Learn2Brew Ltd

INTRODUCTION TO

MILLING & MASHING

A Learn2Brew presentation
By
Nigel sadler

Typical Cask Ale Brewing System

Milling	4 Roller Mill	⟸ Malt
Mash Conversion Mash Separation	Mash Tun	⟸ Grist, Mashing & Sparge Water
Wort Boiling	Copper	⟸ Copper finings & Hops
Wort Clarification	Hop Back	
Wort Cooling	Wort Cooler	⟸ Air / Oxygen
Fermentation	FV	⟸ Yeast
Cask Racking	Racking Back	⟸ Auxiliary Finings & Primings
Conditioning	Cask	⟸ Isinglass Finings

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Typical Bright Lager Brewing System

Milling	6 Roller Mill	⟸ Malt
Mash Conversion	Mash Conversion Vessel	⟸ Grist & Mashing Water
Mash Separation	Lauter Tun	⟸ Sparge Water
Wort Boiling	Wort Kettle	⟸ Kettle finings & Hops
Wort Clarification	Whirlpool	
Wort Cooling	Wort Cooler	⟸ Air / Oxygen
Fermentation	CCV	⟸ Yeast
Stabilisation	Cold storage tank	⟸ Beer Stabilisers
Bright Beer	Filter	⟸ Filter aid

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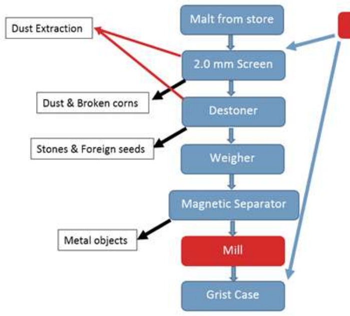
Schematic of Malt Handling



Although malt will have been screened by the maltster prior to delivery it is normal to repeat this at the brewery to remove any remaining unwanted material.

Consistent control of grist particle size is not possible if a wide variety of corn sizes enter the mill.

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4

Milling

5

Milling

Milling splits open the grain husk and grinds the endosperm to smaller particles producing what is known as “grist”

For use in mash and lauter tuns a reasonable quantity of husk is required to help with wort run off during mash separation and act as a filter bed

Mills contain 2, 4 or 6 rolls depending on the mash separation system being used.

Grist particle size affects efficiency and yield:

- Coarse grits - Less extract but good filterability
- Fine grits – Greater extract but may hinder filterability
- Flour – Greatest extract but will clog bed in mash and lauter tuns

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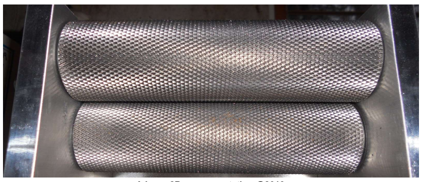
Typical Malt Mills

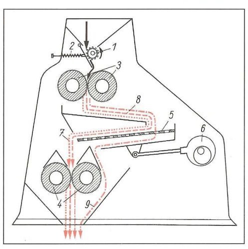
2 roll mill

4 roll mill

Mill Rollers



Four Roller Mill for Mash Tuns

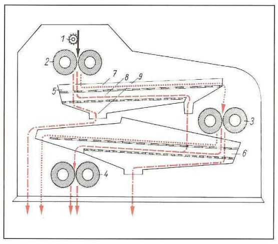


Copied from Handbook of Brewing by William A Hardwick

Four roll mills are used with well modified malts to produces a relatively coarse grist which is principally suitable for an Isothermal Mash Tun.

- All the malt passes through the first set of rollers and then the fine grists, flour and husk by pass the second pair of rollers.
- The coarse grists pass through the second rollers which will produce a balanced amount of fine and coarse grits and flour.
- By adjusting the different roller gaps it is possible to control the grist composition.

Six Roller Mill for Lauter Tuns



Copied from Handbook of Brewing
by William A Hardwick

- Six roll mills used for less well modified malts, they produce a finer grist which is suitable for separation in a Lauter Tun.
- The roller and screens are used to produce the required grist composition for a Lauter tun.

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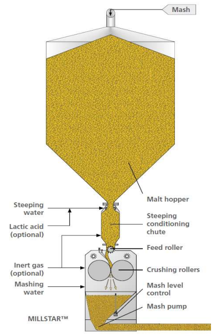
Steep Conditioned Mill for Lauter Tuns

Picture supplied courtesy of Krones



- A more complex solution is to use Steep Conditioned Milling where the grain is moistened before milling and the damp grain passes between two rollers keeping much more of the husk whole but still crushing the endosperm.
- The grist is used in conjunction with a lauter tun where it is reported to give either faster lautering or higher bed loading.

