PURDUE
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STUDENT WORK REPORT

Co-Op Student Information

Date: 11/17/2009

Student Name: Jacob Wooddell

Student Signature: Jacob Wooddell

Student Email: jwooddel@purdue.edu

School/Discipline: Agricultural and Biological Engineering
Major: Biological and Food Process Engineering

Please circle your current work session:

- 3-session – 1 2 3
- 5-session – 1 2 (3) 4 5

Co-Op Employer Information

Does the Work Report contain Proprietary Information? Y or (N) (please circle one)

May Purdue post the Work Report on the OPP website? (Y) or N (please circle one)

Co-op Employer: Tate & Lyle

Supervisor Name: Rob Lyke

Supervisor Signature: Rob Lyke

PROFESSIONAL PRACTICE (CO-OP) PROGRAMS

Co-op Work Report
Session #3

Purdue University
Agricultural and Biological Engineering

Jacob E. Wooddell

Tate & Lyle
Food and Industrial Ingredients, Americas
3300 U.S. 52S
Lafayette, IN 47905
Dates: 1/12/2009 - 5/29/2008

Campus Address:
3172 Pheasant Run Dr. #207
Lafayette, IN 47909

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Robert Lyke

I recently completed my third Professional Practice work session at Tate & Lyle Lafayette South. Tate & Lyle is an industrial food ingredients company which produces a range of corn sweeteners, ethanol, and modified starches. At Lafayette South, they grind corn to produce high fructose corn syrups, crystallized fructose, and many by-products as feed. This session I have been focusing on research and investigation of certain processes and equipment for improvements in energy and water saving.

The largest part of this work session involved the evaluation of performance of the Krystar evaporators. This series of evaporators is fed high purity fructose syrup at low dry solids (DS) and produces the high DS fructose saturated syrup that is used to crystallize fructose. The evaporation train contains a mechanical recompression evaporator (MR), a double effect evaporator, and lastly, a finishing plate and frame evaporator. Each type of evaporator has benefits and flaws both in production and energy. A MR evaporator operates by recompressing the steam vapor that was evaporated and then using the recompressed vapor to evaporate water, creating more steam to recompress. It creates a continuous, practically self-sustaining loop once the evaporator has begun evaporating. MR evaporators only require fresh steam upon start-up to initiate evaporation. Problems occur when evaporation slows or ceases commonly due to temperature drops. When this happens, the evaporator is said to be in surge, as there is not enough vapor to recompress and the compressor pulses making loud churning noises. More technically, the compressor is operating at the far end of the compressor curve allowing the downstream pressure to become too high and blow back into the compressor. In multiple effect evaporators, fresh steam in introduced in the first chest while the steam produced is fed into the next chest. This creates a chain of chests that are fed off of a single chest with fresh steam. Multiple effect evaporators are commonly run under vacuum, effectively lowering boiling points making them superior over other evaporator when feed highly concentrated solutions with high boiling points. With multiple effect evaporators, without accounting for flash cooling, the first chest will evaporate the most and progressively drop through each chest as the steam energy decreases. This makes an economic problem based on cost of equipment versus marginal production. Typically to maximize production and minimize cost, they have two or three chests. A plate and frame evaporator is a simple plate and frame heat exchanger with a vapor separator. Steam is introduced on the other side of the heat exchanger to heat the evaporating fluid to boiling. The fluid is then flowed into a vapor separator that typically due to a pressure drop flash cools the fluid. The plate and frame evaporator is commonly used as a finishing evaporator to make a product at an exact specification due to the simple controlling of the steam and fluid flows.

To evaluate the performance, I completed a mass and energy balance of the systems. I was thankful of a course I took last semester, ABE 301 Modeling and Computational Tools, where I learned skills for performing mass and energy balances on complex systems. I began with a mass balance using the major assumptions as follows: there is no significant sugar loss through the system; the change in %DS accurately provides the water evaporated; and, in the MR, each chest is supplied with the same flow rates of recompressed steam that was evaporated. I created an excel spreadsheet that inputs the RI of each pass and provides analysis of the pounds of water evaporated. For the energy balance, I had to do some research and used many assumptions due to lack of proper operating transmitters such as temperatures and pressures. I utilized some models for estimating heat capacities of corn syrups based on %DS and interpolated tables to create a model for estimating boiling point elevation based on pressure and %DS. After updating my excel spreadsheet, I found potential imbalances around the double effect evaporator. The following shutdown found leaking tubes in a chest, leaking demister valves, and a plugged condenser that was restricting vacuum. It was an interesting experience to see this operation. I analyzed the material plugging the condenser and found it to be oligosaccharide sugars potentially formed from continuous heat. After the shutdown, there is still an imbalance and potential for improvements. The energy imbalance shows that some condensate is leaking back into the syrup lowering the %DS after evaporation occurs in the first effect chest.

