Improving Brewhouse Efficiency for Small Brewers

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I brew on a 7 BBL system, why should I care?

- Improving from 82% to 90% efficiency can result in 45 lbs less malt used per brew
- Being inefficient is NOT artisanal
- It’s easy to do
- The methods for improving brewhouse efficiency can also improve your beer

Brewhouse Efficiency

- Brewhouse Efficiency is a measure of the amount of extract recovered in the wort compared to the amount of extract available in the malt.
- It is a measure of how efficient your mashing and lautering procedures are but does not take into account the boil or anything thereafter

Calculating Brewhouse Efficiency

- Number of pounds of each malt used
- Coarse grind as is extract % for each malt
- Gravity of wort in degrees Plato (P)

  - must be at 20^0 C (68^0 F)
- Volume of Wort

  - must be at 20^0 C (68^0 F)

What is the Coarse Grind as is %?

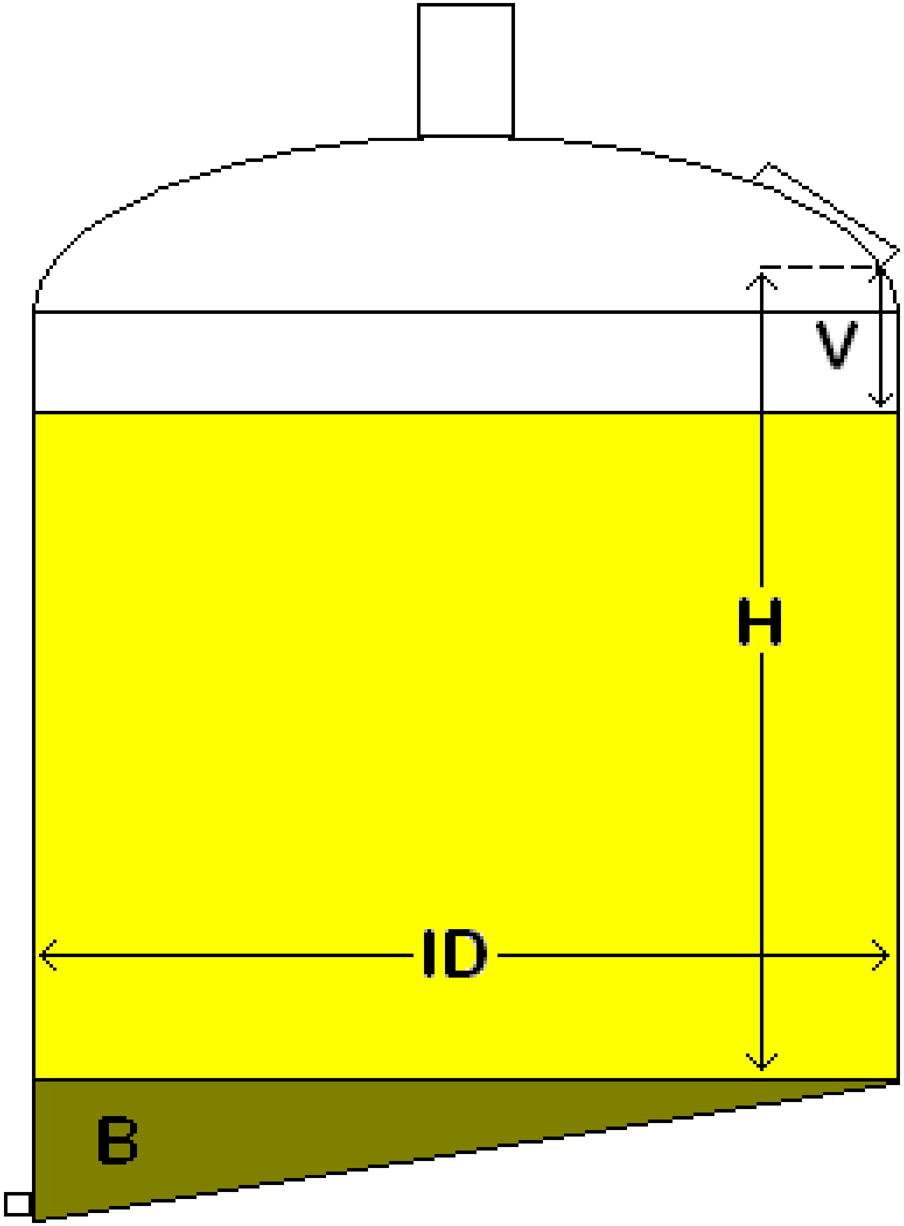
- Percentage by weight of extract obtained from the malt with a coarse grind in a laboratory mash
- Typically in the 75%-80% range for base malts
- Found on the malt analysis sheet available from your maltster

