Segment Five

Smoking Kilns

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INTRODUCTION

The mechanical kilns which are described in this segment are based on the principles developed many years ago at the Torry Research Station. The production of the smoke, by both continuous and batch methods, is also described.

Although the use of traditional chimney kilns has declined considerably over recent years, a description of their principles is also included.

AIMS OF THE SEGMENT

The main aim of this segment is to help you to achieve objective 5 given on page xiii.

When you have completed this segment you should be able to:

- Explain how to control smoke in a smoking kiln.
- State the importance of regular maintenance of a kiln.
- Describe the principles of operation of smoke producing units.
- State the important properties of wood as a fuel for smoke units.
- Explain why PAH substances are of special interest to smoked food producers.

MECHANICAL KILNS

The modern kiln consists of a smoke producing unit which is separate from the smoking chamber. Fan assisted air movement is across the chamber so that the smoke is drawn through the racks of fish.

As the smoke and air mixture passes through the racks it becomes:

- **Less smokey** because smoke chemicals are removed as they are taken up by the fish.
- **More humid** as water is removed from each rack of fish by the warm gases passing over the surface.
- **Cooler** as the smoke travels through the trays.

In order to obtain even smoking of all the fish in a batch it is necessary to subject every fish to smoke having the same properties.

With many kilns this has to be achieved manually by moving the racks of fish from one part of the kiln to another. To make this task easier the racks are mounted on trolleys.

If the kiln is of a more advanced design the air flow within the smoking chamber can be reversed.

Considerable improvements have taken place in kiln design. Amongst these are the methods of monitoring and control.

As a result it is now possible to create a much more consistent quality of smoke throughout the entire process.

The principle of the Torry type of kiln is shown in fig 11.

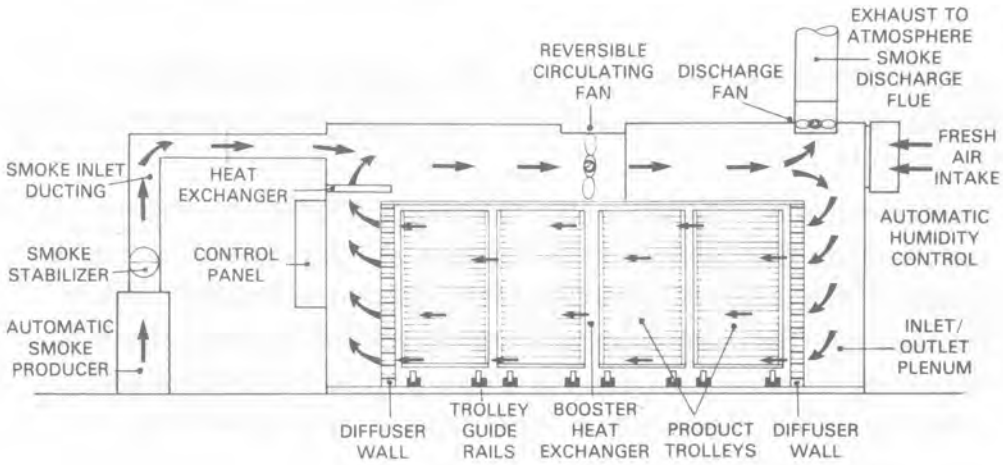

Figure 11 Torry Kiln

Air is circulated around the kiln at a temperature determined by a thermostatically controlled heat exchanger in the top section.

In the largest kiln an additional heat exchanger is inserted between the trolleys to improve this control of temperature.

The humidity of the air is controlled by taking the air in through an inlet damper and allowing a similar amount to exhaust through a chimney via an outlet damper. Correct adjustment of these two dampers, which may be automatic, controls the humidity of the air and produces the correct drying rate.

Smoke is drawn into the kiln through ducts from the smoke producing unit.

It is mixed with both the recirculating air and the fresh air that is entering via the top damper.

A fan in the top section of the kiln causes the air movement through the top section and the smoking chamber.

It is important to maintain an even velocity of the air flow in order to achieve satisfactory smoking and to avoid case hardening of the product. This even flow is achieved by a series of aerofoils and splitter vanes in the top section and by diffuser walls at the inlet and outlet ends of the smoking chamber.