My energy balance also brought questions in the operating parameters of the double effect evaporator. I was asked to look into the effects of changing the temperature inputs into each effect. I developed another energy balance making assumptions of knowns and unknowns. I created a large excel spreadsheet that outputs the potential flow rate, evaporation, and %DS at two different temperatures feeding the effects. The model is fairly accurate despite the many assumptions. This model shows the potential that we are losing due to the energy imbalance in the first effect chest. Future modifications are being considered for energy savings and effective production including new heat exchangers that run at the optimize temperatures predicted from the model.

In the middle of the session, I helped investigate an energy savings project involving starch pre-heat treatment. In the process, starch is pre-heated directly with low pressure steam from the flash system. Then, it is passed through a steam jet where it is cooked and the pasting process begins. If the pre-heat temperature could be increased, less steam would be used in the jetting process. Increasing the temperature increases the possibility of pasting prematurely in the starch line before the jet. I performed bench viscosity testing of the starch at varying temperatures. I found that temperatures around 142°F would cause the starch directly contacted to increase in viscosity. The sample would slowly increase in viscosity as I agitated the suspension. I have passed my data on with the concern of the direct contact steam causing pasting if the temperature is increased too close to 142°F. We currently target a setpoint of 133°F and do not see negative effects from the direct steam-starch contact. This topic will need in-process testing to conclude the possibility of increasing the pre-heat temperature.

Within the last week, I aided Mike Serra, a senior engineer, with investigating a chemical usage reduction. Mike had previously reported he could decrease the amount of soda ash used to neutralize the scrubber water in the feedhouse. His concern was the decreased usage of soda ash could potentially cause an increase in use of Magnesium hydroxide in the waste treatment and increase costs. He asked me to help with a bench neutralization strength comparison of the two basic chemicals with the acidic scrubber water. I had some problems at first due to the high strength of the in-process chemicals. Upon diluting, I was able to get respectable data that confirmed reported relative strengths. Reports showed that waste treatment facilities similar to ours use Magnesium hydroxide for its strong alkalinity. Besides cost savings, the reports support more usage of Magnesium hydroxide could help the treatment process.

I have also continued with my previous tasks involving the isomerization, fractionation, and ion exchange processes. With isomerization (Isom), I perform a process and quality assurance of the reactors three times a week. Based on pH and percentage fructose, I help manage the operating parameters of Isom. With ion exchange (IX), I have gathered profiles of steps in the IX cell cycles. The data can provide information that determines a variety of topics including channeling through resin, overdosing on chemical regeneration, and excessive rinse water usage. This term I have gathered profiles concerning the loss of sugars between Isom and fractionation (Frac). Fractionation is the process that separates fructose and dextrose sugars into higher purity syrups. It is such a complex process of timing additions and extractions of the syrups that a small drop in %fructose or %DS will throw the fractionation curve off and significant drops in purity and recovery are seen. My results suggest the drops occur during the Frac IX service runs in the low pH environment and has some temperature dependence. More tests will need to be gathered for accurate information.

In this work session, I have gained technical knowledge in investigation and troubleshooting of complex systems. Most of my large projects were centered on a researching attitude. These projects have helped my career by gaining experience in understanding and explaining the complex situations at hand. These skills will aid me at any work place. I have learned more than just technical skills. Due to the economic situations, I have witnessed and experienced the effects of the low economy. I have seen decreased projects, decreased contractor manpower, and a layoff of employees. I hope this knowledge benefits me in my decision making skills in my engineering career if the economy falls again in the future. I will be taking an engineering economics course this summer and hope to incorporate the teaching into my career and perhaps the next work session. I hope to continue to gain more technical knowledge and especially more engineering design and problem solving skills. I am looking forward to returning in the fall of 2009.