IMPROVEMENT IN FIRST CARBONATION SLUDGE SETTLING BY SELECTION OF A BETTER FLOCCULENT ADDITION POINT AND THE ADDITION OF STARCH AS A SECOND FLOCCULENT

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Introduction:

One of the key elements for high throughput in juice purification is adequate settling of first carbonation sludge. This sludge is a thick suspension of solids that consists of the solids originally in the diffusion juice, the solids precipitated out of the juice, along with precipitated calcium carbonate. The original solids include pieces of sugarbeets, other plant matter and the dirt carried in with the beets. Soluble pectin and protein are denatured, coagulated and stabilized in the preliming process. Insoluble and partially soluble calcium salts also are contained in the sludge.

The character of the sludge is variable and depends on the condition of the sugarbeets; how well they are cleaned; and the operation of the slicing, diffusion, preliming, main liming and first carbonation stations. Having control over each of the process parameters such as temperature, pH, amount of lime and carbon dioxide and retention time at each station in each of these processes will affect the character of this sludge.

A two-step process is used to separate the solids from the carbonated juice. First the sludge is settled or thickened in a clarifier, creating a clear juice overflow and thick bottom sludge. The sludge drains from the bottom and is pumped to filter presses or rotary drum filters where the solids are separated from the remaining juice and rinsed with water to reduce residual sugar.

A flocculation polymer is usually added before the settling step. This is usually an anionic co-polymer of acrylamide and acrylic acid. Anionic polymers work best when the particulates in solution have a residual positively charged surface that keep them apart. The electrostatic attraction between the negatively charged moieties of the polymer and the positively charged particles attract each other. The particles then grow large enough to settle out.

Using polyacrylamide does have a few drawbacks. First it is petroleum based and has become relatively expensive in recent years. Second, its use is limited in the Code of Federal Regulations (20 CFR173.10) to not more than 5 parts per million in the juice, so even if a situation warrants greater polymer addition it is not legal to add more. Third, polyacrylamide will degrade to form acrylamide, a carcinogen, raising concerns as to whether or not it is appropriate for use in the food industry.

When using a flocculent such as polyacrylamide, selecting the addition point at a point in the process just before the settling basin will result in its most efficient use. The Minn-Dak Farmers Cooperative sugarbeet-processing facility at Wahpeton, North Dakota, has a modified BMA-65 juice purification system originally designed for 5,000 short tons per day slice. In this system, the juice from first carbonation is settled in two thickeners, each containing four individual thickening clarifiers one stacked on top of the next. At the top and between the two thickeners is mounted a conical-shaped juice

distributor. The first carbonation juice is pumped to the bottom of a distributor, which overflows into eight pipes, each feed in an individual thickening clarifier.

For years the point at which the flocculent was fed was before the pump, which pumped the first carbonation juice to the distributor. This addition point ensured good mixing before the thickeners. However, since the distributor had enough volume to allow for a slowing of the flow, the floc formed and started separating from the juice in the distributor itself. The turbulence of the flow out of the distributor and into the thickening clarifiers was great enough to entirely break the floc and remix the juice. The floc had to then form a second time in the clarifier.

Materials and Methods:

First carbonation sludge settling tests were conducted on juice taken from Minn-Dak Farmers Cooperative first carbonation vessel. Though the exact conditions of this juice vary slightly, it has approximately the following characteristics: 11.3 pH, 86º C, and an alkalinity of 0.100 CaO per 100 mL of solution.

The 50% NaOH was JT Baker lot 3727-01 from Mallinckrodt Baker, Inc., Phillipsburg, NJ 08865. The starch used was Pencook®10 lot 08L-422 25115 from Penford Food Ingredients Co., Centennial, CO 80112. The polyacrylamide used was Hyperfloc AF 206, lot UL-363 from Hychem, Inc., 10014 N. Dale Mabry Hwy., Tampa, FL 33618. Deionized water was used for making starch, polyacrylamide and caustic solutions.

The first carbonation juice was brought immediately after collection to the process laboratory, thoroughly mixed and poured into two 1000 mL graduated cylinders. Flocculent was added using graduated disposable pipettes. Once the flocculent was added, it was mixed manually with the solution in the cylinder using a steal mixing wire with a loop at the bottom.

For the sludge breaking and reforming experiments the volume below the breakpoint was recorded at ten second intervals. After settling the first time the sludge was remixed and allowed to settle a second, then remixed a second time and allowed to settle a third time.

