Doctoral Theses

Effects of the mechanical damages on the anatomical, physical and mechanical attributes of the silver lime (*Tilia argentea* Desf.) and the grey poplar (*Populus x canescens* (Ait.) Smith)

Fehér Sándor

University of West Hungary
Sopron

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Graduate School: Wood Sciences and Wood Technology
Head: András Winkler DSc.

Program: Wood Sciences
Head: Sándor Molnár DSc.

Discipline: Sciences of Material Engineering and Technology

Tutor: Sándor Molnár DSc.

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1. The aim of the research

To put into operation the renewed sources of power – such as the forests in Hungary as well as the wood coming from them – is absolutely indispensable for the dynamic growth of our economy. The sustainable conservation and qualitative development of the nation's forest resource also serves that purpose. In order to realise these purposes entirely, the knowledge of the fundamental wood quality from the point of view of the tree utilization, and the relation between the different damages is always considered an important point of view. It is also necessary to explore that the wood coming out of the damaged forests, how to fill the needs of the manufacture of the more valuable products. In the last few decades the quantity of the mechanical damages on green trees has greatly increased. This fact particularly emphasizes the researches in the field of the wood science. The increase of the number of the recent, similar, foreign, professional researches also supports that fact.

The increase of the mechanical damages on green trees is mainly connected with the biotic factors. The exciting agents of the injuries and wounds in the organs and tissues of the plants can be divided into two big groups:

Abiotic factors (demaging agents)	Biotic factors (demaging agents)
• hail	• bacteria
• frost-crack	• fungi
• windbreak	• insects
• snowbreak	• mammals
• immissions	• man

These abiotic and biotic factors can injure the leaves, the bark, the root or the xylem. The measure of these damages usually depends on the measure of the wounds and its frequency of occurence.

These surface defects on the plant that come into being in the course of the damaging can be the gates or the centre of the infection of the secondary pests or pathogens (fungi, viruses). A great number of fungi that live and damage on the bark, and all putrefactive fungi inside the trunk can penetrate into the plants only through the wounds. It is also often the case that the fungi which are able to penetrate through the epidermis or the stoma, in case of injuries they choose this way for their invasion.

From the above-mentioned damaging factors the snowbreak, the hail, the windbreak, the frost-crack, as well as the mammals and man cause mechanical damages. In the past period chiefly the quantity of the damages – caused by mammals and man – has increased suddenly. These damages can mainly traceable to the increased game population, the unsparing forest utilization and the intensive branch pruning. In the course of the forest works (clearing, forwarding and skidding, etc.) we can reduce chiefly the damages that during the mechanized forest utilization, yet in case of the game damage the reduction of the stripping damage demands much more complex accomplishment of task.

Whereas on the basis of the surveys the injuries deriving from the stripping in the different stands mean a much more dedicated difference than those that derive from the forest utilization, therefore in the course of my research work first of all I was dealing with the

mechanical injuries which derive from the stripping damage. Furthermore the injuries come into being in consequence of the inappropriate mechanized forest utilization are found mostly directly above the ground – above the root swelling – which cause some small problems after the cutting in the course of the conversion into assortments – except the wounds that stretch up long – like the injuries higher up on the trunk deriving from stripping.

The red deer – as well as the other cloven-hoofed games – are the part of the forest ecosystem. So their fundamental nourishment is the forest vegetation. One specific form of that nourishment is the bark and the pholem (inner bark) of the trees which is peeled-off by the game's lower incisors. During this specific form of nourishment they can cause bark damage – stripping. These damages can usually be imputed to the next game species: red deer, fallow deer, mouflon, roe deer. On the basis of the height, measure, shape of the wound, the damages of the different game species can be properly distinguished. From these damages the deer stripping has a really considerable importance.

To that the timber of the tree stands that injured in consequence of the mechanical damages – first of all the stripping – can serve valuable timber for the wood products industry, resp. their utilization can be realized to comply with the economical and technical requirements by expanding their field of utilization, we definitely have to get acquainted with the significant attributes of the wood from the point of view of utilization. It is especially important if the same trunk is injured several times.