It is important to realise that a mechanical kiln allows consistent quality of product because of the automatic control that is possible.

In the most recent developments this control of humidity, air intake, drying and timing is by the use of a microprocessor.

Mechanical kilns require some maintenance. Without proper maintenance the quality of the product will deteriorate. A main cause of this is the tar droplets falling on to the product. In the modern kiln this maintenance is mainly routine cleaning but it is important that this includes the removal of these tar deposits from the ducts. Modern kilns may include pre-programmed cleaning units for this purpose.

⚠
Failure to clean the ducts could lead to a fire risk.

The type of kiln described could be used for hot or cold smoking. It has the facility to create a wide range of temperatures within the chamber by using the heat exchangers.

Now for some SAQs!

? SAQ41
What changes in the properties of the smoke are likely to take place between it entering and leaving the smoking chamber?

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? SAQ4
How, in a modern mechanical kiln, is the quality of the smoke in the smoking chamber maintained reasonably constant?

? SAQ10
Why should the routine maintenance include cleaning the smoke ducts?

? SAQ15
What features in the design of a mechanical kiln determine an even air flow around the unit?

SMOKE PRODUCTION

The smoke producer unit associated with the mechanical kiln uses one of two basic principles:

- **Continuous smoke production.** This requires a hopper of fuel feeding automatically on to a heated hearth.

- **Batch smoke production.** This employs fire boxes or drawer type hearths into which a quantity of fuel is placed.

Automatic Smoke Producers
Generally industry favours continuous processes because they reduce **down-time**. 'Down-time' is the time during which the equipment is not being productively used; e.g. time used for cleaning, recharging with fuel and lighting.

To make smoke production continuous fuel must be fed to, and spent fuel removed from, a heated hearth automatically.

An example of this technique is a perforated grate and an air fan, which provides air for the combustion to the underside of the grate.

The sawdust fuel is contained in a hopper and is fed automatically, via a moving feed rack, on to the grate. The action maintains a constant thickness of fuel along the fire bed during burning.

Dampers control the air to the fire bed and the rate of fuel fed to the grate.

In order to prevent the sawdust from flaring a heat exchanger can be placed above the fire bed. This lowers the temperature of those elements in the fuel which would otherwise be likely to flare up.

A smoke stabiliser can be used to cool the smoke before it enters the kiln and remove the excessive moisture content. This allows better control of humidity and temperature to occur within the kiln.

You may come across mechanised arrangements other than the one just described but all continuous smoke producers require:

- An even distribution of fuel on to a heated hearth.
- A mechanism for removing the ash.

Batch Smoke Production
Smaller kilns are sometimes made as single units which include the smoke producer.

In these units the smoke producer consists of relatively simple fire boxes or drawer type hearths.

Up to 3 drawers may be included each having a sliding door type inlet. Adjustment of the door controls the amount of air passing over the fires.

When the unit is in operation a fan draws air through the inlet and over the smoke producers. The inlet control may be operated automatically together with the damper which determines the amount of air recirculating in the kiln. Automatic control ensures a more even air flow. The basic fire box is shown in Figure 12.

