Micro-brewing learning and training program

(LdV Beer School)

Program izobraževanja v mikro-pivovarstvu
(projektno gradivo)

Beer styles

Raw materials

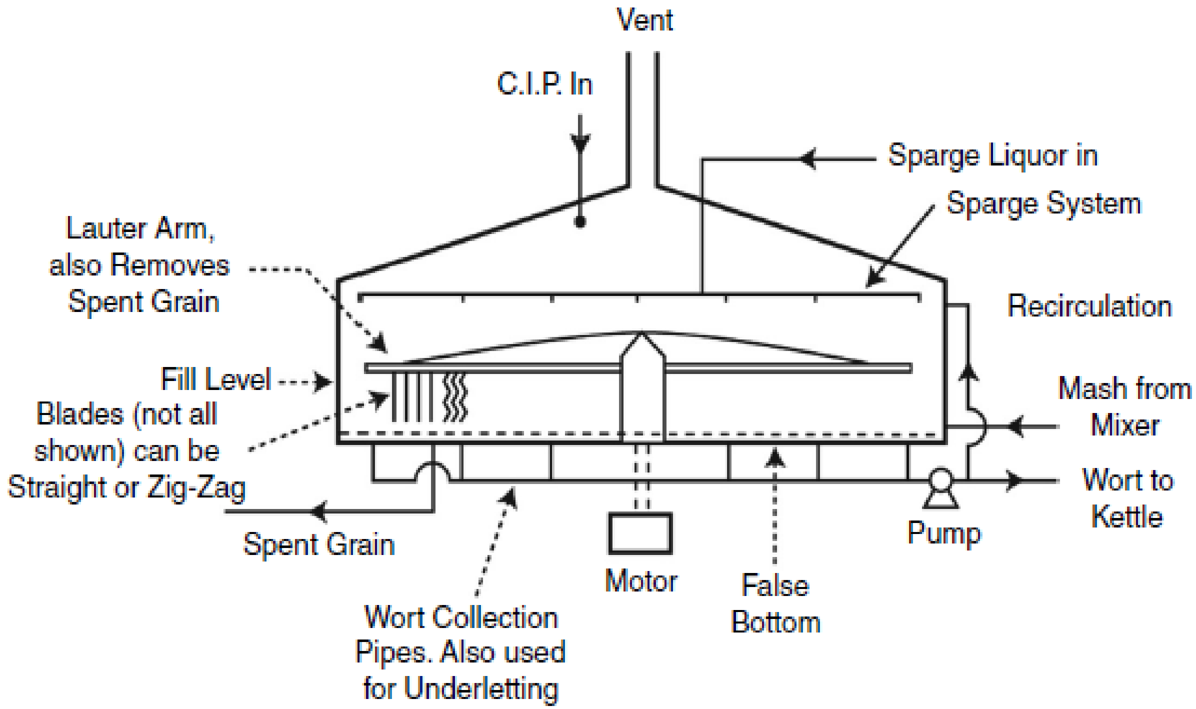
Brewhouse technology

- *mashing and mashing in*
- *lautering and wort boiling*
- *main fermentation and maturation*
- *filtration, filling and stabiliza*tion

Lautering

- Once mash conversion is completed and *the starch* has been broken down to sugars, the aqueous extract solution has to be separated from the insoluble malt solids to produce clear *sweet wort*.
- The method and the equipment used are mainly a matter of choice on the part of the individual brewer, and sometimes of tradition. Wort separation may be carried out by a number of different methods - the mash tun (described earlier), the lauter tun, the Strainmaster - or by several types of mash filtration methods.

