

# Recovery of beer from tank bottoms – a review

**Many early Beer Recovery Systems are still in use today. In the days before ‘duty at the gate’, most breweries in the UK had some sort of recovery system to reduce beer losses. With breweries becoming larger and waste disposal cost increasing, recovering high quality beer from yeast is again becoming a real topic for debate.**

By **Paul Buttrick**  
Beer Dimensions

**B**eer recovery in traditional British breweries often involved the Scott yeast press system. In this process, yeast was skimmed by vacuum from the top of an open fermenter to a tank usually in a room below the fermenting room. The tank was then pressurised with air and the yeast slurry passed over a yeast press, where high value beer (excise paid) was recovered and returned to the fermentation vessel it came from.

Pressed yeast (of about 25% dry weight solids) was either used for repitching or sold at a high price to a well known food manufacturer. However, the plant was difficult to clean, which resulted in a serious microbiological risk, and many breweries stopped returning beer because of this.

With the advent of processed beers, lagers, and small pack beers, additional technology was used to improve the quality of the recovered beer. Beer was sometimes filtered and flash pasteurised before being returned occasionally to the fermentation vessel but more often to the cold store tank.

Even though the risk of microbiological contamination was significantly reduced, there were problems:

a) High beer oxygen levels, coupled with high pasteurisation time and temperatures, made the beer taste poor and had a negative impact on flavour stability, haze stability and beer foam.

b) Despite the pasteurisation process, cleaning and sterilisation of the equipment continued to give problems; this area of the brewery was often away from mainstream production areas, and consequently did not always get the attention required to maintain quality standards.

c) The running costs continued to rise, and the



Figure 1: A one tonne yeast press in a British brewery with polypropylene plates and frames installed in the 1980s.

complexity of the operation increased.

## What happened next?

The financial driver for recovering beer increased as beer duty rose significantly above the rate of inflation. Rotary vacuum filters, OMD filters, and large semi-automated presses (Fig. 1) were installed which were able to handle increased volumes. A pressure squeeze from membrane presses increased beer recovery rates further.

Both the rotary vacuum filter and OMD filter needed a filter aid to recover the beer, which also had high oxygen content. These investment returns certainly kept the accountants happy, but were not good for beer flavour and quality.

## Where are we now?

Despite the move to ‘duty at the gate’ and the value of recovered beer reducing from approx £70/hl (incl. duty at 5% abv at current duty rates) to £5–6/hl, many breweries are still using large presses to recover beer, but problems with beer quality, running cost and complexity are forcing brewers to look at alternative technologies.

Few breweries outside the UK recover beer from surplus yeast mainly because returns on investment were poor, and the probably correct perception that beer quality would be compromised.

## What are the financial benefits of recovering beer from surplus yeast?

The following tables show approximate operational savings that can be made by recovering beer from surplus yeast. The figures are general ones, and each brewery will have to use its own data and costing conventions to get a more accurate value. See Table 1.

## Surplus yeast as a ‘co-product’ not a ‘waste product’

Although beer savings alone may not justify a beer recovery project, the costs associated with effluent and disposal cost for yeast slurry will pay an increasing part in the financial equation. As disposal sites become full and costs increase (probably including government charges – I think these are called taxes) breweries will be driven even more to reduce their ‘waste’.

Companies are beginning to look at surplus yeast as a co-product producing an income stream instead of a ‘waste’ stream with a disposal ‘on-cost’. With food safety being high on the agenda, farmers are looking more at accredited food sources. Brewers’ yeast is an ideal high protein food for pigs for example.

It does, however, have to compete with other feed, and can only be economic if slurries are concentrated before collection. As a basic rule of thumb, yeast slurry from fermentation vessels is about 10% dry weight (dw), from cold storage tanks approx 7% dw, and a positive cash flow is only available with slurries above 14% dw. Depending on circumstances, revenue of approx £1%/tonne above 14% dw, so yeast slurry despatched at 17% dw would attract gross income of £3/tonne.

