Consortium Project

Effect of Storage on Pulpwood and Its Significance in the Manufacturing of Chemical Pulp

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Consortium project: Metsäliitto Osuuskunta, Stora Enso PLC, UPM-Kymmene PLC

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CONTENTS

1 INTRODUCTION

The project looked into the matter of changes in wood properties which take place in pulpwood felled and prepared in different seasons of the year, and the effects of these changes on the manufacturing of chemical pulp and the usage value of the wood. This project is continuation to the 1999 study entitled "*Varastolaho, esiintyminen ja vaikutukset*" (Storage rot: occurrence and its effects). The project was divided into two parts; the first part looked into the changes in woody tissue during storage and the second part examined the effects of these changes on the manufacturing of chemical pulp. The research problem was approached so as to enable the results to be used in branding the method of determining the quality and value of roundwood on arrival at the pulp mill.

This report is a summary of the results of the entire project. Separate reports have been published on both parts of the project: "*Varastoinnin vaikutus kuitupuuhun*" (Effect of storage on pulpwood) (Metsätehon raportti 91 B / Metsäteho Report 91 B) and "*Varastolahon kuitupuun jalostusarvo sellun valmistuksessa*" (Converting value of pulpwood containing storage rot in the manufacturing of chemical pulp) (UPM-Kymmene Pulp Centerin raportti, tutkimus numero 19321 / UPM-Kymmene Pulp Center Report, research number 19321).

2 CHANGES IN THE PROPERTIES OF WOODY TISSUE DURING STORAGE

2.1 Implementation

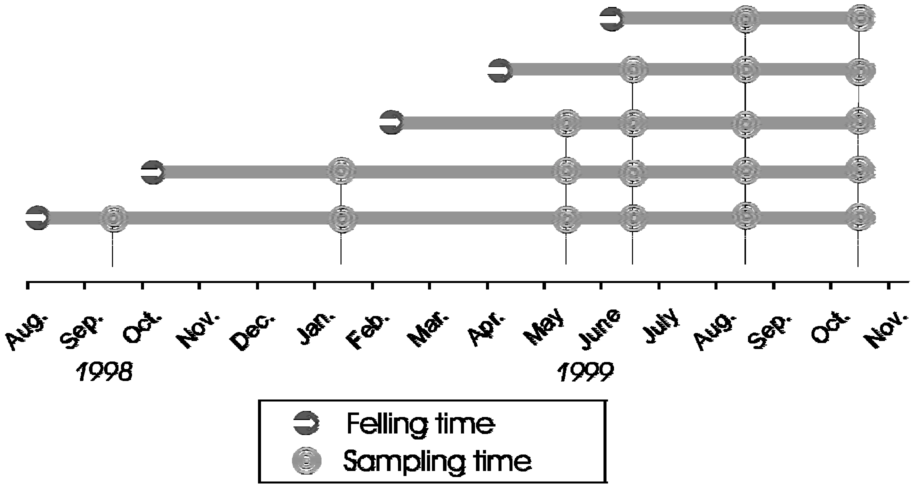
In Finland, this research undertaking was participated in by Metsäteho Oy, the Finnish Forest Research Institute, Metsäliitto Osuuskunta, Stora Enso Metsä, Sunila Oy, UPM-Kymmene Metsä and UPM-Kymmene Pulp Center. In Estonia, the participant was Stora Enso Mets, and in Latvia Stora Enso Mezs. Partial funding for the project was obtained from TEKES.

Storage piles of pulpwood were set up in Finland (Iitti), Estonia (Pärnu) and Latvia (Riga) for the purposes of the study, with pulpwood harvested from final felling operations in different seasons of the year, mainly using mechanised systems. The target size of the storage piles of timber in Finland was 50 - 60 m^3 and in Estonia and Latvia 25 - 30 m^3.

In Finland, birch, spruce and pine pulpwood were placed in storage formations at five points in time. The pulpwood was felled in August and October of 1998 and in February, April and June of 1999. Storing of the wood continued until mid-October of 1999. This being the case, the longest storage times were approx. 14 months and the shortest were 4 months.