Types of lautering devices

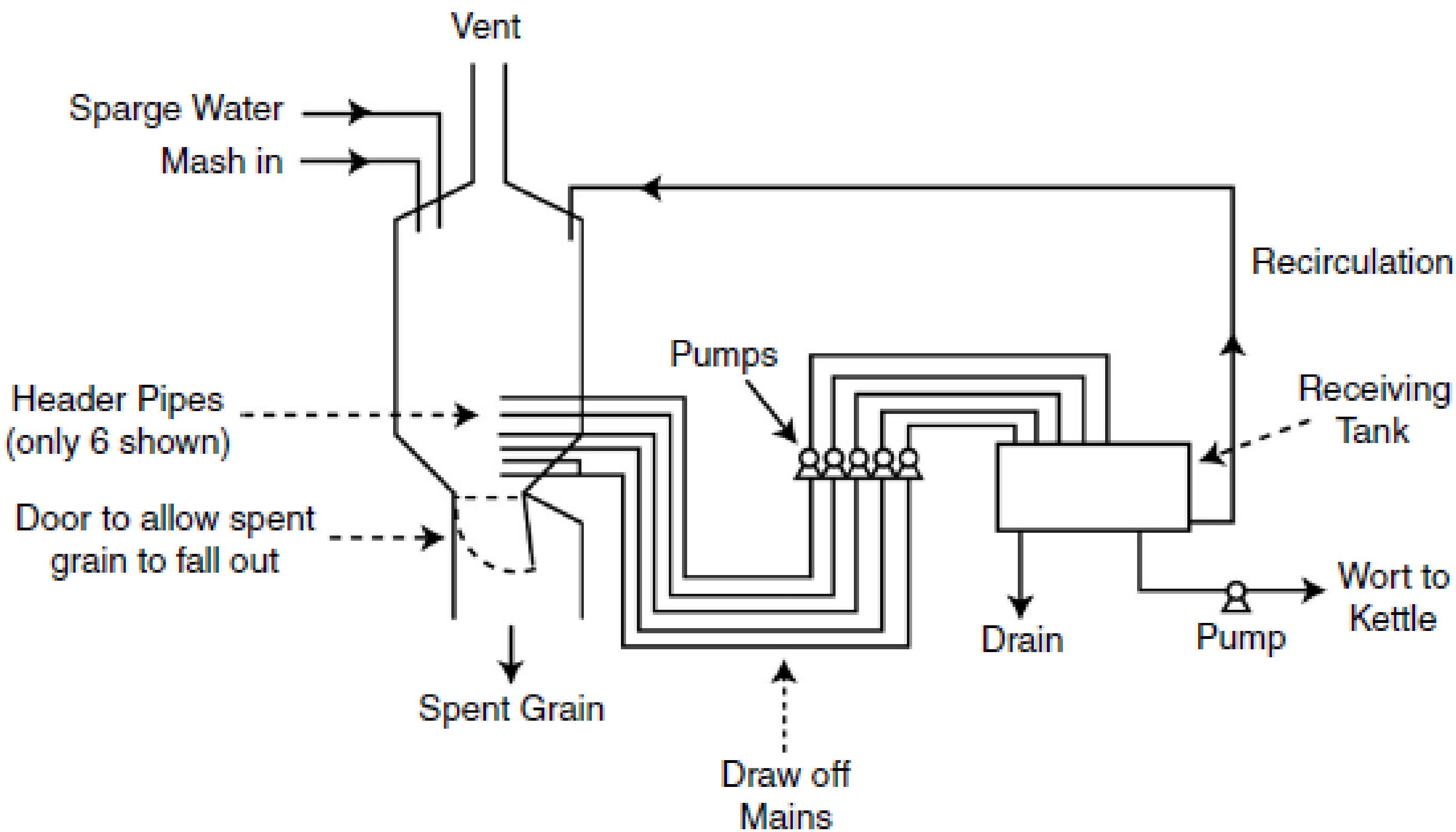


- **<u>The lauter tun</u>** is similar to a mash tun, but the bed depth used is shallower (around 0.5 m) and the vessel has a larger diameter and thus a greater surface area. This gives better filter performance and allows the use of finer grist, which results in higher extract rates. The false bottom consists of an open area comprising 10–22% of the total surface area. Below the false bottom, the base of the tun can be either flat or fitted with collection valleys. The design originated in central Europe and North America and is suited to these areas due to the use of undermodified malts and higher adjunct rates, respectively.

Strainmaster

- The Strainmaster was developed as an alternative to the lauter tun. The concept of this system was to increase the filtration area of the separation vessel by fitting a series of perforated straining tubes through which the wort is drawn leaving the grains inside the vessel.