On the basis of the above drafted statements the aims, I would like to reach, can be attained by working out several question-groups.

The aim of the research:

- The primary aim of my research was to work out a research method that provides an appropriate base to clear up the raised question (relationship between the mechanical damages and the wood quality), first of all in the respect of the change of the wood quality.

- Revealing the prospective anatomical changes in consequence of the course of the wound reaction in the xylem, resp. their consequence to the wood quality.

- To determine the changeability of the significant physical and static qualities of the wood that altered in the course of the defensive reaction in the respect of qualification.

- Presenting the aberration of the anatomical attributes of the callus from the tissues of the intact, sound, unhurt wood, resp. revealing its prospective effects to the other qualities of the callus.

- To examine how the significant physical-mechanical attributes of the calluses evolving as a result of the defensive process of the tree influence the properties of the wood.

2. The scientific antecedents of the research work

The special literature concerning the research work can be divided into three groups: the game damage, the wound reactions and the effect of the injuries to the quality of the wood.

We are in possession of abundant special literature dealing with game damage. Surveying the special literature dealing with game damage, it seems that the mechanical damages (stripping) caused by big games can cause significant damages and losses to the forestry sector in the future, too, both in qualitative and quantitative respect. Consequently the thing is such a field of research that has not by chance kindled the researcher's interest in numerous countries of the world. Without the sake of completeness I make mention of a few Hungarian researcher, who did a prominent significance research work in connection of this subject matter: ***Keresztes Gy., Bencze L., Bondor A., Kató F., Kőhalmy T., Nagy Gy. Cs., Páll M., Walterné I. V.***

The researches dealing with the reaction process of the injuries began in The United States in the end of the fifties. An experiment series began in connection with the nursing of old trees with the direction of Professor ***Alex Shigo***. We can almost say that the first publications in connection with this subject was written by him. There are innumerable publications that hallmark his life-work such as: ***Shigo, Sharon (1968); Shigo, Larson (1969); Shigo, Sharon (1970)***. In the field of the researches of the wound reactions the second half of the seventies meant the real breakthrough, when ***Shigo*** and ***Marx (1977); Shigo (1984, 1985, 1986)*** on the basis of their research works worked out the model of the defensive mechanism evolving due to the different injuries and damages. They named it CODIT (**C**ompartmentalization **o**f **D**ecay **i**n **T**rees) model. By the research of the defensive mechanism of the trees (CODIT) several researcher did prominent work in Europe ***Liese*** and ***Dujesiefken (1988, 1989a)***. At the same period they extended their research work to the relation of the arising time of the damage ***(Liese, Dujesiefken, 1989b; Dujesiefken, Liese, 1990, 1991)***, as well as the effect of the tree protection chemicals in the recovery and healing process ***(Dujesiefken, Liese, 1988, 1992)***.

The research works in connection with the exploration of the fine-structure in the tissues that are touched by the wound reactions are foremost connected with the name of ***Schmitt*** and ***Liese (1990, 1992, 1993)***. In Hungary the first examinations began with the researches of ***Molnár, Schmitt (1994)***.

The number of the researches in connection of the callus – evolving due to the wound reactions – is much fewer. In Hungary the first researches are connected with the name of ***Majer (1961)***. The foreign researches are especially significant: ***Sharon (1973); Moore (1978); Rademacher, Bauch, Shigo (1984); Liese, Dujesiefken (1988); Schulze-Dewitz, Götze (1986).***

In connection with the injuries it is a much debated question that the extent of the wounds how far influence the contamination of the green trees in the respect of phytopathology and forest protection. What is the maximum largeness of the wound, which is still not dangerous for the green tree? The researchers who did research works of this character among others are: ***Pagony (1967), Nolte (1977), Varga (1995)***.

The number of the researches in connection with the coherence between the injuries and the quality of the wood is very low. So there were very few publication appeared about the researches of the damaged wood, or rather the wood of which (abnormal) tissue changed

through the stripping or some other mechanical damage. ***Götze, Schultze-Dewitz, Wenk (1989)*** studied the density and the bulk condensation of the callus of Douglas fir (*Pseudotsuga menziesii*). ***Lowerts, Wheeler*** és ***Kellison (1985)*** did a similar research work in the United States. Then a research began to explore the complex effects of the stripping damages in the collaboration of the ***Faanyagismerettani Tanszék (the Department of Wood Science),*** the ***Vadgazdálkodási Tanszék (the Department of Game Management)*** and the ***Erdővédelmi Tanszék (the Department of Forest Protection) (1995)*** at the Forestry and Wood-Sciences University.

