CO_2 Capture & Treatment in Craft Brewing

TUNS Brewery

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Introduction

Carbon dioxide (CO_2), is both a by-product and a necessary component of the beer brewing process. Many large capacity breweries have capture and treatment systems in place due to their large production rates. Currently, no such system is designed for small capacity breweries.

Project Statement:
Design a system for TUNS Brewery that can collect, purify and recycle the CO_2 for use in the brewhouse.

Constraints:

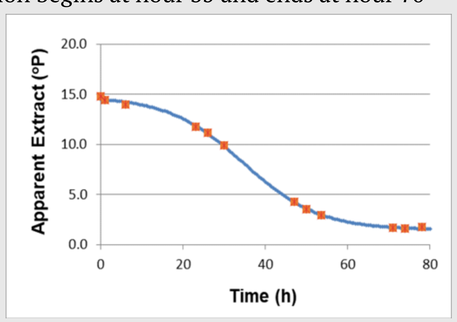
1. Cost
2. Size
3. Food Grade
4. Complexity

Fermentation Process

- Wort sugar (glucose) is converted into ethanol and CO_2 as shown below:

$$C_6H_{12}O_6 \rightarrow 2EtOH + 2CO_2$$

- Collection begins at hour 35 and ends at hour 70



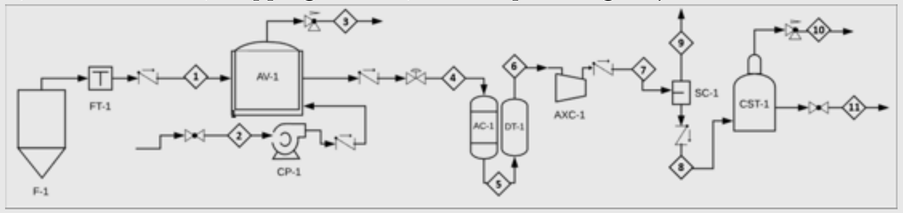
Fermentation model made using logistic model as detailed by Speers et al (2003)

Safety Considerations

- Pressurized System
- CO_2 Asphyxiation
- Compressed gas
- Food grade

Design Overview

The TUNS Brewery CO_2 collection and purification system is comprised of a foam trap, accumulator vessel, adsorbent bed, desiccant tower, stripping column, and compressed gas cylinder.



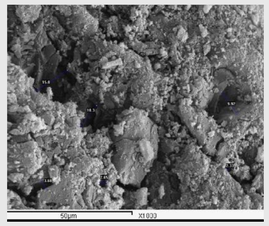
1. Collection

- Effluent gas will exit the fermenter and flow through a foam trap into a bladder accumulator vessel
- The bladder prevents water (the pressure medium) from contacting the effluent gas
- The accumulator vessel will pressurize the effluent gas to 5 bar

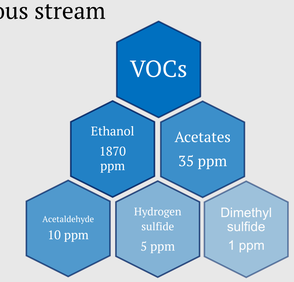
Bladder accumulator vessel from Parker Hannifin (2016)

2. VOCs and H_2O Removal

- The activated carbon adsorption bed targets the volatile organic compounds found in the effluent gas
- BASF F-200 activated alumina adsorbs any water present, drying the gaseous stream

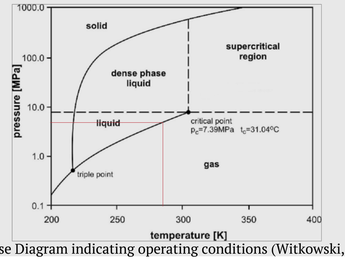


Activated carbon micrograph taken with an electron microscope (Abdel-Wahhab, 2015)



3. O_2 Removal

- O_2 must be removed from beverage grade CO_2 to prevent degradation of taste in beer
- The CO_2 stream is compressed to 55 bar then cooled to room temperature for liquefication
- Next, O_2 is stripped from the CO_2 using N_2



CO_2 Phase Diagram indicating operating conditions (Witkowski, 2014)

ISBT Guidelines

Contaminant	Max allowed
Purity	99.9% min
Moisture	20 ppm max
Oxygen	30 ppm max
Total volatile hydrocarbons	50 ppm max
Acetaldehyde	0.2 ppm max
Aromatic hydrocarbon	20 ppb max
Total sulfur content	0.1 ppm max
Sulfur dioxide	1 ppm max

Guidelines for beverage grade CO_2 (*Brewers Association Draught Beer Quality Manual)*

4. Storage

- The purified CO_2 will be stored as a compressed gas in a gas cylinder
- The storage pressure is 50 bar

3D SolidWorks Rendering

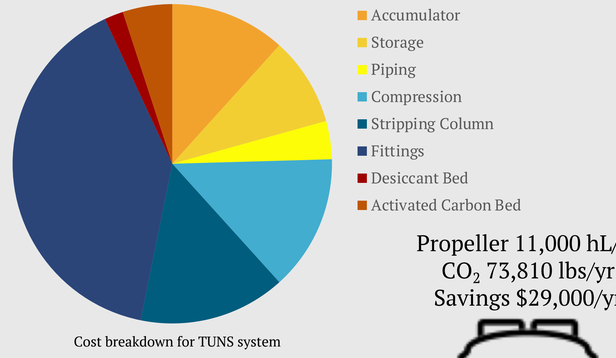
Size constraint: 2.14 m^3

- Height: 1.52 m
- Width: 0.84 m
- Length: 1.68 m

System modeled in SolidWorks

Economics

The cost estimate for the TUNS treatment system is $4600



Cost breakdown for TUNS system

TUNS 48 hL/yr
CO_2 322 lbs/yr
Savings $500/yr

Good Robot 1070 hL/yr
CO_2 7175 lbs/yr
Savings $2800/yr

Propeller 11,000 hL/yr
CO_2 73,810 lbs/yr
Savings $29,000/yr

Conclusion

- Designed system can purify and recycle CO_2 from TUNS fermentation
- TUNS scale is very small compared to many Nova Scotian craft breweries resulting in small CO_2 collection

Future Work & Recommendations

- The system could be economically feasible if successfully scaled to larger craft brewery (>10,000 hL/yr)
- A more accurate assessment of cost scaling for larger system should be performed
- Prototype building and testing for feasibility would need to be completed before pursuing a larger system

References & Acknowledgments

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