Module 2

2.2 Batch Distillation

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DIPLOMA IN DISTILLING

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Abstract

In this Unit of the Diploma in Distilling, 2.2 Batch Distillation, we will continue our examination of the distillation process started in Unit 2.1 Distillation.

This unit will cover the issues specific to the various types of batch distillation. We will start by discussing still design and operation (2.2.2 & 2.2.3) before examining the impacts on product quality of spirit cut points and congener volatility (2.2.4) and of raw materials and still materials (2.2.5 & 2.2.6).

Learning Outcomes

On completion of this section you should be able to:

1. *Understand the design elements of pot stills.*
2. *Describe impact on product quality of cut points during distillation.*
3. *Explain the impact of copper contact on spirit quality.*

Prerequisite Understanding

Basic scientific knowledge and terminology, Unit 2.1 Distillation.

2.2.1 Batch Distillation Design & 2.2.2 Operation

Introduction

There are significant variations between stills of brandy, rum and whisky distilleries, and even within each of these industries there are many different still designs. However, this unit is concerned with the principles of pot still operation, which are essentially the same for all of these products. The few instances where the information is not applicable to all three spirits, but it is sufficiently important for all candidates to know, are mentioned as necessary. The examination questions also have to be based on basic principles, not on the features of a specific type of still, although these may be relevant to some answers.

General aspects of distillation

The separation of a mixture of liquids by distillation depends on differences in volatility. Ethanol, boiling point 78°C, is more volatile than water, BP 100°C. Figure 1 shows the theoretical behaviour at atmospheric pressure of ethanol-water mixtures over the full range of alcohol concentrations. Some deviation will be observed in practice, according to the design of the still and opportunity for reflux, as explained later. Using 10% alcohol by volume as an example, the mixture remains in the liquid phase during heating up to 93°C. At that temperature the vertical 10% abv line meets the "bubble point" graph, i.e. when evaporation.of the mixture begins. Since ethanol is more volatile than water, the vapour phase is richer in ethanol than the liquid phase from which it evaporated. Following the horizontal 93°C line to the right, it meets the "dew point" graph, i.e. condensation, at a point corresponding to 55% abv. Since the alcohol concentration in the condensate is the same as in the vapour, the product of distillation of 10% alcohol in water is spirit of 55% abv. However, as alcohol distilled off, the solution becomes weaker, so the alcohol concentration in the distillate falls and the boiling point rises. Distillation is normally stopped when the vapour and distillate fall to 1% abv, corresponding to 0.1% abv remaining in the still (but the scale of the graph below is too small for the 1.0 and 0.1% relationship to be obvious). The main reason is the cost of the energy.
Distillation of such dilute alcohol costs more than the value of the product.

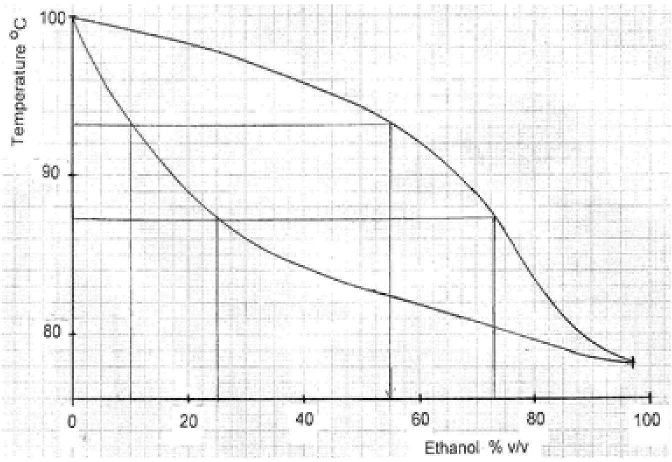

Figure 1 Distillation temperature vs composition of ethanol-water mixtures.

So a single stage of distillation, even from a relatively high start point of 10%, gives a poor yield of distilled spirit of the required strength. At least two successive distillations are required. If all the distillate from the first stage, i.e. from 55% down to 0.1% abv, is combined, its final strength is usually about 20%, the exact value depending on the shape of the still and rate of distillation. Figure 2.5.1 uses 25% as an example of the second distillation, showing first distillate about 73% abv. If spirit is collected down to 55% (but could stop anywhere between 65% and 50%), that complete batch will be about 65% abv, a suitable strength for maturation. The remaining alcohol is too valuable to waste, so is collected down to 1% as tails or feints, which are added to the next charge of the still for re-distillation. The first still is known as the beer still, wine still, wash still or various other local names; the second is usually known as the spirit still.

