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PLANNING AND LAYOUT OF THE TIMBER KILN *

by

S. Schmid **

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1. General

The most exact determination of the size of a dry kiln is usually based on the number of parameters, for example:

- demand of dried timber per year (month, day, etc.);
- timber thickness;
- initial moisture content;
- final moisture content;
- length of timber and kind of conversion;
- thickness of stickers;
- dimensions of packages;
- daily operation time (normally 24 hours).

The required usable net volume is calculated on the basis of the drying time and the timber quantity to be dried per unit of time as well as the required quality of dried timber. (Drying time - hour or day - x capacity - m^3/hour or day - equals usable net volume - m^3).

Most manufacturers of drying kilns have obtained their drying diagrams through research work in laboratories which are always available to the manufacturer and usually to the customer too. Drying times depend on the wood species, timber thickness, initial and final moisture content and the drying system itself (i.e. conventional, condensation or vacuum drying) and in many cases, even the province may affect the drying times.

The following example will explain further:

2. Calculation Example

Requested capacity m^3/year	approx. 1.500
Working days/year	280
Working hours/day	24
Wood species	Beech
Timber thickness	50 mm
Initial moisture content	60%
Final moisture content	8%
Max. length of timber	3.000 mm
Drying time read from table	approx. 14 days
Reserve	" 2 days
	approx. 16 days

2. Calculation Example Cont.

(Reserve for charging and discharging and possible down-times)

$$\frac{1.500\ m^3/\text{year} \times 16\ \text{days}}{280\ \text{days/year}} = 85{,}7\ m^3\ \text{(net) kiln volume}$$

For determination of the kiln size, the stacked packages must be dimensioned and the number has to be fixed.

Timber thickness	50 mm
Sticker	25 mm
Stacking layer	75 mm

A well-balanced proportion of timber thickness and thickness of stickers to the circulating air generated by fans is most important when considering an air velocity through the stack of approximately 2,0 - 3.5 m/second according to the timber to be dried.

Standard thickness of stickers in relation to timber thickness

16 mm for timber thicknesses up to 30 mm;
25 mm for timber thicknesses of 31 - 60 mm;
40 mm for timber thicknesses of 60 mm and more.

A stacked width of 1.200 mm has been adopted, generally, in Europe during the past years (with the exception of the Parquet industry). The package height varies from approximately 1.000 - 1.400 mm. Length according to requirement.

We would assume, for example, the following:

package width	B = 1.200 mm
package height	H = 1,200 mm
package length	L = 3.000 mm

$$\frac{\text{package height (unit)}}{\text{stacking layer}} \quad \frac{1200\ mm}{75\ mm} = 16\ \text{layers}$$

Consequently, the effective timber height comes to 16 layers x 50 mm and equals 800 mm net.

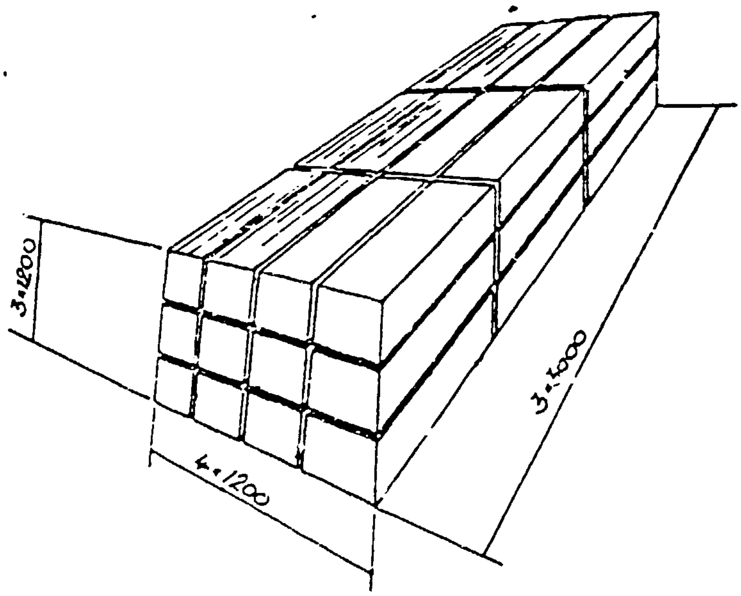
Timber volume per package at a width utilization of 85% equals length 3.0 m x height 0.8 m x width (1.2 x 0.85)

$$= 2.4\ m^3/\text{package}$$

With this data the number of packages for the kiln will be calculated:

$$\frac{85.7\ m^3\ (\text{net})}{2.4\ m^3/\text{package}\ \ (\text{net})} = 35.70\ \text{packages (approximately 36 packages)}$$

Beginning with the fact that the kiln will be front loaded with fork lifts and based on the above calculation, the following arrangement of the packages stacked will be fixed.



