Doctoral Thesis

Detecting red heart in beech (Fagus sylvatica) by electric impedance measurement

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Abstract

This doctoral dissertation submits researches concerning to detect red heart in beech (Fagus sylvatica L.) using non-destructive electrical voltage and resistance measurements. This wood defect is the starting point of the research namely it has a great effect on processing beeches, on its value and on using it as an end-product.

This research concentrate on industrial usable, red hearted beech but there were collected information about numerous forms of this wood defect too. Measurements were made in several steps on the basis of the current phase of this research.

As beginning a ‘simple electric tool’ with four electrodes was used. The goal was a yes/no detection and the development of this method as well as to get known the possibilities of its practical uses.

Later, there were used an impedance tomograph consisting 24 electrodes to detect more exactly the conductivity in wood inside. Red heart has a good conductivity part of the wood therefore further conclusions can be drawn about red heart from the changed conductivity distributions.

Introduction – Importance of the research

Today, the beech is a valuable wood material. It has excellent technical features and good aesthetical characteristics that insure many using possibilities. The beech cutting volume in Hungary reaches 10,2%, annually 675 thousand m^3 (Central Statistical Office, 2016).

The most significant wood defect in beech is red heart which causes the main effect on the used wood quality and on the market value. It influences the recovery value however there are certain market trends demanding especially red hearted beeches.
In view of these causes, there must be laid more emphasis on non-destructive wood research methods occurring standing trees. One of these wood research methods is based on electricity. Through this method parameters inside the wood can be examined without any effect on the vital processes. In that way a snapshot can be made about the inside conditions of the wood.

Research methods based on electricity can be used with advantages also in case of beech. On the basis of numerous previous efforts it can be said that this is the most suitable and also in practice usable method of red heart research.

Materials and methods

While working out the research plan used in this doctoral dissertation, the non-destructive electrical voltage and impedance measurements meant the starting point.

The goal was to detect red heart with help of electrical tools to be able to plan the measurement series.

The first target was the further use of ‘simple electric tool’ which was developed during my university thesis. It is a simple own made tool based on voltage measurements.

The critical point was to make the detection more reliable, so to get known, what size has that minimal diameter in relation of the area ratio which is still detectable. In the same time, also the measuring range of the tool should be got known.

The impedance tomograph available in trade offered a greater quantity and more concrete results on the same concept. The measurements depend on the electrodes placed on the width of the wood. The electrical field is the function of resistance distribution.

To the evaluation, a tomogram can be made which is in fact a resistance map. The diameter of the examined wood is illustrated by the software with triangulation in colourful geometrical figure pieces marking the resistivity values with defined colour scale. Using it the state of health and stability of the wood as well as many other factors can be estimated.

Summary

Altogether 101 entities were examined in the mountains of Sopron mainly, live wood. To be able to compare them directly, measurements were made in period of cutting woods. Measurements were made along the trees in different tallness examining the relation between the diameter, longitudinal, external characteristics and environmental factors of red heart.

The presence of red heart could be detected with all measurement methods. With the method based on voltage measurements, red heart can be detect relatively simply. In addition, the impedance tomograph was used with success to create a 3D-map about the longitudinal extension of red heart. We got a clear picture about the red heart relating to the wood and about the possible reasons of its development.

Red heart is characterised in compare to the normal wood with less, one third of voltage and resistance values. In compare to the normal wood changed impedance distributions can be noticed on the diameter.

Doctoral these

1. **In red heart of beech (Fagus sylvatica), the impedance and the voltage values are approximately three times less than in normal heart of beech.**

   Both wood research methods for detecting red heart were successful. During the measurements, the impedance and voltage values of defected wood were one third of the normal wood.

2. **In case of red hearted beech, there were no definite correlations between the size of diameter and the conductivities and impedances we measured.**

   Because a bigger diameter means red heart inside nearly without exception and red heart influences the measurable voltage because of the conductivity distribution, therefore the decreasing voltage value with the growth of diameter cannot be detected definitely.

3. **In general, about the results of measurements can be said that the results of measurements close to the foot are influenced by root to a great extent so it does not make possible an exact evaluation.**

4. **The longitudinal running down of red heart can be detected using impedance tomograph.**

5. **Red heart in beech can be brought into connection with factors of bringing up trees.**

   A greater part of wood entities likely to have red heart inside had external marks, which helped to come to the conclusion, there is abnormal wood inside.

6. **The most reliable result can be got in case of standing wood or newly cut wood.**

   After cutting trees, moisture loss makes the ability to consider red heart more difficult and the limited availability of the timber influences the right implementation of measurement negative.

7. **Impedance tomograph measurements are suitable to detect double pith as an abnormally wood.**

   The cross-section impedance maps are suitable to detect differences between conductivity in heart wood and in sapwood.

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