Design and operation of pot stills

It is impossible to discuss here all of the possible designs of still. Figure 2 shows a typical beer/wash still for rum or whisky, and its capacity would probably be in the range 2000 – 15000 litres. Most brandy stills are at the bottom end of that range, and have a much shorter neck, but the principle of operation is the same.

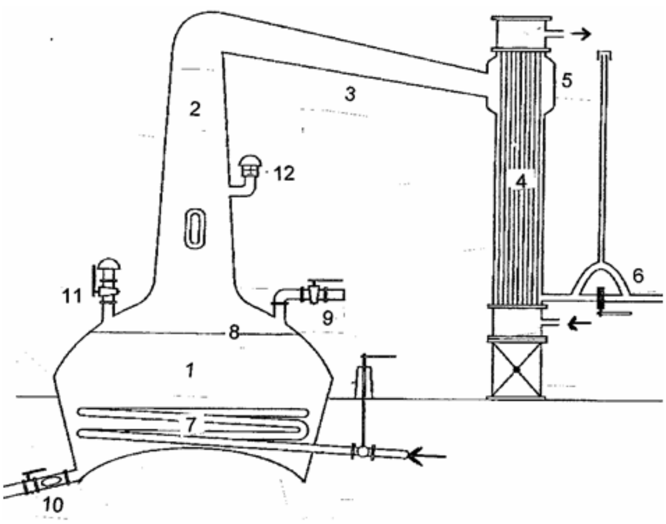

Figure 2 Typical pot still for beer/wash distillation.

- 1. Pot
- 2. Neck*
- 3. Lyne arm* or Lye pipe [* or 2 and 3 may be collectively known as a Swan neck]
- 4. Shell-and-tube condenser
- 5. Vapour chamber of condenser.
- 6. Tail pipe with by-pass valve.
- 7. Steam coil. Steam entry and its control valve are shown, but not the condensate return to the boiler, via a thermostatic stream trap.
- 8. Fill level.
- 9. Charging line and valve.
- 10. Discharge line (with sight glass).
- 11. Valve to release air during filling.
- 12. Safety valve (anti-collapse valve) to release vacuum during discharge. Not shown is a man-door giving access for cleaning and maintenance, fitted just above normal fill level.

The sight glass in the neck is required in rum and whisky distilleries to control frothing of fermented beer or wash with its content of CO_2 and surface-active components of yeast and raw materials. That is unnecessary in the spirit still since its charge does not froth (nor does the clear wine used for most brandy stills). All but the very smallest stills require pressure and vacuum valves for protection during operation, or emptying.

Since this account of distillation has to be applicable to brandy, rum and whisk(e)y, this is an appropriate point to clarify the nomenclature. Although these are the commonly used names, some distilleries may have their own jargon. In this description, the terms Beer and Low Wines will normally be used for the charges to the first and second stills respectively, Heads, Sprit and Tails for the fractions from the spirit still, and Pot ale and Spent lees the non- volatile residues of the Beer and Sprit stills respectively. The Scottish spelling Whisky will be used for whiskies in general, in order that "Whiskey" can specifically mean that product when necessary.

Heating Systems

The still of Figure 2 is fitted with a sufficient length of coiled copper tube to provide the necessary heating surface. An alternative arrangement is a single circle of pipe, fitted with vertical hollow plates (pans) with constitute most of the heat transfer area. The domed base of the still is a relic of the original system of direct firing. That continues in use in a few distilleries, but perhaps now by gas or oil rather than the original solid fuel. Since that gives a higher temperature of the copper surface than on a steam coil, there is a significant difference in flavour. Also, the baking effect of the higher temperature creates a harder deposit.which may be impossible to remove by caustic detergents alone (acid products must not be used on copper!). In Scotland the traditional cleaning system for direct-fired stills is a "rummager", a large rotating brush of copper chains which scrape the deposit from the base of the still.

