

PRACTICE AND TECHNIQUE OF THE DRYING OF
WOOD IN GERMANY AND EUROPE

Robert Hildebrand

It is not simple to talk about the complicated subject of wood drying. Wood is a capricious and diverse material presenting many problems. If I speak mainly of techniques which are used in Europe for the drying of wood, I do so because of long experience with the industry, and because the subject has been fascinating for many years.

Sixteen years ago, I began to concern myself with the drying of wood. An unusual wealth and world wide experience with dry kilns for lumber as well as for veneers is the result of this activity. Through this paper, I would like to outline to you my views of the development.

In the last few years I had the opportunity to study, personally, wood drying methods at nearly all the wood research centers of the world. I had the opportunity of talking with scientists at these centers and becoming familiar with the principles and techniques of many types of wood-drying kilns.

If I speak about the drying of wood today, I am mainly referring to drying of lumber. As far as I know, the limit between veneers and lumber is not yet fixed; it makes no difference if sliced, peeled veneers or thin sawn boards are concerned.

Now the question is, on what factors is the drying of wood actually dependent? These are only a very few of the factors, namely, wood species; initial moisture content; the thickness and width of the wood; the temperature with which it is dried and the climate in the kiln; the so-called drying gradient has an essential influence over the speed of wood drying. The air speed at the surface is important too.

Very little research has been carried out on the reactions which take place at the wood surface. There are different theories regarding this subject - how the heat enters the wood at one side and how it moves out the other side at the same time - how it comes to the surface and evaporates. Technically seen, from the standpoint of an engineer, it does not seem difficult to determine these factors. The practice of the past and the present, however, shows the contrary.

I have carried out detailed tests on these different factors, especially the influence of the air speed. Just as it seems reasonable to believe that there must be a certain flow of air at the surface for the drying of wood, so it is improbable to believe that there are manufacturers of kilns in Europe today who build wood-drying kilns without any ventilation, that is, who simply dispense with a flow of air at the surface.

Professor Kollmann from the Forest Research Laboratory at the University of Munich, whom all of you will certainly know by his books and also by his papers (which he has also read in America), at present is carrying on basic research on the influence of air speed at the surface. At present, in his laboratory, tests are being carried on regarding the coefficient of heat transfer and the coefficient of thermal conduction at the impact of an air stream on materials to be dried.

The different influences of air speed are studied. The tests are carried through to air speeds of 36,000 ft./minute, and are to be continued further. Afterwards, it should be known what conditions over the materials to be dried are to be expected at different air speeds. I tackled this field of lumber-drying at its most difficult stage. Fifteen years ago, I started developing high-temperature kilns for lumber, so-called superheated steam kilns for lumber, with temperatures above 212° F. The thoughts which led me to this development were really very simple. At that time veneers were dried with temperatures between 280° and 320° F., while lumber was hardly ever dried over 160°F. If kiln temperatures at lumber-drying plants were increased at that time, splits, case-hardening, etc. were the result.

My considerations were very simple. I developed a dry kiln which was steam-tight, using temperatures approximately 240° - 250° F. and an air speed at the surface of 360 - 720 ft./min. As a result, normal soft wood could be dried to a desired final moisture content of 6-8% in 6-8 hours. The results were so sensational at that time that I built many hundreds of such drying plants until competitors also turned to constructing such plants some years later. In my factory in Germany I have constructed approximately 400 high temperature dry kilns which have performed well in Germany, the Northern countries and in other parts of the world.

It was a laborious task to develop high-temperature kilns. Problems of steady air circulation, which is especially important with these kilns, problems of the measuring of temperature and moisture content and problems of corrosion had to be solved. It was a long way to find the economic limits of using this extremely economical method of drying. But, this led to the fact that all parties concerned have acquired a considerable amount of experience concerning wood-drying techniques and about the construction of dry kilns. Even very small kilns for small woodworking firms have been developed. These methods used for the drying of lumber automatically led to the construction of veneer dryers.

In the field of veneer drying we have made some modern developments. A new method in veneer drying is the continuous veneer dryer, where the wet veneer passes through the dryer and is clipped afterwards. That means the veneer runs from the peeling machine over a reel to the dryer, or it passes directly to the dryer and is clipped afterwards, as is done with small birch logs in Finland. Experts say the oldest dream of veneer manufacturers has become a reality by this development.

Research in the field of lumber drying has covered even high frequency and microwaves. Especially interesting is the development of automatic controls on dry kilns; this means the regulation and control of the drying process.

