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OPTIMISATION OF PINEWOOD DRYING SCHEDULES

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

In order to develop optimized drying schedules, a series of experimental schedules of convective kiln drying of pinewood has been performed. Boards, 25,0 mm thick have been used as testing materials. The boards have been kiln dried from initial moisture content of 50,2 % to final moisture content of 10,0 % for a period of 8 days. In a drying schedule there were four stages: heating, active drying, equalizing and conditioning. The moisture content difference i.e. moisture content gradient between core and surface of the boards after drying is 2,2 %.

Key words: pine, convective drying, drying schedule, moisture content gradient.

1. INTRODUCTION

Drying is the key to adding value and we dry wood for many reasons: to make it lighter, to make it stronger, to make it stable, so that we can glue it, so that we can machine and process it, so that it can be finished, to make it less susceptible to fungal and insect attacks and so that we can treat it with preservatives. (Miller, 2000). As well as that, determining moisture content gradient across the thickness of the wood and end point after drying has always been a challenge for the kiln operator.

During the early decades, research concentrated on finding safe drying schedules for lumber, which were mostly characterized as drying relatively slowly and unevenly, and, in some cases, also being prone to check and warp. Recently, more emphasis has been put on optimized drying schedule which is used to reduce the total drying time and to improve the amount of adequate quality timber. (Pordage and Langrish, 2000)

By definition, drying schedule is the procedure of adjustment of the underlying factors such as temperature, humidity and speed of air that characterize the drying process. It can also be defined as guidelines in the form of tables where good results in terms of time, quality of drying and energy consumption are expected.

Development of optimized drying schedules is linked to their implementation and if the schedules are difficult to implement or their implementations results in wood defects, then kiln control needs to be improved.

Some of the different methods used by researchers to determine optimal drying schedules for kiln stacks of timber are Monte – Carlo simulations (Kayihan, 1993) and Markov chains (Cronin et al.1997). The aim of these methods is to account for the variability in the moisture content distribution across the kiln stack.

A much more important challenge is to explain the biological variability of the timber (Burdon, 1995) and its thickness when developing optimized drying schedules. Therefore the origin and dimensions of the timber needs to be considered most carefully in optimizing a drying schedule (Zlateski et al. 2013).

2. MATERIAL AND METHODS OF WORK

A total quantity of 80 m^3 pine boards with thickness of 25,0 mm, were dried in the convective kiln drier equipped with automatic system of drying control, manufactured by COPCAL – Italy. (Figure 1). The boards originated from Kožuv Mountain in the South of the Republic of Macedonia.

The information on the temperature and equilibrium moisture content of the air as content of wood was obtained with the probes showed on Figure 2 and Figure 3.

An assessment of moisture content differences (gradient) between core and surface of the boards was carried out by slicing test method (Figure 4).

In order to define the drying schedule, the change in temperature and equal moisture content (EMC) of the air in the kiln chamber has to be registered, as well as the changing in the wood moisture content (MC) during all stages of the drying schedule: heating, active drying, equalizing and conditioning.

Figure 1. Control unit of drying

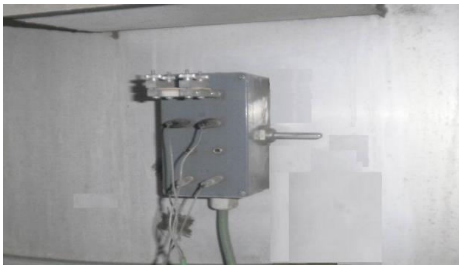


Figure 2. Measuring of temperature of air and equilibrium moisture content (EMC)