There must be sufficient charge that the liquid remaining at the end of distillation covers the heating coils, but the still would normally be filled to the maximum capacity shown in Figure 2. It is common practice to pre-heat the charge to the beer still as an energy-saving measure, through a heat exchanger against the flow of hot (~ 100oC) pot ale from the previous run. The charge enters the still at 50 – 60oC, too low for loss of alcohol (Figure 2.5.1). Heating must begin immediately, before solids settle on the heat transfer area (steam coil, or base of the still in the case of direct firing). Once heating begins they are kept in suspension by the vigorous convection currents. Although rapid heating to boiling point saves time, the risk of ethyl carbamate formation in malt whisky wash is reduced by slower heating. It must be possible to reduce the heat immediately and rapidly when froth is seen in the sight glass (or lower glass, if the neck is fitted with two).

If the still is fitted with a temperature gauge, that provides advance warning. Another warning sign of the start of distillation, if the discharge pipe in the spirit safe it fitted with a flap valve, is fluttering of the flap. Beer in the liquid phase must not pass over into the receiver vessel. That includes the droplets from bursting foam bubbles which could be carried over with the flow ofvapour (entrainment). The distillate must be volatiles only; entrained liquid has not been distilled and therefore includes unacceptable non-volatile congeners. That constitutes a “foul distillation” which must be re-distilled. In Scotland, re- distillation requires special Excise arrangements and installing temporary pipework back to the wash still.

Usually the vigorous frothing is over within 30 min, as CO_2 is driven off and any surface-active components of the beer or yeast cells are inactivated. Then heating can be cautiously increased to hold the remaining froth just visible in the sight glass, or at the level of the lower glass if there are two. Since the boiling temperature rises throughout distillation as the alcohol concentration falls, a gradual increase of heating is necessary to maintain a constant flow rate of distillate at the spirit safe. Although the charge to the spirit still does not froth, it is essential to maintain a precise distillation rate for consistent amounts of flavour congeners in successive distillations. The rate of distillation is less important for tails.

Condensers

Module 3 covers their construction and operation, but the effect of the principal types of condenser on spirit flavour is relevant here. All three types are normally constructed of copper. The beneficial effect on flavour, especially removal of sulphur congeners, is worth the cost of corrosion and more frequent repairs than would be necessary with stainless steel. The still in Figure 2 has a shell-and- tube condenser, a copper shell encasing a bundle of copper tubes. The number and length of tubes (i.e. the surface area for condensation and then cooling to 20°C) is calculated to match the capacity and distillation rate of the still. Many distilleries still have the older “worm” condenser, a spiral of copper pipe built up of flanged sections bolted together, gradually decreasing in diameter as shown in Figure 3. To provide the required cooling area, the total length immersed in the tank (tub) of cooling water could be 100 m. The third possible type of condenser, a plate heat exchanger, is used in only a few distilleries.

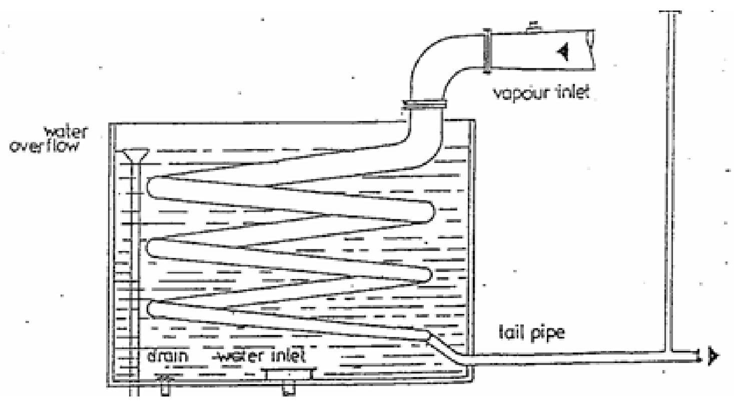

Figure 3 Worm condenser.

2.2.3 Ethanol Profiles & 2.2.4 Congener Behaviour

Distillation of flavour congeners

Figure 1 refers to a mixture of ethanol and water. However, the charge to the wine still of a brandy distillery is a mixture of ethanol and water with the numerous flavour congeners from both the grapes and yeast metabolism. In rum and whisky distilleries the congeners also include structural components of the yeast, since it is normal practice not to remove yeast before distillation. These components vary in volatility, but basically form three groups: (A) more volatile than ethanol, (B) averaging approximately the same volatility as ethanol and (C) less volatile. Phenol itself, shown as the example of type C in Figure 5, is relevant only to peated malt whiskies, but grapes and malt have various minor components which are phenolic in nature and of similar low volatility, as are long-chain fatty acids such as oleic, linoleic and palmitic, from yeast membranes. To be strictly accurate, type (B) compounds are more volatile than ethanol at low ethanol concentrations, but become less volatile as ethanol concentration increases (Figure 5). This is particularly important in the spirit still, since distillate for maturation is collected for only part of the run.

