to face difficulty in public acceptance.

For incineration, the traditional method for dewatering secondary sludge is to mix it with primary sludge, add chemicals to improve water removal and press the mixture as dry as possible to be able to fire it in the power boiler. Incineration in a stoker type power boiler can lead to problems with combustion stability and emissions, loss of steam generation capacity and increased corrosion rates. Combustion of the secondary sludge is typically a negative energy addition as it requires more energy to evaporate the moisture coming in to the boiler with the sludge than the heat resulting in the combustion of the dry solids from the sludge.

Hydrolysis of the secondary sludge

In 1993, the Metsä Fibre mill in Kemi, Finland started-up a sludge hydrolysis system that allowed for the treated secondary sludge to be added to the black liquor prior to final concentration and incineration in the recovery boiler. This project was the subject of a paper presented at the International Chemical Recovery Conference in 1995 [1]. Since then, six other pulp mills in Europe have installed similar treatment systems. The benefits of mixing the sludge with the black liquor is that it allows for the removal of the water content in the evaporators which offer good thermal efficiency through the multiple effect economy. Although the secondary sludge is added to the black liquor only prior to final concentration, the additional vapor produced serves to provide additional evaporation in the other effects of the evaporator train. The recovery boiler is also well suited to handle any sulfur content that comes from the sludge, and the organic content of the sludge forms only a small fraction of the total organic content of the liquor.

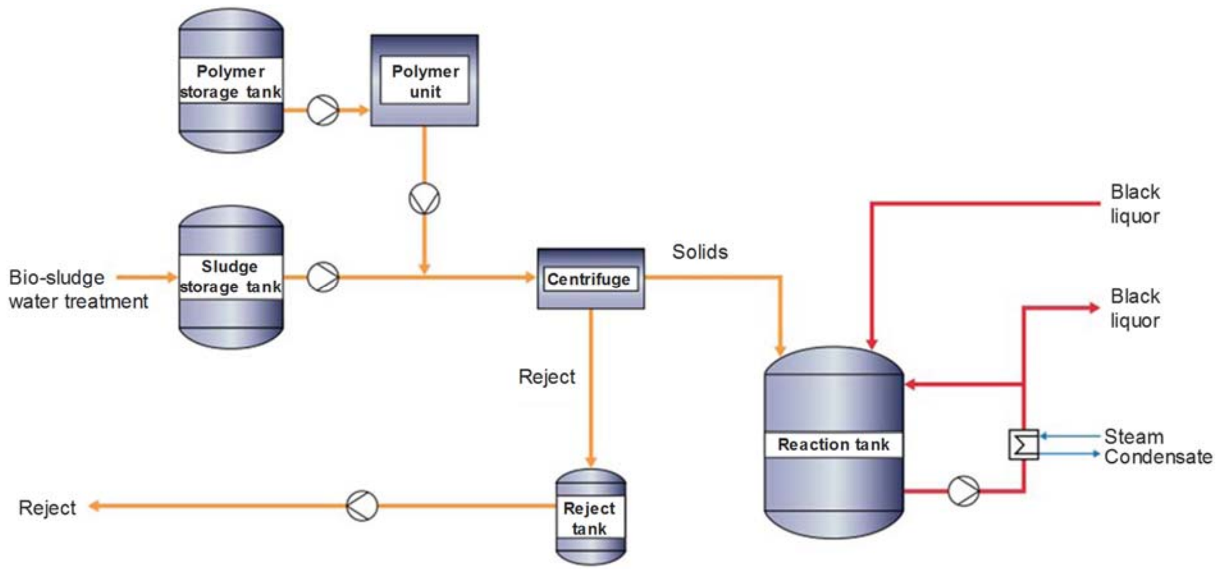

Figure 3. Simple flow schematic hydrolysis system

The hydrolysis systems used at Metsä Fibre Kemi and other mills that have adopted similar systems consists of two main parts; dewatering with the help of polymer addition and hydrolysis reaction to break down the cell walls of the micro-organisms (**Figure 3**). The sludge typically comes to the system at 0.5 – 3.0% solids. The optional buffer tank is used to provide the constant flow of sludge to the dewatering system which is needed for its efficient operation and is not required if the mill already has a tank available for this purpose.

Polymer is injected in the sludge to promote flocculation of the secondary sludge and improve its dewatering (**Figure 4**). After polymer addition, the mixture is sent to the dewatering unit, typically a decanter centrifuge where the solids content is raised to 8 – 12%

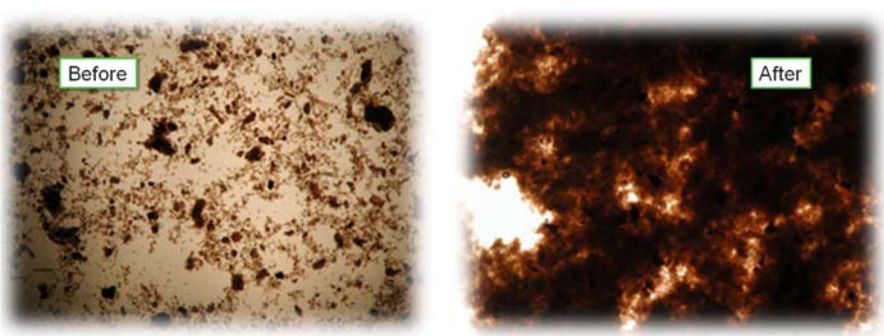

Figure 4. Sludge before (left) and after (right) polymer addition

to minimize the additional evaporation requirements. The reject from the dewatering unit contains a very low amount of suspended solids and is returned to secondary effluent treatment.