Figure 12

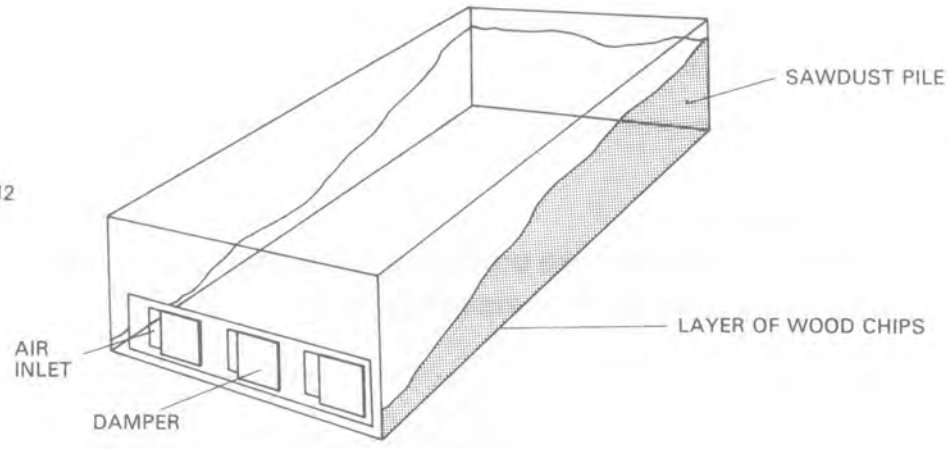

Figure 12 Fire Box

The major disadvantage of the batch system is that, because it is more difficult to control, it is a skill orientated operation.

Now here are 3 more SAQs for you to attempt.

? SAQ20
What are the main advantages of a continuous smoke producing unit?

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? SAQ25
What is the purpose of an inlet damper on a fire box?

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? SAQ30
Why are some smoke producing units fitted with a heat exchanger above the heated hearth?

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TRADITIONAL CHIMNEY KILNS

The traditional kiln is simply a chimney which relies on the natural movement of:

- Smoke rising from piles of smouldering sawdust on the floor;
- Air, entering at the base of the chimney through a damper, being warmed and also rising.

The fish are hung at various heights up the chimney.

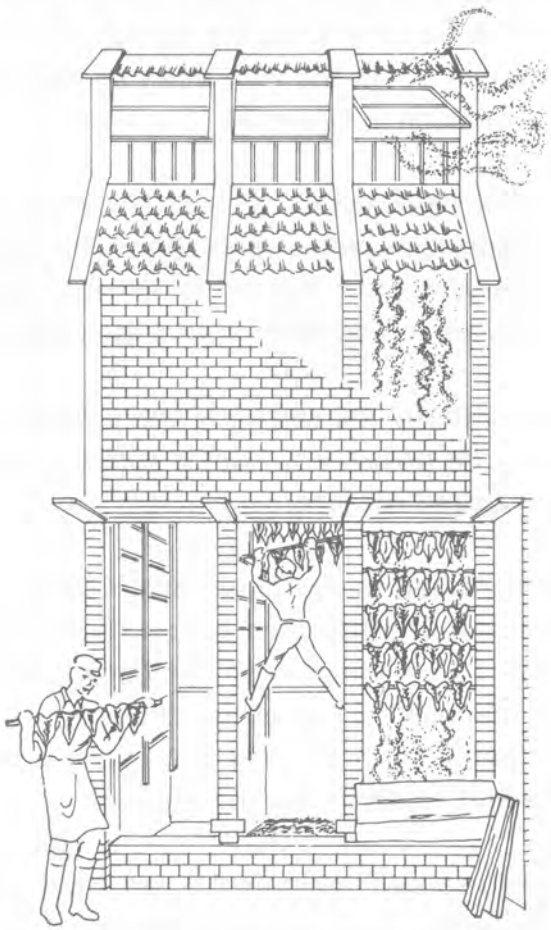

Figure 13 Traditional Kiln

This system can produce good results if used by experienced operators but it has some important disadvantages:

- Control of the smoke is difficult. The smoke does not always follow the same path.

- Control of the temperature is difficult. The piles of sawdust may suddenly flare causing the fish on the lower rails to cook.

- The humidity of the smoke increases as moisture is evaporated from the lower fish. The wet smoke cannot then successfully dry the fish higher up the kiln.

- To even out the process the rails of fish have to be moved during smoking. This is an unpleasant and difficult task. The lower rails are removed from the kiln when they are judged to be of the right colour and texture. The fish on the higher rails are then brought lower down the kiln. You can seen this operation in Figure 13.

- The performance of the kiln varies with the outside weather conditions. The upward movement of the smoke is best in fine dry weather preferably with a steady breeze.

In warm, humid weather the smoke is being mixed with warm air and it may not be possible to heat it sufficiently for it to rise and cause the required draught.