In the case of Estonia and Latvia, the storage operation involved birch and pine pulpwood felled in August-September of 1998 and in the winter of 1999 (no pine pulpwood felled in winter was available for the storage study in Latvia). Storage of the pulpwood continued in Estonia and Latvia until late November-early December of 1999, and so the storage times were approx. 15 and 9 months.

The storage piles in Finland were examined at six points in time: in September of 1998 and January, May, June, August and October of 1999 (see figure on the following page). The storage piles in Estonia and Latvia were examined three times: in December of 1998 and in June and November of 1999.



2.2 Results

2.2.1 Changes in moisture content

Irrespective of the felling time, all the pulpwood dried the quickest in early summer. The wood was at its driest in August, after which its moisture content began to slowly increase towards the autumn. In the case of pine and spruce pulpwood, the moisture content decreased between late May and mid-August by about 20% units. The corresponding figure for birch was a little over 10% units. The final moisture content for all the pulpwood in the autumn was about the same, between 30 - 32%.

The initial and final moisture contents of the birch and pine pulpwood batches in Estonia and Latvia did not differ very much from that of the pulpwood stored in Finland. The same applied to wood harvested at different points in time. The final moisture contents of both birch and pine pulpwood varied within the range of 27 - 33%, depending on when they had been logged.

2.2.2 Changes in dry-green density

Changes in dry-green density in Finland were monitored using the same billets, while in Estonia and Latvia the measurements were made from different billets. The dry-green density readings obtained in the study were fairly high considering the wood was pulpwood in the round; they corresponded mainly to the densities of chipped sawmill material. The fall in dry-green density during the observation period of half a year varied between 0% and 6% in Finland and between 1% and 8% in Estonia and Latvia, depending on the pulpwood species.

2.2.3 Rot defects and staining defects

Birch

Stored birch billets first manifested a pale brown stain, which generally stood out from the lighter-in-colour sound wood. The leading boundary of fungal infection came a little behind the stain defect.

August-felled batch of birch: began to manifest the spread of the stain defect already during the same autumn. Part of the hard rot began to go soft at the onset of summer, and became accelerated in late summer.

October-and-February-felled batches of pulpwood: manifested the stain defect and it began to spread extremely in the early summer, but then it stopped. The proportion of hard rot increased quickly in the early summer and slowed down towards the autumn. Soft rot began to develop from June onwards.

April-felled batch of pulpwood: showed a rapid and even spreading of rot throughout the summer. However, the rot did not become soft by October.

June-felled birch pulpwood: piles were mainly affected by the stain defect only and it spread quickly.

Pärnu and Riga: stored birch pulpwood piles were characterised by the stain defect and hard rot advancing more or less as in Finland, but at the end of the summer the proportion of soft rot increased clearly faster than in corresponding piles in Finland.

Spruce

August-and-October-felled spruce pulpwood: remained almost without defect until mid-May. Thereafter, rot and blue stain began to spread, but (contrary to pine) first relatively slowly and then accelerating towards the autumn.

February-felled spruce: remained well preserved up to mid-June. After that the development of rot and blue stain was about similar as in the previous case.

April-felled spruce pulpwood: manifested blue stain and hard rot after mid-June. Both spread relatively slowly during the summer.

June-felled batch of pulpwood: was infected by blue stain and rot soon after being felled. Towards autumn both the blue stain and the rot spread a little faster in the June-felled spruce pulpwood than in the April-felled batch.

Pärnu and Riga: spruce pulpwood was not examined.

Pine

August-October-and-winter-felled pine pulpwood: batches manifested some blue stain by mid-May and very little hard rot. Thereafter, the blue stain spread fast before levelling out in August. Hard rot spread slightly slower than blue stain. No soft rot was observed.

April-felled pine pulpwood: manifested significant defects only after mid-June. Blue stain and hard rot spread in the wood until October, the blue stain spreading faster than rot.

