BARK EFFECT ON WOOD DRYING DYNAMICS

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Abstract. The aim of the paper is to present the bark effect on the fresh wood drying process with natural convection. The experiments were carried out with plum tree wood and bark. There are drying processes of different sizes of wood and bark using natural convection compared. Moisture removal is not significantly affected by the sample size, but it affects the amount of bark on the sample. There were two different sizes of bark samples compared. It was recognised that the bark chips dry approximately twice faster than the bark pieces. Using the experimental data the theoretical drying coefficients were calculated. The results are useful for description and modelling of the drying process with the time depending drying coefficient for wood bark chips and pieces. The calculated theoretical results of moisture removal are compared with the experimental results obtained from the measurements. The obtained results of this research are parameters, which can be used for other research work and for improvement of the whole drying process.

Keywords: bark, drying coefficient, natural convection, plum wood.

Introduction

Wood is a porous material that is both anisotropic and heterogeneous. Wood continues to be a raw material for a large number of products in many branches, mainly in building construction, in furniture industry, wood carving and other artistic activities. To ensure a suitable and usable end product from wood, most of its moisture content must be removed by drying. It is an important step for improvement of the wood quality before it can be manufactured into stable final products. Wood drying and heat treatment are required processes for lumber, construction components, plywood production etc. These processes are energy-intensive, long and complicated by their physical nature and, therefore, it is important to scientifically explain and describe the process technology.

Wood is divided in softwood and hardwood. Fruit tree wood is considered as hardwood. Hardwood structure is denser and more complex; its moisture permeability is lower than of softwood, making it more difficult to dry. There are about a hundred times more species of hardwood trees than softwood trees. The ability to be dried and processed faster and more easily makes softwood the main supply of commercial wood today.

The most common treatment of timber is drying. General principles of wood drying and heat treatment processes and the common physical-mathematical principles are shown in [1]. There are different research works and aspects of practical wood drying [2; 3], wood drying process investigations [4-6] and similar problems related to wood properties. There is not enough information from the research work focused on drying of wood with bark. It is more complicated as there are two different materials (wood and bark) with different properties, water content and drying coefficients included in one complex material.

Materials and methods

The laboratory measurements were carried out at the Faculty of Engineering at CULS Prague during 1 140 hours since October 17th to 4th December 2014. To determine the effect of bark on plum wood drying, the drying dynamics of large (Fig. 1) and small (Fig. 2) wood samples with different amounts of bark was determined. The changes of the dimension and weight of the wood pieces were regularly measured, registered and statistically evaluated. The results are used for the process of calculation, drying process description and determination of important parameters.

To study the problems and influence of bark on the drying process, the research attention was paid also to the separated bark, removed from the wood pieces and selected for this research study.

Two types of plum wood bark were selected for the studies of bark drying: big particles (Fig. 3) and small particles (Fig. 4). It is supposed that the shape of one bark particle is a rectangular, thin, flat plate. The weight, dimensions and the number of particles were calculated and statistically evaluated. The average dimensions of one bark particle are 84.1 x 32.9 x 3.6 mm (big particles) and 27.4 x 12.7 x 0.5 mm (small particles).

a) **b)** **c)**

Fig. 1. **Wood big pieces:** a – with bark (100 % of bark); b – with partly removed bark (50 % of bark); c – without bark (bark 0 %)

a) **b)**

Fig. 2. **Wood small pieces:** a – with bark (100 % of bark); b – with partly removed bark (50 % of bark)

a) **b)**

Fig. 3. **Big particles of plum wood bark:** a – before drying b – after drying

c) **d)**

Fig. 4. **Small particles (chips) of plum wood bark:** c – before drying; d – after drying

We used the experimental data of wood and bark measured during the natural convective drying conditions in the laboratory with stabilised microclimate. The average air moisture was 54 % with standard deviation 6 % and average temperature 21.3 ± 0.6 ºC during the experiment. Air temperature and humidity were measured and registered by the sensor FH A646–21 including the temperature sensor NTC type N with operative range from –30 to +100 ºC with accuracy ± 0.1 K, and air humidity by the capacitive sensor with operative range from 5 to 98 % with accuracy ± 2 %, connected to the data logger ALMEMO 2690–8.

The samples were weighed on the digital laboratory balance KERN-440-35N with maximum load weight 400 g and with resolution 0.01 g. All measurements are converted in 100 g of material in order to better compare the results with each other. The total drying time was adapted to the need for determination of the final moisture content.

Using the experimental data the theoretical drying coefficients were calculated. The results are useful for description and modelling of the drying process with the time depending drying coefficient for wood bark chips and pieces. The calculated theoretical results of moisture removal are compared with the experimental results obtained from the measurements. The obtained results of this research are parameters, which can be used for other research work and for improvement of the whole drying process (wood with bark).

