12th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

INFLUENCE OF AIR CIRCULATION SPEED ON BEECH WOOD DRYING PROCESS IN CLASIC DRIER

mr sc Atif Hodžić	mr sc Minka Ćehić	Damir Hodžić, dipl.ing
Technical faculty in Bihać	Technical faculty in Bihać	Technical faculty in Bihać
University of Bihać	University of Bihać	University of Bihać
Bosnia & Herzegovina	Bosnia & Herzegovina	Bosnia & Herzegovina

ABSTRACT
Convective drying of wood is a complex thermodynamical process stipulated with number of factors where some of them are changeable and some of them are permanent. Their significancy depends on character of output parameter which is additionally being complicated by wood substance as specific, nonhomogenous materialin the manufacturing process.
The goal of experimental research is to detect speed of air circulation in the chamber during artificial drying of 25 mm thickness of beech and analysis of experimental datas to increase drying speed and to decrease time of drying of material. To achieve this the quality of dried wood must not be decreased and the production costs are to be decreased.
In this paper there will be presented simultaneous analysis of experimental and theoretical parameters with the aim to decrease total time of drying process.
Keywords: drying speed, air circulation speed, drying parameters, time of drying

1. INTRODUCTION
Artificial drying of wood in the chambers with circulation of humid air is usually first phase of technological process of wood drying process. The main function in this phase is to decrease wood moisture on that value which is needed for further production, respectively to the value which matches to exploatation conditions of end product.
Wood is hygroscopic, anisotropic and ortotropic material which madeit to specificmaterialforexploatation compared toother materials. Drying of wood which is anisotropic material is difficult because the parameters which determine it thermophysical properties are not permanent values, but they depend on direction of fibres.
Variability of drying conditions (temperature, relative mosture and air circulation speed) and their dependance on character, state, dimension and final exploatation of wood detain deriving of adequate mathematical model of speed dependance and time of drying for all examples and types of wood. Although theory of heat and substance transfer during wood drying as physical process is well known with appearance of numerical analysis and development of computer techniques, there are opened some possibilities of finding not only one-dimensional but also two-dimensional problems of heat transfer.
According to datas in scientific references, general behaviour of drying gives dependance between rellative air humidity and drying temperature by drying of defined type and thickness of wood, therewith dependance of relative air humidity tothe drying speed is not enough researched and defined. Importance of air circulation speed which is very important factor is also still not enough defined. By reciprocal cennecting of temperature and relative humidity of air, general behaviours of drying process do not define enough the influence of air circulation speed in the chamber and drying quality. Researches about modelling of parameters of wood drying process attend from forces in thedrying process and defining of their dynamics, with necessary defining of moisture and

temperature in the is being dried. It is basic to get technology of drying process, its correct leading and quality of dried material.
Insufficient practical compatibility of recommended drying parameters with wood type which is being dried in concrete conditions, often has got consequence errors appearance and prolonging of process.

2. RESEARCH GOAL

The main goal of experimental research is analysing of influence of air circulation speed which is drying factor in chamber, during artificial drying of 25 mm thick beech lumber and analysis of experimental parameters to increase drying speed and to decrease time of drying. To achieve this the quality of dried wood must not be decreased and the production costs are to be decreased.

3. MATERIAL, EQUIPMENT AND DEVICES

3.1. Material

In this experiment there have been used beech lumber elements with thickness of 25 mm prismatically assorted. Distance between wood elements is filled with dry fir battens 25x25 mm. The starting moisture of beech cutted lumber was in the intervale between 50 and 54 %, and the elements are to be dried to the final transport moisture of cca 20 %. The beech lumber elements are being smeared on the front with pretection facility.

