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MASTER BREWERS ASSOCIATION OF THE AMERICAS

Aspects of in-line instrument measuring principles for alcohol determination with introduction of a new, low cost method

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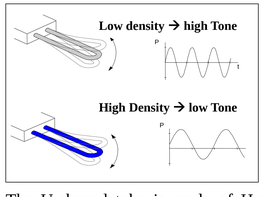
Introduction:

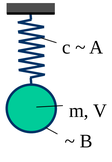
In most countries, alcohol is one of the most important components to measure in beer due to regulatory and compliance requirements. The history and further development of the methods and the most important theoretical and practical aspects of in-line alcohol measurement are described in this poster.
Historically in the laboratory, distillation and density/refractive index methods were used. In the late eighties, sound velocity and the alcohol combustion cell started replacing refractive index. By the end of the nineties Near Infrared (NIR) started replacing these methods and is now the most commonly used method in the laboratory.
In-line instruments using NIR or density/sound velocity were introduced in the late eighties. New NIR methods using Attenuated Total Reflection (ATR) are now also popular.

Measuring principle of in-line instruments:

1. Density:

Density is one of the most important measuring parameters for concentration determination in a brewery. For most in-line instrumentation the oscillating U-tube principle is applied: **Density = Mass / Volume = A * P² - B** (P … period)

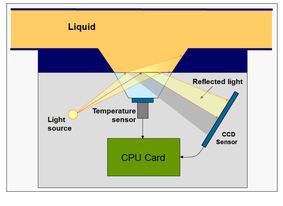




The U-shaped tube is made of Hastelloy C276 and is excited to a continuous oscillation at its resonance frequency by means of a magneto-electrical excitation system. The oscillation frequency is directly related to the density of the beer flowing through the tube.

2. Refractive Index:

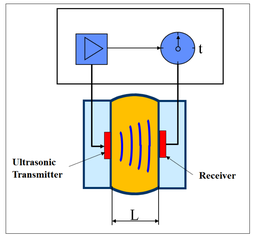
A digital process refractometer, determines the refractive index by measuring the critical angle of total reflection. The position of the light/dark line is a function of the refractive index of the beer and is detected by an optical Charged Coupled Device (CCD) sensor.



3. Sound velocity:

The measurement of the sound velocity is defined as the measurement of the propagation time of a sound pulse through the beer. The sample flows between two piezos, one a transmitter, the other a receiver.
The electronics measure the propagation time and calculate the sound velocity:

Sound Velocity $Vs = \frac{Length\ L}{Time\ t}$

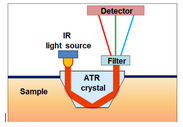


4. Measuring principle based on IR absorption:

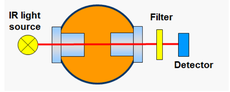
This measurement principle is based on the absorption of infrared light in a sample. Depending on the wave length, the absorption can be measured in transmission method or Attenuated Total Reflection (ATR) method. There are only a few wave lengths where the absorption by ethanol is higher than that of water.

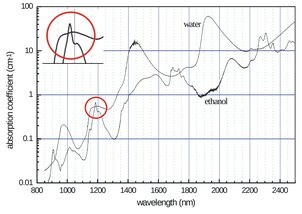
At low wave lengths the absorption can be measured in transmission. E.g. at approx. 1200nm the transmission length is 8mm, at approx. 2230nm the transmission length can be only 1 mm. At higher wave lengths only the ATR method can be used due to the high absorbance. As other components, like water and extract, absorb light, a reference measurement is also necessary to filter out the specific concentration signal. Additionally, the absorption changes with the transmission length and penetration depth of the ATR method. Complex sensor designs and mathematical models are necessary to determine the specific concentrations.

