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Process improvements with innovative technologies in the starch and sugar industries

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Abstract

In the sugar and starch industries, increasing constraints could require producers to significantly modify their manufacturing processes. As main trends, we can mention reduction of the environmental impact of these processes regarding liquid and solid waste discharge, potential alternatives to the use of lime to achieve savings in operating costs and getting value out of the by-products. In this context, this presentation focuses on the introduction of innovative technologies that can potentially replace conventional processes, such as rotary filters, IX resins, centrifugation, etc. These allow Eurodia to propose cost-effective solutions while meeting the above-mentioned requirements. Operating for several years in European mills, the following technologies will be described: (1) Clarification of diffusion juices by *crossflow microfiltration with Scepter® membranes*. While the capital investment might be 50% higher with microfiltration, the operating costs are two times lower than rotary filters, and fixed costs are comparable. (2) Demineralization and purification by *conventional electrodialysis* (ED). Compared with IX resins, this technology allows mainly a reduction of the pollution load and an improvement of the sugar yield. (3) Separation of sugars from non-sugars by the *Improved Simulated Moving Bed (ISMB®) process*. This type of chromatography allows high separation yields at lower capital and running costs than traditional simulated moving bed chromatography. These three techniques were supplied by Eurodia Industrie in European plants and are the basis of innovative process combinations for the production of sugars or starch derivatives.

Keywords: Starch industry; Sugar industry; ISMB process

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1. Crossflow microfiltration with Scepter® membrane

1.1. Description and advantages

Tubular stainless steel microfiltration membranes from Graver Technologies can be considered in the sugar and starch industries to replace rotary vacuum filter for the clarification step.

Scepter® membranes with 18-mm diameter tubes and a TiO_2 layer that give a 0.1-μm porosity can work in extreme process environments, such as temperature over 100°C, high viscosity, high levels of suspended solids and aggressive cleaning agents (steam). The tubes are seal welded in the module to eliminate sealing concerns.

1.2. Applications

- Mud filtration of corn syrup. The original system is still operating after 10 y and was expanded three times. Membranes have consistently shown a 20–30% lower level of protein in the permeate when compared with precoated rotary vacuum filters. This results in reduced refining requirements downstream.
- Fractionation of corn steepwater. Stainless steel membranes can fractionate corn steepwater, allowing high molecular weight proteins to be concentrated and sent to gluten meal. The remaining permeate can be evaporated to higher concentrations and exhibits a much lower tendency to foul the evaporator heating surfaces. This results in a substantial increase, 7–10 times, in the on-stream time between cleaning.
- Gluten thickening. Stainless steel membranes recover 100% of the insoluble protein and also block 20% of the soluble protein in the gluten stream coming from the primary separation centrifuge. This increases the production of gluten meal and provides a "cleaner" water for germ and fiber washing.
- In sugar mills. Rotary vacuum filters that are applied to diffusion juice filtration are replaced.

1.3. Industrial plant

1.3.1. Description and operating conditions

A Scepter® membrane (416 m^2) is installed to treat 50 m^3/h juice at 13–16°Bx with 0.3% of total suspended solids. Clarification occurs in three stages. The recovery rate at each stage is 38–72–97%. The operating conditions are 5 bars at 75°C and 6 m/s as velocity. This microfiltration unit operates at a constant permeate flow rate. The waste stream (retentate) represents 1.5 m^3/h at 1.6 Bx, and the cleaning frequency is once per day (24 h) for 2 h.

1.3.2. Economic figures

The production capacity is 2200 h/y (50 m^3/h) and 13% DS (6500 kg/h at 75°C). A microfiltration investment cost of 1,400,000 € ($1,260,000) is 50% higher than for rotary vacuum filters. However, when considering the maintenance, especially the labor costs, the fixed charges are comparable for both technologies, at around 15 € ($13.5)/ton.

Note that, in this calculation, the lifetime of the membranes has been considered equal to the lifetime of the filters: 7 y. In fact, for this plant, a guarantee of 10 y has been given for the membranes, or 22,000 h (10 y × 2200 h/y), while 7 y represents only 15,400 h.

Regarding the operating costs, microfiltration is half as expensive as rotary filters: 7.5 € ($6.75) even if the power consumption is six times higher with Scepter® membranes. The sugar losses are three times higher with rotary filters.

1.4. Conclusions

In 2002, the European regulations will prohibit the discharge of spent filtration aid in the environment. One possibility to meet the regulations is to replace rotary filters with cross-flow microfiltration, especially for the clarification of sugar diffusion juice or fermentation broth from the starch industry.