Chapman's Brewing Company: Quality

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ABSTRACT

When fermenting beer, the presence of oxygen compromises the flavor of the beer so the fermenting tank must be purged of oxygen with carbon dioxide. We were tasked by Chapman's Brewery to minimize the amount of carbon dioxide they are using to purge oxygen from their fermenting tank before adding beer and to determine a measurable and more efficient purging solution. This project involved background research on the brewing process, oxygen effects on beer, and purging theory; as well as solutions to these problems. Different oxygen sensors and alternative solutions were researched to find the best fit for the needs of the company.

INTRODUCTION

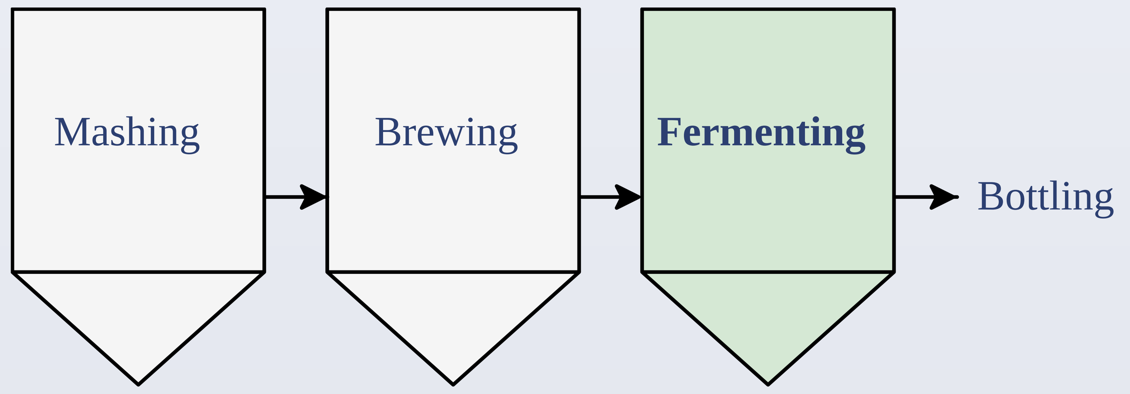

Figure 1

In the beer brewing process (see Figure 1 above) there are three main stages, mashing and milling of the grain, brewing at heightened temperature and then fermenting the beer before bottling. This project focused on the fermenting stage.

The Brite Tank is the tank that Chapman's Brewery uses to ferment beer before bottling. The current purging method that Chapman's Brewery uses is sweep through purging for ~1 to 1.5 hours and then pressure swing purging up to 5 psig for three cycles.

According to calculations based on purging theory, this method would give an end oxygen concentration of 6.9% by volume. A PFD of Chapman's purging setup is shown below in Figure 2. The Brite tank can be seen in Figure 6.