3. The material and methods of the research

3.1. The material of the research

The tree species initiated into the experiment are the silver lime (*Tilia argentea* Desf.) and the grey poplar (*Populus x canescens* (Ait.) Smith), since these two tree species are definitely endangered in the point of view of stripping damage in addition the silver lime (*Tilia argentea* Desf.) and the grey poplar (Populus x canescens (Ait.) Smith) behave different ways against the mechanical damages, thus the reaction processes in the wood are differ from each other. In the silver lime (*Tilia argentea* Desf.) tyloses do not form, since the peristome of the bordered tips are smaller than 3 mm. However the grey poplar (*Populus x canescens* (Ait.) Smith) is a kind of tree that is capable of forming tyloses.

I appointed the experimental plots at the next forestries: Kisalföldi Erdő- éss Fafeldolgozó Rt., Jánossomorjai-, Somogyi Erdő- és Fafeldolgozó Rt., Zselici Erdészet. The directly observed plots were marked out in the next forest subcompartments: Jánossomorjai Erdészet Jánossormorja 5/A and 6/A, item the Zselici Erdészet Bőszénfa 54/B and Kislak 8/B. In these forest subcompartments I drew into the experiment six sampling plots in such a way that I could do the detailed survey relating 100-150 trunks in each plots. These plots are found in such a district that are much-frequented in the point of view of damage. So I had a chance to survey the extent of the stripping damage in the sampling plots, furthermore it came to take notes of several damages during the three years of my work. The age of the stand of the grey poplar and the silver lime was 14 and 21 years at the beginning of the surveys.

In the course of the ranging over in the territory we felled some trunks with different degree of damage for the anatomical, physical and mechanical wood testing. We felled eight trunks in the stand of the grey poplar and eight trunks in the stand of the silver lime.

In order to be able to model, I inflicted artificial wounds on the trunks of the silver lime trees in February and March, and then on the grey poplars in June of 1994. I did it by a scraping knife by which I could make similar wounds on the trunks as the big games (red deer, roe deer, etc.) do it. I made the wounds on 20-20 trunks of each tree species in different width and length. Through the forming of these artificial wounds I could follow up the modifications in consequence of the reaction processes in the wood, such as developing protective zone, tylose formation, deposition of hearthwood matters.

3.2 Sampling for the anatomical research

The anatomical (microscopical) researches cover the survey of the callus evolving in the course of the damaging process of the wood and the wound closing process of the damaged wood closed down by evolving the three defensive walls (1st, 2nd and 3rd defensive walls).

I made some cuttings for photomicroscopical and electromicroscopical measurings to observe the anatomical structure of the callus and the evolving alterations in consequence of the reaction process. I appointed three points on the examined matter to examine the abnormal tissue of the callus. Then I cut out some samples from the damaged wood and the callus from the spots signalled with "**A**", "**B**" and "**C**" in a size of 10x10x10 mm for the anatomical examinations. After that I made some cuttings in the three anatomical directions. The sampling points are at a distance of 2-2 cm from each other, while the point "A" is at a distance of 1,5 cm from the edge of the sample.

A. Sample for examining the callus
B. Transition between the callus and the normal tissue
C. Sample for examining the normal tissue

In the course of the sample taking I was striving after exploring the differences between the callus and the normal parts of the tissue in detail, by the analysis of the of the microscopical structure of the callus For the shake of this I appointed a transition zone "B", too.

3.3. Sampling for the determination of the physical and mechanical qualities

I divided the trunks – that were felled for the physical and mechanical examinations – into two zones on the cross-section for the shake of forming test pieces. Separated it along the pit, one of the sides provided the unsound part, while the other side provided the sound part. So the "ruined" material provided the diseased that is the damaged wood – which was damaged by the stripping and as its consequence the secondary pests and pathogens. The opposed side from the pith provided the appropriate, sound part for the shake of the comparison, which proved really sound according to the examinations.

