Original scientific paper
UDK: 674.047.3

TIMBER DRYING QUALITY EVALUATION IN INDUSTRIAL CONDITIONS

Goran Zlateski, Branko Rabadjiski, Zoran Trposki, Vladimir Koljozov

Ss. Cyril and Methodius University in Skopje, Republic of Macedonia,
Faculty of Design and Technologies of Furniture and Interior – Skopje,
e-mail: zlateski@fdtme.ukim.edu.mk; rabadziski@fdtme.ukim.edu.mk;
trposki@fdtme.ukim.edu.mk; koljozov@fdtme.ukim.edu.mk

ABSTRACT

An evaluation of timber drying quality in industrial dry kiln with convect drying process is presented in this paper. The target moisture content, i.e. the required moisture content, indicates the suitable moisture content in the wooden material when the product is used or produced. Knowledge of allowable range of the average moisture content of a lot relative to the final moisture content after drying is used to calculate drying quality classes according to European Drying Group (EDG) Recommendation. Measurements and data analysis of moisture content distribution in conventional dry kiln process indicate that 80% of moisture content readings were within the range satisfying the Q quality class.

Key words: drying quality, final moisture content distribution, quality class

1. INTRODUCTION

Given the current condition of wood industry, clear understanding of wood drying and its quality contribute to production of quality products from solid wood. In other words, there is no technology of solid wood processing which does not include drying. This process can be realized in many ways and techniques, some of them being classical, vacuum high frequency and microwave drying. In the course of each of these drying processes, it is necessary to set target moisture content before each drying cycle. A convect drying using air with certain thermo-dynamically characteristics is the most commonly applied drying process in the Republic of Macedonia.

The original experiments with wood devaluation of timber drying quality were made by many authors (Welling, 1995, Esping, 1994, Sorensen, 1995, Tronstad, 1994, Noack, 1989, Forsen and Tarvainen, 1994). Better quality classes require at least improvement in stacking and kiln loading.(Ryszard et al, 2002), and optimization of the whole drying process knowledge of the effective drying schedule for different locations in the kiln is needed (Hukka,1996). An inappropriate schedule may lead to development of an undesirable level of internal stress and strain and can result into drying defects such as surface and internal checks, collapse and warp (Lin and Cloutier, 1996).

Taking this into consideration, we have decided to analyze such a process through evaluation of quality of drying according to European standards and rules. We believe that this research and the results obtained will make a major contribution to the introduction of European standards and rules in the field of wood drying treatment in the Republic of Macedonia.

2. METHOD OF WORK

The necessary fieldwork and laboratory works for production of the test pieces, the research and measurement were done according то European Drying Group Recommendation.

Allowable range of MC differences in drying classes S, Q and E as a function of MC_{target} according to EDG (European drying group) is shown on Table 1.

Beech planks originated from the Malesevo Mountains and the research was carried out in the wood working company, Drvo Centar D.O.O.E.L from Kocani, the Republic of Macedonia. The drying of beach planks were performed in the kiln drier type VKS - 60 equipped with an automatic system for drying control, manufactured by, “NIGOS “ Nis, Serbia, Figures 1 and 2.

An assessment of MC differences (gradient) was carried out by successive measurements at the same spot on the selected board, at different predefined depths. For the first surface reading ($MC_{1/6}$, the needle electrodes of the resistance type meter were driven into the timber to a depth of 1/6 of the board thickness, with a mandatory minimum penetration depth of 5 mm.

The second MC reading ($MC_{1/3}$) was made at 1/3 of the board thickness to provide an estimate of average board MC. The final reading ($MC_{1/2}$) was made when the electrode needle tips penetrated to the board’s centre. For each individual board selected, all three measured MC values were recorded. (Figure 3).