Attenuated Total Reflection (ATR):



Tranmission:

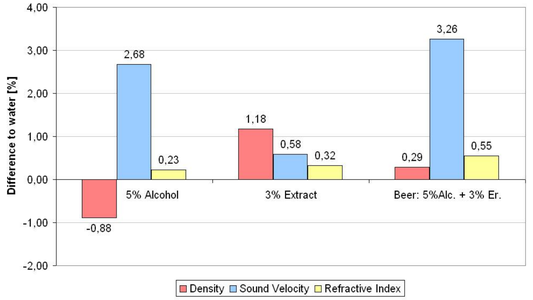




Measurement by transmission in Alcolyzer

Is a low cost alcohol measurement possible?

Density, sound velocity and refractive index are influenced differently by the alcohol and extract of beer:



The alcohol increases the sound velocity strongly and decreases the density. There is only a small influence on the refractive index. Extract increases mainly the density and has a moderate influence on sound velocity and refractive index. From this, it is obvious that the best combination for determining the alcohol and real extract is done by a combination of sound velocity and density.

If the alcohol is of more interest, a new, low cost Beer Monitor Basic based on sound velocity can be applied, which considerably reduces the total cost of ownership. Similar to the Beer Monitor, using density and sound velocity, the alcohol (and original extract) content are determined from the sound velocity and a stored average density of the beer brand. Variations in real extract / density have only a very small influence on the alcohol reading. E.g. a change of 0.001 g/cm³ results in a deviation of only 0.06 % ABV. As density is not measured, the real extract can not be determined. If necessary, a density measurement can be added at any time to determine the real extract content and increase the alcohol accuracy.

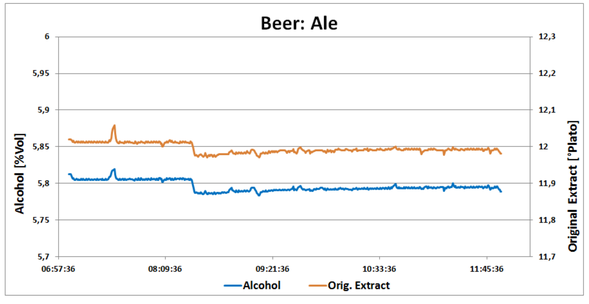
Results in comparison to the Alcolyzer:

Max. deviation	Beer Monitor	Beer Monitor Basic
Alcohol	±0.03	±0.06
Original extract	±0.06	±0.10
Extract	±0.04	±0.15*

* Calculation from stored value only

Results of a trial installation:

A test with the Beer Monitor Basic was made in a craft brewery in Pennsylvania. The test was running for 6 weeks testing four beer brands of a variety of styles. The stability of measurement and the correlation with a reference measurement in a lab was of interest, especially deviations from batch to batch variations. The reference instrument in the laboratory was an Alcolyzer



BEER MONITOR BASIC / ALCOLYZER COMPARISON

Brand	Date	Alcolyzer Alcohol [%v/v]	Beermon Alcohol [%v/v]	Deviation Alcohol
Beer-1	02.05.07	4,51	4,55	-0,04
Beer-2	03.26.14	5,15	5,09	0,06
Beer-2	03.26.14	5,14	5,09	0,05
Beer-3	04.03.14	6,71	6,75	-0,04
Beer-3	04.03.14	6,71	6,76	-0,05
Beer-3	04.03.14	6,72	6,75	-0,03
Beer-2	04.08.14	5,32	5,32	0,00
Beer-2	04.08.14	5,32	5,33	-0,01
Beer-4	04.17.14	9,43	9,37	0,06
Beer-4	04.17.14	9,42	9,38	0,04
Beer-4	04.17.14	9,42	9,36	0,06

Summary:

The stability of measurement was excellent. Also batch to batch variations did not show large deviation. Both filtered and bottle conditioned beer were tested and showed equal accuracy.

The Beer Monitor Basic is an easy to install low cost solution. It does not need any maintenance and has a good accuracy and repeatability. Ideal for checking the alcohol content of beer before filling.

Anton Paar