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Researching the change in the weight of split oak firewood due to different drying methods

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Researching the change in the weight of split oak firewood due to different drying methods

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Abstract. In this paper, the influences of stacking methods and drying places of split oak firewood in winter conditions (Quercus cerris) have been experimentally and theoretically investigated, due to the great importance of use in heating with such wood. The research was conducted on a sample of 48 pieces of logs with bark made of freshly cut oak. The logs were obtained by mechanized technology with the help of grafting by a hydraulic splitter and a chainsaw. Each log was measured for a research length of 0.30 m, marked with numbers 1-24. On each log, the weight was measured on a scale of 5 kg with an accuracy of 0.5 grams. Drying of logs was performed in two places. The first drying place was in outdoor conditions, sheltered from the snow and ventilated. The second place was indoors, at approximately constant room temperature. The logs were stacked in a crossed way for better air circulation. They were dried between 15/12/2020 and 15/02/2021, a total of 62 days. The average initial weight of logs dried in the facility was 1130.3 g, in the dried state the average weight was 952.87 g, which represented 84.3% of the original weight. The average initial weight of logs dried in outdoor conditions was 1192.125 g, in the dried state 1076.37 g, which represented 90.29% of the original weight. The average initial water content in the logs dried in the facility was 37.9%, in the dried state it was 27.5%. For logs dried in outdoor conditions, the average initial amount of water was 36.6%, in the dried state the average amount of water was 31.2%.

1. Introduction

The most important source of energy for people are liquid fossil fuels. Wood burning has also been successfully used on a global scale. Firewood has also always been an important source of energy in different forms. The most important form is logs which are burned in fireplaces, stoves and boilers (central heating). In addition to logs, wood chips, pellets and wood briquettes are also used. Wood is a clean source of energy that has a very efficient combustion. The amount of releases into the environment is small. The basic property of fuels is calorific value. Wood calorific value is the amount of heat generated during complete combustion. It is expressed in kWh/kg, MJ/kg, kWh/m^3 or MJ/m^3. Wood of different tree species has different calorific value and burning properties. One cubic meter of fire wood has an energy value of 2,628 kWh, oak 2,884 kWh, beech 3,078 and spruce 2,178 kWh. The calorific value of wood is influenced by the water content or moisture content of the wood, the chemical structure of the wood, the density of the wood, the tree species and parts of the tree and the health condition. Due to the calorific value, the amount of water in the wood is very important. To obtain ideally dried wood, it is important to obtain log technology. Wood drying is one of the most drastic wood processing procedures. Dryer wood has a higher energy value. When burning damp wood, part of the energy is used to evaporate the water. Air-dried wood with a humidity of up to 28%, which has been dried in covered and air-stored warehouses for at least 6 months, is usually used for heating. Proper drying and storage of wood affects the water content in the wood. The duration of drying depends on the shape of the wood, the time of felling due to the water content in the wood, the place of drying (location) and the type of wood. When drying wood, it is important the season when the wood was cut. In spring, the water content in the wood is higher than in winter.

2. Research

The aim of the research is to experimentally and theoretically investigate the changes that occur in the middle of natural drying of chopped firewood (*Quercus cerris*), in winter conditions. The aim was to investigate how much split oak firewood lost in mass, what was the initial amount of water and the amount of water lost during natural drying in outdoor conditions and drying indoors. The final goal was to show from the obtained results what changes have occurred in different drying methods. One can present whether drying oak is better in outdoor conditions or indoors during the winter.