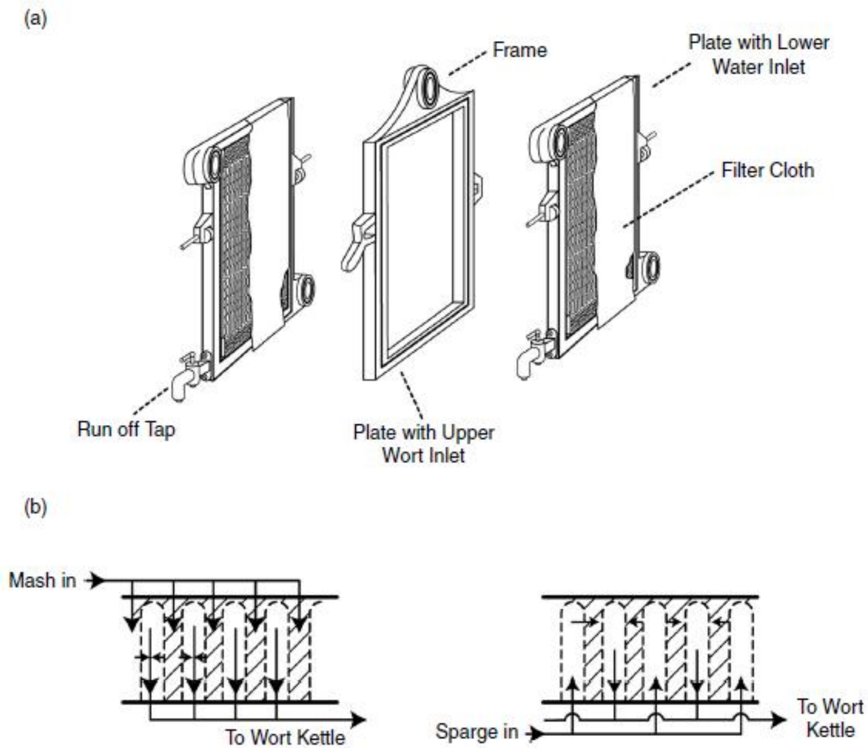
Strainmaster

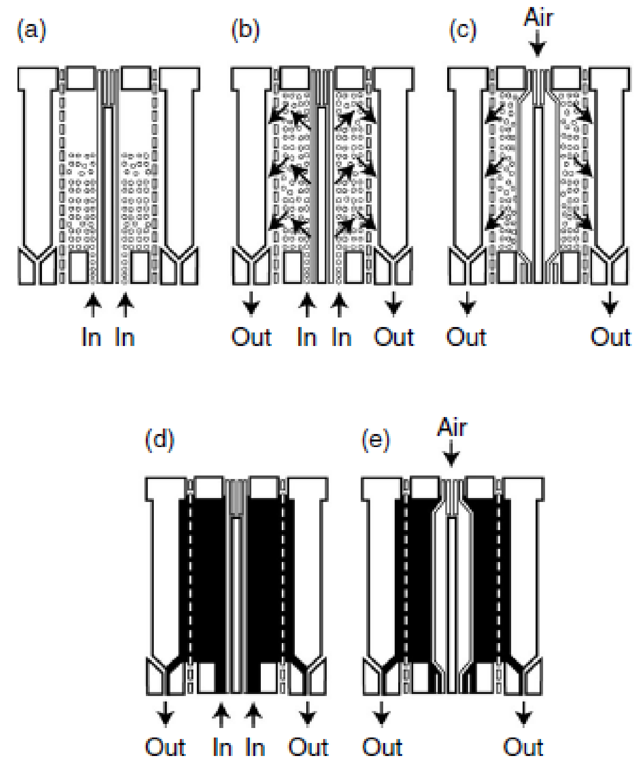


Mash filters 1/2

- **Mash filters** provide an alternative separation system to the lauter tun, but are not yet as widely used. Mash filters are similar to plate and frame filters; they consist of a series of grid-type plates alternating with hollow frame plates suspended on side rails. Each grid plate of the filter is covered on both sides with a monofilament polypropylene cloth.
- The mash filter optimizes the filtration conditions defined in the Darcy equation and is therefore able to handle very fine grist, thus ensuring excellent extract recovery.
- Mash filter grist is produced using a hammer mill.
- **Membrane Mash Filters** are defined by the incorporation of an inflatable rubber membrane into the polypropylene chambers that can squeeze the mash against a cloth.

Mash filters 2/2





Operation of a meura 2001 mash filter system. (a) Filling, (b) filtration, (c) precompression, (d) sparging, (e) compression.

Wort boiling

Hop-boil, which usually lasted for 1.5±2 h but sometimes longer, was regarded as a simple process, the only variations being the duration of the boiling period, the choice of hops, the hopping rate and whether the hops were added at the start of the boil, in the middle or near the end (late hopping, when aroma hops are added).

However, the need to reduce the cost of boiling has resulted in the testing of different technologies for saving energy and the difficulties encountered have emphasized the complexity of the boiling process and the necessity of balancing the changes that occur.

