



FACULTY OF FORESTRY | UNIVERSITY OF BELGRADE

Appearance and development of “sandwich effect” during beech timber drying in the conventional kiln

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Background

- Beech (*Fagus sylvatica*, L.) - the dominant wood species in central and Southeastern Europe
- In Serbia, of all hardwoods used in wood industry, beech accounts for about 75 % (according to “Srbijašume” data)
- Beech timber - the main export product in wood industry in Serbia.

Background



- After log sawing, the beech timber in contact with oxygen and under the influence of increased temperature, starts turning its colour, i.e. it darkens, especially the core
- This phenomenon is called the “sandwich effect”
- Could be present already in air drying, and it is intensified when timber is artificially dried

Objective

- to obtain more information on the moment of occurrence and development of “sandwich effect”,
- and also to quantify the intensity of darkening of the inner core by colorimetric analysis

Material and method

- green beech timber
 - initial MC above 80%
 - nominal thickness 38mm
 - average width 150mm
 - length 2000 mm
- two test runs
- the laboratory kiln (0,8 m³)
- six boards in upper two rows of the stack

Table 1. Heating up and conditioning

Temperature gradient of heating up	2	°C/h
EMC during heating up	16	%
Conditioning temperature	62	°C
EMC of conditioning	11	%
Conditioning time	16	h

Table 2. Schedule of the active phase of drying

	Hardwoods (beech)											
MC (%)	≥60	55	50	45	40	35	30	25	20	15	10	5
T (°C)	37	38	38	38	38	40	43	47	52	58	62	62
EMC (%)	15	15	14.5	14.0	13.5	13.0	12	9.1	6.7	5.3	4.3	3.9

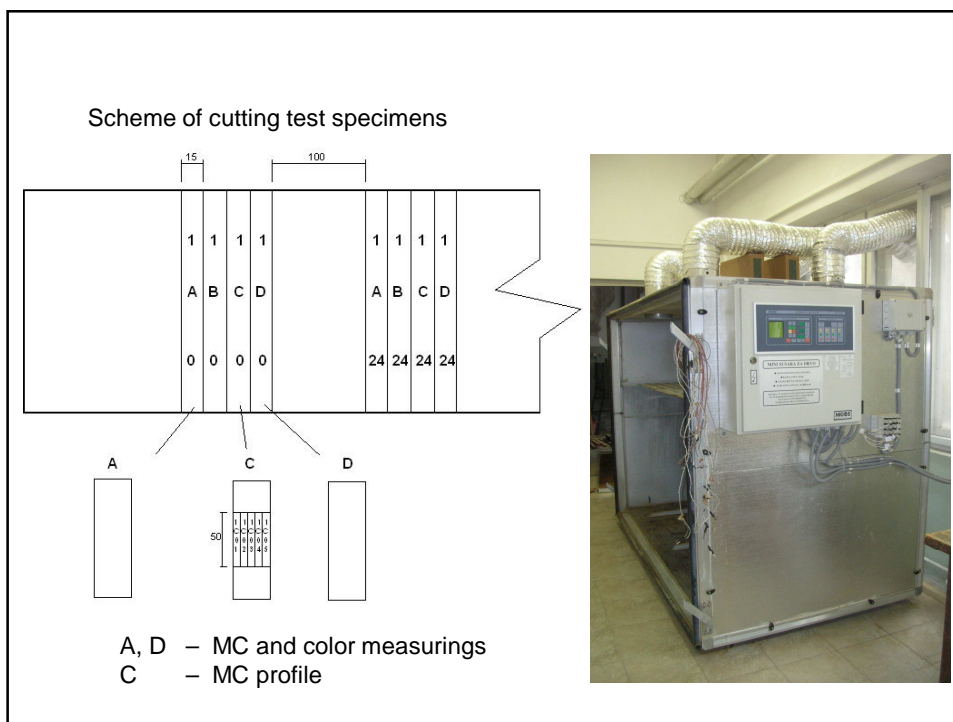


Table 3. Sampling times

Measurement No.	I	II	III	IV	V	VI	VII	VIII	IX
Measurements time from the beginning of drying (h)	0	24	48	72	96	144	192	240	End

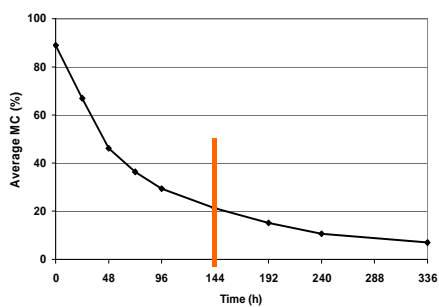


Portable "Gardner" colorimeter

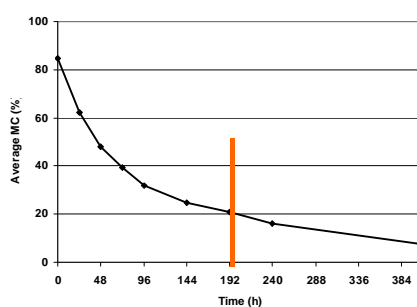


Positions of color measurement along the edge (red) and in the core (blue) (cross section of specimen)

