Crafting a More Consistent Brew – Fork Density Meter (FDM)

Crafting more consistent beer quality

Christian Grossenbacher from Emerson, explains how the latest measurement technology helps craft brewers to increase visibility into the fermentation process and improve quality consistency

The number of craft breweries in the US has increased rapidly over the past few years, with California alone now having over 600, and Colorado more than 300. According to the Brewers Association, 24,868,276 bbls (barrels) of craft beer were sold in the US in 2017, and the country's craft beer market is expected to grow at a 17.6% CAGR by 2021. Many apportion this growth to Americans becoming worldlier and more knowledgeable about the wealth of products available to them, and with this greater awareness comes an increased demand for product consistency. When a consumer discovers a beverage they enjoy, they expect it to have the exact same flavour, appearance and quality every time they purchase it. Consequently, as craft brewers compete for a slice of this lucrative market, they are becoming increasingly focused on the need to ensure greater consistency and repeatability in terms of their product quality.

Of course, there are many aspects to improving consistency in the brewing process, including implementing better production processes, fully understanding aseptic techniques, isolation of pure cultures, and perfecting techniques for enumerating, staining and screening brewing yeast and contaminants. These are all essential to producing a product that meets a specification and agreed quality levels. Measurement technology also has a central role to play in producing consistently high-quality beer. Density and temperature are key variables that need to be measured when brewing, and perhaps the most important aspect of establishing consistent quality is performing and evaluating these measurements during the fermentation process. Density and temperature measurements enable brewers to calculate the wort's specific gravity and establish its sugar content, to know when the fermentation process has finished.

Density Measurement

Within craft brewing, a hydrometer is typically used in the measurement of density. To achieve this, samples of the wort will be syphoned from the fermentation tank throughout the fermentation process. The brewmaster will then perform a manual density measurement using the hydrometer. Once the density is known, a separate temperature measurement needs to be taken. This is because specific gravity relates the density of the wort to the density of water at the same temperature, and therefore any variation in the temperature of the wort will affect its density. This would then require the brewmaster to make a manual calculation, using an adjustment table, to compensate the specific gravity measurement.

Water has a specific gravity of 1.000. Before fermenting, the wort contains sugars which will make it denser than water, therefore giving a higher hydrometer reading – usually in the range of 1.038 to 1.050. This reading is known as the original gravity. During the fermentation process, yeast converts sugars into alcohol and carbon dioxide. Because alcohol in water is less dense than sugar in water, the specific gravity will change, becoming closer to that of water. When the hydrometer reading remains unchanged for two days, the fermentation process is deemed to have finished, and this reading is then known as the final gravity. In beer, this is in the range of 1.015 to 1.005. A comparison of the original gravity and the final gravity is then used to calculate the beer's alcohol concentration.

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Although this method of measurement is widely used within the industry, it has certain drawbacks, including:

- Hydrometers are designed to operate at a specific temperature. If there is any variation in the temperature of the beer, this will affect its density and necessitate a manual adjustment to the specific gravity measurement.
- Testing requires large sample sizes, and whenever a sample is taken from the fermentation tank, it is put into a graduated cylinder for measurement and then discarded, to prevent contamination. The fermentation process can last from 5-7 days for ales, up to around 30 days for lagers. As multiple samples need to be taken over the course of the fermentation process, from numerous fermentation tanks, this can add up to a significant total amount of wastage.
- When the brewmaster opens a fermentation tank to take out a sample, the risk of contamination is significantly increased.
- As with any manual task there is always the risk of human error, even with a skilled brewmaster. Although the sampling process is not overly complex, the brewmaster must still be trained to use a hydrometer and to make calculations using a coefficient table that adjusts readings to compensate for temperature differences. Many samples may have to be taken every day, and mistakes can happen.
- As the measurement process is not continuous, it is not known when the fermentation process has ended. This can then affect both throughput, with the product remaining in the fermentation tank longer than necessary, and product quality.
- Manual measurements limit the possibility of comparing the fermentation process with previous brews because compiling and analysing data sets is a complex, laborious and time-consuming process, requiring resources that may not be available.

Fork Density Meters

Given these drawbacks, the brewing industry is increasingly adopting disruptive technology in the form of fork density meters to provide the brewmaster with highly accurate inline measurements that will help to achievegreater product consistency. Fork density meters use direct insertion sensors to provide real-time continuous density measurement to an accuracy of ± 1.0 kg/m^3.

A vibrating fork is used to measure density. The density of the liquid in which the fork's prongs vibrate changes the resonant frequency of the meter. By monitoring this resonant frequency and applying well-known conversions, the meters can provide highly accurate inline density measurement. Using this technology provides various advantages over the manual measurement method.

As well as providing highly accurate density measurement, fork density meters also have an integrated temperature measurement and can calculate specific gravity internally, eliminating the possibility of human error having an adverse effect on the final quality of the beer.

By knowing the specific gravity continuously, brewers will then gain awareness of precisely when primary fermentation has finished. This means that the product can then be emptied from the fermentation tank at the earliest opportunity, for either bottling or secondary fermentation, allowing the tank to be cleaned and a new batch moved in, thereby improving throughput and increasing efficiency. Also, knowing precisely when primary fermentation has finished enables the tank to always be emptied at the exact same point in the process, to achieve greater consistency from batch to batch. It is important to move the beer out of the tank as soon as possible because once primary fermentation has finished, oxygen will begin to affect the beer, which then produces a stale flavour.

Also, the yeast can start consuming ingredients other than the sugar, leading to some unpleasant flavours in a process known as autolysis.

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Consistent Quality

Gaining visibility into the fermentation process is critical in improving that process and consequently the quality of the beer that is finally produced. Here, the flavour, appearance and quality of the beer will vary the most if the process changes from batch to batch. The measurement data provided by a fork density meter can be studied and interpreted by brewers to give them a clear understanding of what happened during the fermentation process and enabling them to see whether the data differed from their expectations.

Because a fork density meter is a highly repeatable device, the data it produces enables brewers to make minor adjustments from batch to batch to achieve greater product consistency. If the original gravity and final gravity values are not as expected, the brewer can adjust the ratio of ingredients or the boil time for the next batch. This helps to achieve consistent original gravity and final gravity values, and consequently improves the consistency of ABV% values. The data gained from improved visibility into the fermentation process enables brewers to build a process model which can then be repeated to improve product consistency. Measurement data can be sent directly to a PLC or control system or can be read via a local display and user interface that allows for simplified device management.

To improve device reliability, the latest fork density meters incorporate diagnostics to check the meter for measurement alarm conditions, sensor integrity and the presence of coating, erosion or corrosion. This technology expands the availability of diagnostics information and prevents the need to perform unnecessary recalibrations, resulting in significant reductions in maintenance costs and cycle times. Power is usually available at the fermentation tanks, but if no communication cables are available, fork density meters can now communicate over a WirelessHART® network.

Fork density meters are particularly suitable for craft brewing applications because as well as providing accurate and reliable measurements in fermentation tanks, these easy-to-install meters can also be used to enhance measurement at various other points throughout the brewing process.

Conclusion

Measurement technology has a key role to play for today's brewers. In the crucial fermentation process especially, the highly accurate continuous measurements provided by fork density meters are enabling brewers to improve their product's quality consistency, helping to keep their customers happy.

To learn more about fork density meters visit *www.Emerson.com/en-us/catalog/micro-motion-density-fdm*

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