If the fires are increased to overcome this problem the fish may become overcooked. The fish then fall on to the fires and are called 'droppers'. Sometimes the smoke cools enough to start falling before it reaches the top of the chimney. These 'down draughts' may then disturb the fires and cause ash to pass up with the smoke and contaminate the product.

The traditional kiln shown in Figure 13 has a baffle on the chimney opening which is designed to prevent down draughts.

Some chimneys are fitted with rotating hoods. These prevent rain entering and they also stop down draught caused by sudden gusts of wind since they rotate with the wind like a weather vane.

Now try these two SAQs:

? SAQ35
What are the two most likely causes of a down draught occurring in a traditional chimney kiln?

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? SAQ40
Why is a rotating hood sometimes fitted on to the top of a chimney kiln?

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MAKING SMOKE

When wood is heated it is broken down into a large number of different chemical substances. Some of these are given off in the smoke as either invisible vapours or as visible tarry droplets.

The kinds and amounts of chemical substances present in the smoke will depend upon:

- The type of wood used;
- The temperature to which it is heated;
- The manner in which it is heated;
- The water content of the wood.

Whatever type of wood is used it is best used in the form of **sawdust.** In a sawdust fire the air cannot easily get to the fire unless there is a forced rapid air flow. Therefore the sawdust smoulders rather than flares. The resulting lower temperatures, with less oxygen present, give a smoke which has more flavouring and preserving substances.

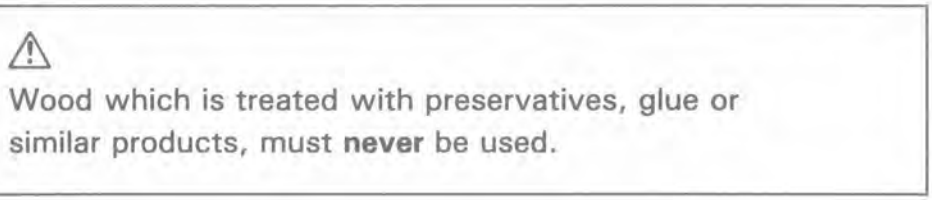
The type of wood is important.

Hardwoods, such as oak, cherry, apple and beech burn to give smoke with more **phenols** present. These are the chemicals which both preserve and give flavour. Hardwood smoke does not, however, give much colour to the product.

Softwoods, such as pine spruce and fir burn to give a smoke which contains more acids. These preserve but give a harsh flavour. Softwood smoke colours the product more quickly.

The range of woods used for commercial smoking is limited by the availability of sawdust. As a result, the sawdust is usually a mixture of hardwoods or of softwoods or both.

The subtle differences in flavour is brought about partly by the type of woods used but also by the amount of smoking carried out.



Finally, in this segment, one particular family of chemical substances present in smoke requires comment. These are collectively known as **PAH** which is shorthand for polynuclear aromatic hydrocarbon. Because this family of substances are known to have toxic properties, they have been specially investigated.

The general conclusions to date suggest that UK smoked foods have relatively low concentration of PAH substances. Certainly the quantity of PAH reaching the fish in a cold smoking process is quite small and is not considered a problem. In hot smoking these substances could, if considered necessary, be removed by an electrostatic precipitation process before the smoke reaches the product.

Since the processes of smoking are no longer primarily intended to preserve but rather to impart flavour and affect texture and appearance the smoking time is much reduced and the PAH content is therefore also reduced to a safe level.

Now attempt the last three SAQs in this segment.

? SAQ42

What types of wood would you use to obtain:

1. Good colouring of smoked fish?

2. Good flavour of the smoked fish?

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? SAQ5

Why is sawdust the best form of wood fuel?

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? SAQ11

Why are PAH substances of special interest to smoked food producers?

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SUMMARY

This segment has dealt with the following topics:

- The principles of mechanical kilns based on the Torry design;
- Control of the operating conditions within the kilns to give a consistent quality of product;
- The principles of traditional chimney kilns;
- Problems associated with the operation of traditional kilns;
- Smoke producing units for both continuous and batch smoke productions;
- Suitable fuels for use in smoke units.

You have now completed Segment Five and achieved objective 5 given on page xiii. Time for a break before tackling the final segment in this module?