CAPSTONE EXPERIENCE 2012
Freeze Concentrated Beer

PURDUE UNIVERSITY

Agricultural & Biological ENGINEERING

Angela Jacquay (Biological Engineering), Margaret Korty (Biological Engineering), Carl Littrell (Biological Engineering), and Courtney McWaine (Biological Engineering)

Objectives:

Design a freeze concentration process for beer with the purpose of decreasing capital and resources spent transporting this product. Identify specific parameters of the system to be able to install the process as a line extension to current beer production processes. Optimize the process based on sustainability and economic implications.

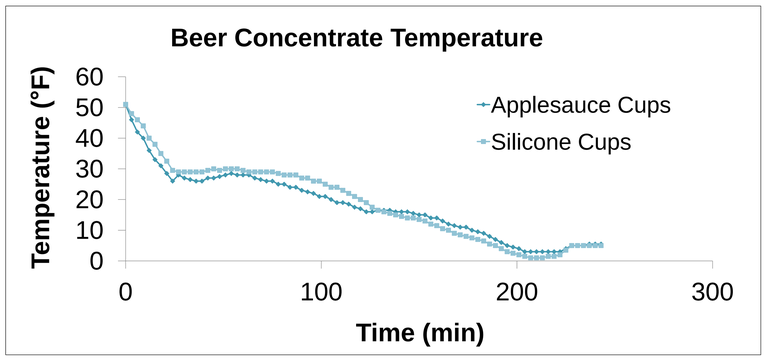
Background & Global Impact:

The current process for mass distribution of beer involves transporting large quantities of product, leading to increased transportation costs. A method for concentrating beer in order to reduce waste, increase shelf life, and lower transportation costs is desired. An alternative method involving freeze concentration of beer has been investigated and can be applied to the global beer market. Execution of this process design will reduce transportation costs and resource consumption.

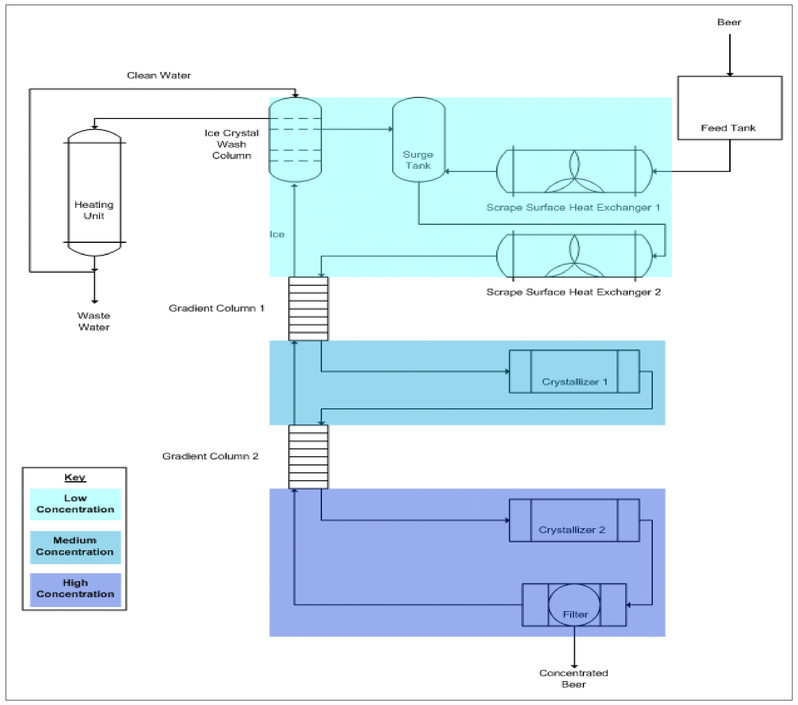
Kitchen Experiments:

The purpose of the kitchen experiments was to investigate the feasibility of freeze concentration of beer and how to achieve this process. The objective was to realize the optimal conditions of freeze concentration of beer on bench top scale, including materials and freezing point of beer. This was achieved via an iterative process by varying freezing containers and thermal couple wires. The initial beer composition consisted of 92.9% water, 4.1% ethanol, and 3% solids by weight. The collected temperature data is displayed in the below graph of temperature versus time.

Freeze Process Parameters	
Effective Molecular Weight (g/mol)	79.4
Mole Fraction Water	0.976
Initial Freezing Temperature (°F)	27.5



Process Diagram:



Market & Economic Analysis:

Beer has been in high demand from the end of 2008, as there has been a steady increase in personal consumption expenditures on beer. This product has successful sales as well as numerous transportation costs. By designing a process that decreases transportation volume of this desired product, money and resources can be saved during distribution, which is beneficial to beer production and distribution businesses.

Personal Consumption Expenditures on Beer in millions of U.S. dollars:

Process Equipment Functionality:

Item	Function	Relation to Design Goal
Feed Tank	Stores inlet beer	Preparation measure to attain steady state operating conditions
Scrape Surface Heat Exchanger 1	Cools liquor	Initial feed cooling unit
Surge Tank	Absorbs liquor overflow	Maintain steady state operating conditions
Scrape Surface Heat Exchanger 2	Cools liquor	Secondary feed cooling unit
Gradient Column 1	Separates ice and liquor	Concentrates liquor & recycles ice
Crystallizer 1	Creates ice slurry	Concentrates liquor
Gradient Column 2	Separates ice and liquor	Concentrates liquor & recycles ice
Crystallizer 2	Creates ice slurry	Concentrates liquor
Filter	Separates concentrated beer & liquor	Removes end product & recycle liquor
Ice Crystal Wash Column	Separates liquor & ice crystals	Concentrates liquor & recycles ice
Heating Unit	Melts ice	Prepares ice for further liquor concentration processing

Process Optimization:

Problem	Solution
Foaming in feed tank	Minimize foaming with installation of a floating cap
Unused heat from scrape surface heat exchanger 1	Reduce energy waste by utilizing heat generated from heat exchanger to heat the heating unit
Generation of waste water from the heating unit	Utilize waste water for CIP purposes

Conclusions:

The current work successfully demonstrates a freeze concentration process for beer that fulfills the project objectives. The ideal process parameters for optimizing the system with respect to sustainability and economic impact have been identified. Application of the reported design is highly suggested for current beer producers to reduce transportation costs and production waste.

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