Accurately Determining the Volume of Wort

- Interior diameter of kettle in inches (often in 3” increments from 48” up) (ID)
- Volume of liquid in bottom “non-cylindrical” section of kettle in gallons(B)
- Sidewall height in inches (H)
- Volume measurement in inches from kettle man way (V)

Note: V is easiest to measure at end of boil, but the wort is at ≈ 100^0C

Wort Volume Calculation



Wort Volume Calculation

- Gallons per inch of sidewall

  $= \pi(ID/24)^2*7.48/12 = (GPI)$
- Volume of hot wort (at end of boil ≈ 100^0C)

  $= (((H-V)GPI) + B)/31$
- Volume of wort at 20^0C (W)

  = .96*volume of hot wort

W = .96*((((H-V)GPI) + B)/31)

Calculating Brewhouse Efficiency

- Extract / BBL = ((259+P)*P)/100
- Total extract = (Extract / BBL)*W = (TE)

i.e. 10 BBLs of hot 14 P wort

= (((259+14)*14)/100)*10

= ((273)*14)/10

= 382.2

Calculating Brewhouse Efficiency

- Total potential extract (TPE)

  $= \sum$(#’s of each malt)(CG as is %)

  i.e. = (500#’s pale malt)(.78 CG as is) + (50#’s crystal malt)(.74 CG as is)

  = 390 + 37

  = 427

Calculating Brewhouse Efficiency

- Brewhouse Efficiency = TE/TPE

$$= \frac{((259+P)*P)/100*(\text{wort volume})}{\sum(\text{\#'s of each malt})(\text{CG as is \%})}$$

$$= 382.2/427$$

$$= 89.5\%$$

		Brew 1	Brew 2	Brew 3
OG (degrees Plato)		14.5	13	14.5
BBLs of Wort (hot)		10.24	10.24	10.24
Kettle measurement (neg)		-10.50	-10.50	-10.50
		Pounds	of	malt
Grist Bill	CG as is	Brew 1	Brew 2	Brew 3
Base Malt	0.766	500	500	567
Wheat Malt	0.8			
Munich, Vienna, etc	0.76			
Crystal Malt	0.74	55	55	55
Roasted Malt	0.66			
Other	0.75			
Other	0.9			
total		555	555	622
Extract / BBL		39.66	35.36	39.66
Total amount of extract		389.69	347.46	389.69
Brewhouse efficiency		91.97%	82.01%	82.04%

Why do I keep using 82% as a low mark for brewhouse efficiency?

- We found that almost 25% of the Rock Bottoms were at or below 82% efficiency
- 33% had 89% - 91% efficiencies

What did we do about it?

- We looked at what the top third of breweries were doing to see what commonalities existed that lead to excellent efficiencies
- Four different tun manufacturers, all with v-wire screens and no rakes, in 8, 12, and 15 BBL single infusion systems
- Check out “Portland Mashing” on You tube

Factors That Affect Brewhouse Efficiency

Mash Parameters

pH of Mash

Mill Settings / Coarseness of Grind

Lautering Technique

Mash Parameters

- Low temperature mashes (65^0C - 149^0F)
  => lower extract
- High temperature mashes (70^0C – 158^0F)
  => higher extract
- Thinner mash – 3:1 or higher liquor to grist
  => higher extract
- Thicker mash – 2:1 liquor to grist
  => lower extract

Results for Mash Parameters

- No consistent differences!
- This is NOT the place to try to increase brewhouse efficiency. It is a place to use brewhouse procedures to make your beer taste the way you want it to.