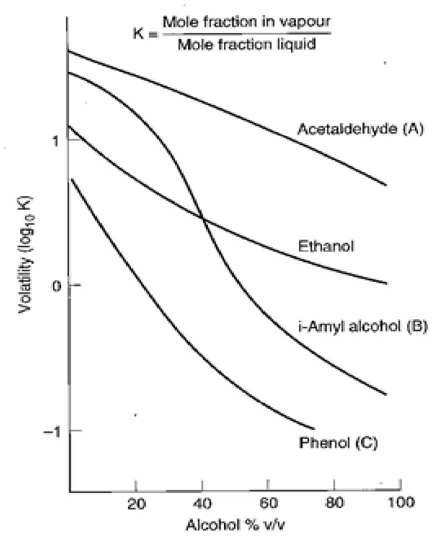

Figure 5 Volatility of typical flavour congeners.

In the second-stage distillation in the spirit still, the first distillate contains high- volatile congeners of unacceptable flavour, e.g. sulphur compounds and acetaldehyde. Methanol is another possible unwelcome high-volatile congener to be removed. The first distillate also contains unacceptable low-volatile congeners, which condensed and formed a residue on the inner surfaces of the still towards the end of the previous run. These compounds, mainly long-chain fatty acids and their esters, are re-dissolved by the strong alcohol at the start of distillation, but if allowed to remain in the spirit would come out of solution again on dilution to bottling strength, forming a haze. So the heads fraction is removed for re-distillation before collecting the middle cut, the spirit fraction. The cut point between heads and sprit may be decided simply by time, from experience of how long is required. A more precise determination involves diluting a small sample of the distillate with its own volume of water: cloudiness indicates that these fatty congeners are still being dissolved into the distillate. Yet another possibility is by sensory assessment: has distillation ceased of undesirable high-volatile congeners, e.g. S compounds?

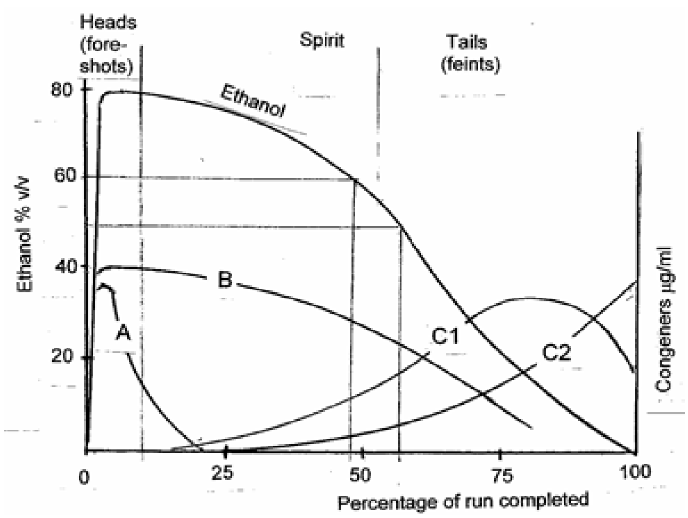

Figure 4 Profile of congeners during spirit distillation.

A, more volatile than ethanol; B, similar volatility to ethanol, C, less volatile than ethanol., and C2 is less volatile than C1.

Figure 4 shows the amounts of the three types of congener distilled over the duration of a run. Two different type C congeners are shown to give a more complete picture of the situation. The graph of type B is similar to ethanol itself. Type C compounds distil slowly at first, then in increasing amount as alcohol concentration falls (and equally important, distillation temperature rises). The difference between cut points 60% and 50% abv is that a greater amount of the type B and C congeners is collected with the 50% cut point, particularly C since they are distilling in increasing amount as alcohol concentration falls.

Incidentally, although 50% abv is well below the usual strength for maturation, that is the cut point, not the strength of the bulk spiirit The alcohol concentration in the distillate is falling so quickly between 60% and 50% abv that only a relatively small amount of weak spirit is collected over that time, and an average of at least 65% abv can be expected. Then the tails fraction is collected down to 1% abv, and the heads and tails are combined with low wines from the beer still for the next run.

