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MOISTURE CONTENT OF TIMBER AFTER DRYING - ESTIMATION OF DRYING QUALITY

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ABSTRACT

The drying quality of kiln dried timber was verified in Polish sawmills and furniture companies. The estimation of the quality was limited to the mean moisture content after drying. The quality classes specified in the European Drying Group Recommendation were primary used in the analysis. The obtained results showed that sawmills might presently satisfy the "S" quality class, while the furniture companies might achieve the "Q" class. The better kiln drying quality may be obtained in sawmills after introducing improved procedures of timber stacking and kiln loading.

Key words: drying quality, mean moisture content, kiln drying, quality classes

INTRODUCTION

The characteristic feature of the timber trade in Poland is the low percentage of kiln dried material in sawmills. The fraction is presently equal to ca. 30%, while in the European Union countries it is over two times higher and equal to 70% [1]. The situation described above has no justification in economic factors and is mainly caused by the low quality of kiln drying in sawmills. The other factor causing the low content is the lack of standards for drying quality estimation. The close perspective of the economic integration of Poland with the European Union requires a number of adaptation changes in the Polish law and the standard system. It can be expected that in the area of timber drying quality Poland will adopt the European Union requirements.

The objective of the paper is to verify if Polish sawmills can satisfy requirements and standards of the European Union in the area of quality of timber kiln drying. The analysis will be limited to the timber mean moisture

content after kiln drying only and will be based on the European Drying Group (EDG) Recommendation [6, 7, 8]. The additional reason for performing the analysis was the fact that the EDG Recommendation did not take into account experimental data collected in industrial conditions in the Central-Eastern Europe countries.

The comparative analysis will be made for experimental data obtained in several sawmills and furniture companies.

METHODS

The selected companies differed because of kiln drying potential as well as because of the type of convective kilns. The measurements of the final moisture content after drying were made in 5 sawmills and 3 furniture companies. All drying processes were performed with the use of the standard procedures including drying schedules normally used in a given company. There were also used normal procedures of timber stacking and kilns loading.

The drying quality was determined on the basis of a large number of the final moisture content measurements, which was much higher than the number found in the EDG Recommendation. The measurements were made with use of Wagner L612 capacitance meter with the scanning area of 100 · 100 mm and the scanning depth of 25 mm. In the case of measurements for timber of thickness equal to the scanning depth or lower, two pieces of timber were put together according to the user's manual of the meter. It was already showed in extensive investigations, partially made by the authors of the paper, that the accuracy of the capacitance meter is at least the same as for resistance pin meters [2, 3, 9]. In some cases the accuracy for the Wagner meter was even higher. The application of the capacitance meter significantly speeded up performing the measurements. The measurements were made for timber of length of 2.50-4.00 m and in the distance of 300-500 mm from an end.

The EDG Recommendation defines three quality classes related to the final moisture content after drying. A specified quality class is obtained when 90% of all moisture content readings of tested boards is within an appropriate moisture content range. For the highest quality class called "E", the range is defined as $MC_{target} \pm 0.1 \cdot MC_{target}$, where MC_{target} is the target value of the final moisture content. For the medium quality class called "Q" the range is $MC_{target} \pm 0.2 \cdot MC_{target}$, while for the lowest class called "S" the range is given as $MC_{target} \pm 0.3 \cdot MC_{target}$.

Besides the quality classes defined in the EDG Recommendation, the other estimators were additionally analyzed. The coefficient of variation of moisture content readings (*CV*) being the measure of scatter of measured values was previously applied in Poland as an estimator of drying quality [4, 5]. The coefficient was defined as:

$$CV = \frac{\sigma}{MC_{mean}} \cdot 100, \% \qquad (1)$$

where: σ – standard deviation, MC_{mean} – mean moisture content from all readings. The other estimator applied by Rafalski [5] and used in the present study was the relative dispersion (*RD*) defined as:

$$RD = \frac{\Delta MC}{MC_{mean}} \qquad (2)$$

where: $\Delta MC = MC_{max} - MC_{min}$ is the absolute difference in extreme moisture content readings. The "good" quality of drying was obtained when the values of the coefficient *CV* were lower than 20%, the "mean" quality was for the *CV* falling into the range of 20-30%, while the "poor" quality was for the *CV* over 30%. Similarly for the *RD* values lower than 0.8 the "good" quality was obtained, while for the *RD* falling into the range of 0.8-1.2 the "mean" quality was obtained.

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RESULTS AND THEIR ANALYSIS

The results of measurements are given in Table 1. The timber was characterized by its species, assortment and thickness. The number of readings, standard deviation, coefficient of variation and relative dispersion were given for each batch of timber. Table 1 also contains percentage of readings satisfying quality classes specified in the EDG Recommendation.

Table. 1. Results of moisture content measurements - statistical estimators and percentage of readings satisfying the EDG quality classes

Code	Species, assortment, thickness	MC_{target} [%]	MC_{mean} [%]	ΔMC [%]	n -	σ [%]	CV [%]	RD -	Percentage of readings satisfying quality class:		
									"S"	"Q"	"E"
1	Scots pine, unedged, 25 mm	6	6.7	3.6	294	0.75	11.3	0.54	90.1	77.6	59.2
2	Scots pine, unedged, 32 mm	10	9.5	7.3	335	1.63	17.2	0.77	96.4	70.7	35.2
3	Scots pine, unedged, 45 mm	10	9.0	6.0	153	1.10	12.1	0.66	100.0	83.0	39.2
4	Scots pine, unedged, 50 mm	12	10.9	6.0	410	1.24	11.4	0.55	98.8	85.4	49.0
5	Scots pine, unedged, 50 mm	12	11.8	7.3	321	1.43	12.1	0.62	99.1	90.0	60.1
6	Beech, unedged, 26 mm	8	7.7	1.7	100	0.38	4.9	0.22	100.0	100.0	94.0
7	Scots pine, edged, 25 mm	8	8.6	2.6	147	0.52	6.0	0.30	100.0	96.6	71.4
8	Scots pine, unedged, 50 mm	8	8.5	3.4	196	0.81	9.5	0.40	100.0	89.8	59.7