Manual of Good Practice ± Wort Boiling and Clarification

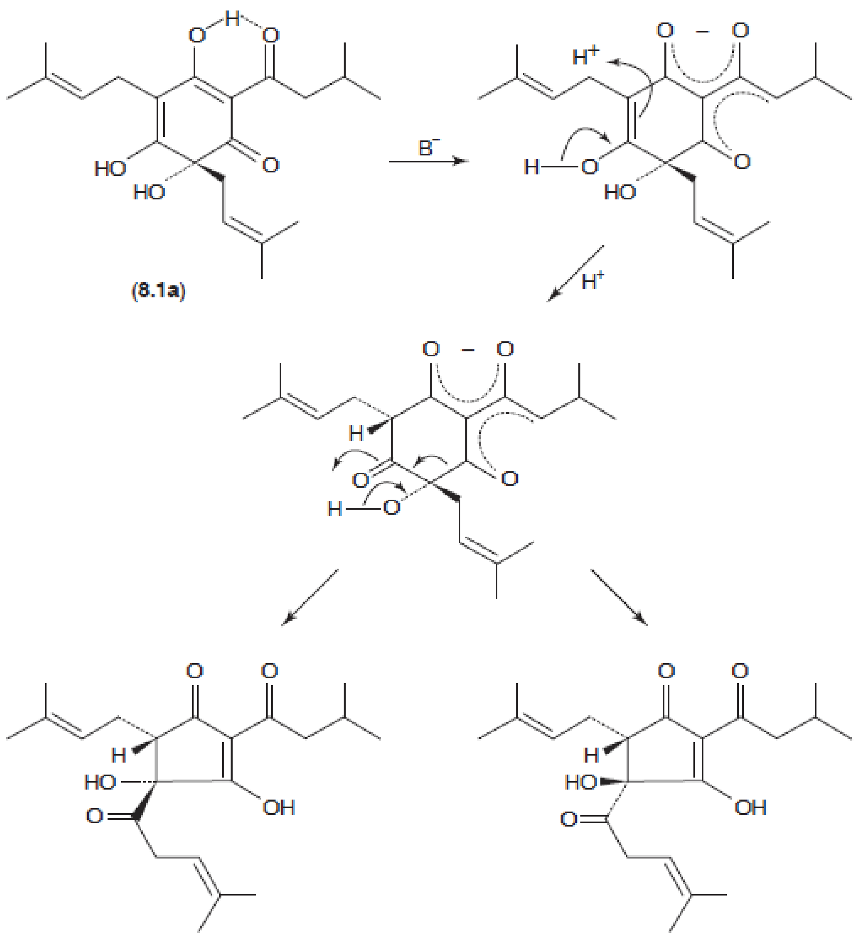
The **EBC** has published a manual (Denk et al., 2000) with the principal changes that occur during wort boiling as:

- 1. Inactivation of malt enzymes
- 2. Sterilization of the wort
- 3. Extraction and isomerization of compounds derived from hops
- 4. Coagulation of protein material in the wort
- 5. Formation of protein/polyphenol complexes
- 6. Formation of flavour and colour complexes
- 7. Formation of reducing substances to give the wort reducing potential, which is thought to protect the wort from oxidation later in the process
- 8. Fall in wort pH
- 9. Concentration of wort gravity through evaporation of water
- 10. Evaporation of volatile compounds in wort derived from mashing
- 11. Evaporation of volatile compounds in wort derived from hops

Isomerization of the α-acids 1/2

- In 1925 it was suggested that the hydrolysis of humulone to humulinic acid proceeded via an intermediate. It was originally called `***Resin A***' but later the name `**isohumulone**' was adopted for the parent of the **iso-α-acids**.
- The iso-α-acids are much more soluble in water (c. 120 mg/l) than the α-acids (3 mg/l) and nine times more bitter. To account for the formation of isobutyraldehyde, a second pathway leading to and `Resin B' (4-acetyl-humulinic acid) was proposed.
- Later the products of this second pathway were thought to be formed via allo-iso-acids. Less than 1 mg/l were found in beer. So the *iso-α-acids*, *isohumulone*, *isocohumulone* and *isoadhumulone* are the major bittering principles in beer.

Isomerization of the α-acids 2/2



(8.43a) *cis* (8.44a) *trans*

Types of wort boiling

- *Atmospherical* – most common (98-100°C).
- *Low pressure* – boiling up to 105°C at constant over pressure, shorter time needed (approx. 60 min.).
- *Dynamic low pressure boiling* – up to 105°C, changes of over pressure, combines best from previous two.
- *High pressure boiling* – up to 130°C commonly not used.