The second part of the process takes place in the reaction system where the sludge is mixed with black liquor, for high pH conditions, at medium strong concentration (40 to 50% DS). The mixture is kept at a temperature above 80 °C in the reaction tank for a minimum of one hour to allow for the destruction of the cell walls of the micro-organisms. A pump is used to recirculate the black liquor to provide the required mixing in the tank as well as transfer the black liquor back to the concentrator. The medium strong black liquor used is typically sufficiently hot for the reaction, but a heater can be provided in order to raise the liquor temperature in the reaction tank; this was required in older designs where colder liquor was used.

Injection of the sludge in the evaporator train

Only secondary sludge can be mixed with black liquor and sent to the evaporators as it does not contain a significant amount of fibers. Experience has shown that the preferred source for the black liquor to be sent to the hydrolysis system is intermediate liquor at 40 to 50% DS after ash mixing and returning the liquor with secondary sludge added to the inlet of the concentrator. The intent is to prevent the recirculation of the sludge to the front of the evaporator train as part of the weak liquor, as this has been shown to cause problems with soap separation and scaling in the lower solids evaporator bodies. With proper treatment in the hydrolysis system, the addition of secondary sludge does not affect the behavior of the liquor in the concentrator. Washing requirements and operation of the concentrator does not significantly change with the addition of secondary sludge.

Disposal in recovery boiler

The impact of adding secondary sludge to black liquor on the combustion behavior was studied at Abo Akademi University [2] where the researchers determined that the combustion behavior of pure black liquor and black liquor mixed with secondary sludge, at a similar ratio as anticipated at the Metsä Fibre Kemi mill, were fairly similar.

Experience at Metsä Fibre Kemi and other European mills

No change in actual boiler operation was noted at the mill after the secondary sludge treatment system was placed into operation and the treated secondary sludge was added to the black liquor at Metsä Fibre Kemi. Reduction efficiency, emissions level and general boiler operation remained unchanged [1]. Similar results were obtained at the other mills that have since implemented this method for the disposal of secondary sludge. The amount of biosludge per produced ton of pulp depends on the mill effluent from the mill. Bleached and unbleached pulp mills will have different amounts of biosludge, the amount is normally in the range of 5 – 10 kg DS/ADT.

The Södra Cell Värö mill in Sweden initially installed a system with a capacity to treat 5.7 ton DS of secondary sludge per day in 2002 (**Figure 5**).

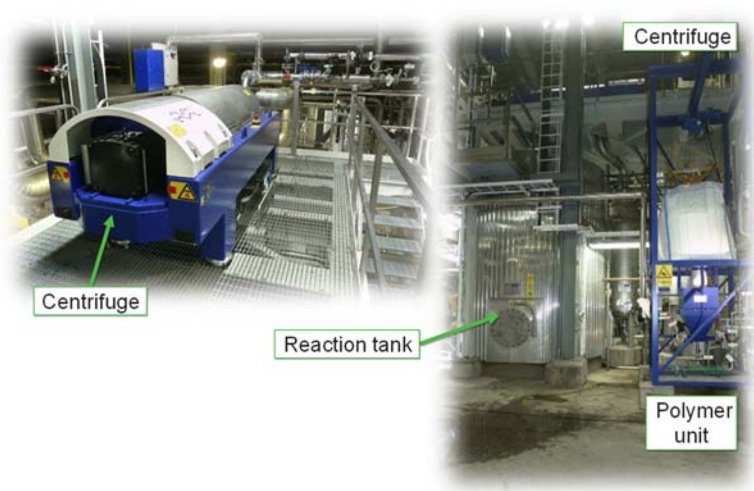

Figure 5. Södra Cell Värö hydrolysis plant (2002)

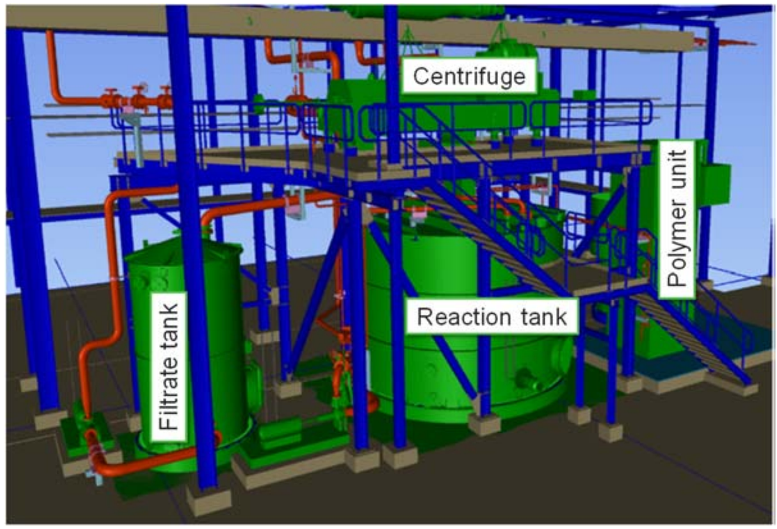

Figure 5. Södra Cell Värö hydrolysis plant (2016)