Considerable research is necessary to develop all points that are necessary for the determination of a drying schedule, beginning with the control point and the adjusting devices. We ourselves today have developed this control technique to be fully automatic, the details of which I shall discuss by the end of this paper. This control requires a few adjustments. All other operations are automatically performed.

Now, I should like to talk about developments in the Scandinavian countries, especially in Finland. Twelve years ago I presented Professor Siemes -- who is also well known in America -- with a high-temperature kiln for tests on high-temperature drying of Finnish pine and spruce at the Forest Products Research Laboratory in Helsinki.

The result of this research in Helsinki and the results of my installations in Finland and of my work in Germany, there is not a firm in Finland today, which manufactures block board, who would not use high-temperature kilns for this purpose.

The quality of the Finnish block board is beyond question. Finnish spruce and pine show great differences in the initial moisture content, which is dependent on both the storage in water and on the season and place of cutting. Such high-temperature kilns are also frequently used in Germany in very many firms. I give you, for example, the drying time of such a high-temperature kiln for soft wood:

Drying of spruce, 1" thick, from 80% to 10% with 260° F. in approximately 8-10 hours.

Also, let us take a look at other countries which are rich in wood; for instance Japan and Brazil:

In Brazil our kilns, not only high-temperature kilns but also brick kilns, are built under license.

In Japan more than 1,000 small dry kilns have been constructed and sold to small business firms by our licensees during the last five years.

In Norway and Sweden, our dry kilns are built under license.

KILNS USED IN GERMANY AND EUROPE

The variety of the kilns in use is almost as large as the variety of the kinds of wood. As I have already mentioned in the beginning, even kilns without any air circulation are built and offered. The circulating air is driven by means of fans which are arranged sometimes at the top, sometimes at the bottom or the sides, small or big, even at the front side. All of these kilns have more or less the same faults and strong points, which I have seen in the U. S. A., in Japan and in all countries which use wood-drying kilns.

The quality of a dry kiln is actually determined by the factors mentioned in the beginning. If I achieve these factors with a dry kiln, especially if I regularly achieve the temperature, the climate and a steady air speed across the entire pile, I have a very good dry kiln. Naturally, controls must

be added. Tests, carried on in your country have shown how difficult it is to correctly measure the drying temperature and the climate conditions in a kiln.

An example, which I should like to describe to you, shows how difficult it is to assess all the factors involved:

Some years ago I visited a well-known firm of the wood industry, in which I was very proudly shown their dry kiln, at the front of which a large fan was arranged. Formerly, the piling ledges had been perforated so that an air stream could pass along the boards. One day, however, for some unknown reason, the perforated piling ledges were replaced by solid piling ledges so that the air actually could only flow around the pile from the front side. The drying time was correspondingly long. As far as I can remember, it amounted to six weeks. Despite this fact, the kiln operator, who had been with this firm for many years, was highly satisfied with the dry kiln. He was not at all open to suggestions that this kiln eventually could be improved by merely perforating the piling ledges.

This example shows you the human factor involved in wood-drying, and that we have to take these problems into consideration.

A group of my engineers has written a book on the drying of lumber in which all problems (that are connected with the drying of wood) are treated in an easily understandable manner. This book has been received with great interest by all parties concerned. To my regret it is up to now only available in German, but I hope that we shall soon be able to publish it in English. In this book we have not only written about the kiln and its regulation, but also somewhat about the construction and the use of fans.

I have written in detail about the air speed in relation to the drying of wood. Our research and test results are contained in an essay, the title of which is "Revolutionary Progress in the Drying of Veneer - Technical State of the Drying of Wood" which probably will be published in the Forest Products Journal. The results of our research have been incorporated in the development of our dry kilns. We don't require any further discussions about the importance of the air speed and its uniformity in the pile of a dry kiln.

With our jet veneer dryers we have changed the direction of the air stream from parallel to the wood surface, to perpendicular to the wood surface and thus have reached substantially shorter drying times with veneers.

In the first place the air has to lead heat to the material and in the second place, to take away evaporated water. The air speed is closely connected with problem of the boundary layer at the wood surface.

INFLUENCE OF THE TEMPERATURE IN THE DRYING OF WOOD

The higher I can choose the temperature for the drying process, the shorter drying times I can reach. It was especially pleasing for me to hear that in America and Canada, too, that interest in high-temperature drying has begun to increase. It is not simply possible to say from the beginning, I can dry a certain kind of wood with temperature above 212° F. But we know from our considerable experience that many kinds of wood - especially if they are cut in thicknesses of 1" - can be dried very economically by means of very high temperatures.

