

Improving Brewhouse Loss Measurements with Coriolis Technology

Introduction

Many brewers have standardized on volumetric flow measurement. A change to Coriolis technology and direct mass flow measurement can improve loss measurement and tracking in a couple of ways. The information that Micro Motion® Coriolis technology can provide may also lead to improvements to process control. First, let's consider how losses are measured and the errors that volumetric flow measurement can introduce.

How are losses measured?

Losses may be measured by the change in volume of wort as it moves through the brewhouse. Using volumetric measurement only, *the drop in wort temperature between the Brewkettle and the Cold Wort Receiver could cause as much as a +4.25% error in the loss measurement.* This reduction of volume with a drop in temperature is sometimes referred to as "shrinkage." Accounting for shrinkage is difficult because it is not linear with temperature. A 15 °P wort¹ will shrink 1% when it is cooled from 210 °F to 190 °F (98.9 °C to 87.8 °C) but only 0.8% from 190 °F to 170 °F (87.8 °C to 76.7 °C).

Another way to measure loss is by the change in amount of extract. The total extract can be calculated if you know the average °Plato and the total pounds of wort. Since mass flow measurement is not available to all brewers a modified formula that uses volume has been used. This modified formula is only valid when the wort being measured is at 68 °F (20 °C) and the °Plato number used is a weight based average.

Correct formula:

Pounds of Extract = (°Plato / 100) X Pounds of wort

Modified formula:

Pounds of Extract = (°Plato / 100) X Barrels of wort X Pounds per barrel @ 68 °F

Assuming that a representative °Plato number is used, this formula only introduces an error of -0.12% if the wort is at 50 °F, which is typical of wort entering the starting cellar. *Using the modified formula on wort at 170 °F (76.7 °C) can result in an error of about + 2.5%.* A positive error indicates more extract than there really is (See Table 1).

In some cases the °Plato used is measured in a grab sample and may not be representative of all of the wort due to segmentation in lines or stratification in vessels. *This segmentation is another source of error.*

What benefit does Coriolis technology provide?

Micro Motion Coriolis technology helps provide accurate brewhouse loss measurements in two ways: Flow measurement is reported directly in mass units, the units required for accurate calculation of the pounds of extract. A Coriolis flowmeter provides °Plato measurement on a continuous basis which is especially important when measuring Lauter Tun run-off (Figure 1).

Using the information gathered from a Coriolis sensor, total extract is calculated by integrating the product of °Plato and instantaneous mass flow:

$$\text{Pounds of extract} = \int \text{°Plato} \times \text{pounds/minute}$$

1. Degree Plato (°Plato or °P) is a unit of measuring for extract content of wort, the unfermented liquid from which beer is made. One °Plato, which is the same as one degree Balling, represents an extract content of 1% by weight.



°Plato	Wort @ 68 °F (20 °C)	Wort @ 50 °F (10 °C)		Wort @ 170 °F (76.7 °C)		Wort @ 210 °F (98.9 °C)	
	#/BBL extract	#/BBL extract	%Error	#/BBL extract	%error	#/BBL extract	% Error
14.0	272.6	273.2	-0.21%	265.9	2.52%	261.1	4.40%
15.0	273.7	274.3	-0.19%	26.0	2.52%	262.3	4.73%
16.0	274.8	275.4	-0.25%	268.1	2.52%	263.3	4.37%
17.0	275.9	276.5	-0.21%	269.1	2.54%	264.4	4.36%
18.0	277.1	277.7	-0.20%	270.2	2.55%	265.6	4.35%
19.0	278.3	278.8	-0.21%	271.3	2.56%	266.6	4.36%

Table 1. Error associated with using #/BBL extract for wort @68 °F (20 °C) for calculating #/BBL extract for wort at other temperatures