In the course of choosing the trunks for the examination, I was taking good care to select the trunks in which the pith has a central position. Hereby I precluded the presence of the tension wood in the wood marked for the mensurations, which was considered a significant point of view, since in the course of the examination the two opposite sides of the trunk was examined. In that event if a reaction tree is found in the matter, it can distort the results and the comparison.

I divided the wood – I took out from the centre plank – into 4-4 zones, and I formed the appropriate test pieces for the different examinations from each zones. In the part of the callus-tissue, namely in the unsound zone I., some marks of insect-gnawing could be detected, which results from the fact, that the bark stripping opens a very favourable penetration gate for the secondary organisms (fungi, insects) chiefly in case if the cambium gets injured, too.

After making the factual mensurations and examinations I compared the zones which are locally analogues of each other – the unsound zone I. with the sound zone I., etc. The values I got this way represented the subject of the evaluation.

Through the mechanical injuries a reaction process took place, in order that the plant defend the "open" tissues from the so-called secondary pets and pathogens. Then after evolving the cambium of the callus the callus-formation begins, in order to block off the injured surface from the outside world. The callus is a different tissue texture wood in comparison with the normal wood. It is probable that it will behave differently against the variant stresses than the normal textured wood. Due to that fact I expanded my researches to the callus, too. In the course of the sample taking I proceeded similar way as I did during the anatomical examination. By this method I also got a true picture of the technical parameters of the abnormal textured wood.

3.4 The methods of the examination

In order to discover the attributes of the damaged wood thoroughly in consequence of the mechanical damages, respectively the changed textured wood, I had to set off my researches fundamentally into five courses:

- The coherence between the size of the wound and the citatrization
- Presentation of the wood that suffered damages
- Comparison of the physical, mechanical attributes of the damaged wood with the attributes of the undamaged wood
- Getting acquainted with the microscopical structure of the callus
- Comparison of the physical and mechanical attributes of the callus with the attributes of the normal textured wood

Connection between the measure of the wound and the healing:

In the course of studying the special literatures I established that the measure of the wound has a significant influence on the quickness of the healing. In the course of my examinations I turned my attention to the cicatrization of the wounds on the trunks, since the stripping damage come into being first of all on the trunks of the trees. I took the exact measurement of the open wounds, then I measured the measurements after the damage, in a year's time again. Finally in three years after the last measurement I drew the conclusions, that is I determined the degree of closure.

The anatomical analysis of the damaged tissues:

Getting acquainted with the tissue alterations in the course of the mechanical damaging is possible through photomicroscopical and electromicroscopical surveys. I took out the samples for the examinations in a year after the damaging. The purposes of the microscopical analysis were the next:

- Determining the alterations following the reaction processes taken as a function of the tree species.
- Revealing the presence of secondary organisms (fungi).

I adopted electromicroscopical examinations, too, since the detection of the individual modifications is easier and simpler by that apparatus. I performed these researches at the Institution of Tree Biology at Hamburg University.

The physical, mechanical properties of the damages wood:

In the course of my researches I strove after determining the most important physical and mechanical properties. The techniques I applied are based on the presently valid Hungarian standards. Unfortunately, the young age of the stands, and so the trunk measures did not make it possible to keep the measure of the test piece which is indicated in the wood-test standards. Therefore I stuck to the techniques indicated in the standards, with the change that I reduced the measurement of the test pieces, however during the forming the test pieces, I kept the rules referring to the scales.