It is important to note that yeast sent for animal feed has to be dead before it is consumed – this means that either the brewer or the feed supplier will have to kill the yeast using heat or chemical addition. Because of the high cost of transport, slurry sent out at less than 14% dw is likely to incur a transport on-cost. (Fig.2)

**Table 1: approximate volumes of waste yeast and recovered beer expected from different sized breweries, and the value of the recovered beer.**

Volume brewed khl	Surplus yeast/bottoms khl	Volume of beer recovered (65%) khl	Volume of yeast for disposal (35%) khl	Value (£) of recovered beer (£6/hl)
500	20	13	7	78k
1000	40	26	14	156k
2000	80	52	28	312k

The calculations are based on: Surplus yeast is 4% of site volume; the beer recovery rate from the yeast is 65%, leaving 35% surplus yeast; recovered beer is valued at £6/hl.



Figure 2: A 44-tonne tanker delivering 28 tonnes of yeast to a pig farm in the UK – photo supplied by Wheyfeeds Ltd.

**What should a brewer's approach be now?**

With costs being squeezed, brewers are being driven to reduce beer losses. Consolidation of brewing plants with increased capacity, makes beer recovery more financially attractive, and most companies are grappling with the 'how are we going to reduce our losses and waste costs?' question.

The answers are not straight forward, even different plants within the same group come up with different solutions. Another significant factor for UK brewers is that those breweries which already have established beer recovery facilities have great difficulty in upgrading to higher quality more efficient operations, because what they already have makes a considerable impact on their costs, and extra investment based on a straight ROCE is difficult to justify.

From my experience, the question of what equipment and process to use will depend very much on what equipment already exists, the quality standards expected, and what level of investment can be justified.

**What are the options?**

There are a number of options and technologies available:

**1) Do nothing**

Some brewers will decide that they do not want to return any recovered beer for quality reasons. These breweries will increasingly have to address the problem of where and how their surplus yeast will be disposed of in



Figure 3: A GEA-Wiegand 20hl/hr falling film alcohol evaporation plant for recovering alcohol from brewery yeast – photo supplied by GEA-Wiegand.

**Table 2: the calculated operational cost saving (including beer) if waste is sold as a "co-product" at £3/tonne as opposed to a "waste" product with disposal costs of £1/tonne.**

Volume of beer brewed – khl	Operational saving( beer and disposal cost) – £k
500	£119
1000	£238
2000	£476

**Table 3 shows the same calculation if waste disposal costs increase to £3/tonne**

Volume of beer brewed – khl	Operational saving( beer and disposal cost) – £k
500	159
1000	316
2000	636

the future. They may decide to concentrate surplus yeast but not return recovered beer to their beer stream.

**2) Continue with existing press operations**

This may be possible for a time, but control of quality and maintaining aging equipment will eventually prove to be uneconomical and unacceptable from a quality perspective. The beer yield from presses is high, with yeast being concentrated to approx. 25% dw.

**3) Alcohol recovery from yeast slurries**

Many UK brewers recovered alcohol evaporated from surplus yeast in the 80s and 90s, and some continue to get good return for their efforts. GEA-Wiegand (Fig. 3) and Unipektin were the main suppliers of this equipment. The technology, based on falling film evaporation working at 60-70°C and reduced pressure, is also used for producing alcohol free beers. The yield is high (up to 94%) because alcohol is recovered from within the yeast cell as well as from the beer slurry. When the calculations are done, the volume of alcohol evaporated from surplus brewing yeast is very close to the maximum allowed to be blended back into beer in by HMCE. With good plant maintenance and carbon filtration of the distillate, there are positive quality aspects of this process, although there were some flavour issues in early plants, where the operational

and control parameters were not ideal.

The distillate is biologically stable and has little effect on flavour, head retention and haze stability. Because the flavour is neutral, alcohol distilled from different brands need not necessarily be segregated and can be returned to beer on transfer to cold storage tank. A downside for this technology is the image of 'chemical' brewing, particularly when premium brands are involved.

