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AIDING THE BREWER IN THE STRUGGLE WITH DISSOLVED OXYGEN USING THE ANTON PAAR CBOX

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Abstract

The Anton Paar CBox is an important instrument in the brewing industry. It is a tool that is responsible for implementing process changes at Rahr & Sons Brewing Co. and improving the quality of the beer. The CBox is useful in many areas of the brewery as well as multiple stages of the production process. This poster focuses on how the CBox can affect the impact of oxygen on beer. There are two points in the production process where oxygen is the main focus: wort going into fermentation and finished beer going into the brite tank and package.

Oxygen is injected into wort so that the yeast are able to strengthen their cell walls by taking up the oxygen during the lag phase of cell replication. Various levels of oxygen (based on flow rates) were measured using the Anton Paar CBox, for both ale and lager strains, to determine sufficient levels of oxygen for each. As multiple batches were brewed to fill one fermenter, oxygen was measured from the fermenter to ensure yeast remain in the aerobic phase. The purpose was to determine whether it was best to oxygenate all at once, or to divide the oxygen evenly among the batches. In a similar manner, we also experimented with pitching all the yeast with the first batch of wort, or dividing the yeast pitches evenly among the batches. Yeast viability was monitored to track yeast health and progress throughout each experiment.

The second area oxygen becomes a concern is when the finished beer is moved into the brite tank and packaged. The CBox is first used to measure oxygen levels in the empty brite tank during the purging of a brite tank. Multiple purging techniques were experimented with and were necessary to find the optimum way of purging a tank with CO_2. The Anton Paar CBox provided the data and was used to identify the centrifuge as the culprit that let oxygen into the brite beer. When looking at packaging, bottles and cans are the most susceptible to oxygen pickup. The CBox has been instrumental in lowering oxygen levels in Rahr's packaged beer and will continue to be a critical tool as Rahr continues to seek improvements in Total Packaged Oxygen (TPO). The oxygen ingress from both canning and bottling has been lowered by ten-fold, since employing the CBox. There are still upgrades necessary to help lower TPO even more, including a jetter on the bottling line and a more advanced canning line. The CBox will allow Rahr to accurately qualify and track those improvements. One additional use the CBox offers in monitoring oxygen levels is allowing Rahr to assign an appropriate shelf-life to its packaged product. The oxygen levels can be monitored consistently in bottles and cans, subjected to various storage conditions. Sensory analysis also plays a part in determining reliable shelf life times for Rahr's packaged product.

Oxygenation of Wort

Figure 1. CBox hooked up to an in-line connection, as used in wort oxygenation

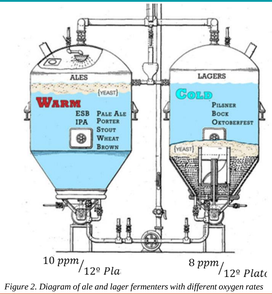

Figure 2. Diagram of ale and lager fermenters with different oxygen rates

The amount of O_2 needed for a given beer is calculated based on 8 parts per million (ppm) for a 12° plato lager and 10 parts per million (ppm) for a 12° plato ale.[1] Math is used for different gravity worts if the density is higher or lower.

Pure oxygen is diffused through the stone and dissolved into the wort after passing through the heat exchanger. ~ 2ppm O_2 was found to escape from the fermenter after being knocked out. After oxygenating at a higher rate due to compensation for the dissolved oxygen (DO_2) loss in the fermenter, there was a dramatic increase in yeast longevity in the ale strain.

Pitching yeast all at once, versus two to six times for multiple batches being brewed into a single tank, was also trialed. This allowed the yeast to be in one aerobic life-stage throughout the lag-phase, rather than multiple groups of yeast acclimating to the fresh wort at different times. Since implementing this approach, more consistent fermentation times and alcohol levels as well as improved yeast health has been seen in the lager yeast strain. The ale yeast strain however, was negatively impacted by pitching and oxygenating all at once. Oxygenating efficiently and accurately is currently being looked at for this negative impact along with the warmer temperature of fermentation. Tables 1 and 2 contain data from the trials, displaying different oxygenation rates and yeast pitching techniques.