2.1. Wood drying

Wood is a porous and anisotropic fibrous material. Wood fibers serve to transport water and nutrients from the roots to the leaves. In the case of wood, there is the moisture content of the wood, which is characterized as the ratio between the weight of water and the weight of absolute dry wood. When drying, the humidity of the wood drops. This causes different deformations in the wood. Each tree being dried has different conditions depending on the presence of water. The wood can be dried to an absolute state by the help of a dryer. Based on the presence of water in wood, it can be divided on fresh wood which contains the most water, semi-dry wood (55%), pre-dried wood (20%) and dry wood (15%), (J. Krpan 1965). By drying the wood, one gets increased dimensional stability, biological resistance, reduce weight and ensure easier processing and use. Due to drying, the wood deforms and cracks. It is noticeable that conifers dry faster, while deciduous trees have tracheae which perform a conducting function and the cell walls are thicker and difficult to be passed through by water. The process of wood drying is complex. Water has two forms; free water in the cells and bound water found in the woody walls of the cells. In the drying process, free water is released first, when the pores are emptied. Drying of wood is divided into natural and technical drying. Natural drying is the placing of wood in the environment, which is the cheapest form of drying. Disadvantages of this drying are high consumption of space, longevity, time depends mainly on the tree species, dependence on climate and air temperature. Technical drying of wood is getting better and began to evolve with the needs of a larger amount of wood. We know two different drying methods based on the mobility of the material. Stationary or chamber wood drying. Based on the temperature, there are low temperature (15 ºC - 45 ºC), normal (40 ºC - 90 ºC) and high temperature (90 ºC - 130 ºC). People are also familiar with the basis of the method, chamber, channel, condensation, vacuum, infrared drying, high frequency and solar drying. In addition to the method of drying the regimes are known. Drying regimes were created on the basis of long-term measurements and the search for optimal drying conditions for wood for individual tree species, thickness and water content in the wood. There are English regimes, American or Madison ones, and Russian drying ones that prescribe gradual drying steps. All newer drying regimes were composed so that the drying sharpness is constant with respect to the tree species and does not change during drying. In addition, there are regimes prescribed by the manufacturers of technological equipment for drying or built into the software for managing the drying process.

3. Methodes

For the preparation of the experimental work, an oak assortment from which the logs were made of the desired dimensions was obtained. Before setting up the experiment, the wood was split making 48 logs. The result was 24 logs from one meter of wood. There was a 2-meter piece of wood. It obtained a tiny 48 logs with bark, 0.30 m long, about the same thickness. There were two different drying places, outdoors and indoors. The logs were folded crosswise with24 logs in each group. The outdoor log was placed under the roof protected from rain and snow, and was located on the sunny side of the house. The inner logs were located in the boiler room. All logs were numbered to make it easier to track changes in log weight. Each week, the mass of the wood using a scale was measured. The measurement devices installed in the premises to monitor the temperature and humidity in the environment.

3.1. Shape form

For the oak shape, a quarter of the fine log was selected, which has a triangular shape (Figure 1). Such a form is suitable for home heating which is the most useful. Two sides were without bark but one side with bark. Such a shape was obtained by splitting logs by a splitting machine into four logs splitted twice into 8 logs.

Figure 1. The shape of a dried log

3.2. Place of drying and stacking of logs

The logs were dried in two places in the winter (in the outdoor environment and in the building). The outer logs were folded crosswise on the tiles and were covered with a roof (Figure 2, left). There was no rain or snow on the logs. It was positive for drying that it was located on the sunny side of the house (south) and that the wind always blew in this place. In such a position the logs should be well dried. The logs stacked in the building were on the tiles, in a part of the house in front of the room with the boiler (Figure 2, right). In such an environment, there was no draft, but the wood was warm which would affect faster drying. Each log was marked with numbers from 1 to 24.

Figure 2. Crossing method of log drying outside and inside

4. Results

4.1. The mass of firewood

The log drying was in two different places and the method of drying had an impact on the logs due to the environment. The measurements lasted from 15/12/2020 to 15/02/2021. The average initial weight of logs dried in the facility was 1130.3 g, in the dried state the average weight was 952.87 g and the average lost weight was 84.3%. The average initial weight of logs dried in outdoor conditions was 1192.125 g, in the dried state 1076.37 g, the average lost weight was 90.29%. Table 1 shows the descriptive statistics given on the mass of logs.

Table 1. The mass of fire wood.

Lable	Measuring unit	N	Min.	Median	Max.	Mean	St.deviation
1	2	3	4	5	6	7	8
$m_{outdoor}$	gram	24	2,85	12,06	16,95	10,76	3,9
$m_{outdoor}$	gram	24	3,7	11	12,98	11,92	4,1
m_{indoor}	gram	24	6,05	11	17	11,3	3,5
m_{indoor}	gram	24	4,5	9,3	15,6	9,5	3,2

4.2. Moisture of firewood

The average initial water content in the logs dried in the facility was 37.9%, in the dried state it was 27.5%. For logs dried in outdoor conditions, the average initial amount of water was 36.6%, in the dried state the average amount of water was 31.2%. Table 2 shows the descriptive statistics given on the moisture content of logs after drying.