**4) Centrifuges**

There are a number of options where centrifuges can be used to recover beer from surplus yeast. These can be split into 2 main types of operation:

**Decanter centrifuges**

These machines have been improved in recent years to being more suitable for foodstuffs, and are in use in a number of large breweries. There have been issues with cleanliness and sterility, and manufacturers say that these have been overcome. Due to their mode of operation, these machines are able to concentrate yeast slurries up to 25% dw. (Fig. 4)

The 'squeezing' element from the decanter screw, is thought by some to cause damage to the yeast cells. The centrate does have high yeast counts and some brewers have a small clarifying centrifuge and flash pasteuriser in line after the main decanter centrifuge, to ensure quality is assured before beer is returned.



Figure 4: A Westfalia CB 506 decanter centrifuge for processing up to 40hl/hr of yeast – photo supplied by Westfalia Separator Ltd.



Figure 5: A FEUX-510 Alfa Laval continuous discharging nozzle disk owl centrifuge (yeast processing rate 20-80 hl/hr) – photo supplied by Alfa Laval Ltd.



Figure 6: A single 'head', 40m<sup>2</sup>, Pallsep Vibrating Membrane Filter (VMF) for crossflow filtration of yeast up to 18 hl/hr – photo supplied by Pall Europe Ltd.



Figure 7: Bright beer quality filtrate from yeast slurry processed on a Pallsep VMF.

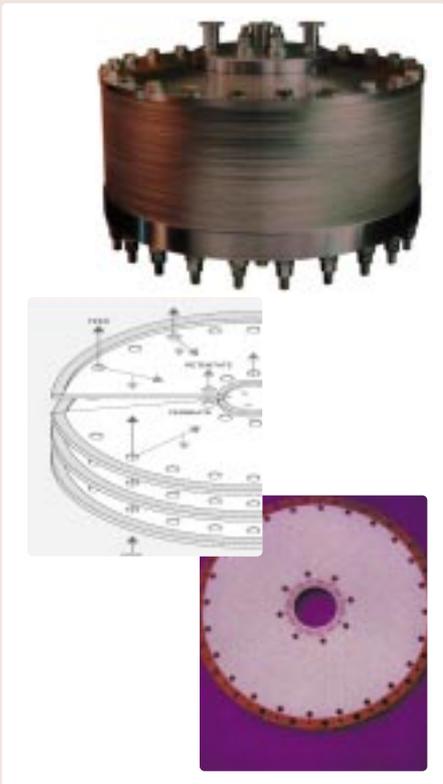


Figure 8: Diagram and photo showing the 40m<sup>2</sup> crossflow filter head of the Pallsep VMF – supplied by Pall Europe Ltd.

The cost of a single decanter centrifuge may be attractive, but the extra equipment needed to ensure quality, increases cost and complexity considerably. Some brewers might decide that centrate with a high yeast count does not have a deleterious effect on quality, and therefore if cleanliness and sterility can be assured and the recovered beer can be blended back immediately, then extra equipment is unnecessary.

Another claimed advantage is the ability to handle a range of slurry thickness fed to it; the control system needs to be very good to ensure consistent centrate out of the machine.

#### Disk bowl and Continuous Discharging Disk Bowl Nozzle Centrifuges

Disk bowl and continuous discharging disk bowl nozzle centrifuges are sometimes considered for recovering beer from yeast slurries. Large disk bowl centrifuges are not often used, and manufacturers more often recommend their decanter machines.

Continuous discharging disk bowl nozzle centrifuges (Figure. 5) are compact hygienic machines that can be used to concentrate yeast slurries, eg of pitching yeast. In beer recovery situations they can also be used 'on-line' to concentrate yeast bottoms and simultaneously dosing the centrate back into the main beer stream, or as "off-line" stand alone machines.

These machines have the disadvantage that the yield is variable according to the thickness of slurry put to the machine. Compared to 25% dw yeast from a decanter centrifuge, the yeast from this machine will be about 18-22% dw. The yeast count on the centrate varies according to the thickness of slurry pre machine and control parameters applied.