For rum and whisky, only the spirit distillation is cut in this way; the low wines from the first distillation are collected as a single fraction. This is not true of brandy distillation (fruit brandies in general, not just grape). An important component of these fruits is pectin, the methyl ester of polygalacturonic acid, and some degradation to methanol is unavoidable, even though the fruit debris is removed early in the fermentation. Since methanol is more volatile than ethanol it is collected as a heads fraction which is normally discarded. Although it is possible to re-distil and separate that methanol-ethanol mixture, that is impracticable for the majority of small-scale brandy distillers.

Measurement of alcohol strength is commonly by hydrometer, but in most countries electronic measurement is an acceptable alternative. Thermometers are also required, since the alcohol strength or specific gravity must be measured at 20oC, or corrected to that temperature by reference to tables. In many countries the measurement is done in a sealed glass cabinet (spirit safe), with the distillate from the still discharging into a bowl in which the hydrometer floats. The spirit safe may be legally required by the excise

authority to prevent unauthorised removal of spirit, but it also has the practical advantage of giving accurate control of cut points. For a rum or whisky distillery, the section of the safe for monitoring the beer still requires only one bowl, and a hydrometer calibrated for greatest accuracy at 1% alcohol (or the corresponding density, from which % abv is determined by tables). The part of the safe receiving the distillate from the spirit still requires two bowls with different hydrometers in each (one for 1% abv, the other for 60% or whatever is the spirit to tails cut point), and a swiveling spout to run the distillate to the spirit receiver or the heads and tails receiver as required. A water tap and a facility for sampling are also required if the heads-spirit cut point is decided by the "misting" test.

Although the process is called batch distillation, in reality the spirit distillation is only partly so. Depending on cut points, 35 – 40% of the distillate from the spirit still is recycled. However, a stable level of congeners is maintained by losses from each cycle of the stills. Type B compounds distil with ethanol. Apart from the small amount distilled into the spirit, type C congeners are either discharged with the spent stillage (pot ale and spent lees), or if distilled into the tails, remain in the charger vessels, either coating the walls or forming s a separate layer of denser liquid. Also, a proportion of the high-volatile type A congeners is lost to atmosphere from each distillation. So the amount of A, B and C congeners in each successive batch of spirit is approximately constant. To summarise, a typical batch distillation process is illustrated in Figure 6, showing the volumes at each stage per 1000 litres of original beer/wash.

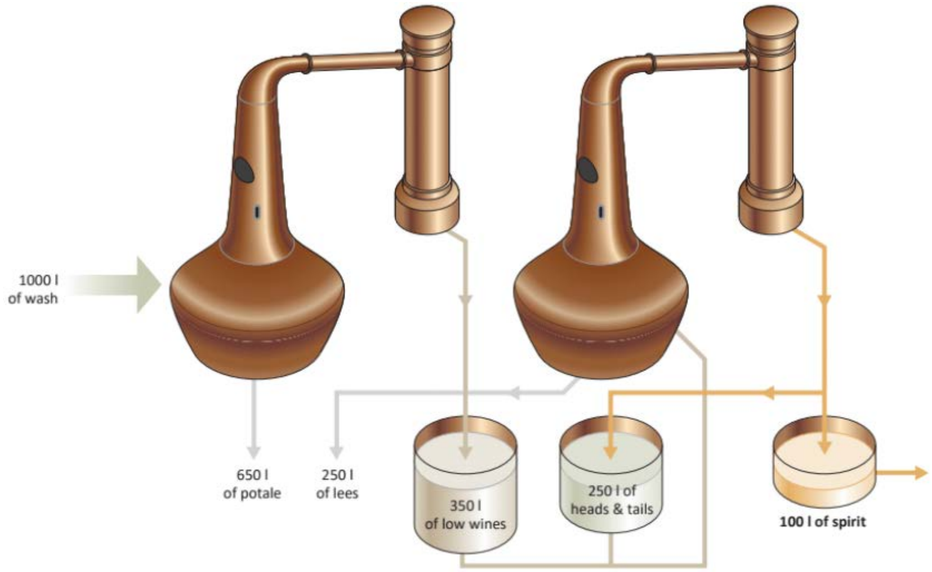

Figure 6 Relative quantities in double distillation per 1000 litres of wash.