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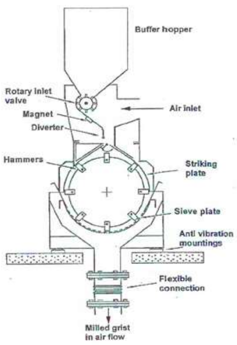
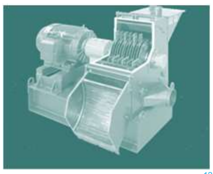
Hammer Mill for Mash Filters



- This pulverises the malt producing very fine grist which is only suitable for use with mash filters
- The hammer mill produces a very fine grist which is produces the high extract yield and fast run off with modern mash filters



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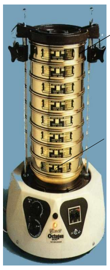
12

Grist Analysis for Different Systems



Typical dimension of Pfungstat Plansifter used in EBC analysis

Sieve	Mesh width mm	Materials held
1	1.27	Husk
2	1.01	Husk
3	0.547	Coarse Grits
4	0.253	Fine Grits
5	0.152	Normal flour
6 Base	No sieve	Fine Flour

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Grist Composition for Different Systems

	Typical grist composition % EBC			
	Husk Sieve > 1.25 mm	Course Grits Sieves 1.25 – 0.50 mm	Fine Grits Sieves 0.50 – 0.125 mm	Flour Bottom < 0.125 mm
Mash Tun	30%	24%	40%	6%
Lauter Tun	20%	45%	25%	10%
Mash Filter	< 1%	9%	55%	> 35%

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Matching Mill to Mash Separation System

Material	Mill Type	Grist description*	Mash System
Well modified malt	2 roll 4 roll	Husk Coarse grind	Mash tun
All normal malts including less well modified malts	6 roll	Husk Medium grind	Mash tun Lauter tun
Less well modified malts	6 roll with Conditioning	Higher Husk Finer grind	Mash tun Lauter tun
All normal malts including less well modified malts	Hammer	Little husk Very fine grind	Mash filter
Normal malts	Wet Milling	Endosperm "squeezed" from husk and mashed directly	Lauter tun

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Malt Safety

Explosion at De Bruce Grain, Wichita, 1998. 7 dead, 10 injured.

People working on the malt plant need to wear dust masks to avoid breathing in any dust.

Safe systems of work (permits to enter confined spaces) are required for people entering malt silos

- Malt mills are designed to prevent explosions.
- Magnets fitted to collect any steel or iron debris that could cause a spark.
- Stone separators are installed to prevent sparks and to protect the rolls from damage/wear.
- The modern mill and malt handling plant is fitted with explosion doors which would direct a blast safely outwards should an explosion occur.

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Mashing

17

Mashing Process

Mashing allows the conversion of malt starch and solid adjuncts into a spectrum of fermentable and un-fermentable sugars to produce a wort of the desired composition.

- Pre-formed soluble substances are leached from the grist
- Enzymes degrade the soluble starch and proteins in the grist
- Chemical interactions between wort components
- Some enzymes become inactivated during the mashing process
- The reaction causes a decrease in pH principally due to Ca^{2+} ions reacting with malt derived compounds such as phosphates.
- Wort composition varies according to type of beer required. Wort is must supply sufficient nutrients to produce an adequate fermentation.
- Weighed grist is mixed with a fixed volume of brewing water at a set temperature to produce a mash.

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Mashing Process

Resultant wort is characterized partly by its `strength‘ i.e. the amount of solids, or `extract‘, that is in solution and the volume of liquid in which the solids are dissolved.

Wort strength can be measured in different units: Degrees Plato and Degrees Gravity being used.

The higher the specific gravity the more concentrated the solution of wort solids and thus potentially the higher ABV of the finished beer.

Mashing regime determines the fermentability of the wort

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Starch Degradation

Three stages:

Gelatinisation: Swelling and bursting of starch granules in hot water.

↓

Liquefaction: Reduction in viscosity of the gelatinised starch by alpha amylase.

↓

Saccharification: Complete degradation of starch to maltose and dextrins by beta amylase.

Iodine test can be used to see if breakdown is complete.

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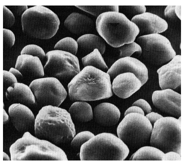
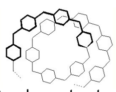
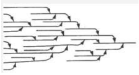
Starch Degradation: Gelatinisation





Amylose structure



Amylopectin structure

Swelling and bursting of starch granules in hot water. As a result of water uptake (hydration) the granules swell.

Starch molecules released, making a viscous solution, are more easily degraded by amylases enzymes.

Degree of viscosity depends on extent of water uptake and is different for different types of cereal e.g. rice starch swells much more than malt starch, this has to be taken into account in the design.

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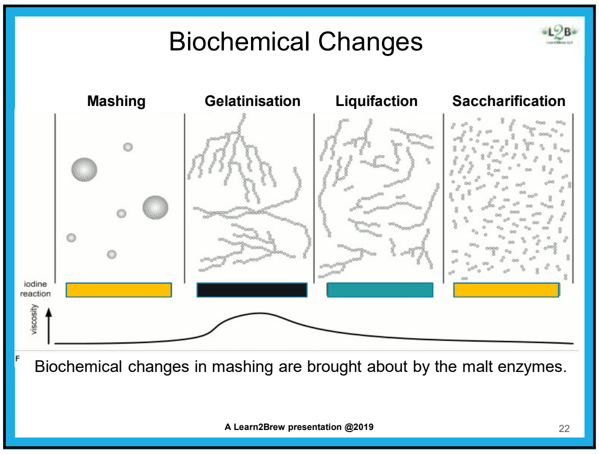
Biochemical Changes
Mashing
Gelatinisation
Liquifaction
Saccharification
iodine reaction
viscosity
Biochemical changes in mashing are brought about by the malt enzymes.
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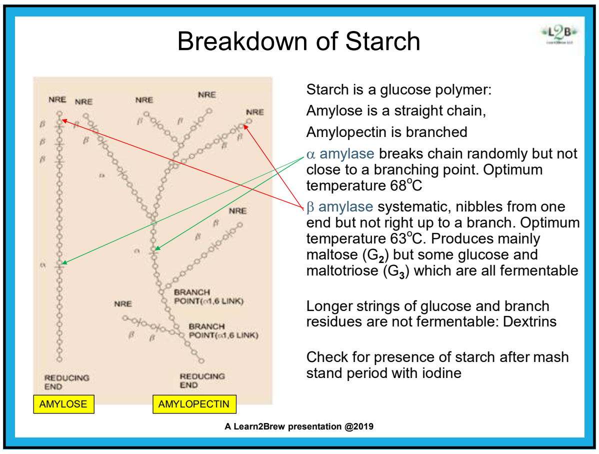
22