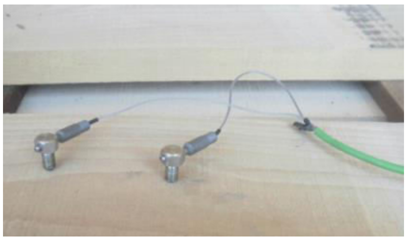
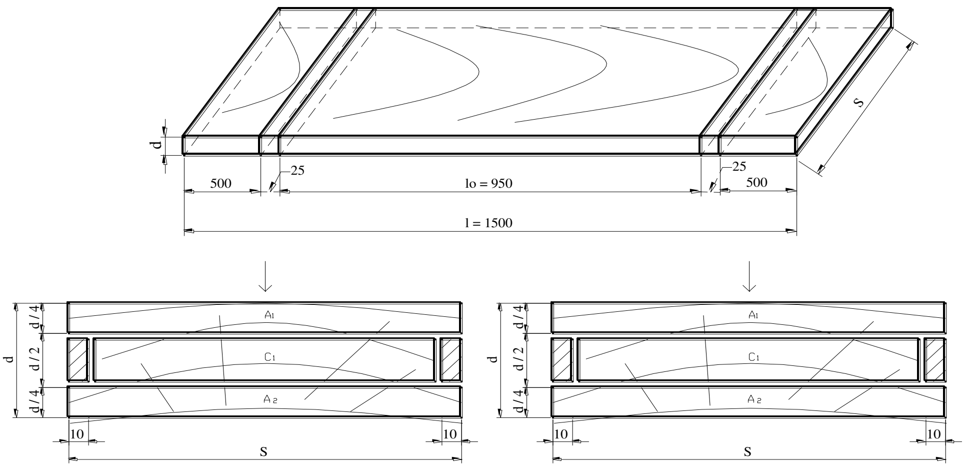


Figure 3. *Measuring of wood moisture content*



A – specimens for surface MC determination

C – specimen for core MC determination

Figure 4*. Slicing test (specimen production) for determining wood moisture gradient across the board's thickness*

3. RESULTS AND DISCUSSION

Based on the values of temperature of the drying air, EMC and the values for the wood moisture content for 25,0 mm thick pine boards, the drying schedule shown in Table 1 and Figure 5 was defined. From the table it can be noticed that the drying schedule starts with air temperature of 45,0 ^{0}C, equilibrium moisture content [EMC] of 11,0 % and average moisture content in the wood of 50,2%. Further in the drying process, the air temperature increased to the value of 75,0 ^{0}C at the end of the drying phase of the schedule. This value keeps constant to the end of last phase of conditioning.

The EMC had a trend of decreasing from 11,0 % to 4,0 % until reaching the phase of equalization, when this EMC increased from 8,0 % to 12,0 %.

Average moisture content in the wood measured by six probes reached maximum value of 50,2% at the start and minimum value of 10,0 % at the end of the drying process. The drying duration of pine wood was 8 days.

Table 1. *Drying schedule of 25,0 mm thick pine boards*

Time of drying (day)	Drying schedule phase	Temperature of air in dry kiln	Equilibrium moisture content	Average wood moisture content
(day)		(^{0} C)	(%)	(%)
I	Heating	45,0	11,0	50,2
II	Heating	50,0	11,0	42,0
III	Drying	55,0	8,0	34,0
IV	Drying	62,0	6,5	25,0
V	Drying	68,0	5,0	20,0
VI	Drying	75,0	4,0	15,0
VII	Equalizing	75,0	8,0	11,0
VIII	Conditioning	75,0	12,0	10,0