Results and discussion

In order to compare the drying dynamics of different sizes of wood pieces, calculation was made per 100 g of material. The results in Fig. 5 show that bark has a significant impact on wood drying and moisture removal. Moisture removal does not depend on the sample size for the samples without or with reduced amount of bark. Moisture removal from the wood samples with bark is significantly lower, and the process of drying is also partly influenced by the size (diameter) of the samples.

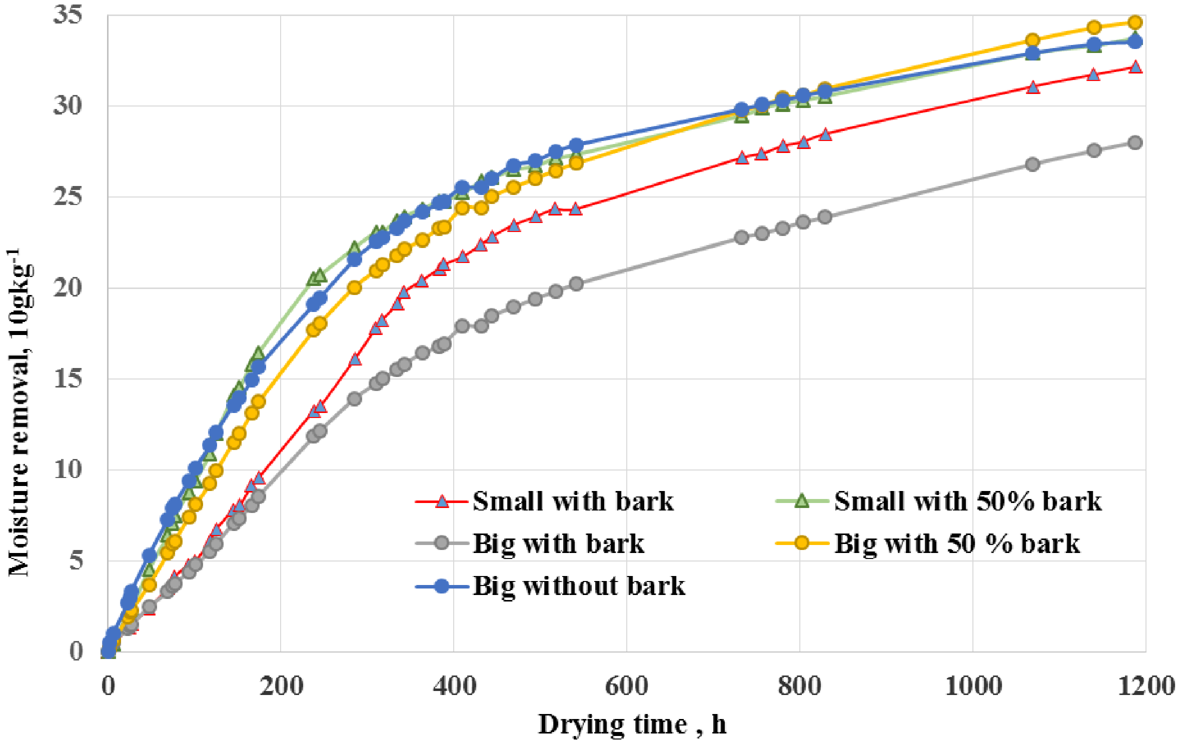

Fig. 5. **Moisture removal dynamics of the drying process of different size and bark amount wood samples**

Based on the above obtained results also drying dynamics of bark samples has been studied. The results are presented in Fig. 6.