3.2. Equipment and devices

Beech cutted lumber has being dried in classic montage drier with capacity of 20 m^3, equiped with automatic devices for drying process control and programming supported by computer. Drier is equiped with very functional elements for maintenance and measuring of thermodynamical parameterslike temperature (t), relative air humidity (φ) and air circulation speed (w), which are properly and precisedetected and saved in the device memory.
Formeasuring and parallel analysis of real parameters detected and analyzed in the drier chamberithas been used mini data logger with for external chanells which is with help of anemometer adapter PCE-AM-402 being measuring air circulation speed in the chamber. Device is equpied with BCP4.3-DL software for logger parameterizing and reading of datas with graphical display and possibility to compare more parametersin one graphic. Measurements are being made every hour during wood drying process. Adapter was placed in the chamber and connected with data logger which was out of the chamber by flexible cables. Measuring process was made also in classic chamber with same capacity and with automatic process control without computer support.
The real air circulation speed in chamber was measured by hand anemometer AV-81AM every eight hours in the chamber nearly to the *PCE-AM-402* adapter

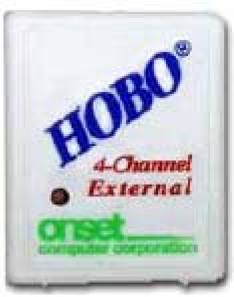

Figure 1. Data logger Hobo H8-ext

Figure 2. Anemometer adapter PCE-AM-402

Figure 3. Hand anemometer AV-81AM

3. EXPERIMENT PLAN

During drying cycle of beech lumber elements with 25 mm thickness from starting moisture of cca 54 % to the final moisture of 20 % automatic device for process control has registrated all changes of important drying factors in the moment in which they appear and the parameters were savedin the central unit memory. In the same time with help of data logger and anemometer for measuring of air circulation speed in the time intervale ($\Delta z = 1h$) there have been measured, registrated and memorized real values of air circulation speed in the chamber every eight hours. Air circulation speed was

measured in two chambers. In the first chamber air circulation speed was in the intervale w = 1,2; 2,2 i 3,6 m/s, and in the second chamber air circulation speed was w = 2,0 m/s.
The user regime of drying is presented in table 1.

Table 1: User regime of drying

PRG	Thickness	EMC	DG	IF	t_1	t_2	dt	T	FMC
	mm	%			^{0}C	^{0}C	^{0}C	h	%
2150	25	18,0	2,0	1	35	45	4	4	20

Drying speed is defined by relation:

$$c = f\,(t,\varphi,w,d,\rho,X) \tag{1}$$

Upon constante conditions drying speed is defined by relation:

$$c_x = \frac{m_{xs} - m_{attro}}{\Delta t_x \cdot A_{px}} \tag{2}$$

Average massof elements before starting of drying process is defined by relation:

$$m_{ps} = \frac{m_{pu} \cdot V_{ps}}{V_{pu}} \tag{3}$$

and average mass of analyzed wood element in absolute state is defined by relation:

$$m_{attro} = \frac{m_{ps}}{u_p - 1} \tag{4}$$

where: A_{ps} – surface of element; V_{ps} – volume of element; V_{pu} – volume of control sample; m_{pu} – mass of control sample; m_{ps} – mass of element; u_p – starting moisture.
Duration of drying process Z_3 is according to Kollman :

$$Z_3 = \frac{1}{\alpha}(\ln u_p - \ln u_k)\left(\frac{d}{25}\right)^{1,25}\left(\frac{65}{t}\right) \tag{5}$$

where:

$\left(\frac{d}{25}\right)^{1,25}$ - influence of woodthickness to the drying duration,

$\left(\frac{65}{t}\right)$ - influence of air temperature to the drying duration,

α - drying factor (for beech 0,0120),

U_p - starting moisture,

U_k - final moisture.

4. EXPERIMENT RESULTS

According to nowadays researches it has been programmed air circulation speed. By wood moisture up to 40 % air circulation speed is programmed to w = 3,6 m/s, from 40% to 30 % w = 2,2 m/s, and from 30 % to final moisture value w = 1,2 m/s. Air temperature and relative air humidity values in chamber have followed defined values.
By decreasing of temperature (t) and increasing of relative air humidity (φ) it is huge influence of air circulation speedin the chamber to the drying speed which means higher valueof air circulation speed means shorter duration of process. With increasing of air temperature and decreasing of realtiveair humidity there is no influence of air circulation speed to the duration of drying process. Of course datas are valid for analyzed air circulation speed in the chamber (1,2 - 3,6 m/s). By lower temperature values and moisture percentage over 60% higher value of air circulation speed leads to increasing of drying speed.