Ale Yeast Strain			
	ABV % Standard Deviation	# of Beer Cycles Achieved	Fermentation Time Standard Dev. (Days)
New O_2 rate @ 12 ppm with Split Up Pitches & Split Up Oxygenation	0.1527%	21	0.67
New O_2 rate @ 12 ppm with Pitching and Oxygenation at First Knock Out Only	0.1914%	15	0.92

Table 1. Data taken from ten batches of Rahr's Texas Red Ale

Lager Yeast Strain			
	ABV % Standard Deviation	# of Beer Cycles Achieved	Fermentation Time Standard Dev. (Days)
Old O_2 rate @ 8 ppm with Split Up Pitches & Split Up Oxygenation	0.1828%	15	2.22
New O_2 rate @ 10 ppm with Oxygenation & Pitching at First Knock Out Only	0.0773%	19+	1.79

Table 2. Data taken from ten batches of Rahr's Blonde Lager

Oxygen Monitoring: Purging of Brite Tanks, Beer Transfer, Filled Brite Tanks

Old Method of Purging	Add CO_2 at ~80 PSI into CIP arm to 12 PSI	Release CO_2 until 7 PSI then add CO_2 back up to 12 PSI	Repeat this process until purged air smells of CO_2	Finish purging within 1 ½ hours and between 2 & 4 % saturated O_2
New Method of Purging	Add CO_2 at ~60 PSI into bottom of BT to 5 PSI	Keep flow the same and let out pressure through a spunde	Measure purged air in headspace with CBox	Finish purging within an hour and under 1% saturated O_2

Table 3. Comparison of tank purging techniques before and after acquiring the Anton Paar CBox

The CBox has helped accurately monitor the purging of Brite Tanks by measuring % O_2 saturation.

Old Method of Transferring	CIP and sanitize lines and centrifuge	Run centrifuge at 3.5-5 Bar bowl pressure	Filter beer in cartridge filter and fill brite tank	Beer finishes in Brite Tank >300 ppb O_2
New Method of Transferring	CIP and sanitize lines and centrifuge	Run centrifuge above 8-10 Bar to ensure air isn't coming in	Measure DO_2 after centrifuge and before filter	Finish beer in BT <100 ppb O_2

Table 4. Comparison of techniques on transferring beer into brite tanks before and after implementing the Anton Paar CBox

Using the CBox with sample port sampling allows for troubleshooting where DO_2 is coming into the beer during beer transfers from a fermenter and into a brite tank.

Old Method of Finishing in Brite Tank	Begin to carbonate beer through stone at ~80 PSI	During high carbonation flow, O_2 was subsequently scrubbed from beer	Using Zahm & Nagel total gas meter, measured CO_2 in beer until target was reached	Beer carbonation was inconsistent (+/- 0.3 volumes of CO_2) due to the functionality of the Zahm meter
New Method of Finishing in Brite Tank	Begin scrubbing DO_2 from beer until below a target amount	Begin to carbonate beer through stone at 20-40 PSI using a regulator	CBox is used throughout the carbonation period to measure CO_2 absorption and ensure consistency in carbonation	All beer is carbonated within 0.1 volumes of CO_2 and having < 20 ppb DO_2 in the beer

Table 5. Comparison of techniques on scrubbing oxygen out of the tank and carbonating beer in the brite tank before and after implementing the Anton Paar CBox

Accuracy and consistency of scrubbing O_2 and carbonating beer has improved since using the CBox.
User-to-user variation since using the Zahm & Nagel meter has decreased significantly with the new instrumentation.

Oxygen Monitoring: Cask Canning Line

The 5-head Cask Canning Line was the first canning line used by Rahr & Sons. When the CBox was first implemented in the brewery the canning line had already been running. The data shows different trials with the Cask Canning Line to lower DO_2 levels in the cans. Before reading levels, the cans were shaken for 3 minutes to ensure gas equalization between the head-space of the can and in the liquid. The first cans tested showed levels between 500 and 600 ppb DO_2. After this, aspects of the canning line were slowly changed until consistency was achieved <100 ppb of DO_2 in the beer. The industry standard for DO_2 levels in packaged beer is said to be 30 ppb or below[2]; however, due to constraints involved with using the Cask Line, the consistent levels achieved were < 100 ppb. The graph shows the steps taken to lower the DO_2, while using the CBox for real-time measurements in the cans.

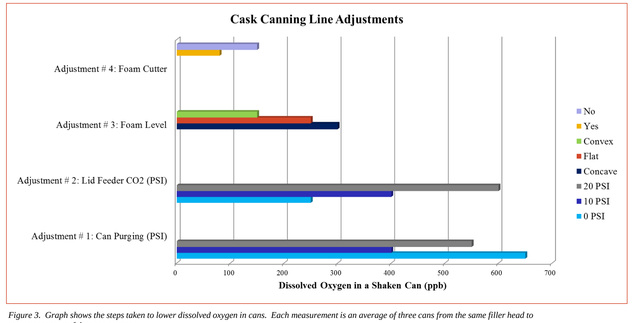

Figure 3. Graph shows the steps taken to lower dissolved oxygen in cans. Each measurement is an average of three cans from the same filler head to ensure accuracy of the measurement.