Breakdown of Starch
NRE
BRANCH POINT(α1,6 LINK)
REDUCING END
AMYLOSE
AMYLOPECTIN
Starch is a glucose polymer:
Amylose is a straight chain,
Amylopectin is branched
α amylase breaks chain randomly but not close to a branching point. Optimum temperature 68°C
β amylase systematic, nibbles from one end but not right up to a branch. Optimum temperature 63°C. Produces mainly maltose (G2) but some glucose and maltotriose (G3) which are all fermentable
Longer strings of glucose and branch residues are not fermentable: Dextrins
Check for presence of starch after mash stand period with iodine
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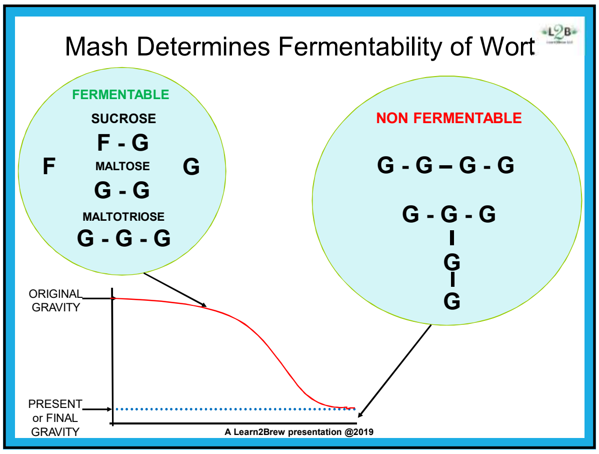
Mash Determines Fermentability of Wort
FERMENTABLE
SUCROSE
F - G
F
G
MALTOSE
G - G
MALTOTRIOSE
G - G - G
NON FERMENTABLE
G - G – G - G
G - G - G
I
G
I
G
ORIGINAL GRAVITY
PRESENT or FINAL GRAVITY
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Key Mashing Parameters

Condition	Low	Optimum	High
Temperature.	Low temperatures do not affect the enzymes much, but the starch must be gelatinised first. Gelatinisation temperature for malt starch is 65°C.	65°C	High temperatures inactivate enzymes including a and ß amylases. The action of amylases is stopped at temperatures over 70°C.
pH.	Acidic conditions kill the enzymes. Enzyme action is stopped at pHs below 5.0	5.4	High pHs slow enzyme action, but it does continue at pHs of 7 or above.
Water. (Mash thickness)	Enzymes are more sensitive to heat in a thin mash. There is a lower concentration of enzyme and starch in a thin mash.	Between 2.5 and 3.5 litres of water per kilogram of dry grist.	Enzymes are less sensitive to heat in a thick mash. There is a higher concentration of enzyme and starch in a thick mash.
Time.	Enzymes take time to attack the starch. Conversion will be incomplete in less than 30 minutes.	30 minutes	Conversion will be virtually complete after 30 minutes. A longer time will not increase the yield of sugar but may make it more fermentable.

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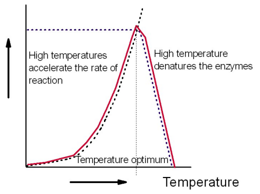
Effect of Temperature on Enzyme Activity

Effect of temperature on the rate of enzyme reaction



Two effects of higher temperature:

- Faster the rate of reaction.
- Damage to the enzyme structure which denatures and so it loses all its activity.

Enzymes have different abilities to withstand temperature effects depending on their internal chemical structure.

Enzymes are able to work below their optimum temperature slightly more slowly but once the optimum is exceeded they denature rapidly and lose their activity

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Optimum Temperatures for Enzymes

Table showing typical optimum temperatures for selected malt based enzymes

Enzyme	Optimum Temperature C	Effect
Alpha amylase	68 – 72	Liquefy starch
Beta amylase	63 – 65	Produce maltose sugar
Limit dextrinase	50 – 55	Break down branched starch
Protease	45 – 50	A range of enzymes hydrolyse proteins & polypeptides
Beta glucanse	40 - 45	A range of beta glucan enzymes break down the endosperm beta glucan cell walls surrounding the starch granules

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Mash Temperature vs Fermentability

Sugar profiles of wort produced at different mashing temperatures can vary greatly due to changes in enzyme action.