Their advantage is that the machines are compact, easy to keep clean and sterile, and are not thought to cause undue stress to the yeast. If a brewer already had a yeast press achieving 25% dw yeast, then the yield from a continuous discharge bowl centrifuge would be less. However brewers who have no current beer recovery operation, would be attracted by the physical advantages of the machine as well as reducing their losses.

#### 5) Cross flow filtration

Cross flow filtration technology has been applied by a number of manufacturers, There are two applications a) crossflow filtration using static membranes and b) vibrating membrane crossflow filtration (Pallsep – VMF) sold by Pall.

The main advantage of crossflow is, that due to the very small pore size of the membranes (typically 0.5-0.8 microns), the filtrate is close to bright beer quality, virtually yeast free, has good palate and physical parameters. The membranes are ceramic or polymer, and installations can be completely automated. With the VMF (using PTFE membranes) most of the energy applied to separate beer from yeast comes from the vibration of the membrane. This means that very little pumping energy is needed to



Fig. 9 - A Filtrix CERinox ceramic crossflow filter. The photo shows a 3 module plant, with each module of 40m<sup>2</sup> capable of handling up to 18 hl/hr of yeast slurry – photo supplied by Filtrix AG.

circulate the slurry across the membrane, consequently temperature rise is minimised and the yeast flow is very gentle and stress free. (Fig ures 6,7 and 8)

With the static crossflow filter, high flow rates are the driving force behind the beer/yeast separation, and a heat exchanger is needed within the equipment to reduce yeast stress and prevent autolysis. These filters eg Kerflux, from Pall, and CERinox from Filtrix, (Figure 9) are based on robust ceramic membrane technology (Figure 10).

Because cross flow filters rely on the pumping of yeast slurries around the membrane, the final thickness of the yeast is less than 20% dw at the end of a batch. In order to achieve an extract recovery equal to a yeast press of 25% dw, a 'dia-filtration' with deaerated water can be used to 'wash out' additional beer from the slurry. Control parameters need to be set so that the 'dia-filtration' process does not wash out any undesirable material from the yeast.

A new development in static membrane technology, is a plate and frame polymer based membrane from Alfa Laval (Figure 11). This equipment has 0.45 micron membranes and is designed to give low pressure conditions and keep energy consumption down

This type of filter concentrates yeast slurry to approx 20% dw so yields are less than from some other plant alternatives.

An initial disadvantage of membrane systems has been the cost of replacement membranes. The manufacture of the membrane has improved significantly, and the guaranteed life is now making this option more affordable.

#### 6) Blending yeast slurry back pre-centrifuge

This process involves taking yeast from the bottom of a vessel and dosing it back as beer is transferred from a fermenting vessel via a centrifuge to a maturation vessel/cold store tank. The proportional dosing of the tank bottoms means that the centrifuge will be able to remove the yeast dosed back because the load is spread over a large volume of beer.

This looks to be an ideal system – a simple



Figure 10: Filtration module from a ceramic cross flow filter – Photo supplied by Filtrix AG.

‘on-line’ process with little extra equipment, especially if green beer centrifuges are already in use. However there are a number of considerations:

a) The centrifuge must be sized to handle the extra yeast dosed from the vessel at the required beer transfer rate. If the centrifuge is not big enough to handle the extra yeast, then investing in extra green beer can be very expensive (Figures 12 and 13).

b) The dose back rate needs to be kept at low levels to reduce the possibility of yeasty flavours in the beer.

c) Planning within the brewery must be such that bottoms and beer transfer can be carried out simultaneously – this is not as easy as it sounds.

**Filtrate/centrate blend-back rates?**

For centrate from presses and centrifuges, most brewers put a 3 -5% limit on blending back. This is chosen because any flavour or quality differences will be blended away and not be noticed in the final beer; it also happens to be approximately the amount of filtrate produced. With crossflow technology, producing bright filtrate, brewers have blended back at up to 10%. With alcohol blend back, the maximum is set by HMCE and is approx 2-3% depending on the strength of the beer.