MC_{target} - target value of the final moisture content,
MC_{mean} - mean moisture content,
ΔMC - absolute difference in extreme moisture content readings,
n - number of readings,
σ - standard deviation,
***CV* - coefficient of variation – Eq. (1),**
***RD* - relative dispersion – Eq. (2).**

It was found for each analyzed batch of dried timber that at least 90% of moisture content readings was within the range satisfying the "S" quality class. For two batches of timber dried in furniture companies and only one batch of timber dried in a sawmill (Code 5) the "Q" quality class was obtained. The highest quality class "E" was obtained for only one batch dried in a furniture company (Code 6).

As it was expected the high differences in drying quality were found for sawmills and furniture companies. In the case of timber kiln dried in furniture companies practically all batches satisfied the "Q" quality class.

The majority of kiln dried timber in sawmills had no clearly defined end use. Therefore, the obtained results of quality estimation should be recognized as good. It may be also stated that sawmills are potentially prepared to dry timber to a final moisture content satisfying the higher quality classes defined in the EDG Recommendation. The above conclusion is also based on the statistical analysis of moisture content readings for individual timber batches. The analysis showed that the moisture content diversification has satisfied the normal distribution for three companies only (Code 4, 7 and 8). Figure 1 presents an example of a histogram and the normal distribution obtained from moisture content readings made in the company Code 4. However, for the majority of companies there were obtained results not satisfying the normal distribution. An example of such a distribution is presented

in Figure 2. It results from the presented histogram that a portion of boards was not dried to the target moisture content. The possible improvement of the situation may be achieved by more careful loading of kilns (i.e. elimination of zones with lower velocities of air flow) and concealing kiln zones with uncontrolled air flow. It should significantly improve drying quality, and allow obtaining higher quality classes of dried timber in sawmills.

Fig. 1. Histogram and the normal distribution of moisture content readings in the company Code 4

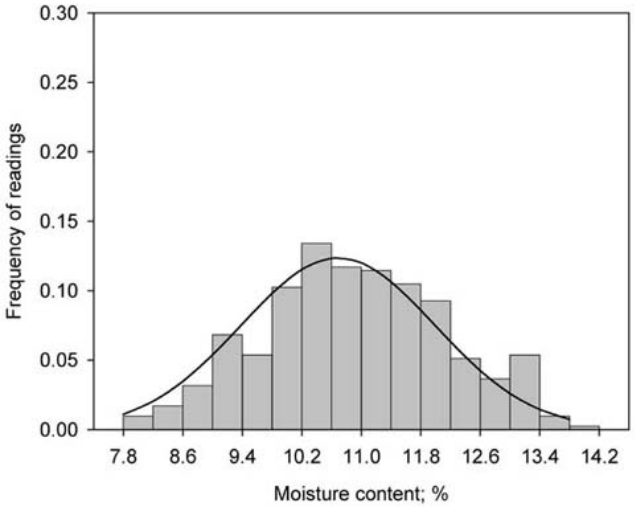
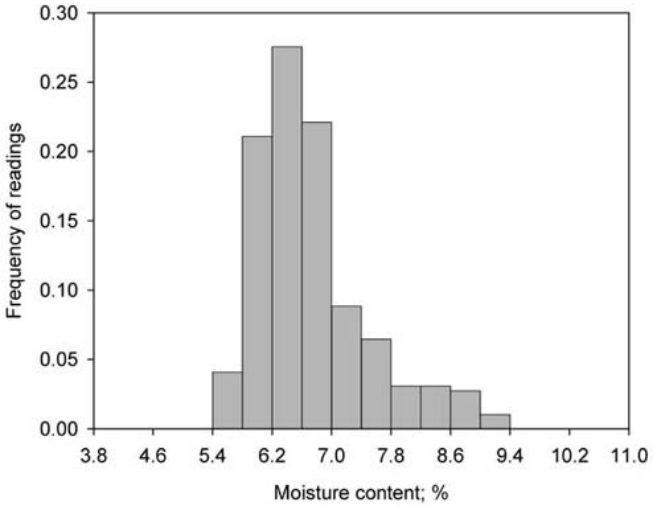


Fig. 2. Histogram of moisture content readings in the company Code 1



The quality of kiln drying was also estimated on the basis of the additional statistical analysis. The obtained values of the coefficient of variation and the relative dispersion showed "good" quality of drying. The values of the *RD* coefficient allow to rate the drying processes as "good". The absolute difference in moisture content was lower than 8% for each batch. Simultaneously, the *CV* coefficient was varying from 5 to 17%. It also showed that the moisture content distribution within individual batches was relatively uniform and therefore the drying processes could be evaluated as correct.

FINAL REMARKS

The presented analysis is practically the first attempt of timber drying quality evaluation in Poland in industrial conditions. The quality estimation was made with the use of the basic criterion found in the EDG Recommendation. The estimation shows that kilns, drying schedules and qualifications of personnel in sawmills are presently sufficient to obtain the "S" quality class. However, obtaining better quality classes requires at least improvement in timber stacking and kiln loading. Furniture companies can presently guarantee significantly better drying quality (the "Q" class) than sawmills (the "S" class).

The performed analysis also leads to the conclusion that Polish companies may compete in the market of timber and timber products in the aspect of timber drying quality.

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