Physical properties:

• density	MSZ 6786-3: 1988
• shrinking-swelling	MSZ 6786-9: 1989 MSZ 6786-18: 1989

Static properties:

• compressive strength	MSZ 6786-8: 1977
• bending strength	MSZ 6786-5: 1976
• modulus of elasticity	MSZ 6786-15: 1984
• impact-bending strength	MSZ 6786-7: 1977

The anatomical texture of the callus:

Callus formation is the reaction of the green tree that tends to cover up the open wounds evolving as the consequence of the mechanical damages. The anatomical texture of that callus-tissue – deriving from its function – differs from the texture of the normal tissues. To reveal the differences between the microscopical texture of the normal and the abnormal wood I took samples from the neighbourhood of the wound in three spots. From this procedure I expected to detect the most searching possible differences between the tissues. After reviewing the special literature I set myself the aims of measuring the next microscopical parameters:

- number of the tracheas (vessels)
- territorial rate of the tracheas (vessels)
- average diameter of the tracheas (vessels)
- number of the libriform fibres
- territorial rate of the libriform fibres
- territorial rate of the cell walls
- number of the longitudinal parenchymas
- territorial rate of the longitudinal parenchymas

The physical, mechanical properties of the callus:

In the course of the examination of the callus I had to act similar way as I did it in case of the examination of the damaged wood. In this case I could neither keep the measures of the test pieces indicated in the wood-test standards. In the course of the tests of the callus I had to decrease the measures – the diameter is 8x8 mm, in turn the measure of length changes depending on the bearing force, – but in the course of forming the test pieces, here I kept the rules concerning the dimension, as well. In case of the determination of the technical attributes of the callus I applied the mensurations to the most important parameters:

Physical properties:

• density	MSZ 6786-3: 1988
• shrinking-swelling	MSZ 6786-9: 1989 MSZ 6786-18: 1989

Static properties:

• compressive strength	MSZ 6786-8: 1977
• bending strength	MSZ 6786-5: 1976
• modulus of elasticity	MSZ 6786-15: 1984

3.5. Evaluation procedure of the results of the examination

In the course of evaluating the results (mass facts) I got through the accomplishment of the individual examinations, I adopted descriptive statistics – minimum, mean, standard deviation, variance %. Since the descriptive statistics by itself is not sufficient for the objective evaluation of the deviation between the individual variable quantities, so I submitted the mass of facts to a significance analysis and variance analysis. To decide whether the average value of the mass of facts of the analysed attribute indicates a significant deviation with the means of other mass of facts a significance analysis must be done. In the field of the forestry and wood products industry in the course of the surveys the applied confidence limit is 95% in practice, which is considered as an acceptable limit in these two special fields.

4. Summary of the new scientific results

The researches in connection with the mechanical damages ran up from the second half of the 80's. From that time we can date the researches dealing with the fine texture of the reaction processes evolving in consequence of the injuries. The researches set off particularly in Western Europe and North America. It may be owning to the fact that they felt the need of the three care (damaged, unsound trees), first of all in the stands of towns, cities and parks. Unfortunately the researches were almost limited to the reaction processes taking place on the level of cytological. Research works dealing with the reaction effect on the wood quality were only met with sporadically, and they dealt wit only a physical attribute each. To retrieve this scantiness I began dealing with the relation between the mechanical damages and the wood quality.

By my researches I covered first of all the examination of the injuries caused by stripping, and since the clearsightedness around the state of this subject always raised some problems. Pros and cons professional debates were delivered, and in the course of these arguments the contending parties gave voice to their opinions in connection with the importance of the stripping damage. The primary purpose of my research work was to develop an investigational procedure, which provides an appropriate base for the clarification of the raised problem – relationship between the mechanical damages and the wood quality – especially from the viewpoint of the changing of the wood quality.

4.1. Results

In Hungary I am the first person who began dealing with revealing and coming to know of the reaction processes in consequence of the mechanical damages. I set up my examinations first of all in the respect of the change of the wood quality. Since the foreign researches cover only a smaller part of this subject each, so I examined the effects of the mechanical damages on green trees on the whole. Accordingly my examinations covered the determination of the wood tissues developed to defending wall in consequence of the reaction processes, as well as the anatomical, physical and mechanical properties of the wood damaged in the meantime. Furthermore the healing of the open wound, evolved in consequence of the damage, and the complete examination of the developing callus, as well as the revealing of the anatomical, physical and mechanical attributes. I am the first person in Hungary, as well as on a world scale, who determined the anatomical, physical and mechanical properties of the altered, damaged, then newly developed wood tissues.

