Dewatering Fibrous Sludge with Soy Protein

For mills that generate a mostly fibrous sludge, use of the soy additive can be justified on both a cost and a green basis.

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As much as 4 percent of the feedstock that enters a paper mill is discarded as sludge. This adds up to several million tons of waste material that is dumped into landfills, spread over terrain or burned every year.

Dewatering sludge with a belt, screw press or centrifuge squeezes some of the liquid out and makes the resulting cake less costly to transport. Compacted cakes also take up less space in landfills.

If the sludge is burned, fuel costs decrease as cake solids increase due to the lower water content of the material.

DEWATERING WITH SOY PROTEIN

Cake solids can be increased by more intensive pressing and/or by using agglomerants to promote dewatering. Agglomerants, such as cationic polyacrylamides (c-PAMs), neutralize the negative charge on the sludge particles, which reduces their mutual repulsion and allows them to consolidate.

Research conducted at Georgia Tech and supported by the United Soybean Board (USB) demonstrates that c-PAMs can be partially substituted with soy protein for conditioning fibrous paper mill sludge prior to dewatering. Cheaper than the petroleum-based polymers presently used, soy proteins can increase cake solids during belt pressing of fiber or fibrous sludge. Displacing petroleum-based polymers with renewable, sustainable soy protein provides additional environmental benefits.

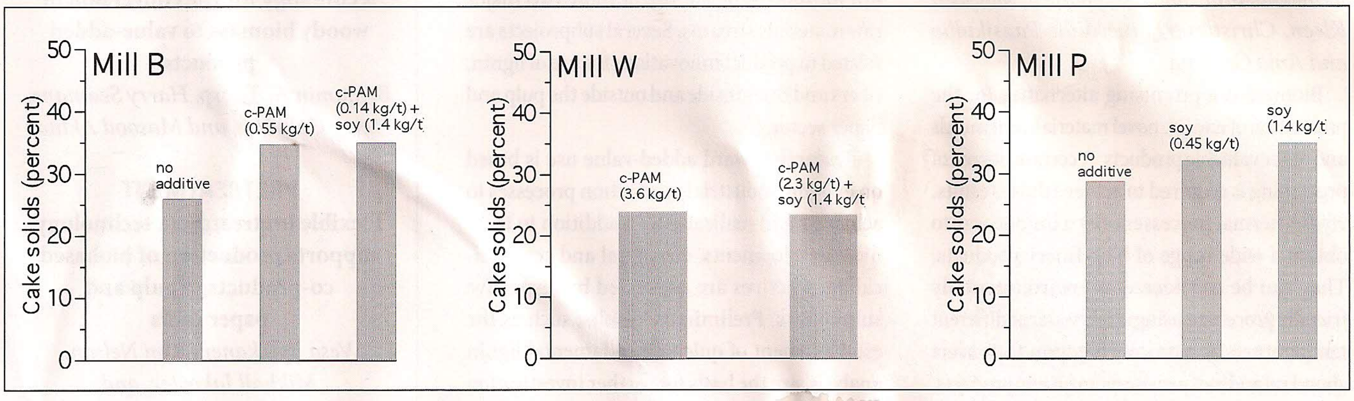
For more than a decade, USB has helped fund the development of many successful new uses for soybeans in products, including soy-based wood adhesives, plastics, foams, rubber, lubricants, soy methyl esters and soy-based coatings and inks. Research to find new applications for these products continues in an effort to utilize more U.S. soy.

SUCCESSFUL PAPER MILL DEWATERING TRIALS

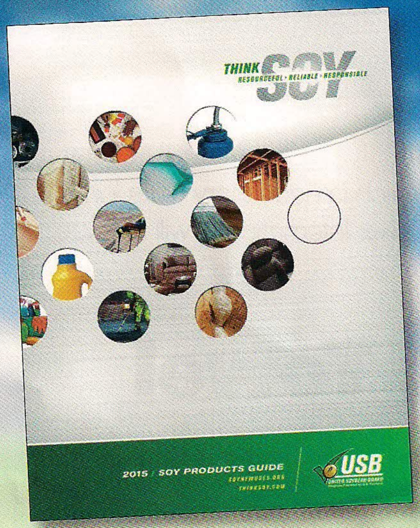
Results from dewatering three paper mill sludges with mixtures of c-PAM and crude soy protein are illustrated in Figure 1. The c-PAM and soy doses were optimized. The crude protein was prepared by stirring soy flour in water at pH 10 and adding the resulting paste directly to the sludge. The pH can be lowered to 7.5 if warm water is used. For mill B sludge, the soy/c-PAM combination provides the same cake solids as the c-PAM alone, but at a much lower c-PAM dose, which translates to a lower cost. Mill P does not use any sludge conditioning polymers, but is interested in obtaining higher cake solids. The soy protein does this quite well and the application is particularly well suited for mills of this type. The results for Mill W sludge are similar to those obtained for Mill B in that the soy protein reduces the c-PAM dose.

When the trials were conducted in 2013, the c-PAM was nominally priced at $4.80/kg and the soy protein at $0.66/kg. Consider the results of Mill B. The chemical cost for the conventional case with c-PAM alone is $2.64/tonne. The c-PAM/soy combination costs $1.60, for a 39 percent reduction in cost. The corresponding numbers for mill W are $17.28 and $11.96, respectively, for a 30 percent cost reduction. For mill P, the value is provided by the greatly increased sludge solids.

The result was unexpected because both the sludge particles and the soy protein are negatively charged and they should repel each other rather than bind together. Conventional sludge conditioners are typically cationic. Because soy proteins are isoelectric at pH ~4.5 they would be negatively charged under typical dewatering conditions where the filtrate is essentially neutral. However, soy protein contains a sufficient number of cationic



▲ **FIGURE 1.** Dewatering sludge with hydrolyzed soy flour.



sites to bind to anionic sites in the sludge and vice versa. Further mechanistic detail is provided in Banerjee, *Process Biochem.*, 49, 120 (2014).

FULL-SCALE MILL TRIALS

Several laboratory and full-scale mill trials have shown that the soy protein works best for fibrous sludge or sludge containing a small amount of biological material. The approach is ineffective for fully biological sludge. The cost: benefits for recycled sludge are not compelling because this sludge can be conventionally pressed to high solids because of its high ash content and the soy increases cake solids by only a small amount. Nevertheless, there are several mills that generate a mostly fibrous sludge, and for these, use of the soy additive can be justified on both a cost and a green basis. Although the green value is difficult to quantify, consumer-products companies view it as significant in reducing their environmental footprint. Markets sensitive to environmental issues should find this especially true.

In conclusion, soy proteins can increase cake solids of pressed sludge. Commercial formulations of soy flour that can be made-down on site are available. The soy is much cheaper than the c-PAM, so the economics will dictate the balance between cost and the supplemental c-PAM dose. Overall, the cost of the c-PAM-supplemented soy is much lower than that of the c-PAM when used alone and its green value is a bonus. A patent application on the approach has been filed. 360

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SUSTAINABLE & VERSATILE SOY

The soybean provides a sustainable source of protein and oil worldwide. Soy's versatile properties are used in a variety of applications, from animal feed and human consumption, to biodiesel fuel and other industrial uses. Because soy grows throughout the world, it represents a viable and renewable replacement for petrochemicals.

Paper-related pre-commercial products developed with USB funding include dry strength additives, surfactants and stickies control agents for paper recycling.

Since 2001, worldwide production of soybeans has increased by more than 40 percent. In the same time period, soybean farmers have increased their use of sustainable farming practices, reducing energy use and carbon emissions.