June-felled pine pulpwood: became infected with rot a little more than pulpwood felled in April.

Parnu and Riga: piles of pine pulpwood did not rot faster than the pulpwood in Finland.

2.2.4 Spreading of rot in billets

Rot in autumn- and winter-felled birch pulpwood began to spread fast from the ends and more slowly from the sides of the billets. Rot in spring- and summer-felled birch pulpwood began to spread fast also from the sides, apparently due to pronounced coming off of barking. In the case of pine and spruce pulpwood billets, the rot spread from the ends and sides fairly evenly irrespective of the felling time.

2.2.5 Factors affecting the degree of rotting in pulpwood stored in Finland

Felling time

The felling time and the length of the storage period had the most effect on the development of rot. The proportion of rot increased when the period of storage lengthened. The exceptions in the case of pine and spruce pulpwood were the batches which had been felled before the onset of the trees' vital functions (in April); these kept better than those felled later in June.

Billet diameter, length and taper

With pine and spruce pulpwood billets, an increase in billet diameter was reflected as a decrease in the total amount of rot. With birch, increasing diameter had the opposite effect.

In the case of pine and spruce pulpwood billets, short billets rotted faster than long billets, whereas birch billets behaved the opposite.

Fast-tapering billets generally originate from the heavily-branched part of tree stems. In these rot was present more than in others.

Moisture and dry-green density weight

In the case of birch, billets containing a lot of sound wood were more moist and heavier than billets containing little sound wood. An increase in soft rot significantly reduced both dry-green density and green density.

In the case of pine and spruce pulpwood, billets containing a lot of sound wood were drier than those that contained little sound wood. Pine billets containing a lot of rot were more moist than billets containing little hard rot. Pine billets containing a lot of sound wood had lower dry-green densities than those with a lot of blue stain.

2.2.6 Spreading of rot in pulpwood stored in Finland and in Estonia and Latvia

The models calculated with the collected material as the basis were used in determining the changes in piles of pulpwood comparable as regards their time of felling. In the case of birch, the amount of soft rot at the beginning of the summer was more or less at the same level in Finland as in Estonia and Latvia. Soft rot spread considerably faster during the summer and autumn in Estonia and Latvia when compared to Finland. In the case of pine pulpwood, there was no consistent difference between the storage places in this respect.

3 CONVERTING VALUE IN THE MANUFACTURING OF CHEMICAL PULP OF PULPWOOD AFFECTED BY STORAGE ROT

3.1 Implementation

3.1.1 Sampling

The study billets for the part dealing with the manufacturing of chemical pulp were taken from storage piles located in Iitti (Finland) and Riga (Latvia). In the case of the pulpwood in Finland (pine, spruce and birch), the wood in rot category 1 had been felled in the late winter of 1999 (in February). Wood in rot category 2 had been felled in October of 1998, which meant that the spores of rot-causing fungi had been able to infect the wood before the onset of winter. The pulpwood was stored in piles until the end of August of 1999. This was when the sample billets were picked and transported to Pietarsaari. The billets were kept outside for two to three weeks in September before being debarked and chipped. Once they had been chipped, the sample material was deep-frozen prior to laboratory cooking treatments.

In the case of the Riga pulpwood (pine and birch), the pulpwood in rot category 1 had been felled in the late winter of 1999 and that in rot category 2 in August-September of 1998. The billets had been stored in piles until mid-October, which was when the sample billets were picked. They were brought to Kemi by ship and onwards to Pietarsaari by truck. The billets were debarked and chipped at the end of October. The samples, in chip form, were then deep-frozen.