Balanced or unbalanced distillation

It is common practice to collect the low wines, heads and tails in a single receiver vessel, since they have to be mixed anyway for the next distillation. For the discussion so far of the process it has been assumed that the two stills are started simultaneously and operated over approximately the same time. This is a common procedure, although the distillation time could vary from 4 to 10 hours in different distilleries. Alternatively, the beer still could be run over half the time of the spirit run where slow distillation is considered to contribute to the characteristic flavour of a particular distillery's product. So, for example, two 5-h runs of the beer still could provide low wines for a 10-h run of the spirit still. Only one batch of heads and tails would be available for recycle, but with two volumes of low wines the total charge would require a spirit still approximately the same size as the beer still (e.g., according to Figure 2.5.6, the spirit still charge would be 350 + 350 + 250 = 950 litres).

Both of these schedules are examples of "balanced distillation", giving each successive run of the spirit still a charge of the same volume and composition, and usually in the range 20 – 25% abv. Higher or lower strengths may be encountered in distilleries operating with unusually high or low abv values of cut points. The volume and alcoholic strength of low wines, spirit, heads and tails are remarkably constant for a specific still system operated in a consistent way, although there is wide variation between distilleries.

The alternative of unbalanced distillation has the advantage that the first still to complete its run can be started again without waiting for its partner to finish, maximising the use of expensive plant. Against that economic logic is the problem that the charge for each run of the spirit still could have different composition, according to what was available at the time of filling, so each distillation produces a slightly differently flavoured spirit. The problem is not so serious in larger distilleries with several pairs of stills, each at different stages of the distillation cycle. However, even in a basic 2-still layout, separate receiver vessels for (a) low wines and (b) the combined heads and tails from the spirit still, may allow preparation of more consistent charges with respect to both congener composition and alcoholic strength. In any case, combining spirit from a number of distillations for cask filling helps to even out variations between individual distillations.

Number of stills

The great majority of distilleries use either one pair of stills as described above, or multiple pairs. Some small-scale distillers operate with a single still, which first produces several batches of low wines and then is used for a spirit distillation, but otherwise follows standard procedures. Triple distillation is also sufficiently common to require description of a typical programme here:

- First stage: the beer/wash still operates in the same way as for double distillation, and its low wines pass to the intermediate still (IS).
- Second stage, the IS distils only two fractions, since there is no need to recycle first runnings here: The first fraction, called heads or high wines, proceeds to the next run of the spirit still and the tails are returned to the next IS distillation. The IS heads-tails cut point can be a much lower % abv than would be possible for a spirit fraction intended for maturation, even down to 20%, but even so, the charge to the spirit still is much stronger than in double distillation, typically > 50% abv.
- Third stage: the spirit still, charged with the heads from the IS and its own heads and tails recycle, is operated in the normal way except that the higher % abv of the charge means that it produces a stronger final spirit, > 80% abv.

Therefore the final matured product from triple distillation is "lighter" in flavour, for three reasons: (a) the greater rectification of three rather than two distillations, (b) three opportunities rather than two for the copper still surfaces to remove sulphur congeners, and (c) the stronger spirit requires greater dilution for maturation, and ultimately bottling, which further dilutes congener flavour in the final product. In a few Scotch whisky distilleries, a programme similar to triple distillation is operated with pairs of stills, using a spirit still as an IS as required.

Reflux

Condensed vapour in the neck of the still runs back into the pot as reflux. Compounds of lowest volatility reflux most actively. For example, the theoretical alcohol concentrations from distillation of the ethanol-water mixture in Figure 1 are lower than one's practical experience in the distillery because they do not take into account the effect of reflux. The preferential reflux of low-volatile water creates a stronger alcohol vapour to pass to the condenser, than indicated on the graph.

Factors affecting reflux are (a) the shape of the still, (b) additional refluxing equipment, (c) the rate of distillation, (d) the fill level of the still, (e) the ambient temperature and (f) the cleanliness of the outer surface of the still. The first three are the most important. Consider stills A and B of Figure 2.5.7. Clearly, the neck of A has greater surface area, and therefore more reflux, and condensation in the upward-sloping lyne arm also refluxes back into the still. In B, reflux in the arm runs forward into the condenser as spirit.