The mill is currently in the process of starting up an upgraded system (**Figure 6**) capable of handling 21 ton DS of secondary sludge per day as part of a large capacity upgrade project of the mill that will see its capacity increase from 425,000 to 700,000 ADMT/y. A paper providing more details on this upgrade of the mill was presented at TAPPI PEERS in 2015 [3]. In addition to the new secondary sludge treatment plant, the mill upgrade also includes an upgrade of the evaporators that includes going to high solids firing and an upgrade of the recovery boiler. The outage to complete the mill upgrade is currently underway and expected to be completed in early June 2016.

Impact on NPE in liquor cycle

Incineration of the secondary sludge in the recovery boiler has the potential to increase the amount of non-process elements (NPE) in the liquor cycle; such as Al, Ca, Fe, K, Cl, Mg and P. Several papers and reports were published on the impact of incinerating secondary sludge in the recovery boiler, including papers by Dahlbom about the mill at Skutskär [4], Taylor and Bossons on Harmac [5], and a research report from Dahlbom and Wadsborn [6]. They discuss NPE in the liquor cycle due to burning of secondary sludge in the recovery boiler after adding it to the black liquor. The key findings are that the impact of adding secondary sludge to the liquor cycle on potential increase in NPE will be very mill specific based on the source of NPE in the mill process (wood chips, make-up chemicals and make-up lime), their purge at various points in the process and their concentration in the secondary sludge.

Cl and K are typically controlled through either purge or treatment of the ash from the recovery boiler. Normally biosludge is not a main source of Cl and K intake to the mill. The most critical NPEs with the biosludge are Si, Mg and Al. Phosphorus can even be added to the secondary treatment plant to optimize its performance. Al can be more troublesome with the formation of sodium - aluminum – silicate scale in the evaporators. The addition of Mg in the green liquor can be used to precipitate Al and remove it in the dregs. Additional make-up lime may also be needed to reduce the impact of P enrichment in the lime cycle. Dahlbom [4] reported that at the Skutskär mill, the use of $MgSO_4$ in the bleach plant provided enough Mg to cause the Al removal in the dregs. An addition of make-up lime at the rate of 2 to 5 kg/ADT of pulp was needed to control P accumulation. Similar results were reported in other mills where a secondary sludge hydrolysis system was installed to allow for incineration in the recovery boiler. Taylor and Bossons [6] concluded that secondary sludge could be added to the black liquor at Harmac provided that good quality lime rock was used and regular analysis for NPE was conducted.

Recently also N-content has become important due to lower and lower NO_x-emissions from the recovery boilers. Increased N-content in the black liquor is directly affecting the NO_x-emission from the boiler.

Valmet has conducted a number of mill balances that track NPE in the liquor cycle and can be used to evaluate the suitability of mixing secondary sludge in the black liquor and incinerating it in the recovery boiler. These balances are mill specific based on the wood sources for the mill and the chemical used in the process and help identify methods of control that could be necessary for NPE in the liquor cycle.

Most of the studies have been performed for older mills with "traditional" losses of chemicals. In modern mills with closed system and minimized losses the problems due to NPE are foreseen to be increased. Control of NPE will be an additional balance to be controlled in the closed mills.

Conclusion

Hydrolyzing secondary sludge (biosludge) and mixing it with the black liquor prior to the concentrator to allow its incineration in the recovery boiler has proven successful in several European mills as a means of disposal for secondary sludge. This method offers benefits compared to the more traditional methods such as landfill (now banned in Europe for biomass material), composting and land spreading (odors, costly treatment and public opposition) or incineration in the power boiler (loss of thermal efficiency / steam generation, combustion stability problems, corrosion and air emissions).

No significant negative impacts have been experienced in mills that have adopted incineration of the secondary sludge in the recovery boiler. Hydrolysis of the secondary sludge prior to its introduction in the evaporators, ahead of the concentrator, is required in order to destroy the membrane of the micro-organisms and allow for the internal water to be removed.

Control of NPE in the liquor cycle is an important consideration for mills that consider implementing this method and mill balances that can evaluate the changes in NPE in the liquor cycle resulting from the addition of the secondary sludge to the black liquor need to be conducted to determine what methods, if any, need to be implemented to maintain an acceptable level of NPE in the mill liquor cycle.

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This white paper combines technical information obtained from Valmet personnel (Raymond Burelle, Kai Lüder, Kristin Lindholm, Mats Nordgren, Anders Wernqvist) and published Valmet articles and papers.