Mash Efficiency and Brewhouse Efficiency

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Definitions

Mash Efficiency: The percentage of the total possible (theoretical) sugars and dextrins from the mash that actually make it *to the boil kettle*.

Brewhouse Efficiency: The percentage of the total possible (theoretical) sugars and dextrins from the mash that actually make it *to the fermenter*.

Total Possible Sugars and Dextrins…

Total Possible (Theoretical) Sugars and Dextrins

- How much Sugars/Dextrins can you (theoretically) get from a pound of malt?
  - depends on the malt
- Determined by a "Congress Mash"
  - method provided by the American Society of Brewing Chemists, used to determine several attributes of a malt, including…
    - Extract Yield Dry Basis Fine Grind (DBFG)

What's Dry Basis Fine Grind?

Dry Basis Fine Grind (DBFG)

- Measures the theoretical maximum sugars and dextrins that can be extracted from a dried, finely ground malt, expressed as a percentage of the total (dried) malt weight.
- Example: a DBFG value of 80% means that a maximum of 80% of the weight of the (dried) malt can be extracted as sugars and dextrins.

Why do you keep saying “Dried?”

Dry Basis

- For the DBFG measurement, the malt is first dried to remove moisture.
- But the malt we buy contains moisture as part of its weight.
  - So 80% (for example) of a dried malt's weight is *not equal* to 80% of the weight of a malt that contains moisture.
    - An adjustment for Moisture is needed
    - Luckily, moisture content is included on malt analysis sheets

Points per Pound per Gallon (PPG)

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- PPG indicates the maximum "Points" of Sugars/Dextrins that can be extracted from One Pound of Malt in One Gallon of Wort.
- Example: 35 PPG means the theoretical maximum total gravity of a gallon of wort from a pound of malt is 1.035.

DBFG, Moisture, and PPG…

Computing Points per Pound per Gallon (PPG)

PPG = DBFG x (1 - Moisture) x 46.21 PPG

Example: If…

DBFG = 80%

Moisture = 4%

Then…

PPG = 80% x (1 - 4%) x 46.21 PPG = 35.5 PPG

Why multiply by 46.21 PPG?

What's the 46.21 PPG Multiplier for?

- 46.21 PPG represents pure sucrose
  - One pound of sucrose in one gallon of wort has a gravity of 1.04621
- Pretend a malt was made of pure Sucrose
  - Its DBFG would be 100% and Moisture would be 0%.
    - 100% x (1 – 0%) x 46.21 PPG = 46.21 PPG

So, malt PPG is referenced to sucrose PPG… the DBFG and Moisture indicate how much less extract is available from the malt as compared to the "ideal" of 100% sucrose.

Calculating Mash Efficiency

Mash Efficiency: The % of the total possible (theoretical) sugars and dextrins from the mash that actually make it to the boil kettle.

- Computing Total Possible Sugars and Dextrins from "X" Pounds of Malt
  - Suppose we have 10 pounds of a 38 PPG malt. The total possible "Points" (ignoring wort volume for now) , would be:

    (10 Pounds x 38 Points per Pound) = **380 Points**

Calculating Mash Efficiency continued….

Calculating Mash Efficiency (cont.)

- **380 Points** (from previous slide) are the maximum theoretical yield from our 10 Pounds of 38 PPG Malt.
- Suppose we actually got 6 gallons of wort into the kettle and it had a gravity of 1.048. We can say that the Points that made it to the kettle are:

  48 Points per Gallon x 6 Gallons = **288 Points**

Calculating Mash Efficiency continued….

Calculating Mash Efficiency (cont.)

So we have…

- **380 Points** theoretical Maximum
- **288 Points** actual to the Boil Kettle

Now we can compute our Mash Efficiency = (Points in the Kettle) / (Total Possible Points)

288 Points / 380 Points = 75.8% Mash Efficiency

But why not 100% Mash Efficiency?

Some Reasons We Can't Get 100% Mash Efficiency from Real Mashes

- some of the starches in the malt kernels are never converted to sugars and dextrins.
- some sugars/dextrins are left behind in the mash tun, trapped by the grains (i.e. "grain wort absorption")
- mash tun "dead space" (e.g. the space beneath a false bottom)…some sugars/dextrins left behind in the wort in that dead space.
- If wort is pumped from the mash tun to the boil kettle, some wort may be left behind in the pump/hoses.

How to Improve Mash Efficiency…

Some Ways to Improve Mash Efficiency

- Crush Grains Finer
- Reduce Mash Tun dead space (redesign tun)
- Reduce or eliminate pump/hose losses.
- Batch Sparge instead of “No” Sparge
- Fly Sparge instead of Batch Sparge
- Use more total water, thus leaving “thinner” losses. But note that a longer boil would be required.
- Control Mash pH

What about Brewhouse Efficiency?

Brewhouse Efficiency

Remember, Brewhouse Efficiency is a measure of the percentage of the total possible (theoretical) sugars and dextrins from the mash that actually make it to *the fermenter*.

So for Brewhouse Efficiency, the sugars/dextrins need to get all the way to fermenter (not just the boil kettle).

Brewhouse Efficiency Calculation

Brewhouse Efficiency Calculation

Continuing our example, with 380 total possible points in our mash, and 288 points (75.8%) making into the boil kettle...

Suppose after the boil, cooling, and transfer, we get 5 gallons of wort in the fermenter, with a gravity of 1.053. So, the points making it to the fermenter are:

53 Points per Gallon x 5 Gallons = 265 Points

Now we can compute our Brewhouse Efficiency =

(Points in Fermenter) / (Total possible Points)

265 Points / 380 Points = 69.7% Brewhouse Efficiency

Why is Brewhouse Efficiency (always) Lower than Mash Efficiency?

Mash Efficiency vs. Brewhouse Efficiency

- Brewhouse Efficiency is *always* lower than Mash Efficiency
- Brewhouse Efficiency accounts for losses happening *after* the boil, as well as before the boil. More losses mean lower efficiency.
- What are those additional losses that Brewhouse Efficiency accounts for?
  - Boil Kettle Dead Space
  - Hop/Trub Losses, i.e. wort absorbed/blocked by hop material and other trub that never makes it into the fermenter.
  - Kettle to Fermenter Hose/Pump/Siphon Losses

Which Type of Efficiency Is More Important?

- From a financial perspective (important to commercial brewers), Brewhouse Efficiency is an important bottom line, because it more directly depicts resources translating into product
- From a recipe design and formulation standpoint, it makes a lot of sense to think in terms of Mash Efficiency, because the stage for much of the beer's final character has been set by the end of the boil.

Why do some people claim Mash Efficiencies of greater than 100%?

Mash efficiency higher than 100% is impossible, and in real life, even getting very close to 100% is impossible, and indicates an error somewhere in the calculation. A fairly common error is to not take into account the *actual* volume of wort when taking an original gravity reading. For example, if you boil off more water than expected, the wort volume is lower and the gravity is proportionally higher. But there's not more sugar, it's just more concentrated, which does not affect actual efficiency.

Why do I get lower mash efficiency when I mash recipes with large grain bills as compared to recipes with smaller grain bills?

Recipes with larger grain bills (but the same pre-boil volume) require more total water, because of more grain wort absorption. So the ratio of absorbed wort to total wort (including absorbed) is larger. Therefore a smaller percentage of the total sugars/dextrins produced makes it to the kettle. The math (which also takes into account other types of losses at the mash/lauter stage) is fairly complicated. (BrewCipher includes a sheet for estimating mash efficiency changes when changing grain bill size and/or sparge method.)