Table 1. *Allowable range of MC differences in drying classes S, Q and E as a function of MC_{target} according to EDG (European drying group)*

Quality class	90 of all differences (gradient) between $MC_{1/2}$ and $MC_{1/6}$ must be smaller than:	*Examples for max. allowable differences if MC_{target} is:*		
		10%	14%	18%
S (standard)	MC_{target} x 0,4	4,0	5,6	7,2
Q (quality dried)	MC_{target} x 0,3	3,0	4,2	5,4
E (exclusive)	MC_{target} x 0,2	2,0	2,8	3,6

Figure 1. *Industrial dry kiln*

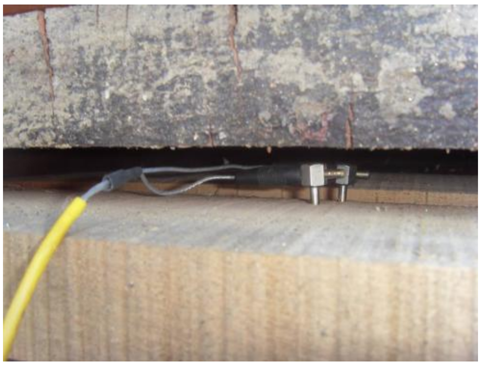

***Figure 2**. Needle electrodes of resistance moisture meter*

Figure 3. *Automatic control unit*

3. RESULTS AND ANALYSIS

Several drying processes were performed with the use of standard procedures including defined drying schedules (Table 2). The table evidently shows that the temperature of the air in the chamber (dry bulb temperature) increased from 54 to 71^{0}C. The wet bulb temperature had a trend of decreasing from 52 ^{0}C to 43 ^{0}C until reaching the phase of equalization, when this temperature increased from 55 ^{0}C to 76 ^{0}C. Moisture content of the wood was decreasing from above 40% to 10% at the end of the drying process.

Table 2. *Drying schedules of beech planks – thickness 25,0 mm*

Wood moisture (%)	Dry bulb temperature (^{0}C)	Wet bulb depression (^{0}C)	Wet bulb temperature (^{0}C)	Equilibrium moisture content (%)
<40	54	2	52	17.8
40-35	54	3	51	15.5
35-30	54	4	50	13.8
30-25	60	8	52	9.8
25-20	66	17	49	5.6
20-15	71	28	43	3.2
15-10	71	28	43	3.2
10	71	28	43	3.2
Equalization phase	71	16	55	6
Conditioning phase	71	4	67	13

The results of moisture content gradient and timber drying evaluation are given in Table 3. The timber was characterized by its target MC, core MC, surface MC and quality drying class.

Table 3. *Moisture content gradient ($MC_{1/2}$ - $MC_{1/6}$)as a function of target moisture content (MC_{targ})*

Drying process	MC_{target} (%)	Core moisture content $MC_{1/2}$ (%)	Surface moisture content $MC_{1/6}$ (%)	MC gradient ($MC_{1/2}$ – $MC_{1/6}$) (%)	Quality drying class
1	10	10,5	8,4	2,1	Q
		11,7	8,7	3,0	Q
		10,3	8.9	1,4	E
		10,6	8.1	2,5	Q
		10,5	8.0	2,5	Q
2	10	11,6	9.1	2,5	Q
		11,0	8,2	2,8	Q
		10,7	8,1	2,6	Q
		11,4	8.6	2,8	Q
		10,5	8,4	2,1	Q
3	10	11,0	9,0	2,0	Q
		10,0	7,5	2,5	Q
		11,4	8,2	3,2	S
		11,6	8,5	3,1	S
		10,5	9,0	1,5	E
4	10	10,9	8,3	2,6	Q
		10,6	8,4	2,2	Q
		11,3	8,2	3,1	S
		10,7	8,1	2,6	Q
		10,2	7,8	2,4	Q
5	10	10,4	8,1	2,3	Q
		10,8	8.2	2,6	Q
		11,4	8,8	2,6	Q
		10,7	8,.4	2,3	Q
		10,5	8,3	2,3	Q

It was found for all analyzed drying processes of dried timber that 80 % of moisture content readings were within range satisfying the Q (quality dried)quality class, 12% within S (standard) quality class and 8% within E (exclusive) quality class. The majority of kiln dried timber in the company is used for production of solid wood panels; therefore the obtained results of quality estimation should be recognized as good.

4. CONCLUSIONS

From the preformed investigations of the timber drying evaluation in dependence of moisture content gradient according to EDG Recommendation, one can conclude that this is one of the first attempts of timber drying evaluation in the Republic of Macedonia.

The drying schedules and the condition of dry kiln are presently sufficient to obtain majority the Q quality class (80%) of dried timber, which guarantees quality production of solid wood panels, as well as and final products from solid wood.