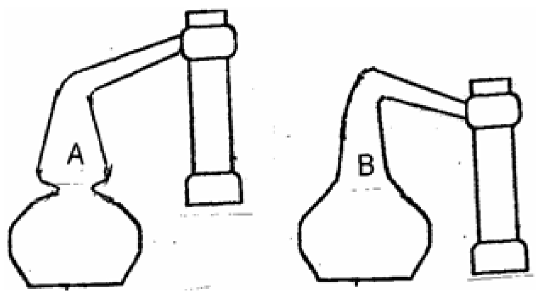

Figure 7 Effect of still geometry on reflux. Note the greater condensation area, and therefore greater reflux, of A.

It is possible to increase reflux even more, e.g. by perforated plates (sieve plates) in the neck of the still. Even the increased reflux with 1 or 2 plates has a significant effect on congener profile, but with 10 – 20 it becomes essentially a small column still operating batchwise.

High-volatile heads are not released to atmosphere; a heat exchanger is normally fitted at the top to recover part of the heads, especially any ethanol it may contain, for reflux. Stills for Armagnac brandy have a similar appearance, but since they actually do operate in continuous mode, continuous overflow from the pot of low-volatile tails (as well as the vinasse/spent lees) is also necessary to maintain a constant volume, and concentration of alcohol and congeners.

Yet anther possibility for increasing reflux is a small condenser fitted in a downward-sloping lyne arm which returns condensate to the still rather than allowing it to progress to the spirit receiver vessel. At first sight, an upward sloping arm as in Figure 2.5.7A is a simpler way to achieve that effect. The advantage of a "purifier", one design of which is shown in Figure 2.5.8B, is that the reflux can be altered from one distillation to the next by the flow rate of cooling water to produce two or more differently-flavoured spirits from the same still. Such a system can be found in some rum and whisky distilleries. The general effect of greater reflux is a "lighter" spirit, and less reflux increases the content of low-volatile congeners in the spirit. The latter situation is particularly important with peated Scotch malt whiskies, to maximize the effect of the low- volatile phenolic congeners from peat smoke. A faster rate of distillation reduces reflux since the vapour has less chance of condensing in the neck of the still, therefore a greater amount of low-volatile congeners can be expected in the spirit. The converse applies to slower distillation, but another benefit is the stronger spirit resulting from refluxing more water. Less reflux also affects flavour in another way: there is less opportunity for the copper surface to react with S congeners, further adding to the stronger flavour of the spirit.

Three other factors are much less important, but nevertheless worth mention. Lower ambient temperature, a dull external surface (more heat loss by convection and radiation) and the additional air-cooled surface from a low fill level, all lead to more condensation within the still, i.e. more reflux.

2.3.5 Pre-Distillation Influences on Quality

Yeast metabolism and microbial infection influence all three of brandy, rum and whisky. The importance of consistent fermentation procedure was discussed in module 1. However, raw materials also have important effects on quality and flavour, which can be very different in brandy, rum and whisky distilling. One specific type of each is discussed below as an example.

Cognac brandy

The specified grape varieties are low in sugar and high in acidity, giving a sour wine of only about 8% abv which is more suitable for distillation than stronger table wine, concentrating the fruity flavours of the grapes along with the alcohol. Additionally, the temperature of distillation encourages copper-catalysed non-enzymic esterification of alcohols with the acids from the grapes. Also, the common practice of a natural inoculum of yeasts contributes a desirable complexity of fermentation flavour

Caribbean dark rums

In many distilleries, inoculation of the fermentation is either entirely by a naturally occurring inoculum of yeasts and various bacteria, or by cultured distillery yeast supplemented by natural inoculum. Although the spirit retains characteristics of cane juice or molasses, the congeners from the mixed-culture fermentation have more impact on aroma.

Scotch malt whisky

Much of the flavour of malt develops during drying (kilning) after germination, but dimethyl sulphide formed from S-methyl methionine is an unwelcome congener from kilned malt. More seriously, the carcinogen nitrosodimethylamine (NDMA) is a possible product of faulty kilning which could theoretically be distilled with the spirit, but must be prevented for health reasons (see unit 2.8, Quality). Although there is no need for the malt to impart colour to the wort, some development of colour is unavoidable during kilning. More importantly, all of the following malt components or derivatives make an acceptable contribution to whisky flavour: aliphatic acids and aldehydes, and Strecker degradation products (amino acids => aldehydes) and Maillard (browning) reactions from kilning. Also the volatile heterocyclics derived from ○- amino ketones of these kilning reactions may be important. For some malt whiskies, the malt is exposed to smoke from smouldering peat during the kilning. Peat has a high content of the phenolic polymer lignin (unit 2.7, Maturation, includes an explanation of lignin structure). So peat smoke adds various phenolic compounds (phenol itself, *ortho-, meta*- and *para*-cresols, guaiacol, etc) which add their flavour to the spirit.