Width 3 x 3.000 mm

Depth 4 x 1.200 mm (36 packages of 2.4 m^3 each = 86.4 m^3 usable net volume of the kiln)

Height 3 x 1.200 mm

3. Other Details to be Considered for Dimensioning a Kiln

3.1 Drying of different wood species and thicknesses

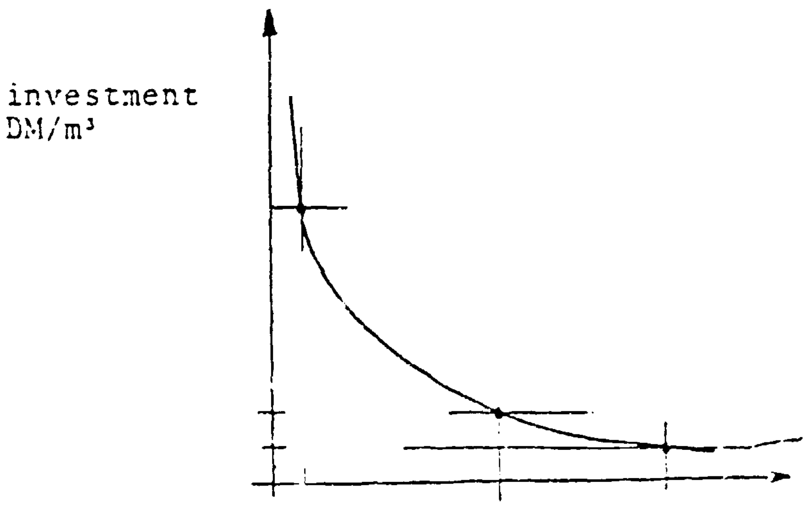
The condition of planning a drying plant in the most favourable and economical way is, of course, the availability of similar material regarding species and thicknesses as well as initial moisture content. But, if several wood species of various thicknesses have to be dried, one has to have the following in mind:

a) To install several kilns adjusted to the corresponding volumes;

b) Common drying of various species and thicknesses. This method, of course, requires a kiln operation according to the timber with the most difficult drying operations;

c) Separate drying of whole charges according to wood species and thicknesses, with intermediate storage of the excess capacity.

The investment costs are one of the important points to be considered when deciding for one or several kilns to be installed. The more kilns the smaller the usable net volume and the higher the investment costs.



Cost Comparison:	Kiln Size	Specific costs/m^3
	more than 100 m^3	approx. DM 1.000, --/m^3
	up to 60 m^3	approx. DM 2.000, --/m^3
	up to 7 m^3	approx. DM 6.000, --/m^3

The example given hereunder illustrates the aforementioned: the smallest kiln with a usable volume of 7 m^3 timber costs approximately DM 40.000 including a fully automatic control unit, that is per m^3 usable volume approximately DM 6.000. For dry kilns having a usable volume of 100 m^3 or more, this specific cost may be less than DM 1.000 per m^3 usable volume (these figures are based on 1981 prices for conventional kilns).

This proves that the decision whether several small or one bigger kiln shall be installed can only be made upon consideration of the above mentioned. Each fact has to be taken into account according to its priorities. Since the money required per m^3 of dried timber is of prime importance, it is advisable to prepare a cost analysis for each particular case. This also applies to the drying method to be chosen. Three methods are practiced at present: a) conventional drying according to the fresh/exhaust air process; b) condensation drying; and c) vacuum drying.

Condensation drying kilns should all have the same dimensions (however certain manufacturers of the condensation drying kiln neglect to observe this rule). And as for vacuum drying, special parameters must be considered making discussion of this as well as the condensation drying kiln difficult in a paper of this scope. Therefore, we will concentrate only on the conventional system of drying which is the most well-known and frequently used method.