REFERENCES

[1] Aquiar, O., Perre, P. (2000): The "flaying wood" test used to study variability of drying behavior of oak, COST action E 15, Advances in drying softwood, Sopron.
[2] Carlsson, P., Arvidsson J. (1999): Optimized wood drying, 6 th International IUFRO Wood Drying Conference, Stellenbosch.
[3] Denig, J., Wengert, E., Simpson, W. (2000): Drying Hardwood Lumber, Madison.
[4] EDG – Recommendations (1994): Assessment of drying quality of timber.
[5] Esping, B. (1994): Preparing the Swedish sawmill industry for the EDG recommendations. Proceedings for the 6th International EDG Drying Conference, Hamburg, Germany, 13-14.Oct.
[6] Forsén, H., Tarvainen, V. (1994): Überpprüng der Qualitätsanforderungen der EDG Richtlinie in finnischen Sägewerken. Proceedings for the 6th International EDG Drying Conference, Hamburg, Germany, 13-14.Oct.
[7] Hukka, A. (2006): Proceeding, Quality wood drying through Process Modelling and Novel Technologies, IUFRO Wood Drying Conference, Quebec, Canada.
[8] Keey, R. (1998): Understanding kiln – seasoning for the benefit of industry, Canterbury.
[9] Kollman, F. (1951): Technologie des holzes und der holzwerkstoffe, München.
[10] Lin, J., Cloutier, A.(1996): Proceeding, Quality wood drying through Process Modelling and Novel Technologies, IUFRO Wood Drying Conference, Quebec, Canada.
[11] Noack, D. (1989): Die Bedeutung der Normung für die Verwirklichhung des europäischen Binnenmarkie'92 in Bereisch der Holzwirtsschaft. Holz – Zentralblatt
[12] Oliveira, L. (2003): Analyzing industrial lumber drying data, Quality drying, the key to profitable manufacturing, International conference, Madison.
[13] Rabadjiski, B., Zlateski, G.(2000): Temperaturni režimi za sušenje na bukova i dabova neokrajčena bičena gragja, Jubileen godišen zbornik, Faculty of Forestry, Skopje (in Macedonian).
[14] Rasmussen, E.(1961): Dry Kiln – Operator's manual, Madison.
[15] Ryszard, G., Jerzy, M., Wieslaw, O., Jan, D. (2002): Moisture content of timber after drying – estimation of drying quality, Electronic Journal of Polish Agricultural Universities, Vol. 5, Issue 2.
[16] Sebastian, P., Joman, W., Turner, W. I. (1996): A new model for the vacuum drying of wood based on the concept of the transition layer, Quality Wood drying through process modeling and novel technologies, 5-th International IUFRO wood drying conference proceedings, Quebec, pp 191 – 205.
[17] Scaar, C. (1972): Water in wood, Syracuse.
[18] Simpson, W. (1987): Vacuum drying northern red oak, Forest Products, Vol. 37, No.1, Madison.
[19] Simpson, W.(2000): Drying Hardwood Lumber, Madison.

[20] Sorensen, C.B. (1995): Training of kiln operators and quality control staff – some preconditions for ISO 9000 certification. Proceedings for the 6th International EDG Drying Conference, Hamburg, Germany, 13-14.Oct.
[21] Swigon, J. (1993): Some thermodynamic aspects of wood vacuum drying, Vacumm drying of wood' 93, International conference on wood drying, High Tatras pp 35-44.
[22] Todorovski, S. (1983): Hidrotermička obrabotka na drvoto, Šumarski fakultet, Skopje.
[23] Tronstad, S.(1994): Kiln Drying Clubs – exchange of experience in industrial practice, Proceedings for the 6th International EDG Drying Conference, Hamburg, Germany, 13-14.Oct.
[24] Welling, J.(2000): Industrial needs and scientific expectations, COST action E -15, Advances in drying of wood, Sopron.
[25] Welling, J. (1995): Drying quality assessment and specification – a challenge for the future. Proceedings of the 4th International IUFRO Wood Drying Conference – Rotourua, New Zeland.
[26] Zlateski, G. (2004): Proučuvanje na režimite i kvalitetot na kontaktno vakuumsko sušenje na pilanski sortimenti, Doktorska disertacija, Faculty of Forestry, Skopje (in Macedonian).