3.1.2 Effect of storage on the manufacturing of chemical pulp

Due to the smallness of the sample, all the stages were performed on laboratory scale. The billets were peeled using debarking tools while at the same time estimating the degree of difficulty of debarking. Chipping was done using a small disc chipper, after which the chips were screened by means of a small screen. The chip size distribution was determined using a Gradex sieve emulating the SCAN standard. The chemical treatments were applied using the conventional batch cook recipe and laboratory cooking apparatus. Branch wood and reject were removed from the cooked pulp by screening. This was followed by bleaching the pulp using the standard mill bleaching recipe (sequence O - D - EO - D - EP - D).

The effect of rot on the manufacturing of chemical pulp is presented as differences in the manufacturing costs. The reference value is provided by the freshly-felled pulpwood of which sample billets were taken when setting up the storage piles. The unit prices of wood and chemicals correspond to the price level in 1999.

3.1.3 Effect of storage on the quality of chemical pulp

The pulp batches cooked and bleached in laboratory conditions were then ground using a PFI refiner. The quality properties of the pulp batches were then measured using standard methods (an accredited laboratory).

The effect of rot on the quality of chemical pulp is presented by means of a quality index. The foremost quality parameters (strength, fibre dimensions and optical properties) were used in computing the quality index.

In addition to the quality index, this study presents the converting value index, which is the result of the manufacturing cost index and the quality index. The idea in doing so is that then one value can be used to demonstrate the value of the raw material at the pulp mill. Using the converting value index is a simple way to compare and estimate the effects of storage rot, for example. A number of assumptions and simplifications applying to mills producing standard chemical pulp qualities were made in computing the index. This being the case, mills producing special qualities are advised to look at these results in more detail.

3.2 Results

The results obtained in this research undertaking support those of the earlier Metsäteho-co-ordinated work entitled "*Varastolaho, esiintyminen ja vaikutukset*" (Storage rot: occurrence and its effects).

Storage rot spreads fast under favourable conditions (spores, warmth, moisture). The proportions of rot as determined by the Finnish Forest Research Institute (Metla) when examining sample billets from Tillola were as follows:

		Hard rot, %	Soft rot, %
Pine	LL 1	19.4	0
	LL 2	39.8	5.2
Spruce	LL 1	5.0	0
	LL 2	12.6	0
Birch	LL 1	28.7	3.6
	LL 2	42.4	4.6

(LL = Rot category)

Metla researchers did not determine the proportion of blue stain defect in the sample billets, but observations made following chipping indicated that the blue stain defect in spruce was considerable (the chips were bluish-grey throughout).

In the case of pile storage of birch pulpwood, the converting value index was found to diminish between 15% and 20% during one summer. In terms of the price in the mill yard, this means a diminishing of the value of the wood by between FIM 35 and FIM 45 per cubic metre. Half of this fall in value is attributable to higher manufacturing costs. The other half is explained by the poorer quality (opacity and tearing resistance). A warmer climate (as in Estonia and Latvia) promotes the spread of rot and reduces the converting value.

Storage of pine and spruce pulpwood can lower its converting value by more than 20% during one summer. The majority of this fall in value is caused by the poorer quality (reinforcement ability). The fall in the converting value of pine pulpwood is further increased by warmer climatic conditions and the storage place more effective in promoting release of initial moisture (conditions corresponding to rot category 2 for Estonia and Latvia). Freshly-felled spruce pulpwood is an excellent raw material for mills where quality is valued. Rot infecting the sapwood spoils the good strength properties of spruce during summer storage. The reinforcement ability of the pulp manufactured from rot-containing spruce pulpwood included in this study had fallen by as much as 25%. This finding should, however, be viewed with some reservations because part of the explanation for the low strength properties is also in the high growth rate of trees from which the sample billets originated (young cambium). When focused on prices in the mill year, the fall in the value of pine pulpwood was between FIM 40 and FIM 60 per cubic metre. In the case of spruce pulpwood, the fall in converting value was even greater because once blue stain infects spruce pulpwood it is no longer suitable as raw material for mechanical pulp. Thereafter, storage rot causes the value of spruce wood as raw material for chemical pulp manufacturing to fall by some FIM 60 per cubic metre, with the overall effect being as much as FIM 95 per cubic metre.