A Brief Comparison of Four Beer Fermentation Systems

These pages will attempt to address the various advantages and possible drawbacks of each particular system when used by home brewers.

- A single fermentation stage carried out in one vessel.
- A two stage fermentation system where after completion of fermentation the beer is racked to a second enclosed tank to mature further prior to packaging.
- A two stage method known as "The Dropping System"
- Fermentation in a Cylindro-Conical vessel sometimes known as a "Uni-tank".

The Single Tank Method; This was widely used by UK breweries until fairly recently and is the simplest of all systems. Typically a square tank was filled with wort at around 15C and mixed with yeast which was of necessity a top cropping variety which would flocculate well on completion of fermentation. The heat generated would cause a natural rise to around 20C and excess yeast was occasionally skimmed from the surface of which some was stored for re-pitching the next batch. After fermentation had reached around a quarter of the original gravity the square was cooled using internal coils to 15C before racking into casks, this usually taking place after seven or eight days for average strength beers.

For home brewing a plastic fermenter is commonly used with a snap-on lid and airlock which is quite suitable for both fermenting the beer and maturing it for a further week or so, always providing that the lid is placed on tight once fermentation has ceased and an airlock or cotton wool bung fitted in the hole provided. If a top-cropping yeast strain has been used then it may be necessary to skim off any excess yeast from the surface of the brew after about a week and before snapping on the lid and airlock. The beer can then be left to mature further on the yeast sediment which will assist in cleaning up any undesirable by-products from the fermentation such as diacetyl or acetaldehyde.

The Secondary Method; Once widely used by home brewers this is not quite so popular these days with more brewers preferring instead to just ferment and mature the beer in a single tank. Typically with the two stage system a beer would be fermented to roughly a quarter of the original gravity, left to settle for a couple of days and then racked to an enclosed container fitted with an airlock. The objective here being to mature the beer before kegging or bottling whilst leaving the heavy yeast sediment and cold break debris behind.

Primary v. two stage (secondary) system;

Advantages of Single Stage:

- Only one vessel required with reduced time spent on cleaning
- Reduced risk of oxidisation as no transfer needed
- Adequate time for yeast to clean up any unwanted by-products formed during fermentation

Advantages of Secondary:

- Trub (cold break) and the bulk of the yeast including the dead cells deposited on the tank base are removed. This will minimise the risk of autolysis which is caused from dying yeast cells or deleterious effects from excess trub, the latter having being reported as having a negative effect on foam stability and flavour.

- If dry hops are added during this stage then the process is likely to be more effective as an excess of yeast cells may absorb some of the hop aroma compounds.

How long can the beer be kept in a primary fermenter?

Yeast manufacturers such as White Labs suggest that a period of two to three weeks should cause no problems in the wide bottom vessels commonly used by home brewers, always provided that the yeast is in good condition and not been stressed. That may well be a conservative estimate as many home brewers have reported keeping fermented beer in a carboy for a month or even longer without negative effects on the finished beer. However as different yeast strains vary considerably regarding stability it is perhaps wise to be cautious when trying a new or different strain and keep the time in the primary within the suggested limits. If an extended fermentation period should render the beer absolutely star bright then it may be wise to add fresh yeast at packaging along with the usual primings, this is particularly important for strong beers where the residual yeast may well be exhausted and in poor condition.

And whatever system has been used once fermentation is completed the beer must be protected from oxygen either by a tight fitting lid with airlock or seal, alternatively a narrow necked carboy can be used.

Although there now seems to be a greater proportion of home brewers who are fermenting and maturing their beer in a single tank, there are still many who prefer racking to a secondary fermenter, citing improved beer quality as the reason and both methods look like continuing to have their particular devotees.

The "Dropping System" of Fermentation; was widely used commercially till the 1960's but has almost faded out during the last thirty years. However one medium sized brewery did continue to use it and more recently three smaller breweries have followed suit.

Fermentation begins in an open tank as usual with yeast pitched at around 15C and when the temperature of the wort rises to about 20C and the "rocky heads" begin to subside, the beer is dropped or pumped into a second tank. This usually takes place at around 16 – 24 hours in a brewery although when practised by home brewers 24 - 48 hours is more usual, the reason being that commercial breweries generally pitch a greater quantity of yeast. Trub and dead yeast cells (which tend to sink to the tank base) are thus discarded whilst the wort gets thoroughly roused. In a brewery there is some oxygen picked up during dropping, however this is very quickly absorbed by the yeast leaving none left to cause oxidised flavours in the finished beer. Home brewers who use this method to ferment their beer can choose either to hold the racking pipe over the receiving tank, this causing some air to be picked up, or alternatively keep the pipe at the base under the beer in which case very little air will be absorbed. Recently I've started using this system for most of my low gravity beers, preferring to aerate the wort thoroughly when pitching the yeast and do not consider it necessary to aerate further when dropping.

Possible Advantages in dropping;

- the wort gets thoroughly roused which assists in keeping a mixed or highly flocculant strain in suspension
- dead yeast cells, cold break and debris are left behind in the first tank and a cleaner tasting beer is claimed by some brewers
- if no in-line aeration system is used by the brewery air can be picked up at the dropping stage which will benefit the fermentation process
- a cleaner yeast crop can be recovered for further use

Disadvantages;

- higher cleaning costs and investment in extra equipment, increased beer losses all of which are significant to a commercial brewer
- on a homebrew scale particular attention must be paid to avoid under pitching yeast or letting the temperature fall in the receiving tank after dropping, the latter can cause the fermentation to falter with the risk of elevated terminal gravities.