Mash pH

- Correct mash pH leads to higher extract
- 5.5 – 5.6 @ 20^0C (68^0F)
- 5.2 – 5.3 @ 65^0C (149^0F)
- Sufficient calcium levels (over 50 ppm) in the mash lead to better β-amylase function

Results for Mash pH

- At the Portland brewery we noticed up to a 2% decrease in brewhouse efficiency when pH was at least .2 out of specification. i.e. 5.0 or below mash pH, or 5.5 or above mash pH at 149^{0}F

Mill Setting:
Using Sieves to Check Your Grind

- 8”dia x 2” deep testing sieves No 10, 14, 18, 30, 60, 100 and pan
- Available from McMaster-Carr for $44 per sieve and $25 for the pan and lid
- Mechanical shaker

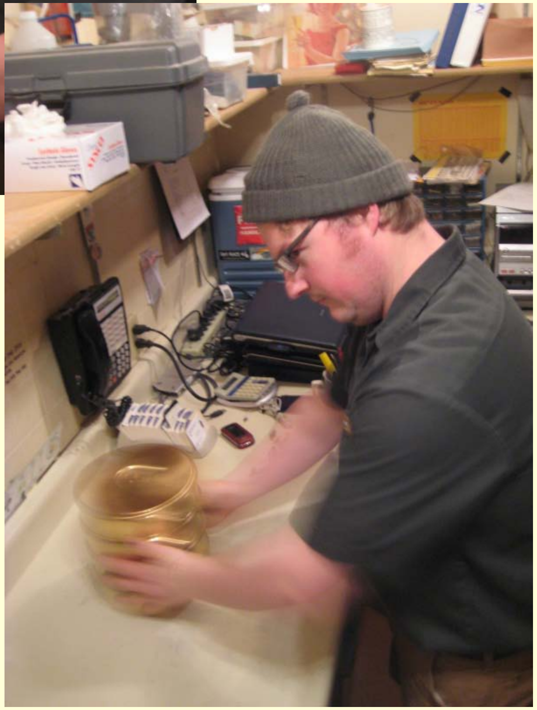
We just used 14, 18, 60 and pan - total cost under $175 with shipping

ASBC method Malt-4

- Use 100 – 130 grams of grist - about a cup
- A rubber ball in each sieve

ASBC method Malt-4

- Shake side to side for 15 seconds – tap
- Shake back and forth for 15 seconds – tap
- Repeat for 3 minutes



The sieves will separate the grist into fractions




Weigh each fraction and calculate percentages

Results for Mill Setting

- ALL of the breweries with a VERY coarse grind had good brewhouse efficiencies (89% and above).
- NO breweries with finer grinds had efficiencies in the 89% or higher range.

Results for Mill Setting

Sieve #	British Mash Tun	U.S. Craft Mash Tun	Rock Bottom
14	53%	31%	68%
18	14%	32%	12%
60	22%	27%	14%
Pan	11%	9%	5%

Data from MBAA Practical Handbook for the Specialty Brewer, Vol. 1, ed. Karl Ockert

Lautering Technique

- Loose, permeable mash bed
- Even bed consistency
- Even bed depth
- Proper run off speed