Wort Sugar Profiles - Percentages of sugar compounds at various mash temperatures (Data after G. Fix et al)

	60ºC	65ºC	70ºC	80ºC
Monosaccharides	10	9	8	3
Disaccharides	61	55	41	15
Trisaccharide	9	12	16	30
Dextrins	20	24	35	52

Fermentable (Monosaccharides, Disaccharides, Trisaccharide) ✓; Dextrins ✗

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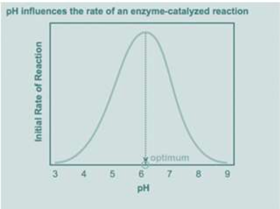
Effect of pH on Enzyme Activity



Changes in pH will affect the three dimensional folding of the enzyme leading to a change in the structure and hence a loss of activity.

When the pH returns to the optimum the level of enzyme activity will be restored.

Optimum range of conditions for an enzyme can be extended by external factors such as mash thickness (water to grist ratio) and ionic composition

Rate of reaction also affected by concentration of substrate.

Amylase enzyme concentration is measured by diastatic power (DP) of the malt.

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Effect of pH on Enzyme Activity

Table showing typical optimum pH for selected malt based enzymes

Enzyme	Optimum pH	Effect
Alpha amylase	5.3 – 5.8	Liquefy starch
Beta amylase	5.4 – 5.6	Produce maltose sugar
Limit dextrinase	5.0 – 5.5	Break down branched starch
Protease	4.5 – 6.0	A range of enzymes hydrolyse proteins & polypeptides
Beta glucanse	4.7 – 5.0	A range of beta glucan enzymes break down the endosperm beta glucan cell walls surrounding the starch granules

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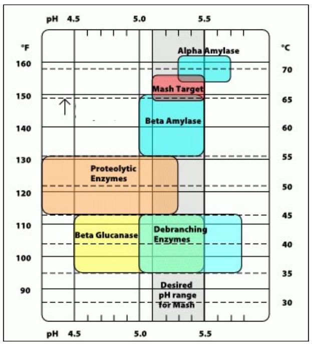
Brewer's Window



Courtesy of John Palmer

Mash Density

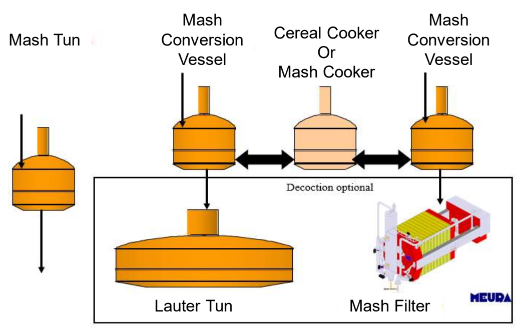
Mash Density: High liquor to grist ratios = thinner mash:

- Reduces the stability of mash enzymes
- Dilutes enzymes and substrates
- Leads to quick conversion but rapid destruction of enzymes
- Used in Decoction systems as mash is pumped and roused –
- Thicker mashes are stable but risks poor hydration

Mash bed floats

Image Courtesy Hayley Marlor

Mashing Systems



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Mashing Systems

There are different mashing systems dependent on the type of malt used and the type of beer being produced:

- **Mash tun: Isothermal infusion:** mashing in, conversion and wort separation system. Well modified malt is needed as no facility for heating.
- **Mash conversion vessel:** mashing in and mixing in a vessel with heating facilities. Less well modified malt can be used because different temperature stands can be used. Mash has to be transferred to another unit for separation.
- **Mash conversion vessel** with separate **mash cooker**. Traditional decoction system. Correct stand temperatures can be achieved by transferring specified volumes of mash into the cooker, boiling them up and returning them to the main mash.
- **Mash conversion vessel** with separate **cereal cooker**. This decoction system is the same as above except that the cooker is used to boil a cereal mash of maize or rice. Maize and rice have high gelatinisation temperatures and cooking is required if their starch is to be converted.

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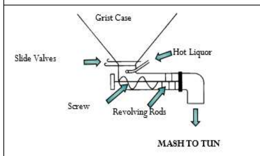
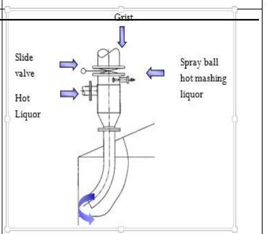
Mashing in: Grist Hydration

Traditional Mash Tun	Mash conversion Vessel
	
Steels Masher used with Mash Tun	Modern Vortex Mixer used with Mash Conversion Vessel
It is necessary to thoroughly mix the dry grist with mashing water into the vessel	

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Calculating Strike Temperature

Quick method of calculating strike temperature for HLT. Ensure mash tun is heated fully prior to mashing in and plates covered by 2.5-5cm of hot liquor:

$$T_{(strike)} = \frac{0.4 \times (T_{(mash)} - T_{(malt)})}{\text{Mash Density}} + T_{(mash)}$$

Where T = Temperature

If we want a mash at 65°C and our malt temp is 10°C and mash density is 3:1 i.e. 3 litres of liquor per kilo of grist then:

$$T_{(strike)} = \frac{0.4 \times (65-10)}{3} + 65$$

Then $T_{(strike)} = 72.3^{o}C$

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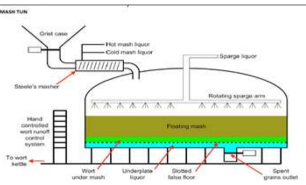
Mashing: Mash Tun

Traditional Ale Mash Tun – where mashing and conversion occur in the same vessel



The mash tun is first heated and a cushion of water (Foundation water) is run in to cover the false bottom to a depth of 4 mm. The weighted grist from the grist case is mixed with water in the steels masher and is allowed to drop into the mash tun where it stands for approximately one hour or until all the starch has been converted (Iodine end point check).