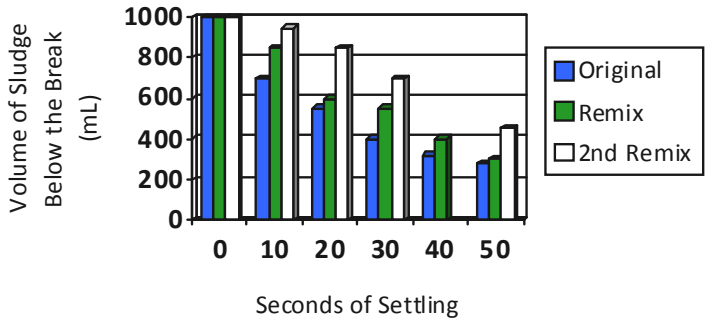
For the experiments with starch and polyacrylamide, comparisons were made by dividing the first carbonation solution into two 1000mL-graduated cylinders. The appropriate amounts of the flocculants were added to the cylinders, and then both were mixed simultaneously. The volumes below the break points were recorded at various time intervals.

Results and Discussion:

Laboratory studies at Minn-Dak showed that the effectiveness of the polyacrylamide flocculent diminished the more times the floc was broken and reformed (Figure 1). Upon letting the sludge settle a second time, not only did the solids floc together and settle slower, but the resulting solution above the thickened sludge was not as clear. After the studies the polymer addition point was moved to after the distributor. The polymer was added to the lines coming off the distributor, feeding the individual thickening clarifiers.

Individual polymer pumps were used so the operater could control addition to each tray. This is helpful since the settling characteristics can sometimes vary from tray-to-tray.

Figure 1. The Affect on Floc Settling of Breaking the Floc and Letting It Reform



One of the products produced at Minn-Dak is powdered sugar. Cornstarch is added as an anti-caking agent at about three percent by weight. It was the practice to reprocess powdered sugar through the beet end as dissolving it in the sugar end led to plugging of the pressure-leaf standard liquor filters. Operations personnel found that reprocessing powdered sugar through the beet end enhanced settling of first carbonation sludge. Investigation by Minn-Dak's Laboratory personnel confirmed that cornstarch worked as a flocculent in first carbonation juice, helping to settle out the sludge.

Further experimentation showed that its flocculating ability worked only upon dissolution. The starch had to be heated to ensure it went into solution. In addition, further improvement was noticed if caustic was added to the dissolved starch solution. Other starches besides cornstarch were tried and found to work about the same. The current preparation of flocculent starch is a follows: A batch solution of 2.69% potato starch in hot water is made. Once this has mixed, enough caustic is added to reach a final concentration of 0.167%. The starch is added to the juice for a final concentration of between 10- and 30-parts per million. Recent lab work at Minn-Dak suggests that adding more caustic and heating the solution to boiling for 30 minutes improves the flocculation ability of the starch.

Starch is commercially available from wheat, rice, potato, corn and cassava as well as others. It is relatively inexpensive and is a food. There are no restrictions on the amount that can be used in the processes, so processors can increase the amount as long as an increasing effectiveness is seen.

Early in the 2008-2009 beet-slicing campaign, Minn-Dak experienced significant carryover of dirt from the washhouse to the diffusion system and into the raw juice due to extremely muddy sugarbeets. During this period, the effectiveness of starch as a settling aid seemed significantly diminished.

By changing the addition point for the flocculent and utilizing starch, the BMA thickeners at Minn-Dak have been able to handle purification of juice from slicing up to 12,500 short tons per day, even though their original design was for only 40% of that load.

Bench trials of utilizing starch a flocculent for settling mud from the flume water have given variable results. At times it has worked well but at other times it appears totally ineffective. This is the subject of some future research. In addition, there are several types of food-grade starch that could be considered in these functions. Acid-

modified, cross-linked, oxidized, cationic, acetylated, stabilized and Dextrans could all be useful as settling aids in the beet-sugar factory.

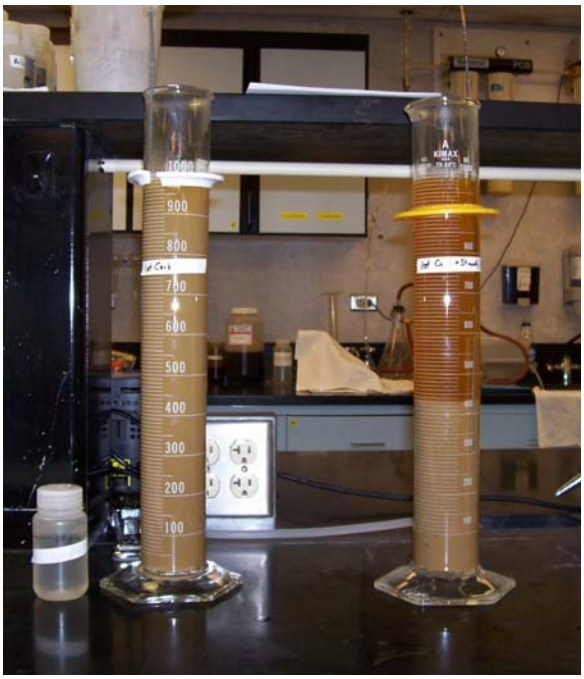


Figure 2. First Carbonation Juice Without and with starch addition after 1 minute of settling.