Prediction of required duration of the conditioning process to reduce the casehardening level in LT-dried sawn timber – Initial experiments

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An initial work to prepare a method for calculating the required duration of the conditioning process to attain a desired casehardening level in LT-dried sawn timber is described. The casehardening level after the drying period is determined from the relation between gap and gradient of moisture content. The gradient of moisture content is detected by measurements based on electrical resistance in different layers in the sawn timber. The ΔEMC is further calculated from the moisture content measurements in the outer layer of the sawn timber and the EMC in the conditioning climate. Then the given formula can be used to calculate the required duration of the conditioning process. The formula is tested on two planks, and there is correspondence between the calculated and real values for gap. However, this test material is far too small to make safe conclusions. In future work, functions for how the parameters vary with respect to the conditioning climate have to be worked out. It is also logical to include the effect of temperature in the model.

Auch der Einfluß der Temperatur sollte vernünftigerweise in das Modell aufgenommen werden.

1 Introduction
To reduce the casehardening level in sawn timber dried by circulation of warm air, a conditioning period is performed in the last phase of the drying process. The conditioning process is normally performed by elevating the relative air humidity (RH), and perhaps the temperature, in the surroundings of the sawn timber. The climate in the conditioning process is of vital importance concerning the required duration of the conditioning period to attain the desired reduction in the casehardening level.

Right now new European standards concerning drying quality are prepared, and the casehardening level is one of the quality parameters. Therefore it is very important for the sawmills to be able to produce sawn timber that fits the requirements in the actual quality class in the standards. This means that the sawmills must be able to predict the casehardening level in the sawn timber after the drying period, and thereafter predict the required duration, if any, of the conditioning process to reach the specified quality class.

Some research has been done to investigate the effect of time, temperature and RH to reduce the casehardening level in dried sawn timber. Churchill (1954) found that temperature alone plays an important role in the removal of casehardening set and stresses, and that by an increase in RH, the time required for relief is greatly decreased. Morén (1987) has investigated the influence of temperature and time on the removal of the casehardening during a conditioning process, and an empirical relation between conditioning duration and temperature is given. Morén (1993, 1994) has also brought the steam conditioning process normally used in connection with the HT-drying into the low temperature drying (LT-drying). An advantage, in addition to the possibility to keep the RH very high, is that the steam also causes a temperature rise in the wood because of the release of latent heat of vaporisation and heat of sorption as the water vapour enters the wood.

Fløtaker et al. (1996) have done several conditioning experiments where the effect of different climates concerning the release of the casehardening after LT-drying of sawn timber was investigated. At the same temperature level, it was found that the difference between the equilibrium moisture content (EMC) in the conditioning

Vorhersage der benötigten Dauer der Klimatisierung, um Versalzung bei der Niedrigtemperatur-Trocknung von Schnittholz zu verhindern – Erste Experimente


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climate and the actual moisture content in wood at the end of the drying period, had significant influence on the conditioning effect.

Very few models and methods to predict required conditioning time for different climates are worked out. Morén (1987) and Flotaker et al. (1996) have proposed to use the very good relation between moisture content gradient in the cross section of the sawn timber and the casehardening level as a method to control the conditioning process. Flotaker et al. (1996) have found the relation shown in Fig. 1.

The measurements are performed by cleaving the cross-sections into three slices. The moisture content gradient is the difference in moisture content between the middle slice and the average of the two outer slices, while the gap is measured by excluding the middle slice and then putting the two outer slices together. The relation is very good, and a possible way to control the conditioning process is to measure the moisture content gradient by the method based on measurements of electrical resistance in the wood. Then it is possible to put the electrodes in different depths in the wood.

However, the humid conditioning climate will result in a high risk of large deviations between the measured and real moisture content. An experiment was performed to test this method (Sandland, unpublished work). Sawn timber with dimension 50 mm × 100 mm was dried and then conditioned in a climate with a dry bulb temperature of 80 °C and a wet bulb depression of 2–3 °C. In two planks the moisture content was measured by electrodes in nine depths. At different times during the conditioning, test pieces were cut from the same planks. These test pieces were cleaved in nine slices, and the moisture content in each slice was determined by the oven-dry method. For each depth it was then possible to compare the measurements of the electrodes to the measurements done by the oven-dry method. The results are given in Fig. 2.

Before conditioning, it is possible to measure the moisture content rather exactly by the method based on the electrical resistance, but during the conditioning process there will be large deviations from the real moisture content. It is the very humid conditioning climate that disturbs the measurements of electrical resistance.

The aim of this article is to describe a possible method of controlling the conditioning process. The casehardening level after the drying period is calculated by a relation between moisture gradient and the casehardening level, and thereafter the required duration of the conditioning process is given by statistical models.

2 Material and methods
Two of the conditioning experiments done by Flotaker et al. (1996) are used in this work. The research material of Norway spruce (Picea abies (L.) Karst.) was selected at a sawmill near Oslo. The sawn timber dimension was 50 mm × 150 mm. The material was already dried in a progressive kiln at the sawmill, but not conditioned. The sawn timber was taken straight from the sawmill to the laboratory kiln without any intermediate delay. In the laboratory kiln the sawn timber was warmed up again and a drying climate was established. The duration of the drying period was 1–2 hours. Table 1 shows the moisture content in the sawn timber before and after conditioning, and the conditioning climates.

The temperature was stable during the conditioning process, but there were some deviations from the given mean values. Steam from an external steam boiler was used as humidifying agent.

The EMC is based on mean wet bulb depression during the conditioning. However, it is not easy to give exact values for the EMC, and the values in Table 1 have to be considered as an approximate level. The EMC-tables in Esping (1992), based on values from Keylwerth, are used to estimate the EMC.

Before conditioning, the planks were cut in lengths of 1, 2 m and end-sealed with silicone. Four planks were selected for testing in each test run. Test samples for evaluation of casehardening and moisture content were taken immediately before the conditioning started, during the conditioning and at the end of the process. This was performed by cutting a section of about 15 cm in the longitudinal direction from the test planks at different times during the conditioning. Each time the planks were end-sealed again and placed into the kiln. For this purpose, two lamellae were cut from each of the test sections. These lamellae were used for 2-sliced and 10-sliced test samples. The procedure is shown in Fig. 3.

All the lamellae were weighed immediately after slicing. Then the 2-sliced test samples were moisture equalised for 48 hours in a climate of 20 °C and 65% RH. After this period the gap between the slices was measured according with Fig. 4, where also the negative casehardening is defined. The oven-dry method was used for determination of the moisture content.

![Fig. 1. The relation between the gap on 3-slicing tests and the moisture content gradient; linear regression together with the individual observations (Flotaker et al. 1996)](image)

Bild 1. Beziehung zwischen der Verformung der Spaltproben und dem Feuchtegradienten; lineare Regression und einzelne Beobachtungen