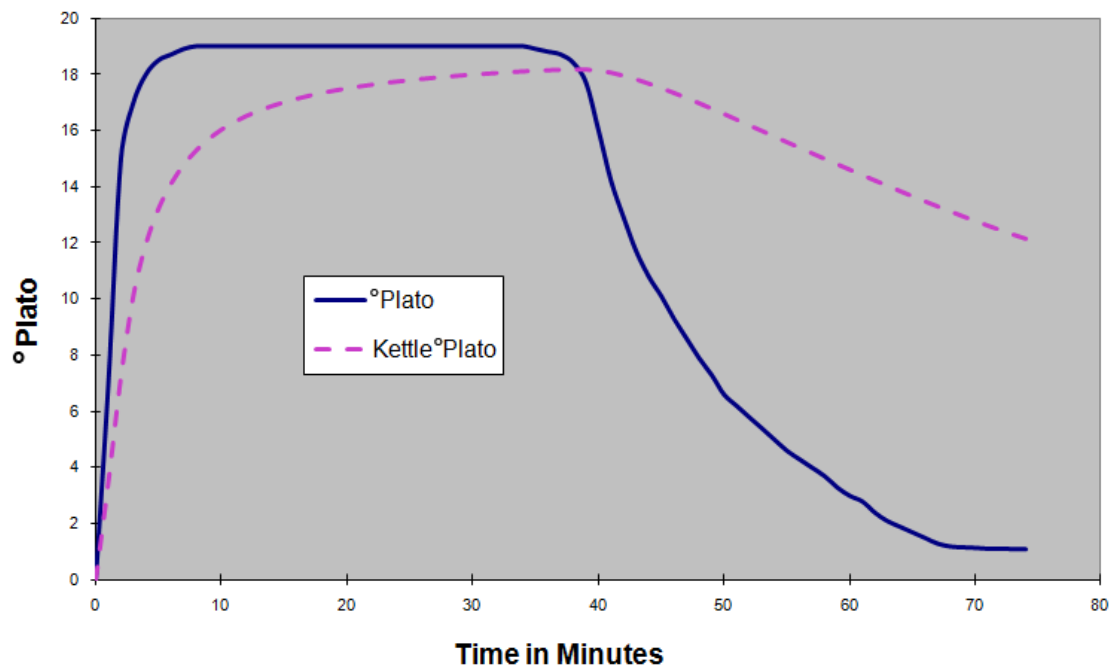


Figure 1. Lauter tun run-off °Plato and Kettle °Plato vs. Time

Improvements to process control

Some brewers use continuous °Plato measurement to track the progress of the brew through the Brewhouse. The °Plato of the wort can show whether the process is within the control limits. Many other benefits can be realized. Some of the locations that Coriolis meters could be installed are:

- after the Lauter Tun for immediate yield from malt and adjuncts
- after the Hop Strainer to evaluate its performance
- after the Hot Wort Receiver to identify carry over of trub
- after the Cold Wort Settler: for an accurate starting cellar °Plato or for an accurate loss measurement across the brewhouse

Examples

Let’s consider two identical process lines intended to have a 15 °P starting cellar. One brewhouse will use volumetric flowmeters. °Plato measurements will be taken with a hydrometer.

The second system will use Coriolis technology for mass and volume flow, °Plato, total extract and temperature measurement.

The flowmeters and the grab sample °Plato in the first example provides the following information:

- First wort from the Lauter Tun was 18.8 °P.
- The 33 Barrel volume change after the Brewkettle was due to shrinkage and loss.
- There was volume change of 10 Barrels after the Hot Wort Receiver due to trub and wort loss and shrinkage.
- 14.5 Barrels were lost in the Wort Cooler due to shrinkage.
- One-half of a barrel of cold break and wort were lost in the Cold Wort Receiver.
- A total of 58 Barrels or 9.7% were lost in the Brewhouse due to evaporation, shrinkage and wort loss.