Oxygen Monitoring: Comac Canning Line

The installation of the Comac Canning Line took place after the CBox was being used at Rahr & Sons. During the canning line installation, the CBox was instrumental in providing data for the operator, which lead to real-time adjustments on the line in order to lower DO_2 levels in the can. When the new line was commissioned, DO_2 levels in a shaken can were above 300 ppb. Since applying the CBox, Rahr has effectively adjusted the filler and seamer to consistently package cans of beer below 50 ppb, averaging 35 ppb. Below is supporting data, showing the effect of adjusting the bowl head pressure, the bubble breaker pressure and position, and the underlid gasser pressure.

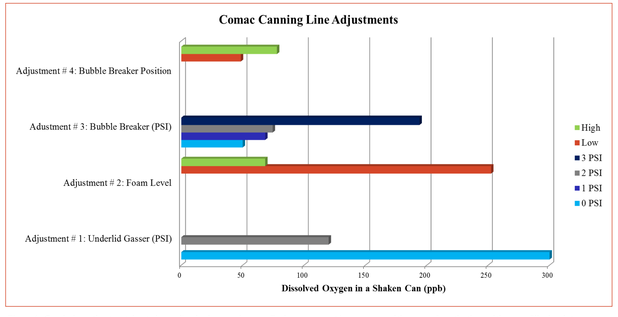

Figure 4. Graph shows the steps taken to lower dissolved oxygen in cans. Each measurement is an average of three cans from the three of the same filler heads to ensure accuracy of the measurement.

Oxygen Monitoring: Eurostar Bottling Line

The primary reason for the purchase of the CBox was to monitor DO_2 on the 24-head Eurostar Bottling Line. Since utilizing, this instrument has helped lower DO_2 by ten times. The CBox proved helpful in looking at individual filler valves. If the oxygen problem is in the filler, the meter will pick up a higher level of oxygen in an unshaken bottle versus a shaken bottle. Using this technique allowed the brewery to narrow its focus to the bowl and filler valves. Then, taking measurements on bottles after maintenance days and targeting specific filler valves guided the replacement of certain gaskets and helped lower the DO_2 in the bottle. Installing a jetter also allowed for consistently low DO_2 values in the bottles.

Conclusion and Final Remarks

The Anton Paar CBox has benefitted the brewery in many ways, as highlighted in this poster. The most beneficial attribute of the CBox, or any other portable DO_2 meter, is the ability to take real-time data points when packaging, filling, or transferring beer. The knowledge provided by a DO_2 meter can lead to small but very impactful adjustments to every process involving oxygen uptake.

While the Anton Paar CBox is an important and worthwhile investment, there are a few limitations: limited range readings, specific amount of pressure needed to take a sample, and difficulty when reading turbid beers. Also, the CBox is not intended for wort and high-level DO_2 readings. To elaborate, when used for wort samples, it is difficult to obtain truly accurate readings because of the maximum readout limitations, and the turbid beers are problematic because the small inlet can get clogged very easily. Turbidity of a beer, especially hoppy beers, and pressure requirements are two main factors to consider when using this piece of equipment. If the brewery produces a large amount of hoppy brands without filtering, the CBox will clog easily and provide frustration for the operator. The pressure needed to push the sample through has proven to be above 8 PSI for accurate results; the lower the pressure, the slower the sample reads. And the slower the sample reads, the more opportunity for temperature variation. These are some considerations that should be taken into account when looking to use the CBox in a brewery.

As stated previously, the CBox has improved processes tremendously and continues to do so. The next step in using the instrument is to provide a timeline for shelf-life monitoring. Measuring the DO_2 on a consistent basis in the bottle from package until the expiration date will be useful data to collect in the future. Using this data along with a tasting panel will help determine when oxidation is present and is a detriment to the presentation of the product.

References

[1] White, Chris, and Jamil Zainasheff. *Yeast: The Practical Guide to Beer Fermentation*. Boulder, CO: Brewers Publications, 2010. Print.
[2]Benedict, Chaz. "Benchmarking Dissolved Oxygen Content: What Is the Industry Standard?" *Tap Into Hach*. Hach, 14 May 2012. Web.