The summary of the main results of the research work are as follows:

After the mechanical damage a callus develops from the living tissue from the edge of the wound, which bilges at the edge of the wound. In case of smaller wounds these border on and the wound heals. According to my examinations the width of the wound plays a great part in the healing of the wound. In case that the measure of breadth surpasses the 4 centimetres, the healing process cannot finish before the secondary organisms (fungi, insects) do such a considerable damage in the wood, which has a significant effect to its further life. In consequence of that fact the trees which suffered damages with wounds of which breadth is smaller than 4 centimetres must be removed from the stand in the course of the clearing and thinning cuttings. In case of the wounds that are smaller than 4 centimetres, the trees can still provide quality wood, since in that case the damage appears only as a discoloration in a smaller or larger area.

- The damages that evolved in winter, mainly cause such kind of injuries that lead to the devastation. In the course of the winter damages through the surface of the open wound a considerable drainage come into being in the outer tissues that prevents the development of the wound-cambium, or puts it back for a longer time.

- In a few days after the stripping a reaction process begins in the xylem. In the course of that process the parenchyma cells near the open wounds begins to produce hearthwood material, then they obturate the cells – which are found in the surroundings of them – with that material. Certain species – like the grey poplar I examined – defend themselves not only by loading of hearthwood materials but by tylose formation. In some cases in that

protection zone the suberinizalation takes place in the parenchyma cells, as well. By these defensive reaction process the plant – the green tree – blocks the inner cells and tissues from the damaging effect of the of the various microoranisms.

- In the course of the analysis concerning the density (physical properties) it was established that the density of the tissues decreased near the wound. In turn in the event that preventive defensive reaction passes off in time, the density of the wood increases. According to my researches the grey poplar reacts more quickly and effectively to the damage, because the density decreased only in zone I., in comparison with the unsound wood, since in the inner zones the density increased. The shrinking-swelling also supports the above-mentioned fact.

- In case of the tylose forming species the compressive strength is the attribute – from among the examinations of the static properties – in which no decrease observed in the quality. In turn the species which do not produce tylose suffered decrease in the quality. In the course of the analysis of the bending strength and the modulus of elacticity a serious difference can be detected for the benefit of the sound wood in contradiction to the damaged wood. In the course of the test of the dynamic strength – impact-bending strength – I did not observe a significant difference between the damaged and undamaged wood in case of the silver lime similarly as in the course of the examination of the compressive strength, in turn in case of the grey poplar an increase can be detected in consequence of the tylose formation.

- The research in connection with the production profile also points out, respectively supports the fact that if some damaged parts burden – weaken – the wood coming to utilization, we have to reckon with considerable reduction of the bending strength, as well as the weakening of the elastic attributes of the damaged wood.

- On the basis of the statistics analysises, in the course of the variance analysis it can be demonstrated among other things, that even if the average values of the static attributes are similar, the research results of the changed texture wood tissue had a considerable standard deviation. On the basis of these observations it can be drafted that the damaged wood is unreliable in the respect of the physical-mechanical attributes. According to the above-mentioned facts, the injured wood will raise some problems later in the course of the industrial utilizations, first of all from the view-point of the deformations and the structural reliability.

- The anatomical research of the callus points to the fact that its anatomical structure is greatly differs from the normal wood. The territorial proportion of the tracheas drastically decrease, first of all in consequence of the decrease of trachea diameters. The parenchyma cells go through a significant quantitative increase (their number of pieces nearly double) while the proportion of the fibres also increase by 5-10%. The volume of all cell walls increase as well.

- The density of the material of the callus is very changing. It is not possible to establish unambiguously that it increases or decreases. In the case of callus of the grey poplar, the density increases, and it decreases in case of the silver lime. The bulk shrinkage in turn takes a turn for the better in the callus tissue.

- In the respect of the static properties an unambiguous decrease can be observed in the callus in comparison with the normal wood, especially in case of the bending strength and the modulus of elacticity, where 20% of loss of value can be detected.