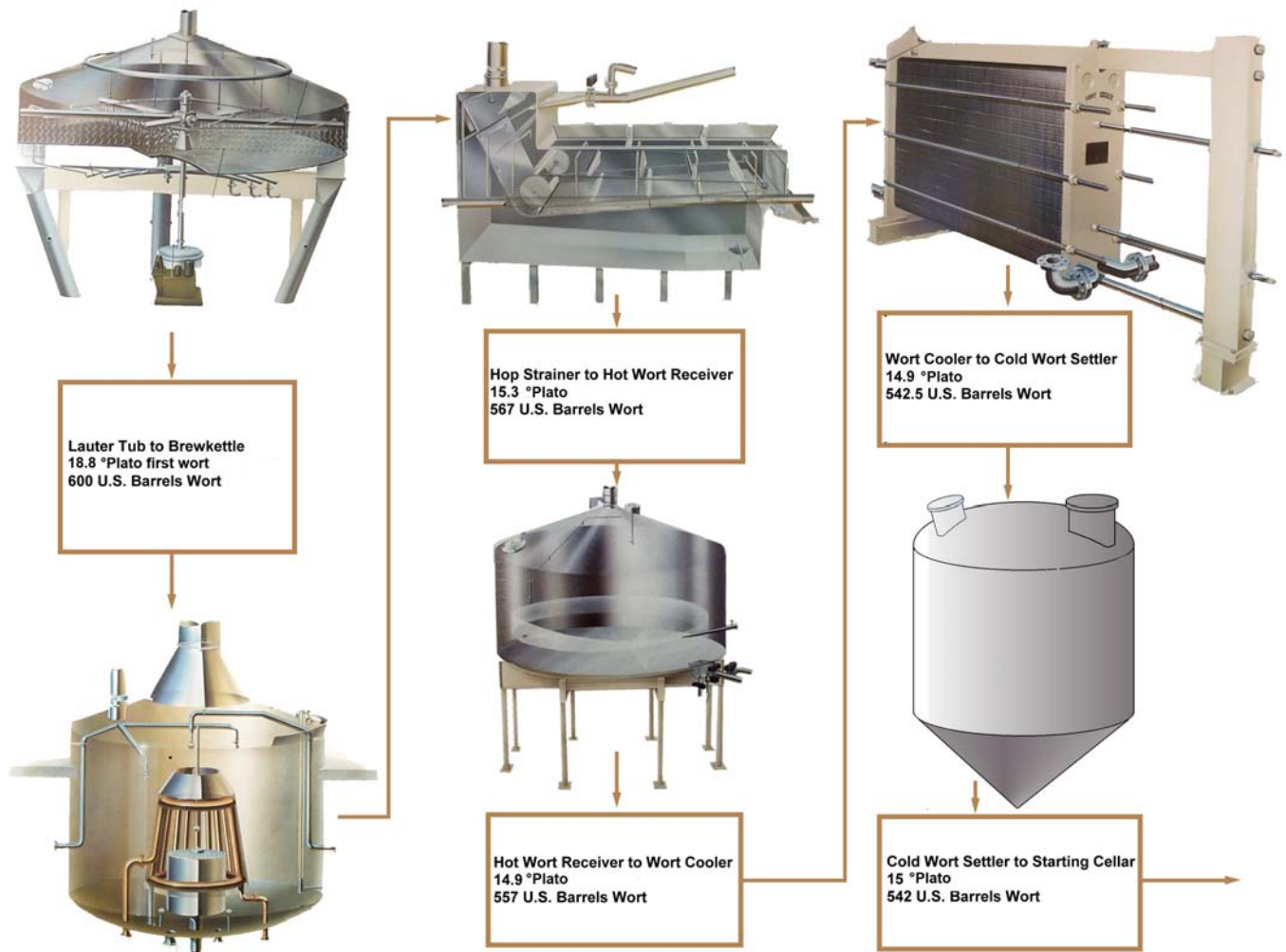


Figure 2. Example 1: Brewhouse with Volumetric flowmeters and grab sample °Plato measurement

The Coriolis flowmeters and the continuous °Plato measurement in the second example (see Figure 3) provides the following information:

- First wort from the Lauter Tun was 19 °P, last runnings were 2 °P. The average °Plato was 14.3 °P. Based on the grain bill, 23,232 pounds of extract were in the Lauter Tun, 1.5% of the extract was left in the Lauter Tun.
- 115 pounds of extract were lost with hops disposal at the Hop Strainer.
- The 33 Barrel Wort loss was due to Brewkettle evaporation and hops disposal.
- 369 pounds of extract and trub were lost in the Hot Wort Receiver.
- There were 14.5 Barrels of shrinkage at the Wort Cooler but no mass was lost
- 7 pounds of cold break and extract were left in the Cold Wort Settler
- 58 Barrels or 9.7% of wort were lost in the Brewhouse to evaporation, shrinkage and loss. Only 7% by weight or 11318 pounds of wort was lost. Of that only 521 pounds was extract or 3.7% of the starting extract.