With all factors, which affect the drying of wood, such as air speed, climate etc., a close watch must be kept when higher temperatures are used.

All of us know that people who carry through artificial drying procedures, must have a comprehensive expert knowledge. As a result of the variety of factors determining the drying program, so many possibilities are open that only very experienced drying operators are in a position to obtain optimum results, both regarding the quality and the time needed. If we analyse the procedures, the following working processes become necessary:

Determination of the Drying Schedule

The following data is to be determined:

- A. Drying temperature.
- B. Kind of the wood to be dried.
- C. Cut of the wood.
- D. Thickness of the wood.
- E. Initial moisture content.
- F. Desired final moisture content.
- G. Moisture gradient of wood.
- H. Conditions in the kiln used, regarding air speed and steady flow of air.

We have partially based these factors on data of Professor Köllman, but partially on our own tests and experience and have gathered them in a schedule, which enables us to determine the drying time and the drying procedure in advance. We have already published this curve in our book "Die Schnittholztrocknung". Now by means of this curve, the drying time is determined, then the various data - for instance drying temperatures are entered in a curve. If this curve is stipulated, the drying operator can dry according to this curve. Here in America, often dry and wet temperatures are turned on by means of a cam operated controller which automatically regulates these two conditions. This type of American controller has been recently used in Germany.

The exactness of the regulation is very important, because every inaccuracy in maintaining the temperature and the relative humidity of the air, has a substantial influence on the length of the drying time and the quality of wood. In the field of regulation you will recognise the two-point regulator, which has two positions of switch - "on" and "off". This two point regulation has the greatest variability. Then there is a three-point regulator which has three positions of switch, that means - "opening - pause - closing" or "on - pause - off". The pause causes a more regular observance of the desired value. An even better observance of the desired value is obtained with proportional regulation. In this case continuously working adjusting devices, for instance valves and vents are used, slowly releases the closing and opening process.

In Germany there are similar controls to what are used here for the control of temperature and the relative humidity of air which is regulated by vents and steam spraying. Very frequently, electronic controls are used, especially with electrically heated dryers, this means that all changes of the controlling parts are carried through electrically, as compared to pneumatic controls.

Especially important is the correct positioning of the valve and vents. In the latter case the correct arrangement is very important. Lately, fully automatic controls have been developed in Germany. I should like to describe to you two designs.

By fully automatic control the arrangement of the drying schedule and the necessary operating conditions are carried through by a fully automatic control gear. Thus, the operation of the kiln is no longer necessary during the drying process. The drying process is much more precise than that obtained by hand. A visual or sound signal indicates the end of the drying.

Moisture content sections are taken out of the wood to be dried. The moisture content of the section is measured. By means of this actual moisture content, the corresponding moisture gradient is

controlled and the conditions of the drying process are set. This control method is especially interesting because the control process is determined by the actual moisture content of the wood.

Of course it is somewhat difficult to install the electrodes and to handle them in the wood piles. This regulation of the process becomes somewhat complicated with woods with high initial moisture contents, because the electronic measurement of the section is only possible to a limited extent. At any rate, this automatic control has already been used in practice.

Our own firm has developed a fully automatic control, which computes the drying schedule. This automatic control contains a computing machine, which determines the drying schedule and a controlling device, which controls the actual drying process. This control has the advantage that only by preselecting the kind, thickness, initial and final moisture content of the wood to be dried, is the control turned on. After these adjustments have been finished, even the heating-up-process and the climatizing process are automatically turned on by the end of the drying.

With this automatic control, a great many dryings have been made, the results of which have been fixed by automatic recorders. This means the actual de-hydrating curve can be compared with the drying curve, obtained by means of the automatic control. One important point with this type of automatic control is that it can be regulated very simply.

A trained operator is not necessary. Even the drying temperature is chosen by the control gear. The drying operator does not need to know with which psychrometric differential the dry kiln is working.

The continuous dryers, which are very frequently used in the Northern countries are particularly interesting. High frequency drying has proved practical only in special cases, for instance for thick and very short pieces of wood.

I hope that I have given you with this short talk, a survey of the methods and techniques used in the drying of wood. Wood-drying, as natural and simple as it is, has so many problems that it is difficult to present a comprehensive survey in such a short talk. We have a team of engineers working both in the field of research and in the practical use of the wood drying, in order to bring all these factors - which contribute to the problems of the drying of wood - technically into control. The aim of this work is to make the drying of wood better, more simple and more economical in order to give WOOD better qualities for its further use.