- The decrease of the physical and static properties, I got in the course of the researches of the callus, is inconsistent with the anatomical changes, since in consequence of those opposed changes should take place. The reason for the fact that it happens differently must be sought for in the structure of the cell wall. In the course of the anatomical researches I revealed that the callus contains a great quantities of gelatinous fibres. That points to the fact, that the tissue texture of the xylem, which develops in the callus, is similar to the tension wood, which is characteristic of the deciduous trees. In such cells the stratum S3 can completely be lacking in the cell wall, and in this case the gelatinous stratum substitutes that, moreover it can fill in the cell cavity entirely. The gelatinous stratum does not contain any lignin at all, but only cellulose builds it up. In the respect of the static attributes The wood of this kind is weaker than the normal wood.

4.2. Utilization of the results of the researches

By my research work I worked out a kind of method for examining the damaged wood by which its technical attributes can be revealed objectively, as a function of their possible usability. In order to choose the greatest possible worth scope of utilization of the wood which suffered stripping damage, I determined the most important physical-mechanical attributes that influences the quality, for the sake of revealing what quantity reducing effects must be considered in the course of the damaging.

The tree specimens, which were damaged by stripping in winter conditions, must be removed from the forest stand on the occasion of the clearing and thinning cuttings, because their chance of wound healing is precious little, in addition they will die owning to the serial damages of the secondary organisms (pests and pathogens).

The healing of the wounds of which diameter is wider than 4 centimetres is also doubtful, so the removal of these trees from the stand must be solved for the sake of the utilization of the wood which can be considered valuable in the course of the forest utilization.

5. Theses of the dissertation

1. In the course of my research work I worked out a complex researc method. By means of this method the relation between the anatomical attributes and the physical-mechanical properties of the wood tissues – which changed in consequence of the mechanical damages (injuries), then developed again – can be objectively revealed. All these help on clearing up the relation between the mechanical damage and the wood quality, on a large scale, especially in the respect of the change of the wood-quality.

2. I am the first person who disclosed that the factor that determines the successfulness of the closing of the wounds caused by mechanical damages, is not the measure of the injured surface, but the width of the wound. If the width does not surpass the 4 centimetres, the healing (closing up of the wound) can happen before the secondary pests and pathogens would do considerable harm. There is only a precious little chance

for the healing of the injuries, which come into being in winter, in consequence of the intense loss of water which hinders the development of callus-cambium.

3. I established that from among the technical attributes of the wood that changed in consequence of the reaction processes, following the mechanical damages, the resistance against the bending bearing force decreases significantly. In the base of the above-mentioned things, a wood like that is not suitable for constructional use. In the respect of the other attributes we cannot reckon on any significant quality decrease.

4. I pointed it out that the anatomical texture of the callus differs from the structure of the normal wood. The territorial proportion of the tracheas recedes by 30-35% in consequence of the decrease of the diameter. At the same time the rate of the parenchyma cells increases nearly twofold, however the quantity of the libriform fibres grows by 5-10%. The territorial proportion of the cell wall also changes, nearly 20 % of increase can be observed.

5. According to my researches the physical-mechanical attributes of the callus mostly show a downward tendency as compared to the normal wood. Yet, the change of the elastic attributes rise from these factors, because the loss of value is around 20% compared with the normal wood.

6. I revealed the contradiction that in case of the callus the change of all physical and static parameters are opposed with the modification of the anatomical structure. The increase of the quantity of the libriform fibres and the volume of the cell wall should determine the improvement of the technical attributes. In contradiction that fact they show a downward tendency in consequence of the gleization of the libriform fibres.

7. By my researches I definitely proved that the stripping damage, which is caused by the red deer during the winter time, is an outstanding root of danger in the respect of the health condition of the forests, which has two significant relations:

    - If the width of the wound does not surpass the 4 centimetres, a reduced quantity wood rises with a false hearthwood.

    - In turn if the width of the wound surpasses the 4 centimetres, a reduced quantity wood arises, besides the further life of the tree will get into danger, in consequence of the secondary organisms attacking through the permanently (more than 3 years) opened wound surface.

6. Publications connected to the subject

Book chapter

1. Fehér S. (2000): A faanyag műszaki tulajdonságai. In Faipari Kézikönyv I. Szerk.: Dr. Molnár S., Faipari Tudományos Alapítvány, Sopron, 74-88.

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