Table 2. The amount of moisture in the wood of the log

Lable	Measuring unit	N	Min.	Median	Max.	Mean	St.deviation
1	2	3	4	5	6	7	8
$m_{outdoor}$	%	24	31,2	31,7	36,6	33,36	2,14
m_{indoor}	%	24	27,5	32,1	37,9	32,16	4,1

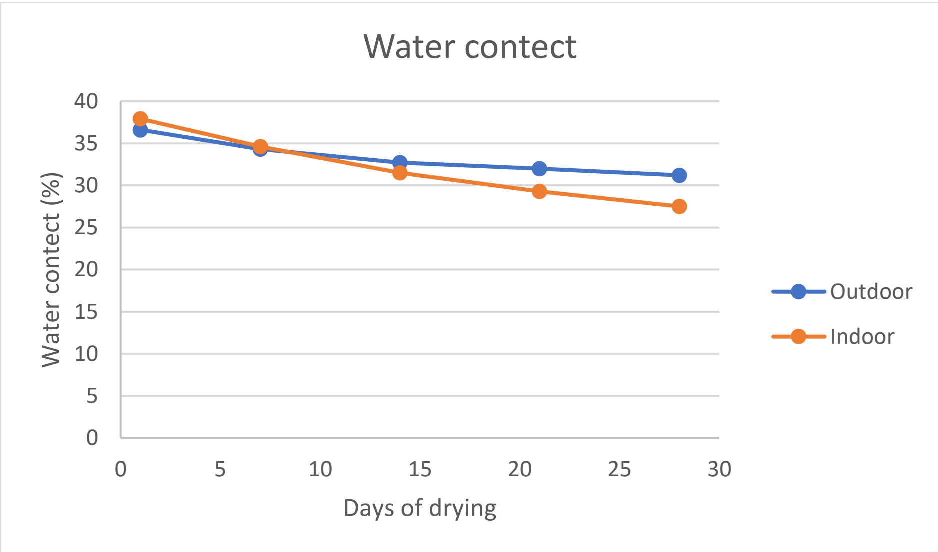

Figure 3. Water content of oak logs dried in the outdoor environment and in the building

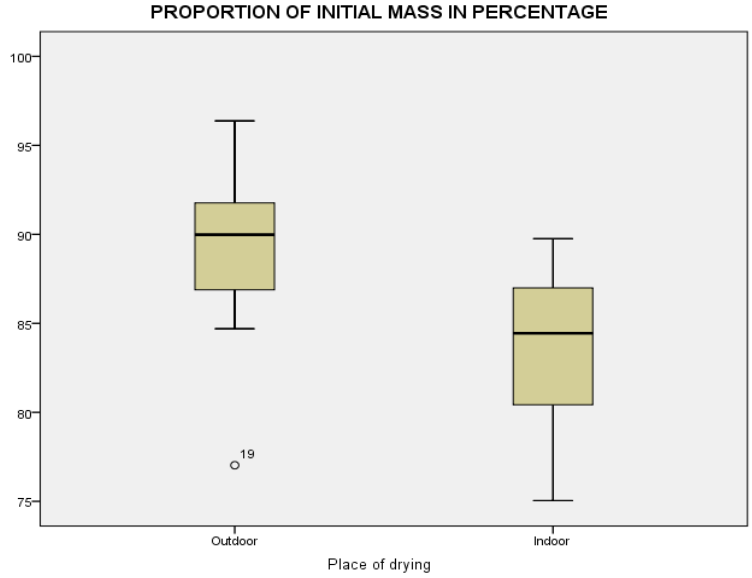

Figure 4. Influence of drying site on the mass of oak logs shown in percentage

The results (Figure 4) showed that logs stacked in the facility had 84.3% of their initial weight and logs stacked outside had 90.29% of their initial weight. According to the Mann-Whitney U test (p <0.001), the differences in the drying site were statistically significant. Based on this data, it can be confirmed that the logs in the building dry faster than outside logs.

5. Conclusion

The logs dried in the facility actually lost more moisture than the logs dried outside. The outside dried logs were dependent on the weather and due to the very difficult drying of oak logs, the choice of drying logs outside was not a good solution. The logs in the outdoor environment dry slowly and take longer. If one wants to dry the logs as quickly and better as possible, a better solution for drying in a closed facility was confirmed by the results of the research. According to research, logs dried in the building lost water faster, are drier and had a higher calorific value. The weight of logs dried in the building averaged 84.3%, in contrast to logs dried in outdoor conditions where it was 90.2%. During natural drying, there was a drop in moisture in the wood, the average moisture content of logs in the raw state dried outside was 36.6%, while in the dried state the humidity dropped to 31.2%. During the natural drying of logs in the building, the average moisture content of logs in the raw state was 37.9%, while in the dried state the humidity dropped to 27.5%. With this it can be concluded that logs that were cut in the winter with a large amount of water and can be quickly dried and used for burning. In the indoor building the logs can be easily dried to an acceptable humidity and used in heating.

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