After mash stand wort run off takes place in the same vessel (see next section)

Typical water to grist ratio	One kg of grist is mashed with 2.0 to 2.8 liters of water
Typical water strike temperature	The mashing liquor is usually around 72 ± 2 C
Typical mash stand temperature	The mash stand temperature is usually around 65 ± 2 C

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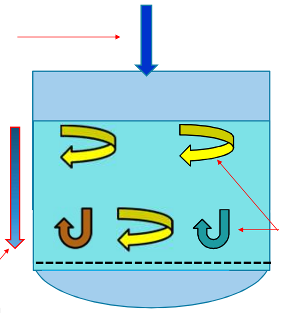
Mashing Tun: Small Scale

HLT water enters at the top of the mash bed and mixes with grain in hydrator.

If tipping by hand then add grist to hot water in batches and ensure thorough mixing before adding next batch.

Temperature will decrease at the bottom unless well mixed.



Operation:
Preheat vessel (sparge arms?)
Add foundation water 2.5-5cm.
Mash in with 1kg malt to 2.8-3 litres water/kg grist

Two motions: Circular and up and down

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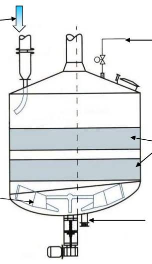
Mash Conversion Vessel Design

(for use with a Lauter Tun or Mash Filter)

Mash enters against the side of the vessel through the hydrator, or alternatively at the bottom of the vessel to minimise oxidation.

The mash is stirred continually by the agitator.



Vessels can be easily connected to CIP sets for automated cleaning

Steam jackets heat the vessel as required.

Mash can be pumped from the mixer to any receiver, or an alternative entry point to the vessel for mashing in.

During mash conversion the mash is subjected to a series of temperature stands and rises to produce the quality of wort required from malt supplied.

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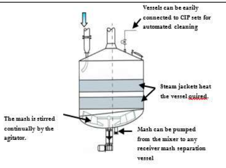
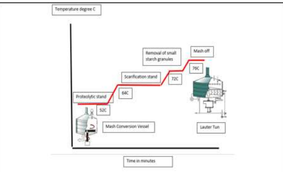
Mashing: Mash Conversion Vessel

Programmed Infusion Mashing – temperature programs to handle less well modified malts





A small amount of mashing water is run in before the grist mixes with the mashing water through the pre-masher. It is usually at a lower temperature for a Proteolytic/Beta glucanse stand before being heated up to above 60C for starch gelatenisation and conversion of starch to sugar. There may be a short rest at 72C to complete small starch degradation before being heated up to 76C to halt further enzyme action. At the end of approximately ninety minutes when the starch has been converted (Iodine end point check), the contents is transferred to a separate vessel for mash separation (see next section)

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Wort Separation Objectives

The objectives of effective wort separation are the removal of unwanted material while at the same time extracting all the available wort.

Effective wort separation means:

- Maximising extract recovery.
- Absence of particles in the wort.
- Absence of starch in the wort.

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Three Wort Separation Systems

Principal methods:

- Mash Tun
- Lauter Tun
- Mash Filter

Use the same basic principals:

- Husk material acts as filter bed (mash and lauter tun)
- Filter bed supported by screen or plates (mash filter)
- Strong worts extracted first followed by hot sparge water to wash out remaining extract.
- Extraction flow is controlled to maximise clarity and extract recovery
- Spent grain removal and disposal afterwards

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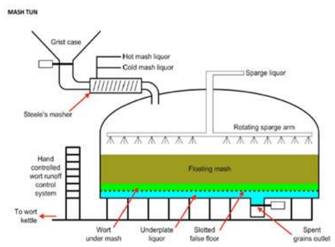
Mash Tun: Separation



Traditional **Isothermal** mashing where mash conversion (at 65ºC) and run off occur in the same vessel.

Run off strong worts **slowly** through a slotted false bottom.

Once strong wort is collected – add sparge (77 – 79ºC) to rinse through residual extract.

Stop runoff when final gravity achieved (1004OG or 1ºP).

Drain down vessel.

Discharge spent grains

Typical cycle time 3 to 4 hours. Up to 5 brews per day with 400 kg grist/m^2 bed loading

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Sparging

The spraying of hot liquor onto the mash bed to rinse out any residual sugars. This helps to achieve maximum extract efficiency.

High temperature (77-79ºC) halts enzyme activity and fixes wort sugar profile. Reduces wort viscosity aiding run off.

Before continuous sparging, the mash tun was refilled with hot liquor, often repeated a number of times, with successive worts getting weaker.

Mechanical sparging more efficient; liquor is sprayed onto the top of the mash bed continuously and drained off from the bottom direct to one copper.

Successful sparging requires a careful matching of inflow and outflow as too fast or too slow a sparge will result in an overflow or a stuck mash.

Sparging liquor can be treated to maintain a low pH in the mash. Too high a pH, >5.8, can result in excessive extraction of tannins and silicates from the grain husk, which can give the finished beer an undesirable flavour

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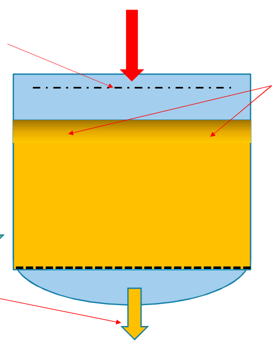
Sparging: Inside the Mash Tun

Hot sparge (77-79ºC) water sprays the top of the mash bed through turning sparge arm

Mash bed "drops" as wort gravity dilutes and sits on the false bottom

Wort run off starting at 1085-1090OG (?)