Heating of kettles

- Direct heating:
  - solid fuels (history)
  - liguid fuels
  - electrical heating
- Undirect heating:
  - oil bath
  - steam heating

Heating with solid fuels $\Rightarrow$ specific taste of beer

Types of kettles 1/6

- **Direct Fired Kettles**

  Traditionally, wort was boiled in large open vessels manufactured from copper. The term “copper” is still in use today as an alternative to “kettle” although few genuine copper vessels are still in use.

  Heating is by direct firing by either coal or gas, restricting the area of heat exchange to the base of the vessel, thus limiting the size of such vessels to not more than 330 hl. Another disadvantage is that the heating area becomes very hot causing rapid fouling with burnt wort.

Types of kettles 2/6

- **Kettles with External Heating Jackets**

  This design was intended to avoid problems with internal heaters by providing an external heating jacket. In order to promote turbulence, the jacket was placed on one side of the vessel only, resulting in a rather small heating area.

  To compensate for this, a mechanical mixing system is provided to ensure good heat exchange. Such kettles require less cleaning (every 6–12 brews), but tend to have problems with excessive foaming. Extractor fans are often installed in an attempt to control the process.

Types of kettles 3/6

- **Internal Heater with Thermosyphon**

  This system of wort boiling operates by using the natural circulation that occurs when a thermosyphon is created to produce a well-mixed boil at a pressure of 3.0–3.5 bar. A thermosyphon is established by the difference between the product of the wort head and density on the inlet to the boiling tubes (98°C) and the product of the two-phase head and density within and on the outlet side of the heater (105°C). As the two-phase density is much lower, a significant differential pressure exists, which is sufficient to generate flow rates equivalent to six to ten times the kettle volumeper hour. This is aided by concentrating devices and spreaders.

Types of kettles 4/6

- **External Heaters**
  The external wort boiler with forced circulation is a development of the above system, in which the heater is placed outside the vessel. Wort is pumped out of the kettle through the boiling tubes, where it may pass several times up and down the unit before being returned to the vessel. Wort is returned to the kettle through a venturi mixing tube with spreaders fitted above. The system is usually constructed as a combined kettle and whirlpool.

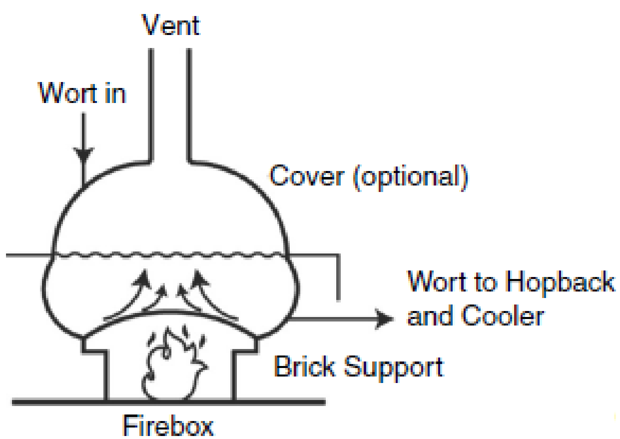
Types of kettles 5/6

- **Merlin System with Wort Stripping**

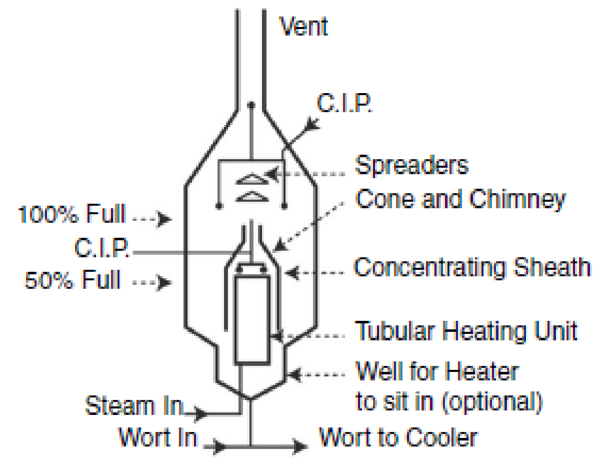
  This method is a departure from the aforementioned methods and makes use of a completely different vessel type and arrangement It was introduced by Steinecker in 1998. For heat exchange, the system uses a conical heating surface that uses falling-film and thin film evaporation during preheating, boiling, and an extra stage of wort stripping in place of tubes. The system is designed to be used with an energy storage system and the manufacturers claim an energy saving of 72% over conventional systems.