Darcy's Law

$$Q = \frac{K\Delta PA}{L\mu}$$

Q = flow rate

K = permeability of the filter bed

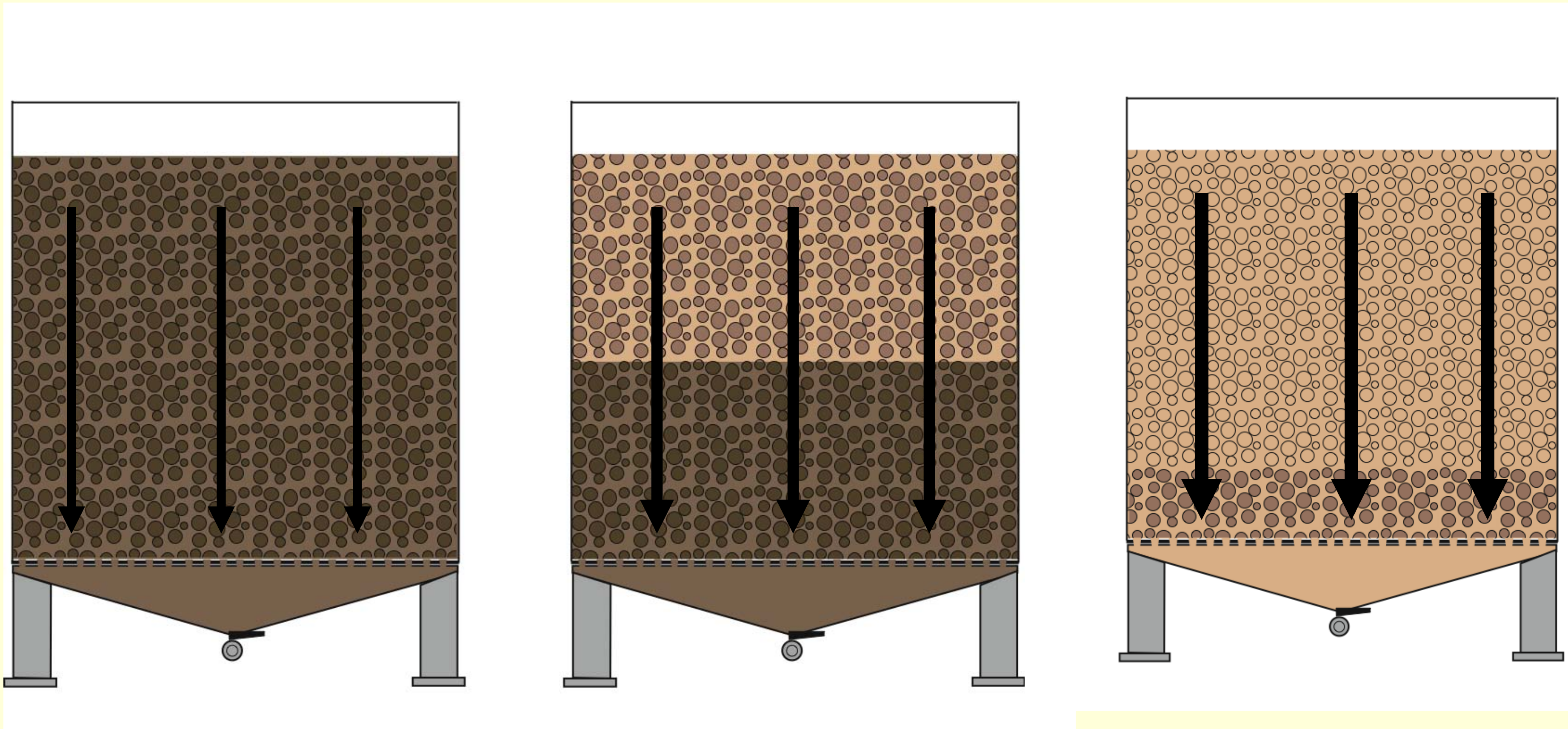
ΔP = pressure across the filter bed

A = surface area of the filter

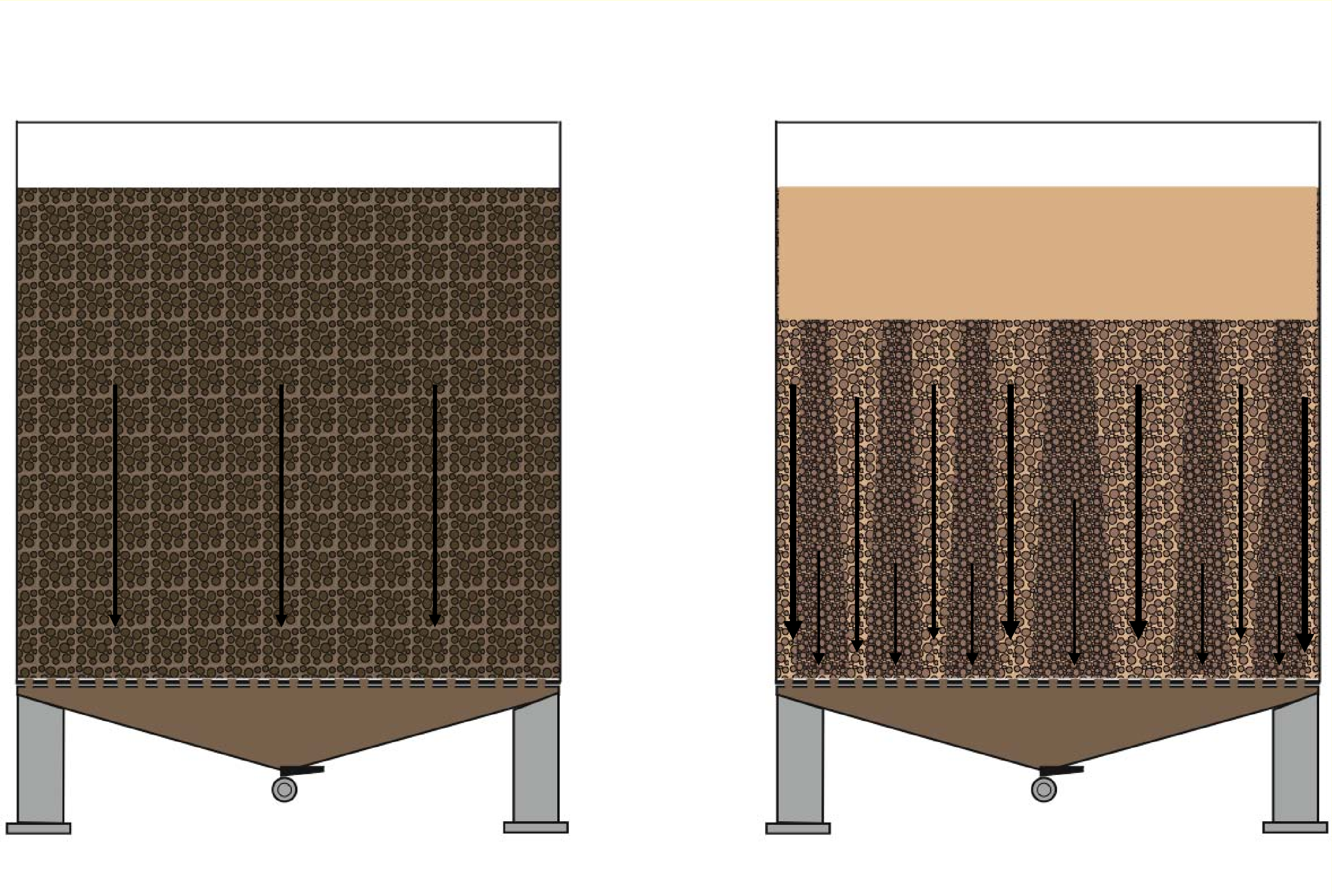
L = depth of the filter bed

μ = viscosity of liquid

Coarse grind leads to loose, consistently permeable mash beds



Finer grind leads to tight beds that may channel.



Rock Bottom Case Study #1

- Brewery initially at 86% brewhouse efficiency with 120 minute lauter times
- The brewer excessively stirred the mash during mash in and just before vorlauf, resulting in tight mash beds

- Changing to minimal stirring (just enough to ensure consistency and none before vorlauf) resulted in looser beds
- Efficiencies increased to 89%, Lauter times decreased to 90 minutes

- The mill was then reset to a more coarse grind

Sieve #	Initial Grind	New Grind
14	59%	71%
18	18%	10%
60	16%	13%
pan	7%	6%

- Efficiencies increased from 89% to 90.5%

Rock Bottom Case Study #2

- Brewery initially at 84.5% brewhouse efficiency with 60 minute lauter times
- The brewer slowed his initial lauter speed for the first third of lauter, then resumed his original speed
- The mill was also reset to the recommended coarse grind
- Efficiencies are now at 90% with 90 minute lauter times

Rock Bottom Case Study #3

- Brewery initially at 82% brewhouse efficiency, with tight, uneven mash beds

Sieve #	Initial Grind	New Grind
14	59%	67%
18	14%	12%
60	19%	15%
Pan	8%	6%

- The mash beds loosened significantly
- The previously uneven mash beds evened out
- Far less sparge liquor was seen migrating to the walls of the tun
- Brewhouse efficiencies increased to 89%

Recommendations

- Calculate your brewhouse efficiencies on a regular basis (record on brewsheet)
- Buy a #14 sieve with pan and cover then set your mill so that approx. 70% of your grist remains on the sieve

Recommendations

- Do whatever else you can to keep your mash beds loose and even (don’t over stir!)
- Run off slowly at first, then more quickly
- Use a pH meter, and keep your mash pH in the correct range

Thank You

- To all the brewers of Rock Bottom Breweries, past and present

- Vhavig@gmail.com if you would like a copy of the brewhouse efficiency spreadsheet