Top of mash bed in contact longest and with hottest water starts to leach tannins, silicates etc.

Monitor pH levels of runnings: <pH5.6-5.7

Trade off in wort quality against volume. Stop run off at 1004OG (?)

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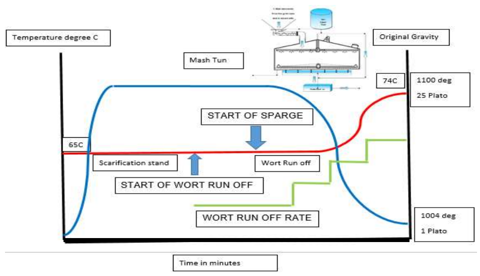
Mash Tun: Run off



The strong worts is run off first relatively slowly at a constant rate since it has the highest viscosity. After sparge is added the gravity falls and the temperature increases leading to a reduction in viscosity and the run off rate can be increased. This process continues until the gravity fall to around 1004 or 1 degree Plato when run off stops

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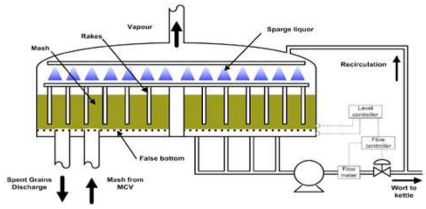
Lauter Tun Separation



- Operation: Preheat vessel / Add foundation water; 5cm / Lauter tun fed with converted mash from the mash conversion vessel.
- It runs off through a slotted false bottom; benefit of rakes to increase permeability of bed. Bed doesn't float.
- Operates in similar method to the Mash Tun
- Typical cycle time 2 to 3 hours, 6-12 brews per day.
- Bed loading of 160-200 kg grist/m^2

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Rakes Inside Lauter Tun

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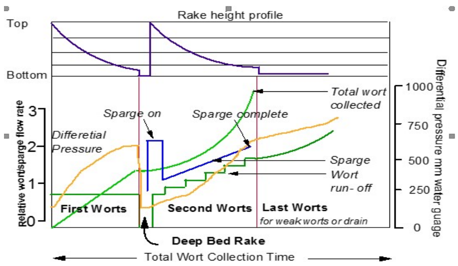
Lauter Tun: Run off



The finer grind increases the resistance of the bed to flow and this is compensated by the use of rakes which open the bed to allow faster filtration. The rakes must operate in such a way that sparge is not channeled. The differential pressure above and below the lauter plates is measured.

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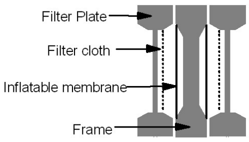
49

Meura 2001 Mash Filter



The Mash filter is fitted with fine pore polypropylene filter sheets and a can handle a fine grind without particles bleeding through the sheets. This forms a tight filter bed and means that no re-circulation is required before first worts are drawn off.

The fine grind gives a large surface area with a thin filter bed, resulting in very good extract efficiency without the decrease in filter performance found in other wort separation systems.

These slides are courtesy of Meura

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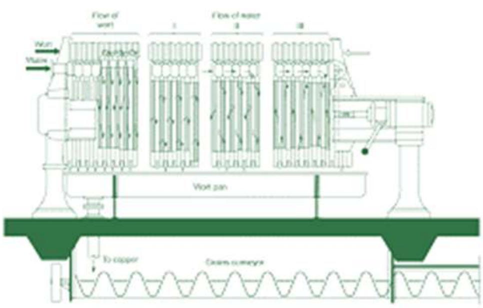
Meura Mash Filter



This image courtesy of MBAA

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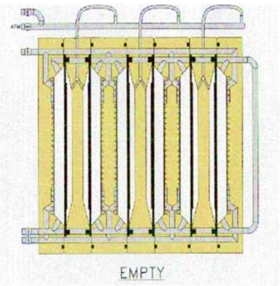
Mash Filter Stages: Empty



After spent grains discharge, the filter is closed automatically and is ready for the next brew.

There is no need to clean it after each brew. It generally requires a CIP. (lasting 5 to 6 hours) once of twice a week.

The empty Mash Filter is ready for the next batch once it has been closed and the low level probe is not covered.

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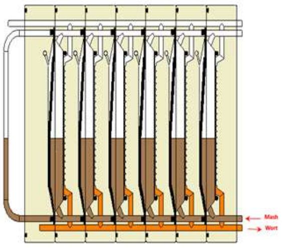
Mash Filter Stages: Filling



Mash is pumped from the mash conversion vessel into the frames of the mash filter through the bottom ports displacing the air in the chambers. As the mash is pumped in it fills all the chambers equally.

With the pump pressure a small amount of the wort will be forced through the polypropylene cloths and filtration will begin.

Duration 5 minutes
Pressure 0.6 bar
Run off low

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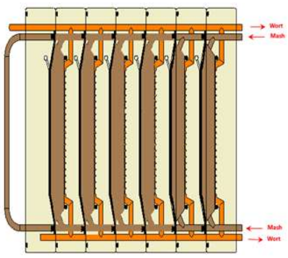
Mash Filter Stages: Filtering



The frames soon become full of wort and mash and the liquid wort is forced through the cloths with some of the finer husk material acting as a filter bed. The polypropylene cloths provide most of the filtration.