Cylindro-Conical Fermenters

These were first developed in the 1930's, however did not come into widespread use in the UK until the 1970's and are now the most widely used high-capacity fermenters found in breweries throughout the world. Initially used by large breweries in the UK to brew mass produced lagers and keg beers they can now be found in several traditional ale breweries. In this latter capacity the aspect (height – width) ratio has often been adapted to 1:1 instead of the more common tall narrow vessels seen at larger breweries. This ratio is claimed to produce a beer with similar characteristics to those produced by batch fermentation and several traditional breweries have found that their particular yeast strain has adapted well to the new vessels.

Several models have become available on the home brew market which range from basic plastic models to temperature controlled stainless steel units at a varying range of capacities and prices. These units all share in common a "racking valve" situated about half-say down the cone and a "dump valve" at the cone base, the latter should ideally be of a wider diameter than the former as to ensure the efficient removal of yeast and trub. In the cheaper models the valves are often plastic, nickel plated brass or stainless steel ball valves whilst some of the more expensive units now are fitted with "tri-clamp" s/s valves which permit easier cleaning and maintenance. These units are usually supplied with a sealing lid and enable an airlock to be fitted. It is usual for the entire fermentation and conditioning to take place in the unit, the trub and yeast can be discarded at intervals during the fermentation process. It is easy to collect clean yeast when necessary for re-pitching in a subsequent batch.

Advantages of Conical FV's

- Both fermentation and maturation can be carried out in a single tank
- Trub and spent yeast can be discarded when thought necessary
- Clean yeast can be collected at a suitable time for re - pitching
- The fermentation process can be slightly quicker than a conventional FV due to convection currents caused by the shape of the cone

Disadvantages

- Initial cost particularly with the higher quality stainless steel models
- Cleaning and maintenance can be a nuisance particularly if the unit is not fitted with tri-clamp valves

Peter Jones from Cambridge Craft Brewers has kindly provided the following observations;

My experience with conical's is generally very favourable, but that might be more about the entire set up and not just the conical. I designed and had built 2 x120L conical's 450mm in diam with a 60° cone, there is a racking arm via a 15mm stainless tube with a ½" valve and a ¾" valve on the bottom. On the lid is a fitting that takes either a blow off tube or a valve (see below), a pressure gauge and the fittings to hold the cooling loop in position. The temperature is controlled via a PID, with heating been provided via an underfloor heating cable wrapped around the outside and cooling via a stainless steel convoluted loop in the fermenter and cooling provided via a Cornelius Maxi 110, via the python loop. The cooling is controlled by switching the pump on/off which circulates cold water, this set up keeps it within 0.1°. I tried a copper coil around the outside but that did not drop the temperature enough below ambient. The conicals will happily ferment 90L and store it for weeks if necessary. The conical without the ancillaries is just another vessel and it does not make better or worse beer than other vessels, what it does do is allow for a more controlled fermentation that does not expose the beer to O2 or contamination. It also makes the process easier to use and sample and store the beer. If I had to recommend one thing regardless of what type of vessel, that would be the control of fermentation temperature. This is more important than the conical if truth be told.

What I do is transfer the wort to the conical by pump, if I have a lot of trub carry over after the addition of late hops then I leave it overnight without adding the yeast, let the trub settle and then remove it via the bottom valve in the morning. I then add the yeast, otherwise I generally add the yeast after transferring. During fermentation I can take samples to test OG via the racking arm, after a quick squirt of Paracetic to sterilise the valve. I generally drop the yeast trub within 10% of the final gravity and again at final gravity, and perhaps a third time just before racking. I generally ferment at 18°C and on completion crash cool it down to 6-8° or lower in the winter. When I designed the fermenter I wanted to have the ability to apply a slight (0.2 bar) of back pressure either via a cylinder or naturally, so my set up has a sealed lid that I do not open once it is closed at the start of fermentation. The trub that gets thrown up at initial fermentation sticks to the lid so does not go back into the beer and I have a blow off tube that goes into a bucket filled with Iodine solution to keep it clean. Once fermentation dies down I disconnect the blow off tube and attach a valve that leads to a CO2 cylinder and occasionally give it a shot of CO2; this is useful after dropping trub so minimal O2 gets into the fermenter. With this set up I can, but rarely do serve direct from the fermenter, as the beer will (with the right yeast) drop clear. It is very useful to be able to store the beer for an additional week until I can get around to racking off. Racking is a doddle as all I do is connect up a sterile tube to the racking arm and transfer to Cornies as the racking arm is at the correct height for gravity transfer. One brew produces x4 cornies, once all the losses via trub etc are taken into

account. Once it is empty of beer there is always yeast still present in the bottom. To be honest the racking arm is able to rotate 360º but it could easily be fixed as the trub is dropped before racking. I either keep the yeast , put another batch straight in or wash it out. The cleaning is a case of opening all the valves and hosing down. I also have a CIP that I designed to work at low pressure from the March May pump. This sprays recirculating water/antiformin around to clean it or sterilising solution prior to fermentation.

I really like using the conical but the thing I do not like is the number bits involved when cleaning and putting it together, valves, racking arm set up, pressure gauge, cooling etc does mean for a lot of odds and sods. Most of these problems could be solved by going to TriClova fittings but I have not got around to fitting them yet and the Triclova valves are pretty punchy. Also x4 conicals is a lot of beer so, I am building another rig with reduced capacity but this time with square conical, a "squanical". This behaves exactly the same as a round one but less than half the price, although sealing it is more of a challenge.

I have attached a couple of pictures, one shows the working set up w/o pressure gauge and the other without the insulation, in what was then a messy garage.

To conclude it would be interesting to hear opinions from members about the merits of the system they use, and in particular relating to beer quality when comparing the benefits of a single stage v. two stage fermentation process.

Peter Fawcett (MCB)
with thanks to Peter Jones (CCB)


FRAGILE
Maxi 110