Results



Test run I

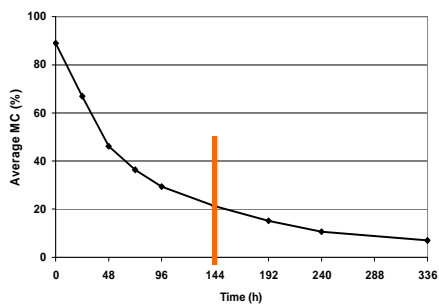


Test run II

Sandwich effect was observed for the first time:

- after 144 hours in the first test run
- after 192 hours in the second test run

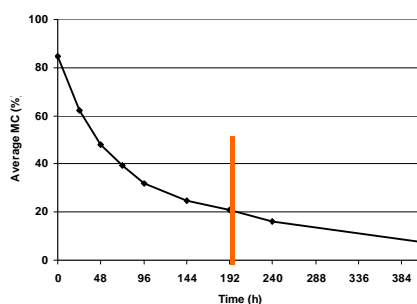
Results



Test run I

Sandwich effect occurred:

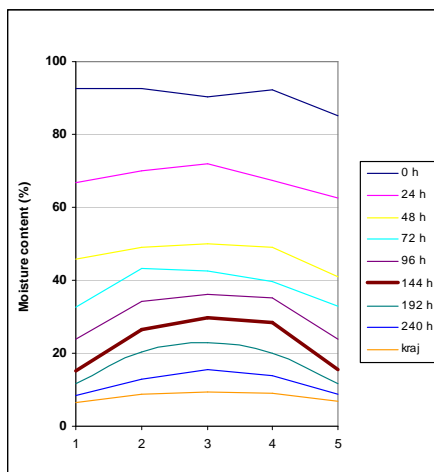
- Time 96 - 144 h
- $t = 45 - 49^\circ\text{C}$
- EMC = 10.5 - 8.1%
- MC = 29 - 21%



Test run II

- Time 144 - 192 h
- $t = 45 - 47^\circ\text{C}$
- EMC = 10 - 9%
- MC = 25 - 21%

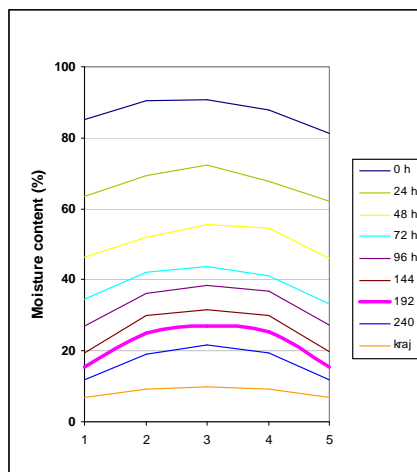
Results



Test run I

MC surface ~ 15%

MC core ~ 25-30%



Test run II

Results of colorimetric measurements

- done after couple of weeks, and after oven drying of samples
- 20mm head radius included also a great part of the darker portion of the sandwich

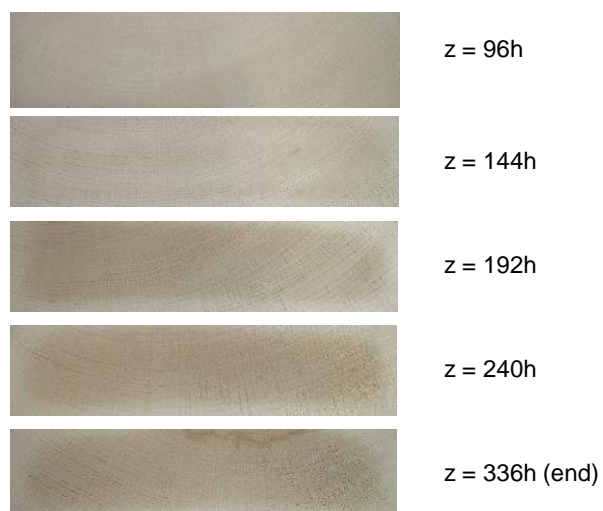


- the real colour differences are considerably higher than the obtained results

Results of colorimetric measurements

- still, clearly visible increase in the colour differences (ΔE) can be seen, from the moment of sandwich detection to the end of drying
 - test run I: sandwich detection moment $\Delta E=1.95$
end of drying $\Delta E=3.54$
 - test run II: sandwich detection moment $\Delta E=1.27$
end of drying $\Delta E=2.47$
- ΔE increase through time mainly due to decreasing of L (lightness) values for core layers measurements

Development of sandwich (board from test run I)



Before sandwich occurrence and at the end of drying

Board in test run I



z = 96h; t = 44.8°C, EMC = 10.8%

Board in test run II



z = 96h; t = 41.2°C, EMC = 11.7%



z = 336h; t = 60.1°C, EMC = 4.3%



z = 408h; t = 60.6°C, EMC = 4.8%

Conclusions

- The discolouration occurred in both test runs dried by the same schedules
- It detected later than expected, in different periods, but at the same mean wood moisture contents of approximately 21% (surface 15%, core 25-30%)
- Moisture content (and MC profile) is more important factor than time (of exposing to relatively high temperature)
- Sandwich detected at 45-49°C, showing that maybe higher temperatures, than usually recommended (30°C), can be applied for this thickness

Thank you for your attention!