From the chart in figure 4 it is possible to detect that theoretical duration of drying process derived by Kollman (234,67 h) was near to the value in chamber with programmable air circulation speed (248,0 h), then in chamber with average prose speed (288,0 h).

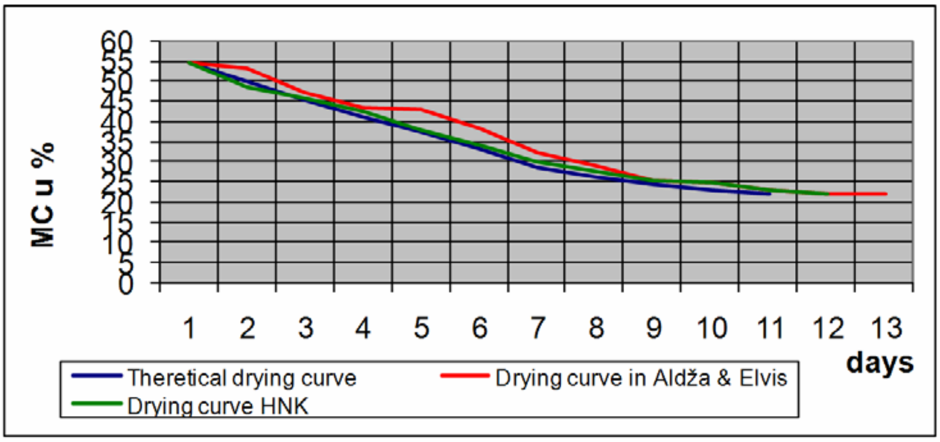

Figure 4. Chart of drying duration according to theoretical drying curve

5. CONCLUSION

Experiment was made for drying of beech lumber elements with 25 mm thickness in the metal chamber capacity of caa 20 m^3 in which was analyzed influence of air circulation speed in the chamber which is one of the important drying factors. According to the results of experiment and parallel analysis we can conclude following:

- increasing of relative air humidity and decreasing of air circulation speed leads to higher influence of air temperature to the process,
- by analysing of relative air humidity influence and air circulation speed influence in the chamber to the drying speed and temperature we can see two different areas: area of eliminating free water from wood and area of eliminating chemical water from wood ,
- air circulation speed have huge influence to the drying speed and process duration in the area over the saturation point, and that influence is lower in hygroscopic area.

According to the experiment we give modified regime of drying beech lumber elements in the table2.

Table 2. Modified regime of drying beech lumber elements with 25 mm thickness

Wood moisture $U_{M\,\%}$	Dry thermometer temperature ºC	Moist thermometer temperature ºC	Psychrometer difference ΔT	Relative air humidity φ %	Air circulation speed w m/s
<50	30	27	3	75	3,6
50	35	31	4	70	3,6
40	35	29	6	62	3,6
35	40	31	9	56	2,2
30	40	30	10	52	2,2
25	45	35	10	48	1,2
20	50	39	11	42	1,2

6. REFERENCES

[1] Čikić A.: "Prilog ispitivanju kvaliteta i utjecajnih parametara pri umjetnom sušenju piljene drvne mase", doktorska disertacija, Sveučilište u Zagrebu, Fakultet strojarstva i brodogradnje Zagreb, Zagreb, 2002.
[2] Hodžić A.:"Modificirani sistemi kompjuterskog vođenja procesa sušenja drveta", magistraski rad, Tehnički fakultet Univerziteta u Bihaću, Bihać, 2006.
[3] Ilić M.: "Hidrotermička obrada drveta", Mašinski fakultet Sarajevo, Sarajevo, 1990.
[4] Kolin B.: "Hidrotermička obrada drveta", Jugoslavijapublik, Beograd, 2000,