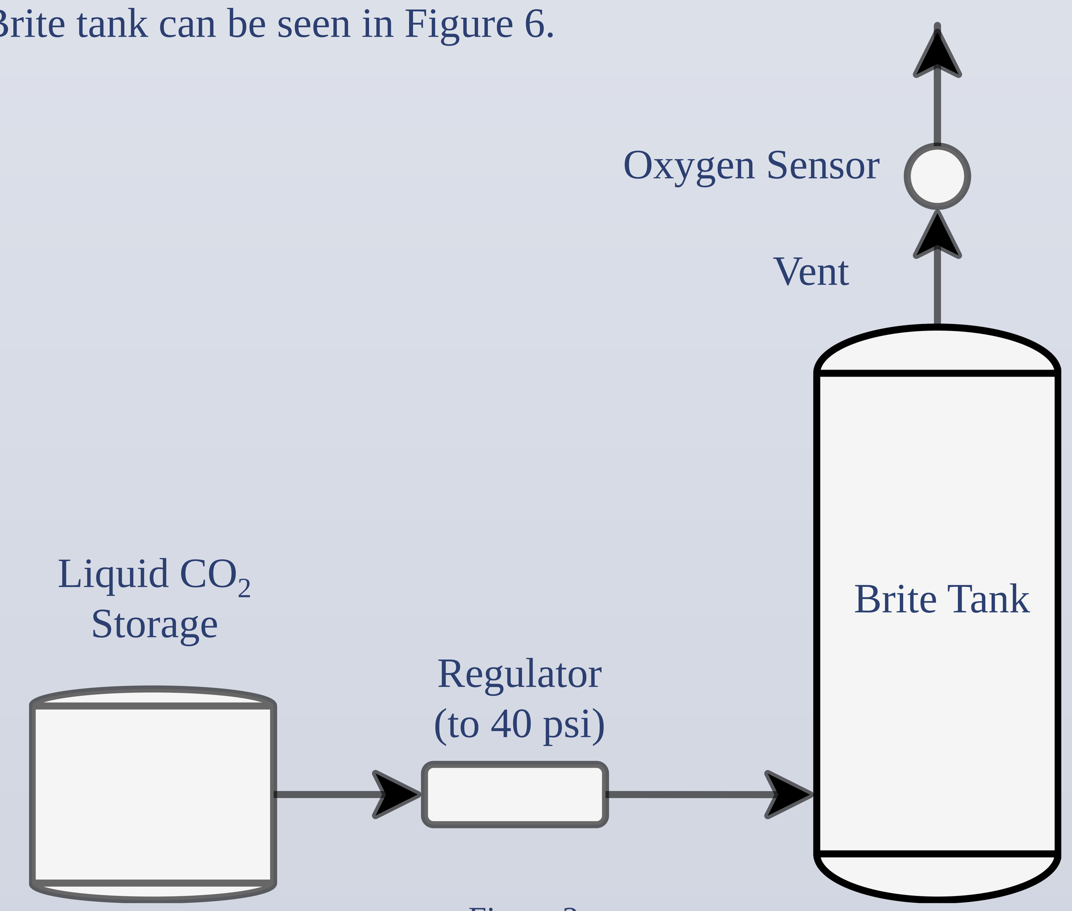

Figure 2

According to literature, the oxygen content of beer should be lower than 50 ppb when packaged to prevent spoiling.

Several oxygen sensors were investigated to collect data on oxygen levels leaving the tank when purging to be compared to the model.

PURGING THEORY

The two purging theories used in this project are sweep through purging and pressure swing purging.

Sweep through purging is where the vent of a tank is opened, and it is filled with the purge gas from the other end which sweeps through the tank. This is described by Equation 1 below.[1]

$$Q * t = V * \ln\left(\frac{C_0}{C_{desired}}\right)$$

Equation 1

Where Q is inlet gas flowrate, t is time and V is the tank volume.

Pressure swing purging is when a tank is sealed and pressurized with the purge gas up to a certain pressure when the tank is opened, and pressure is relieved until it returns to atmospheric pressure. This is done for several cycles and is described by Equation 2 below.[1]

$$C_{desired} = C_0 * \left(\frac{P_{low}}{P_{high}}\right)^{cycles}$$

Equation 2

These equations are modeled based on Chapman's current purge procedure of sweep through purging for 1 hour and then pressure swing purging for 3 cycles. This is described below in Figure 3.

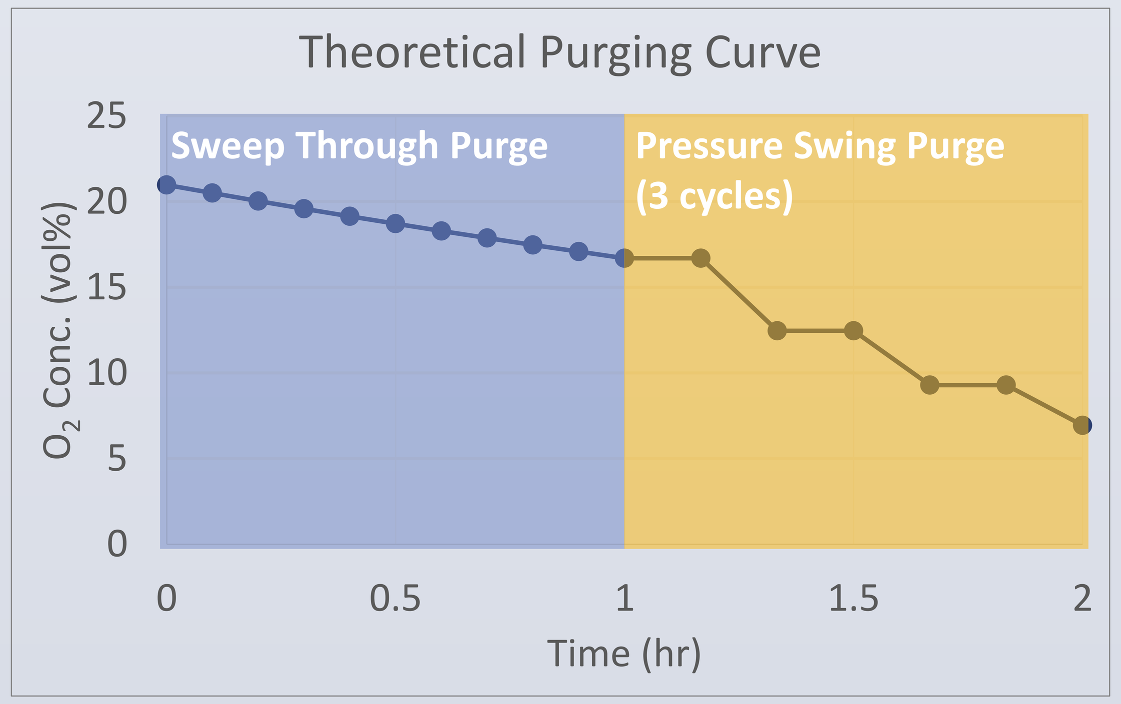

Figure 3

The O_2 sensor that was used was provided by Chapman's Brewery. The tank vent with the oxygen sensor is shown below in Figure 4.

Figure 4

OXYGEN PURGE DATA & ANALYSIS

The data gathered varied greatly from the model, mostly in the O_2 concentration at the end of sweep through purging. The main reason for this is the theoretical model assumed perfect mixing of gases in the tank. This is not the case in reality.