3.2 Heating of Timber Drying Kilns

The heating is divided into 2 methods:

3.2.1 Direct heated plants

3.2.2 Plants heated indirectly via heat exchangers

Each heating method is naturally based on different principles. As for the drying itself, the heating method is important only regarding the requested maximum drying temperatures.

As a guide line, you can start from the fact that the available temperature in the kiln is approximately 20° C below the average temperature of the available heating medium.

Consequently, the following factors are important considering the choice of the heating system:

- requested drying temperature
- required heating capacity
- possible future extensions
- existing heating plants
- location
- energy costs (oil, gas, electricity, solid fuels, waste utilization, etc.)

Regarding the indirect heating systems, the heat is transferred to the circulating air via heat exchangers (radiators) which will be installed over the whole length of the kiln. Direct heating is used very rarely and only if boilers cannot be operated economically.

Heat exchangers are heated either with steam (high or low pressure), water, hot water or thermo oil.

As for the automatic control technology, the liquid heating media are more advantageous than the gaseous heating media.

The required heat quantity will be fed by a volume control via a mixing circuit. Using a proportionally controlled heating valve, the kiln can be run without fluctuations in temperature. Using furthermore a circulating pump, a uniform heat distribution is guaranteed even if long heating pipes are installed.

In order to lay out the heating equipment which is fed with vaporous media in a sensitive way and largely without regulating movement, a complicated design is required.

3.3 Ventilation Systems

With the exception of certain small kilns, the air is always guided across-grain. The circulating air has to heat up the timber uniformly so that moisture evaporates. Then, the circulating air has to absorb the moisture from the timber surface. The more constant the circulating air flows through the stacked packages, the more uniform the final moisture will be. Different fan arrangements generates the air movement. During the past years, direct driven axial fans were increasingly adopted which can also be operated in reverse contrary to the radial fans.

3.3.1 Air guidance with ventilation units are located above an intermediate ceiling. The supply and discharge side are clearly separated. The air will be blown over the package once.

A uniform air distribution within the whole cross section has to be achieved.

3.3.2 Fans located at the sides.

Here the air will be reversed at medium height of the package and thus flows through the packages twice. The advantage of this method is that the air volume of the single ventilation units flows only through half of the package height and therefore, you can operate with half power demand at the same air velocities.

The disadvantage is that a clear separation of supply and discharge sides is more difficult.

3.3.3 Another possibility of arranging the ventilation units is to locate the fans at the sides through reversing certain determined longitudinal sections. This means again an advantageous low power requirement and also an inexact separation of supply and discharge sides.

3.3.4 The laterally located fans with favourable power requirements and the disadvantage of the inexact separation of supply and discharge sides. Laterally located axial fans generate different air velocities in case of inadequate calm region. Today, then, more and more kilns with intermediate ceilings are accepted.

In our time energy saving has become a serious problem all over the modern world. Therefore every measure possible will be taken to reduce the energy requirements even with timber drying kilns.

At present many drying kilns are geared to the handling of many different wood species and timber thicknesses. When drying timber thicknesses which vary (i.e. a charge of 25 mm timber will be dried and after completion the kiln can be charged with 65 mm thick timber). The power requirement can be reduced considerably by using pole-changeable motors.

$$\frac{N1}{N2} = \frac{n1}{n2}^{3}$$

The power requirement is changing to the 3rd of the rotation.

$$\frac{3{,}0 \text{ kW/h}}{X} = \left[\frac{1.500}{750}\right]^{3}$$

$$X = 3{,}0 \times \left[\frac{750}{1.500}\right]^{3} = 0{,}75 \text{ kW/h}$$

Moreover, the emission laws more frequently require a reduction of the sound pressure level, i.e. in combined residential/industrial areas. For drying kilns of average size, the reduction comes to approximately 10 dB/A according to the change of speed from 1.500 - 750 rpm.

4. Spraying Units

In order to soften possible casehardening or existing surface stretch before starting drying, efforts will be made in the first phase of a drying cycle (heating up) to achieve a high air humidity (between 80 and 95 per cent) by spraying low-pressure steam or water.