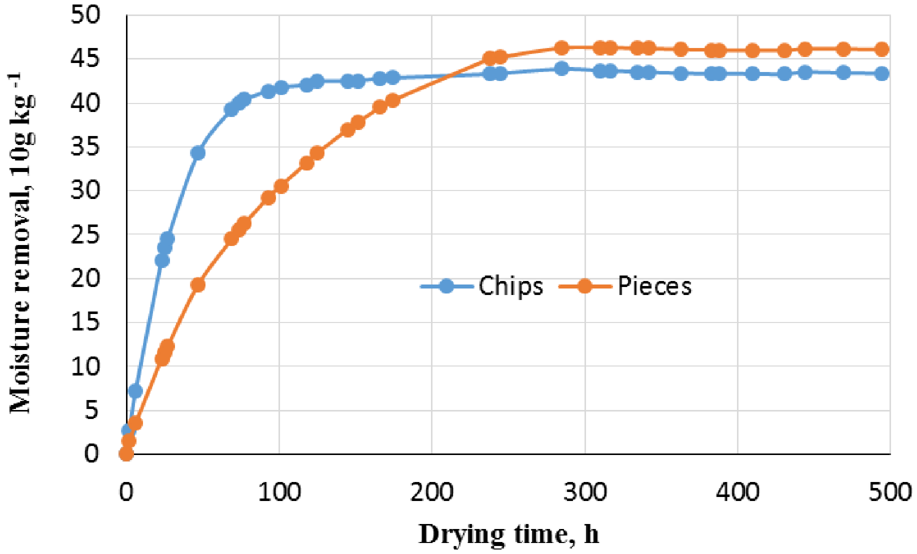

Fig. 6. **Moisture removal dependence on the size of bark (bark chips and pieces)**

As shown, in the case of bark chips moisture runoff is rapid; it means that the initial moisture is drawn from the surface. The chip thickness is smaller than the thickness of the pieces. In this case, internal diffusion has less impact on sample drying than in larger pieces and overall moisture removal is faster. The difference between the bark chips and pieces at the end of the process can be explained by the fact that in the sample preparation time, part of the initial moisture from the samples is removed more from the chips.

Using the methodology for thin layers described in [7] and the experimental data, the variable drying coefficients $K(t)$ from both types of the samples are obtained (Fig. 7, 8).

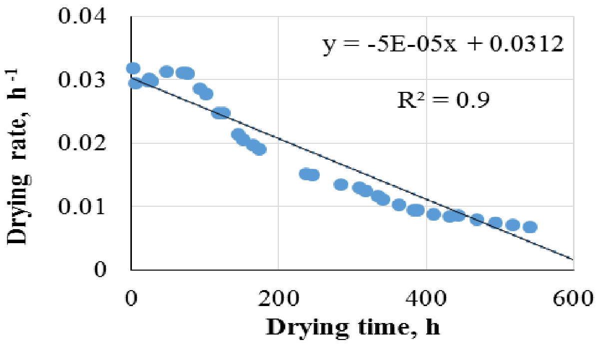

Fig. 7. **Linear drying rate *K*(*t*) calculation for bark chips**

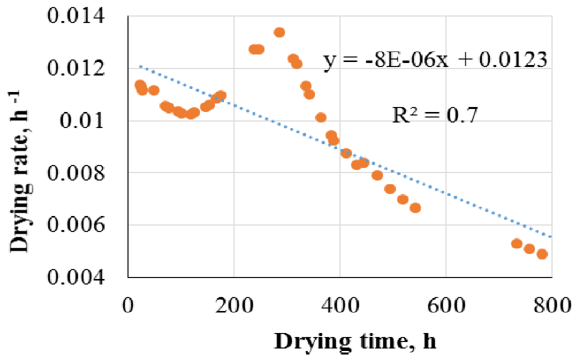

Fig. 8. **Linear drying rate *K*(*t*) calculation for bark pieces**

The theoretical linear drying coefficient for bark chips is

$$K(t) = 0.0312 - 5 \cdot 10^{-5} \cdot t \qquad (1)$$

with the coefficient of determination $\eta^2 = 0.90$ and for bark pieces is

$$K(t) = 0.0123 - 8 \cdot 10^{-6} \cdot t \qquad (2)$$

with the coefficient of determination $\eta^2 = 0.90$,

where t – drying time, h.

The theoretical bark weight changes can be calculated using (1) and (2) according the theory and methodology published in [7]. The average absolute value of the difference between the corresponding theoretical (for linear $K(t)$) and experimental data of bark chips was 0.48 g with standard deviation STDEV = 0.28 and for bark pieces 1.89 g with standard deviation STDEV = 1.84 g (initial chip sample weight was 59 g and pieces weight 183.5 g). The constant drying coefficient is calculated as average value from all experimental data $K(t)$ = 0.0123 (chips) with standard deviation STDEV = 0.01 and $K(t)$ = 0.075 (pieces) with standard deviation STDEV = 0.004. The results show that the wood chip drying coefficient is approximately twice bigger than the drying coefficient of wood pieces. Great non-linearity in Fig. 8 could be explained by stronger diffusion effect on the drying process.

Conclusions

1. The previously developed mathematical model for determination of drying coefficients can be applied to wood and bark materials.
2. Moisture removal is not significantly affected by the size of the wood sample, but it affects the amount of bark on the sample.
3. Bark chips dry approximately twice faster than bark pieces.
4. This methodology can be applied to find the drying rate of the material at different temperatures and combining the results to find the coefficient dependence on both the drying time and temperature.
5. The results can be useful for other researches in this area, as well as for the practical applications in drying of some wood materials or bark used for special purposes.

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