Because the CO_2 was added from the bottom of the tank, it pushed the lighter air (O_2 and N_2) up and out of the top of the tank where the vent was located, meaning the sensor would read normal air levels of O_2 (21 vol%) until the CO_2 had pushed most of the O_2 up and out of the tank.

	Theoretical	Data	Actual
	vol% O_2	vol% O_2	vol% O_2
Start	21.0	21.0	21.0
End of Sweep	**16.7**	**14.1**	**2.9**
End of First Swing	12.5	2.6	2.1
End of Second Swing	9.3	1.6	1.6
End of Third Swing	6.9	---	---

Table 1

The data gathered, theoretical model and actual concentration of oxygen in the tank as the purge was happening can be seen above in Table 1 and below in Figure 5.

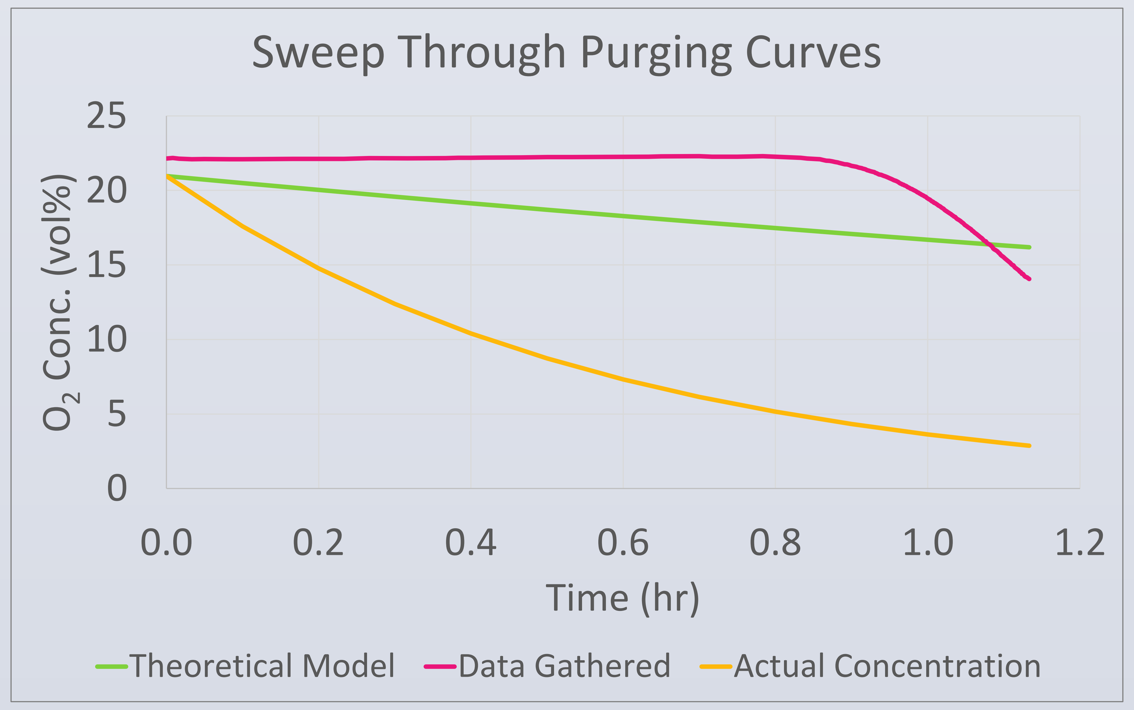

Figure 5

There was no third swing performed when the data was gathered as the tank was determined to have already reached an acceptable level of oxygen according to Chapman's.

The actual concentration of vol% O_2 in the tank was calculated by backing into the final sweep through purge O_2 concentration based on the final pressure swing purge recorded by the O_2 sensor. This is believed to be the perfect mixing concentration that was actually present in the tank when data was gathered.

This concentration is different from the model because the inlet flowrate of CO_2 from the tank was unclear and guessed based on CO_2 delivery system specifications when performing calculations.

The O_2 concentration is the tank is higher than anticipated, this is because the difference between the desired O_2 content in beer and O_2 content required in the atmosphere beer is fermenting in.

CONCLUSIONS & RECOMMENDATIONS

The major goals of this project was to help Chapman's Brewery save time and money. During testing, it was found that most of the O_2 in the tank was gone after about 50 minutes of sweep through purging. The O2 levels were reduced to 1.6 vol%, an acceptable level according to Chapman's Brewery after pressure swing purging for two cycles. It is recommended that this becomes Chapman's new Brite tank purging procedure.

However, due to the schedule of the brewery, only one purging test was run with the O_2 sensor attached and more tests should be run to further optimize this procedure. For example, sweep through purging for less time and then pressure swing at a higher pressure could produce a lower final O_2 concentration while using less CO_2 and saving time. Overall, the new method of purging was able to decrease the average amount of CO_2 being used per batch to purge the Brite tank in half and it would also save the brewery about 40 minutes as compared to the previous purging procedure.

Figure 6

ACKNOWLEDGEMENTS

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REFERENCES

1. Dr. Wagner's book