4.1 Saturated steam of 0.5 bar will be easily absorbed by the surrounding air. Owing to the condensation at the kiln walls or at timber packages, heat is set free (entalphy) which, at the same time, increases the kiln temperature (energy saving effect).

4.2 Atomized water is added to the surrounding air. As no heat is set free as it would be when spraying steam, but on the contrary heat has to be extracted from the surrounding air for evaporation, the heating-up phase of this system will be extended. This extension however is acceptable in general practice proven by the fact that water spray systems are increasingly used because many companies prefer liquid heating media instead of vaporous ones if the central heating system is particularly designed for kilns.

5. Kiln Construction

5.1 Kiln Housing

For the construction of drying kilns, aluminium is used most of the time. Great importance is attached to the maximum resistance to corrosion, of course, (aluminium or stainless steel being the most effective resistors). All of the requirements regarding static and thermal insulation are also met by either aluminium or steel. So adept are we now at using these metals that nearly anything can be required of them regarding the ventilation systems, charging systems, etc.

Many factors contributed to the development of the so-called "prefabricated kilns", however, to mention a few of them:

a) high resistance against the acids released when drying timber;
b) erection without any problems due to far-reaching standardization;
c) possibility of disassembly and re-assembly at another site.

Drying plants in sheet steel construction will be hardly offered anymore and are not recommendable either due to susceptibility to corrosion (not to mention the considerable cost of permanent maintenance - protective coating, etc.). Combined aluminium/sheet steel constructions are only suitable in special cases due to the affore-mentioned reasons.

In addition to this, the different contact potential series (Volt) of aluminium (1.45) and steel (0.45) have to be taken into account. At the points of connection, contact corrosion will arise which may result in a quick wear in case no corresponding protective coating is applied.

These facts are all well-known to timber kiln manufacturers using exclusively aluminium for the kiln construction.

Only a very few drying kilns are still being made in brick work. Should such a drying kiln be preferable, however, care must be taken that a floating ceiling be incorporated and that corresponding expansion joints are made available. If this is not done, the formation of cracks and leakage should be expected shortly after operation has begun. It would also be necessary to provide for the corresponding insulation for double-walled construction. Experience has proven that damage to the kiln in brick-work execution cannot be avoided (in any case, the masonry for such a kiln should be completed with steel concrete.

5.2 Door Types

Concerning the door types it is also vital to note that all requirements of door construction and so on are met. The following door designs could be used:

a) wing-type door
b) folding door
c) lifting/sliding door
d) lifting door
e) roller shutter door (only for low-temperature kilns because of improper insulation)

Wing-type doors are certainly the most simple and the most favourable design in terms of investment. They will usually be installed in front-loaded kilns up to a door width of approximately 4 metres.

In case bigger doors are required (those up to a width of 13 metres), folding or segmented doors will be used. They are also suitable for front-loaded or cross-loaded kilns. The only disadvantage to these doors is the free space needed within the kiln but then these doors are less tight fitting and altogether easier to handle than the lifting/sliding or lifting door.

If several kilns were placed side by side then the lifting/sliding doors can be used. Designed for manual operation and for a minimum of 2 dry kilns, however, they are not more expensive than the folding or segmental doors. A decisive advantage to them is that the door is pressed onto the frame by its own weight and therefore is extremely tight. They can be moved afterwards by truck and/or rail and with normal handling damage to them is rare. Of course, lifting doors can be used instead of the doors mentioned before. This is undoubtedly the most elegant but also the most expensive solution.

Reason: A very expensive safety apparatus is installed to prevent the door from falling. This safety apparatus is required by the Safety Regulations Board and has to be made of stainless steel for reasons of corrosion. The required rope winch is a considerable cost factor as well. The lifting structure is exposed to heavy fracturing loads due to wind pressure with the doors in an open position. The dimensions of the doors have to be much bigger than the actual weight of the door dictates, in fact.

The door type should be chosen according to the following factors:

a) location (space requirement in front of the kiln)
b) inside width and height
c) costs
d) frequency of possible damages
e) requested operating standard

NOTE: The main purpose of this rather general discussion of the planning of drying kilns was to show the reader which technical considerations to keep in mind when undertaking the production of any type of drying kiln.