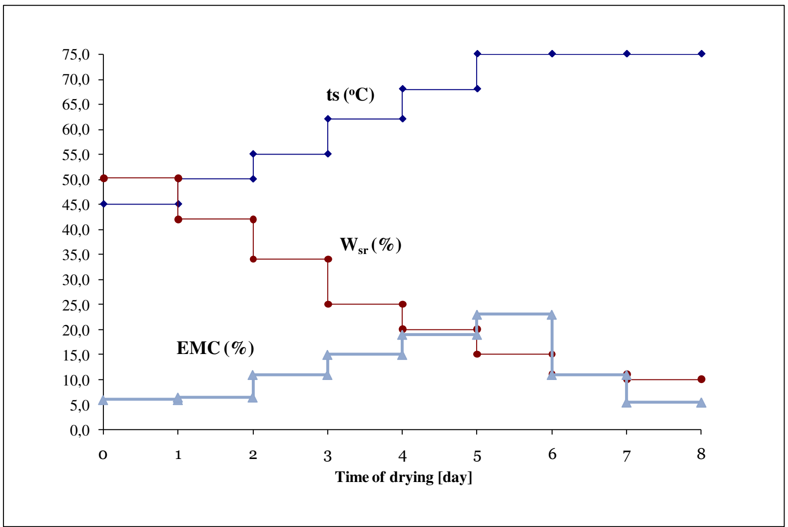


Figure 5. *Graphical view of drying schedule, 25,0 mm thick pine boards*

The results of moisture content gradient are given in Table 2. Based on the data shown in Table 2, it can be concluded that the surface moisture content of the board is 8,50 % (layer A).The core moisture content (layer C) of the boards is 10,70 %. The moisture content gradient, which is moisture content differences between the board's core moisture content (MC core) and the board's surface moisture content (MC surface), in absolute value is 2,2% (Figure 6).

Table 2. *Data on surface and core moisture content of pine boards*

Thickness of the wood [mm]	Layer of the wood surface (mark)	Layer of the wood core (mark)	Average moisture content Xsr ± fxs	Standard deviation S ± fs	Coefficient of variation V ± fv
25,0	A		8,50 ± 0,046	0,290 ± 0,032	3,408 ± 0,381
		C	10,70 ± 0,109	0,488 ± 0,077	4,558 ± 0,721

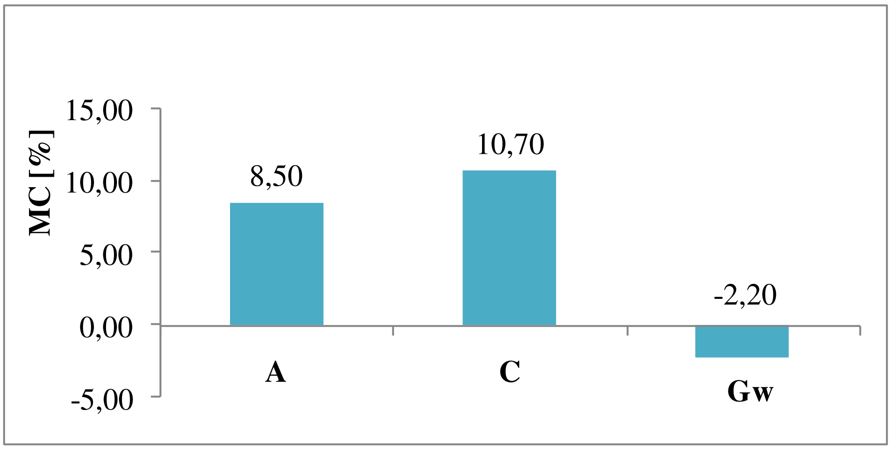


Figure 6. *Wood moisture content distribution (gradient) across the board*

4. CONCLUSION

According to the data presented and results obtained during the drying of pine boards, the following can be concluded:

1. The schedule of drying pine boards was defined. There are four phases in the drying schedule: heating, drying, equalizing and conditioning. It was found that the boards were dried from their initial average moisture content of 50,2 % to their final average moisture content of 10,0 % for a period of 8 days.
2. Air temperature increases from 45,0 ^{0}C to 75 ^{0}C.
3. The EMC has a trend of decreasing from 11,0 % to 4,0 % at the start of drying until reaching the phase of equalization, and trend of increasing from 8,0 % to 12,0 % at the end of the drying.
4. The surface moisture content of the boards is 8,50 % (layer A)
5. The core moisture content of the boards is 10,70 % (layer C).
6. The moisture content distribution (moisture gradient) across thickness of pine boards during convective drying is 2,20 %, which is quite suitable for production of products from solid wood.

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