Improving Riceland's Rice Bran Oil Extraction Efficiency Through Drying

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THE PROBLEM

Each year, Riceland's Rice Bran Extraction Plant in Stuttgart, Arkansas produces approximately 55 million pounds of rice bran oil (Riceland, 2016). The oil, in its crude form, is extracted from full fat rice bran and undergoes chemical refining to improve quality and remove odors.

During the chemical refining of the crude rice bran oil (CRBO), soapstock (fig.6), an undesirable byproduct, is created. The forming of the soapstock leads to significant refining losses because it can retain up to 50% of its weight in CRBO (Dumont & Narine, 2007). However, if the moisture content (MC) of the soapstock is lowered, it can be rerun through the refining step and release some of the absorbed CRBO. An additional three million pounds of refined oil can be produced annually if the soapstock is dried and re-processed.

The goal of this project was to design a drying system to lower the MC of the soapstock from 60% to 25%.

THE PROJECT

Based on the properties of the soapstock, the drying system was narrowed down to four alternatives: Rototherm (fig.1), drum dryer (fig.2), impingement oven (fig.3), and convection oven. Several MC tests were carried out to determine an average initial MC for the soapstock.

Assuming an elevation of 64m, standard pressure of 10,1660 Pa, average temperature of 16 ºC, and 70% relative humidity, an engineering analysis was performed on each method to determine how much water needed to be removed from the soapstock, final MC, drying time, drying temperature, and energy usage.

After the engineering analysis was completed, an economic analysis was performed. Several manufacturing companies were contacted to obtain quotes for each alternative. The annual profit of each alternative was calculated and with the help of Precision Tree, a risk analysis tool, the best alternative was picked.

EQUIPMENT

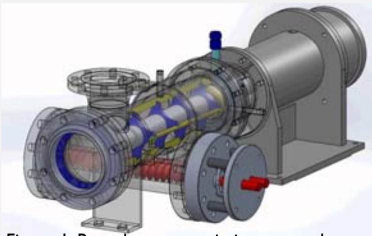

Figure 1. Rototherm, permission granted by Artisan Industries Inc.

Figure 2. Solidworks drawing of drum dryer

Figure 3. Impingement Oven - Poultry Pilot Processing Plant

Figure 4.VWR oven used for MC testing

Figure 5. Desiccator used for MC testing

Figure 6. Soapstock a) 60% MC b) 25% MC

METHODS

Determining Initial Soapstock MC

1. Label each drying pan corresponding to a sample and record the weight of the pan (W_1).
2. Place 50g of soapstock in drying pan. Record weight of the soapstock sample + pan (W_2).
3. Place pans in VWR oven (fig.4) at 128 ºC for 2 hours
4. After oven, allow samples to cool in desiccator for 5 minutes
5. Record weight of each pan + dried sample (W_3). Calculate moisture content (MC) on a wet-weight basis (wb), as follows:

$$\%MC_{wb}=[((W_2-W_1) - (W_3-W_1)) / (W_2-W_1)] *100$$

METHODS CONTINUED

Impingement oven testing

1. Set a heat resistant aluminum pan on the scale and zero the scale.
2. Load a 50g sample of soapstock onto pan.
3. Set the oven to 250F and the fan to 1000 RPM. Wait until settings stabilize.
4. Place loaded pan on the conveyor belt and roll into the oven.
5. Take out the soapstock every 1,3,5, and10 minutes to measure weight.
6. After the last measurement, store soapstock into a plastic bag, and label the sample with temperature, initial mass, and final mass.
7. Repeat steps 2-6 with different temperatures (300 F ,325 F ,350 F, and 400 F).
8. Conduct a moisture content test to determine if the samples dried down to 25% MC.

SUSTAINABILITY

When the efficiency of oil extraction increases, less rice that must be process in order to meet the demand. If less rice is required for oil production, it would be possible to allocate more for human consumption; therefore, addressing social sustainability and the equal distribution of resources among the existing population. The increased efficiency could also lead to lower prices for rice oil since the supply would increase but not the demand, making it more accessible to all economic classes.

As biological engineers, this project challenged us to look at complex, dynamic systems and understand how changing one affected the rest. By analyzing a waste project and understanding what happened during its creation, it made us realize that there is always a way to improve the efficiency of a system, find another use for a waste product, and how to add value to something that was previously considered of little worth.

THE OUTCOME

The current preliminary analysis indicates that the Rototherm is the most efficient and cost-effective method for lowering the MC of the soapstock. It is the most suitable for handling the sludge-like consistency of the soapstock during drying, as well as having a significantly lower initial cost than both the convection and impingement ovens. Both ovens have an estimated cost of $1.5 - $2 million, while the Rototherm is approximately $300,000.

Out of the four alternatives, the drum dryer was least effective. The drum dryer requires the drying product to be able to stick to a rotating barrel. The surface area of the barrel is heated and the product dries while it is in contact with it. The soapstock, however, is not able to adhere to any surface without running. Due to this physical constraint, the drum dryer is not a recommended drying method.

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