Mash continues to be pumped until the full contents of the mash conversion vessel has been transferred.

It is important to match the mash conversion quantity with the filter capacity.

Duration 30 minutes
Pressure 0.6 bar
Run off 175 hl

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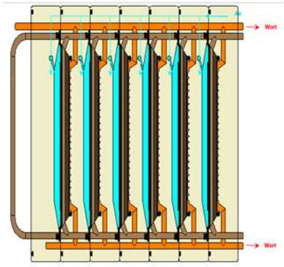
Mash Filter Stages: Pre-Compression



Duration 5 minutes
Pressure 0.6 bar
Run off 30 hl

Pre-compression prior to sparging gives a homogeneous cake porosity reducing the amount of sparge needed.

After all the mash is in, the inlet valve is closed and air is blown on the elasticated membranes.

By squeezing the thickness of the cake decrease by 1 cm.

When the pre-compression stage is completed, the sparging water cycle starts.

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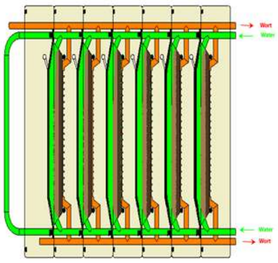
Mash Filter Stages: Sparge



Duration 35 minutes
Pressure 0.7 bar
Run off 250 hl

These slides are courtesy of Meura

Sparging is fed at a constant pressure through the mash inlet ports.

As air is released from the membranes, water is simultaneously pumped in the main inlet to fill the resulting space between the grain bed and the membrane.

The filter is filled up with water final extract is washed out under a constant flowrate until the gravity falls to between 0.8 and 1° Plato.

The sparging is finished as soon as the preset volume of water has flown out of the filter.

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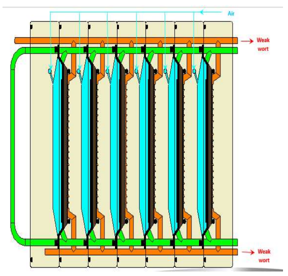
Mash Filter Stages: Final Compression



Duration 10 minutes
Pressure 0.7 – 1.0bar
Run off 50 hl

These slides are courtesy of Meura

Similar to pre-compression, the objective is to collect the last extract and dry the grains.

Air pressure is put on the elasticated membranes to squeeze the cake one more time.

1st Compression 0.6 - 0.8 bar
2nd Compression 0.8 - 1.0 bar

Spent grains: dry substance: 25 to 30%

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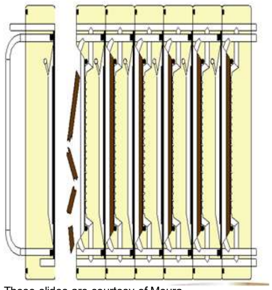
Mash Filter Stages: Draindown & Discharge



After compression residual water is drained and the inlet main is flushed with water ready for the next brew.

When the filter is opened the spent grains should drops off automatically. Often some manual intervention is needed. In later models spray bars have been installed.

The spent grains moisture is very low at 65-70%

These slides are courtesy of Meura

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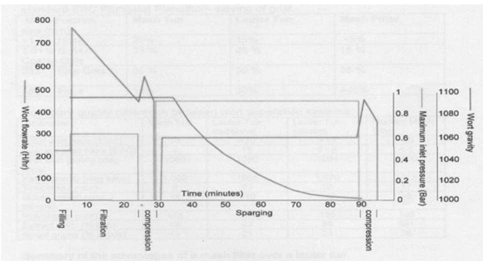
Mash Filter: Run off



- There is a high initial flow rate as the mash is being pumped which slows down when all the mash has been collected from the mash conversion vessel. The mash bed is then squeezed which sets the filterability of the bed for sparging.
- All the chambers must be filled otherwise the membranes will be damaged by the compression.

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Mash Filter Video

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Summary: Wort Separation Systems

	Mash Tun	Lauter Tun	Mash Filter
Milling system	Dry: 2 or 4 roll	Dry: 6 roll or wet milling	Hammer mill
Grist	Coarse	Med-fine	Very fine
Density (litres/kg)	2.5-3	3-3.5	3
Sparge ratio (litres/kg)	4	3.5-4	2.5
Bed depth (mm)	800-1200	300-500	40-60
Bed loading (kg/m2)	400	160-200	28
Typical extract recovery (%)	95	98	102
Brews/day	5	6-12	12+

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61

Wort Quality

- It is necessary to obtain good quality worts for a successful fermentation and to avoid extracting unwanted compound such as lipids and polyphenols which will give undesirable flavours in the final beer. This is why wort clarity, the final run off extract gravity and sparge temperatures and pH are important.
- Wort haze: Should be < 20 EBC 10 minutes after the start of run off. This can be measured with an in-line hazemeter.
- Suspended solids: No more than 8-10 ml as sediment after 2 hours stand in an Imhoff cone (mash tun).

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Wort Quality

Typical consequences of poorer wort quality are:

- Variable yeast flocculation
- Premature stale flavours
- Harsh astringent flavours
- Starch carryover
- Poor filterability

- Potential shortening of shelf life due to haze formation
- Brewhouse manufacturers have placed a lot of emphasis on reducing mash and wort oxidation, whilst it is generally accepted that undue oxidation is undesirable, it is has not been established that total elimination of oxygen is beneficial.
- A small amount of mash oxidation is probably inevitable and may even be desirable.

