Large Scale Ethanol Production with CO_2 Separation

Jared Baird, Keith Convery, Kyle Roth
ABE 556, April 20, 2006

Project Description

Ethanol production is receiving a tremendous amount of attention as an alternative energy source. Current ethanol production facilities are capable of producing nearly two hundred million gallons of ethanol per year. The goal of our project was to design an ethanol plant that is capable of producing one million gallons of ethanol per day while maintaining zero discharge and minimum energy requirements.

Objectives

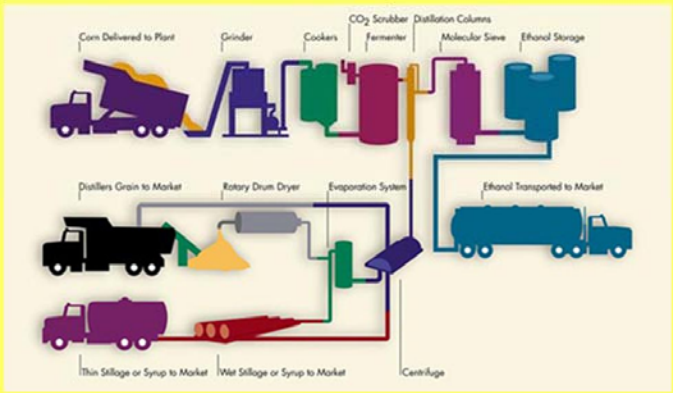
Design a zero discharge, minimum energy ethanol production plant

Design a plant capable of producing one million gallons of ethanol per day

Design a CO_2 separation process to concentrate ethanol prior to distillation

Determine economic feasibility of this facility

Current Production Method

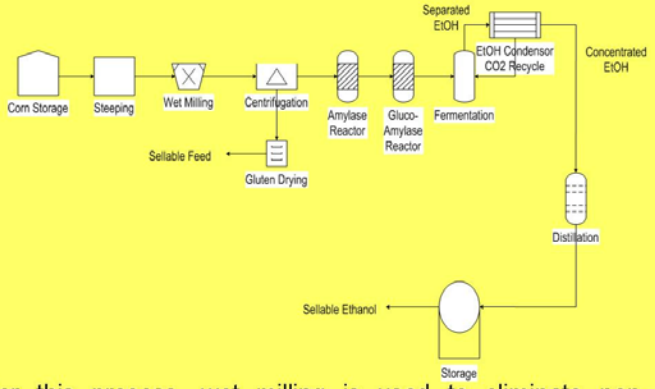


Current ethanol production utilizes dry milling of corn. Dry milled corn is then processed and fermented to ethanol. By current production methods, the fermentation medium is centrifuged before distillation to eliminate particulate matter, and the resulting effluent is sent directly to distillation columns to isolate ethanol. The fermentation occurs in a batch process and is capable of reaching 10-15% ethanol concentrations by volume. At these concentrations, ethanol is lethal to yeast and ceases the production process. Unused glucose in the medium is sent directly to distillation and is unutilized. Therefore, a process needs to be designed such that glucose conversion is increased. Different procedures for increasing conversion are listed below:

- CSTR production of ethanol (increases probability for contamination)
- Higher ethanol tolerance of ethanol producing organism (requires genetically modifying such organism)
- CSTR production of ethanol with heat tolerant microorganism (allows continuous production while heat helps maintain sterility)
- Fed-batch operation with continuous removal of ethanol via carbon dioxide stripping

Proposed Production Method

Four possible solutions to increase glucose conversion are listed below to the left. CSTR production of ethanol is likely to compromise the sterility of a fermentation. However, CSTR production of ethanol with a heat tolerant microorganism becomes an exciting idea. Elevated temperatures would help to reduce the level of contamination of competing organisms. However, this method introduces the risk of selecting for microorganisms that are heat tolerant and would still continue to contaminate the fermentation. Therefore, the method that appears most feasible is the continuous removal of ethanol from a batch operation. It also is the most practical for the equipment that is in use for today's production facilities. The general process flow diagram below lists the steps for continuous ethanol removal from a batch fermentation via a carbon dioxide stripping method.



For this process, wet milling is used to eliminate non-fermentable solids before the fermentation process. After saccharification, the glucose solution is used for fermentation in a batch process. CO_2 generated by fermentation is collected, bubbled through the fermentation medium, and used to extract ethanol from the medium. The CO_2/ethanol enriched vapor is then run through a condenser. The condensed material is enriched in ethanol and subsequently distilled. By this method, ethanol concentration in the fermentation is kept low, allowing longer fermentation cycles and higher glucose conversions.