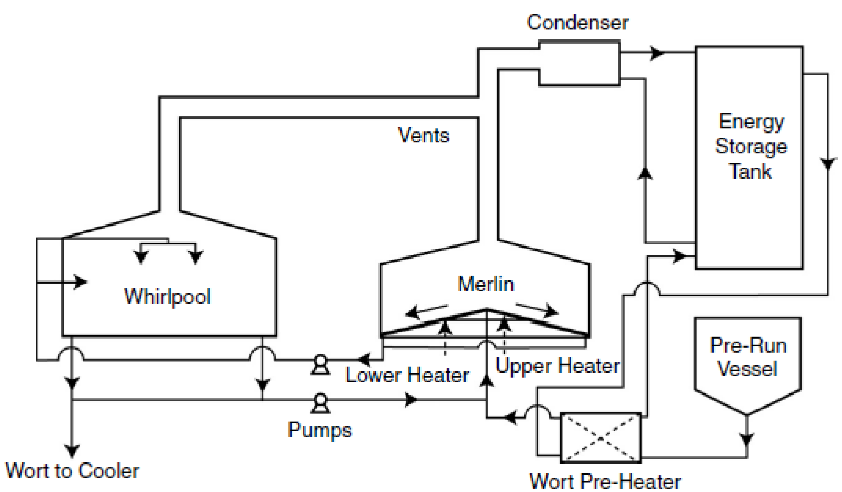
Types of kettles 6/6

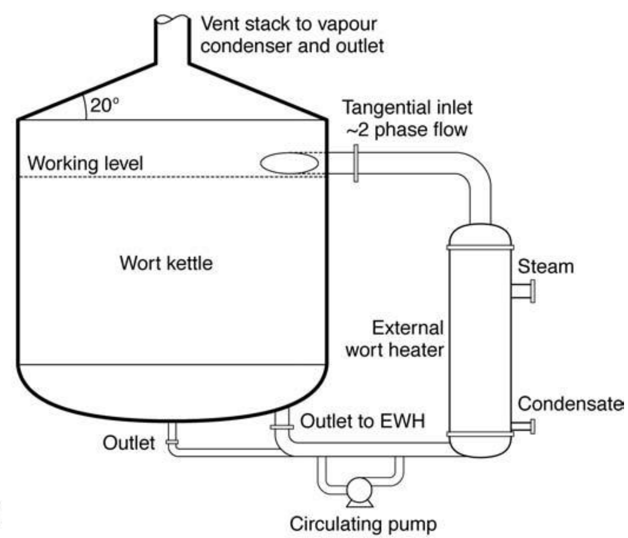
a)



(a)







(b)

Bitter-acids dossage calculation

$$\mathbf{W_{\alpha} = V_W * 0{,}92 * BU * 10 * k}$$

W_{α} - weight of alpha acids

V_W – volume of hot wort

0,92 – coeficient for cold wort

BU – bitter units

10 – recalculation from BU to mg of alpha

k – utilization of alpha-acids at brewhouse (brewery)

Typical dosage of hops

- **Most common are two or three batches during wort boiling.**

1st: 50% of total alpha – hop extract or high-alpha hops – only for bitternes, no aroma.

2nd: 25 – 35% of total alpha – usually semi-aromatic hops.

3rd: 15 – 25% of total hops – aromatic hops, usually 10 – 15 minutes before the end of boiling for aroma.

Other ways of hopping

- To Whirlpool – for aroma only, no problems with coloidal haze, aroma like during the wort boiling
- Dry hopping – to cold phase of beer production, for aroma (more flowery, herbal, grassy), can cause haze
    - » During fermentation
    - » During maturation

Cooling the wort

- The hot wort must be cooled to the temperature at which it is pitched (inoculated) with yeast. Traditionally this is about 15±22 ëC (59±71.6°F) for ales and 6± 12°C (42.8±53.6 °F) for lagers, but other temperatures are used. The cooling should be carried out rapidly and under aseptic conditions to stop chemical reactions continuing and to minimize chances of growth of any contaminating microbes.
- As the wort cools it becomes hazy as a cold break forms. This may or may not be removed. In addition the wort must be charged with oxygen to an appropriate level. In modern breweries the heat from the hot wort is partly recovered in hot water.