

The choice for the future:

Timber Drying by vacuum or by conventional methods?

Part 1: A survey of alternative methods, distinctive features of vacuum driers, the processing involved

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For many operators an important step in the rationalisation of timber drying may be the introduction of vacuum drying – with drying times which may be 2 to 6 times shorter than in conventional processes. If the correct method is selected better timber quality and lower drying costs will also be obtained. The following notes provide clear, concrete help in deciding which option to take.

I. New Ideas from the New World

An article entitled "Secret lumber-drying process remains shrouded in mystery" appeared recently (February 1993) in the US journal "Woodshop News". The inventor, Eugene Sexton of Tennessee, claims that his "ESP '90" process can dry whole trees naturally, cheaply and without special equipment, with little or no timber reduction. Eugene Sexton has declared his intention of cutting a large tree (red oak) into three equal sections and drying only the two end parts. All three sections are then to be examined for moisture, discoloration and other changes by scientists from the US Department of Agriculture's Forest Products Laboratory (FPL) in Madison, Wisconsin. The parties are so far in agreement; but no-one has yet declared himself willing to cover the costs of transporting the three pieces (each 3 m long, 1/2 m in diameter and weighing 450 kg) from Tennessee to Wisconsin. The three pieces of trunk have already been stored for over a year on Sexton's premises. The two dried sections are in "good condition", says Sexton, but the central part is "away from the window" and may possibly split right through.

This "heavenly" drying method has not yet reached Europe; we realists still have to rely on conventional fresh air/exhaust air drying and increasingly on vacuum drying. Nevertheless this article shows that new drying methods are being considered all over the world, in research laboratories and industrial development centres. At a time when rationalisation measures are characterised more and more by terms such as "just in time" and "lean production", oak drying times of one or even six months sound rather antiquated and can hardly be justified economically.

Fig.1 Hot steam vacuum drier High Vac B40/10

II. A survey of alternative drying techniques

Even in the past there has been some variety in the vacuum driers available, in respect of the basic process (continuous or discontinuous) and the type of heating – by convection, heating plates or microwave. As drying terminology is now well known, only extremely important features will be mentioned, briefly. More space will be devoted to a less well known method, microwave heating.

In discontinuous vacuum drying (always with convection heating, i.e. with heat transfer by circulating air) the wood undergoes repeated changes, first being heated at atmospheric pressure then demoi-
 sturised at low pressure without any heat. This saves on fan capacity in the design of the chamber; however there is considerable risk of discoloration owing to the presence of a high oxygen component during the heating phase.

In continuous vacuum drying there is simultaneous heating and demoi-
 sturising most of the time, at reduced pressure; external air is excluded. With convection heating the air speed, i.e. the fan capacity, must be suitably high owing to the low density of the drying agent. With direct heating no fans at all are required but there are serious problems: heating plates are only used individually and only for small useful volumes owing to their limited size and the very laborious, time-consuming job of stacking and removing from the stack.

The other direct heating method, viz the use of microwaves, is at present being tried out on miniature driers in Japan. Apart from the comparatively high capital costs and greater likelihood of malfunctioning it is very difficult to obtain homogeneous intensity distribution over the whole stack, i.e. the risk of local overheating of the timber is relatively high when rapid drying is carried out. But the main drawback of microwave heating at the moment is that all the energy required for drying has to come from the electricity network. Nor is the efficiency of ordinary power oscillators all that high (e.g. it is less than 70% for continuous wave magnetrons); the excess operating heat of the "transmitter" has to be dissipated by intensive cooling. At any rate "waste heat" from chip or bark combustion cannot be utilised with this type of drier.

III. Some details of the vacuum drying process

The distinctive features of vacuum driers described above can no longer provide the designer with a basis for costing models specifically to customer requirements. Plate or microwave heated installations no longer meet (or do not yet meet) the high demands which the rapid technological developments of recent years have brought with them. They are also inappropriate for large chambers; yet there is more and more demand in the market for these particular installations.

The old classification takes too little account of the importance of physical state variables in a low vacuum; these are a decisive factor in determining the drying result (drying time, quality and cost, degree of discoloration, final moisture dispersion) and purchase price.

Limits reflecting the effect of state variables on individual stages of the process and drying targets must therefore be drawn so that the vacuum drier models and drying methods of the future can be regrouped.

The distinction between continuous and discontinuous vacuum drying should be retained so long as both methods are widely used in practice. But the distinction according to the type of heater can be dropped, since heating by forced convection (fans) has clearly gained acceptance and is almost universal.

Drying in pure superheated steam or a steam-air mixture

Selection of the drying agent is of great importance, since design, control and drying targets are equally concerned with it. Either pure superheated steam or a steam-air mixture is used. Residual quantities of air can never be completely discharged, so there is no clear division between the two versions, especially at very low operating pressures below 100 mbar. The difference should therefore be defined a bit more accurately: in superheated steam drying an attempt is made to keep the partial pressure of air as low as possible; in drying with a steam-air mixture dosed quantities of air are systematically fed in for specific purposes.

Table 1

With pure steam high demands are made on the vacuum pump and the tightness of the drying chamber in respect of the lowest partial pressure of air obtainable (less than 30 mbar). However the demoi-
 sturising rate can be increased almost at will by appropriate cooling of the condenser, since the steam on the way to the condenser is not slowed down by any appreciable resistance caused by diffusion.

If a mixture with air is used instead of pure steam, and if there is the same partial pressure of steam and an unchanged temperature, there will be the same relative moisture, i.e. the climatic values will remain unchanged. Owing to the higher total pressure prevailing and the accompanying higher gas density, there are no problems with conventional heat transfer to the timber: the required fan capacity or speed is reduced. But the higher total pressure simultaneously reduces the mobility of the water in the timber (coefficient of circulation) and thus increases the risk of drying stresses. The diffusion resistance which the air molecules set up to the steam must also be taken into account. It impedes compensation of the partial pressure of steam in various stacking areas and limits the demoi-
 sturising rate upwardly, without additional apparatus. But even at the conditioning stage it may be helpful to use this impediment systematically, e.g. in order to slow down dispersion of wood moisture (more on this in Section V).