2.2.6 The Effects of Copper

There has been frequent incidental mention in these notes of the effect of copper on spirit quality. This section deals specifically with three aspects of reactions involving copper: (a) removal of sulphur congeners, (b) catalytic effects.and (c) exhaustion and reactivation by resting.

Although the original choice of copper for still construction was its malleability for construction of complex shapes, and perhaps also its high conductivity of heat, the removal of sulphur compounds by reaction with copper is now the main reason for its use. The beneficial effects of copper on spirit quality are its high level of reactivity in reflux and condensate with S congeners, and catalytic effect on non-enzymic esterific-ation. The higher the temperature, the greater the reactivity, but also the faster the rate of corrosion. The reactions with S compounds produce both soluble copper salts, e.g. CuSO4, and insoluble copper salts and complexes. In Scotch malt whisky production, although copper levels are < 10 mg/litre in the pot ale from wash distillation, as much as 50 mg/litre is possible in the spent lees from spirit distillation.

Since the same reactions also occur in the condenser, it is inevitable that some copper is dissolved into the spirit, but with the lower average temperature and much shorter contact time the amount is small, well below the safe limit. Also, some of that copper is removed during maturation. Shell-and-tube and worm condensers are known to have different effects on spirit flavour, largely due to reactions between Cu and S. The worm operates at a lower temperature, and being a single tube, has a higher flow rate. Both of these factors reduce reactivity in the worm, resulting in higher content of S congeners in the spirit.
However, provided the amounts are not too high in the og/litre range, many S congeners add a desirable note to the aroma, variously described as meaty or spicy.

The section on balanced/unbalanced distillation referred to the immediate re-use of stills. As well as unbalancing the cycles, another disadvantage of such haste is the "exhaustion" of the internal surface of the still. If stills are refilled and restarted immediately after each run, the level of S compounds in the spirit rises to unacceptable levels over the course of a week's operation. At the same time the amount of dissolved copper falls, but gradual loss of still structure is necessary for good-quality spirit. Although longer should be allowed if possible, even 1 – 2 hours of lying open to the atmosphere after each run allows oxidation reactions which "reactivate" the exhausted copper surface to Cu salts which are dissolved in the next run of the still. Except for the heating surfaces, from which deposits of yeast and other debris must be removed as necessary, it is generally considered that there is no need for cleaning internal surfaces of stills with caustic detergents.

Efficiency of distillation

The 10% abv example in Figure 2.5.1 is rather ambitions for most brandy, rum and whisky distilleries. The following example is based on a charge of 10000 litres of 8.2% abv, which could reasonably be expected from complete fermentation of wort of 15o B, SG 1060. The theoretical yield of the two (or three) stages of distillation is 10000 x 0.082 = 820 litres.of pure alcohol (LPA), or 1171 litres of spirit of 70% abv, but this figure does not allow for the 0.1% abv left in each still at the end of distillation.

Calculating from the amounts per 1000 litres quoted in Figure 2.5.6, 6500 litres of 0.1% abv residue remain in the beer/wash still, accounting for a loss of 6.5 LPA; and the 2400 litres of stillage from the spirit still a further 2.4 LPA, i.e. approximately 9 LPA in total. However, a distillery should come close to a revised theoretical yield of 820 – 9 = 811 LPA from 10000 litres of 8.2% abv. The loss of about 9 litres of un-distilled alcohol from each run of the pair of stills (i.e. 12.9 litres of 70% spirit, or 22.5 litres at 40% bottling strength) is significant, but the energy requirement to recover that volume is not justified.

Further Reading

D. A. Nicol's chapter Batch Distillation in Whisky, Technology, Production and Marketing, ed. I. Russell (Academic Press, 2003) covers general aspects of distillation in pot stills.

Also, various chapters in the Proceedings of the Aviemore Conferences and Distilled Spirits Conferences of the IBD cover relevant aspects of batch distillation.