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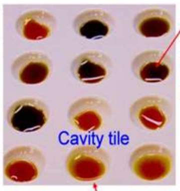
63

Starch End Point: Iodine Test

It is necessary to check that all the starch has been broken down during mashing and this is achieved through check the starch end point with iodine and this is usually done before mashing off (raising the mash to its final temperature to deactivate the enzymes).



The iodine reaction is not always easy to see in darker worts!

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64

Practical Iodine Test

This is the most common test in a brewery to ascertain a starch free wort or beer.

You will need:

- Oral iodine solution (available at most pharmacies)
- White ceramic tile / small plate
- 2 x pipettes

Take 2-3cm³ of wort from the mash tun or under-back and let cool on the tile/plate for a few seconds. Then add two drops of iodine/potassium iodide solution. A blue-black colour indicates the presence of starch.

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65

Extract & Original Gravity

Amount of material in the grist which dissolves, the soluble solids, during mashing to make wort is known as the "extract", around 80%.

Amount of extract can be measured using a hydrometer (saccharometer) which gives a density reading known as "Original Gravity" or "OG".

Not all the extract is fermentable, only about 75% is in the form of simple sugars which the yeast can utilise. The rest e.g. lipids, dextrins and proteins is unfermentable.

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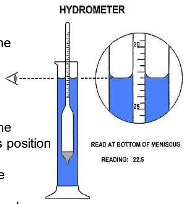
How to Use a Hydrometer - 1

Before using the hydrometer:

- Make sure both the hydrometer and hydrometer jar are clean.
- If the liquid to be tested is not at room temperature, allow it to reach room temperature before testing (20°C).
- Degas beer by filtration or rapid shaking
- Pour the liquid carefully into the hydrometer jar to avoid the formation of air bubbles. Do this by pouring it slowly down the
- side of the jar.
- Stir the liquid gently, avoiding the formation of air bubbles.

Taking a Reading:

- Carefully insert the hydrometer into the liquid, holding it at the
- top of the stem, and release it when it is approximately at its position of equilibrium.
- Note the reading approximately, and then by pressing on the top of the stem push the hydrometer into the liquid a few millimetres and no more beyond its equilibrium position. Do not grip the stem, but allow it to rest lightly between finger and thumb. Excess liquid on the stem above the surface can affect the reading.
- Release the hydrometer; it should rise steadily and after a few oscillations settle down to its position of equilibrium.



67

How to Use a Hydrometer - 2

Taking the Temperature:

- Using a suitable thermometer, take the temperature of the liquid immediately after taking the hydrometer reading.
- If there is any chance of a change in the temperature of the liquid it is safer to take the temperature both before and after the hydrometer reading. A difference of more than 1°C means that the temperature is not stable, and the liquid should be left to reach room temperature.
- If the temperature of the liquid is not the same as that on the hydrometer scale, the hydrometer reading should have a correction due to temperature applied.

Handling the Hydrometer:

- The hydrometer should never be held by the stem, except when it is being held vertically.
- When holding the stem, always hold it by the top, as finger-marks lower down can affect the accuracy of the instrument.
- Always handle with care.

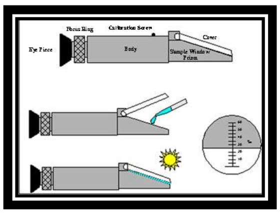
68

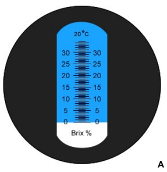
Using a Brix Refractometer

1. To convert the refractometer scale from °Brix/WRI to °Plato, you need to divide the reading by 1.04.

2. To convert °Plato to specific gravity, the approximation equation is:

$$SG = 260/(260 - P)$$





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Brix Refractometer: Conversion

Brix/WRI	Plato	SG
1	1.0	1.004
2	1.9	1.007
3	2.9	1.011
4	3.8	1.015
5	4.8	1.019
6	5.8	1.023
7	6.7	1.027
8	7.7	1.030
9	8.7	1.034
10	9.6	1.038
11	10.6	1.042
12	11.5	1.046
13	12.5	1.051
14	13.5	1.055
15	14.4	1.059

Brix/WRI	Plato	SG
16	15.4	1.063
17	16.3	1.067
18	17.3	1.071
19	18.3	1.076
20	19.2	1.080
21	20.2	1.084
22	21.2	1.089
23	22.1	1.093
24	23.1	1.097
25	24.0	1.102
26	25.0	1.106
27	26.0	1.111
28	26.9	1.116
29	27.9	1.120
30	28.8	1.125

Digital Brix/Plato Refractometer

Portable digital refractometer for food products designed to report the sugar content of aqueous solutions as % Brix.

Accuracy of ±0.2% Brix/Plato.

Simple operation: two buttons: one button is to calibrate and the other to take a measurement.

All readings are automatically compensated for temperature variations.

Result displayed within a 1.5 second response time.

Sealed flint glass prism and stainless steel well are easy to clean

Divide refractometer “Brix” by 1.04 to give “True Brix/Plato”

SG = 260/(260 – P)

71

Thank you

Any Questions?

Learn2Brew Ltd

72