**Where to blend-back?**

This is determined by the quality of filtrate/centrate and policy of the brewer. Some brewers add beer back to the whirlpool or into the wort stream just before wort cooling. This can be successful as long as



Figure 11: A DSS M39-H Alfa Laval plate & frame polymer membrane crossflow filter capable of handling 35 hl/hr yeast slurry –photo supplied by Alfa Laval Ltd.



Figure 12: Picture of two large Westfalia SC 150 disk bowl centrifuges rated up to 600 hl/hr suitable for a yeast dose back operation – photo supplied by GEA- Westfalia Separator Ltd.

there is no yeast in the filtrate which will be autolysed by the hot conditions. The hot environment also has a pasteurising effect. This type of operation is not as straight forward as it seems, because recovered beer is not always produced in synch with brewing.

Options for centrate with higher yeast count include being added to actively fermenting yeast in fermenter, where the purging effect of fermentation washes out any flavour defects. Most brewers add beer back between fermenter and cold storage tank, and some add beer from crossflow equipment to beer before filtration.

There is an old brewer’s ‘rule’ which says that any addition to a beer should be made going forward in the process; the benefit here is that any quality issues are restricted to beer from the point off addition. When adding returned beer just before filtration, care must be taken to ensure that there are no issues with haze stability.

**To sum up**

Recovery of beer from tank bottoms can be justified, with spent yeast from a recovery process considered as a co- product with

value instead of a ‘waste’ on-cost.

There are numerous alternative technologies for recovering beer from bottoms. Each brewery needs to assess its own quality and operational requirements before deciding what is best for them. There is no ideal solution which can be universally recommended and applied.

A word about total investment costs. The justification for installing beer recovery equipment can easily be made on the basis of a single piece of recovery equipment. However, the associated plant can increase the overall project cost at least 2-3 times, and brewers need to be very clever in identifying the minimum practical cost of this plant in order to justify their investment. ■

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**● The Author**

After a long career with Whitbread and Interbrew, including time as Head Brewer of Boddingtons and Stella Artois Brewmaster, Paul has started his own independent consultancy Beer Dimensions. Paul has an MSc in Brewing Science from Birmingham University and is one of only a handful of British brewers to have studied at Weihenstephan (T.U. Munich). You can contact Paul on paul.buttrick@beerdimensions.com or www.beerdimensions.com

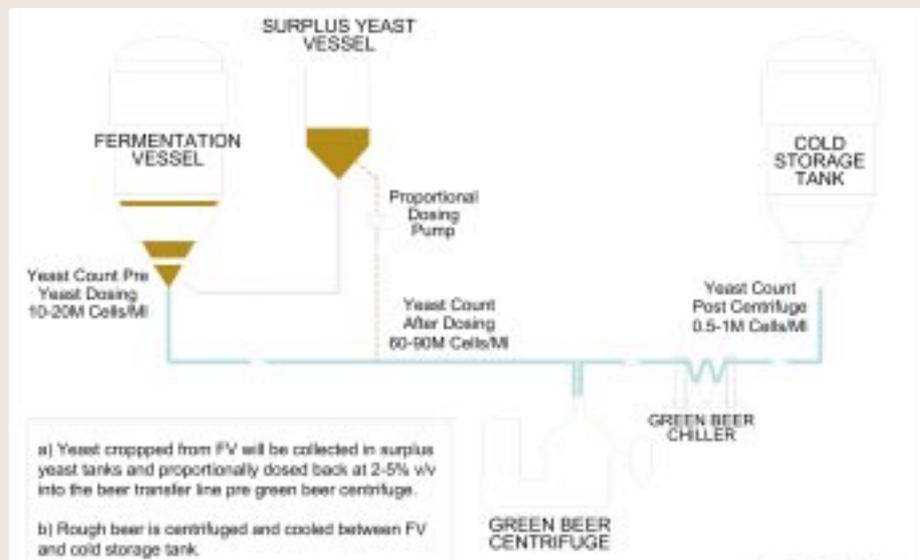


Figure 13: Process diagram of a yeast dose-back pre-centrifuge process – Diagram supplied by CAL Systems Ltd.