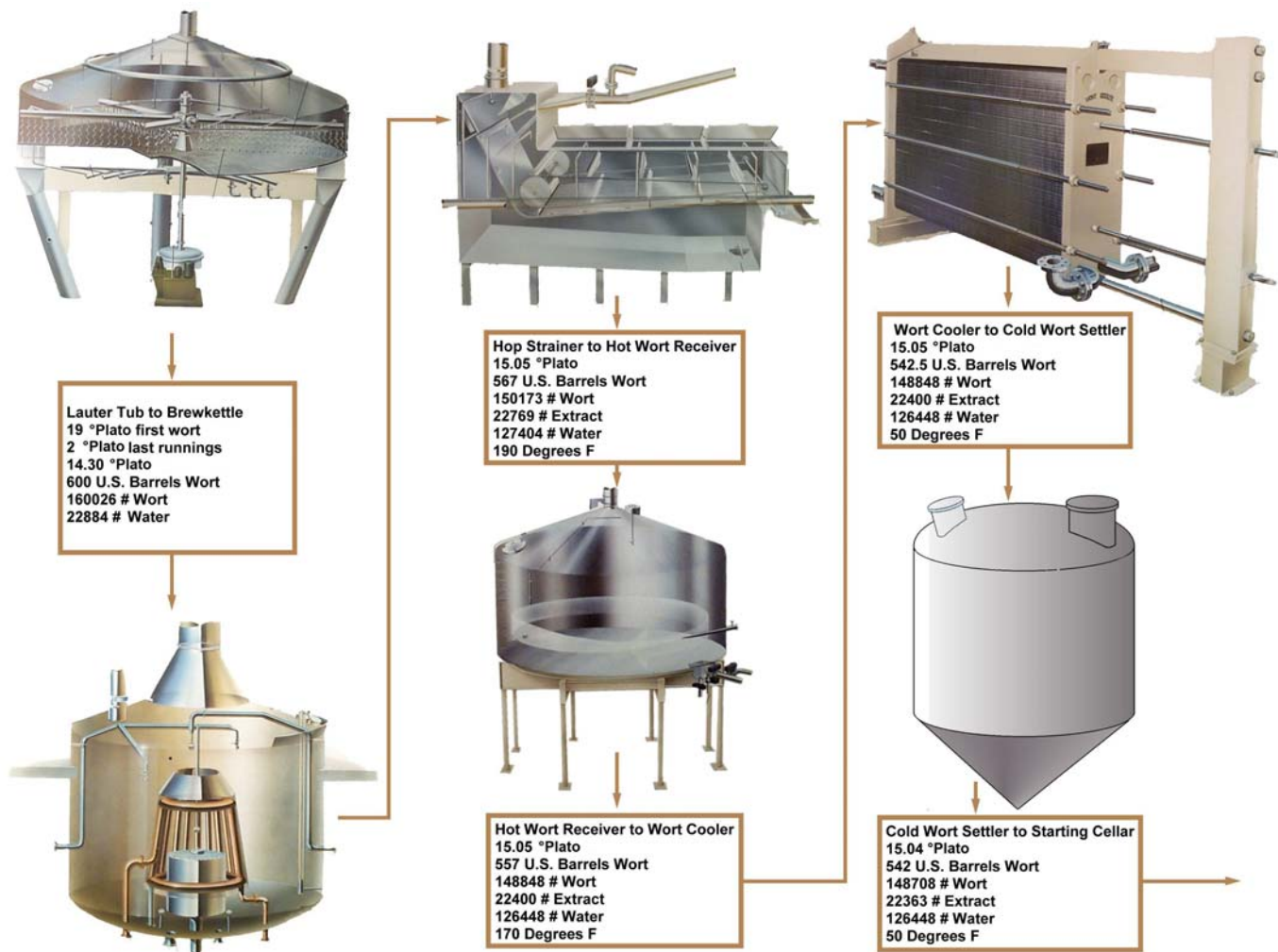


Figure 3. Example 2: Brewhouse with Coriolis flowmeters

Conclusions

An investment in Coriolis technology can provide information required for accurately calculating Brewhouse losses. This information can also be used to target the point and possible cause of the loss and improve process control by identifying changes in the process.

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Micro Motion, Inc. USA
Worldwide Headquarters
7070 Winchester Circle
Boulder, CO 80301
T +1 303-527-5200
+1 800-522-6277
F +1 303-530-8459

Micro Motion Europe
Emerson Process Management
Neonstraat 1
6718 WX Ede
The Netherlands
T +31 (0) 318 495 555
F +31 (0) 318 495 556

Micro Motion Japan
Emerson Process Management
1-2-5, Higashi Shinagawa
Shinagawa-ku
Tokyo 140-0002 Japan
T +81 3 5769-6803
F +81 3 5769-6844

Micro Motion Asia
Emerson Process Management
1 Pandan Crescent
Singapore 128461
Republic of Singapore
T +65 6777-8211
F +81 6770-8003

