Sorting of logs and planks before drying for improved drying process and panel board quality

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Abstract

The objective of the research work has been to investigate whether the quality of dried and planed sawn timber can be improved by sorting logs and planks before the drying process. The research material was selected by randomly choosing 30 butt logs and 30 middle logs in a given diameter class at a sawmill. The logs were sawn in a 4 x log pattern, and one inner plank (near pith) and one outer plank (near bark) were chosen from each log. Various properties were measured on the logs and on the sawn timber before and after drying. The material was then planed, and the quality of the panel boards was registered.

Based on the results, different models for sorting the timber before drying to optimise the drying process are proposed. One of them is to separate outer and inner planks. An evident improvement is then expected, both due to possibilities for adjusting the drying process to the moisture content before and after drying, and the possibilities for optimising the drying process in accordance with the requirements of the various wood products. In addition to a separation of inner and outer planks, it is also of interest to separate planks from different types of logs (*e.g.* butt logs and middle logs) to be able to further optimise the drying process according to the wood properties.

The project results also show that the best wood quality for production of panel boards is found in the inner planks from middle logs, mainly due to the knot pattern in the stems.

1 Introduction

In the growing stem of a tree, there will be more or less systematic variations in the wood properties from pith to bark, and from butt end to the top. This is also the case for Norway spruce (*Picea abies*), the most industrial utilised wood species in Norway. In the stems of Norway spruce, there is a clear difference in moisture content between heartwood and sapwood, which will influence the drying behaviour of the wood. And in addition, the portion of heartwood in the cross section will be dependent on the height in the stem.

Other wood properties also have a regular variation in the stems. Near the pith, the juvenile zone is localised, with higher fibre angle than the mature wood. This will influence the amount of twist in the dried sawn timber.

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Another important property is the knot pattern in the stems. In the zone nearest to the pith, there are sound knots, while in the outer parts of the stem there will be more dead knots/black knots. The size of the dead knot zone is dependent on the age of the tree and the site conditions. In older trees, where the branches have felled off in the lower parts of the stems, a knot free zone can be formed in the outer part of the stem. Typical knot pattern in stems of Norway spruce is more closely described by Vestøl (1998) and Øien (1999). However, for wood panel for indoor use, the occurrence of the various knot types is very important. Dead knots/black knots are not accepted. Therefore, the raw material for producing indoor wooden panel should mainly contain sound knots, and should therefore be taken near the pith in the stem to avoid risk for dead knots.

With this background, the objective of the research work was to examine:

- Possible advantages concerning the drying quality by sorting logs and planks before drying.

- The effect of a sorting system for logs and planks for selecting raw material for indoor panel production.

This paper is based on the work of Sandland, Gjerdrum & Hamar (2001).

2 Material and methods

The research material was selected by randomly choosing 30 butt logs and 30 middle logs (middle log is the log above the butt log in the stem) in a given diameter class (240-250 mm) at a sawmill (Moelven Soknabruket AS). The logs were sawn in a 4 x log pattern, and the nominal dimension of the four planks in the centre yield was 44 mm x 125 mm. A total of 120 planks were produced, 30 planks in each of the following groups:

- Butt logs, inner planks
- Butt logs, outer planks
- Middle logs, inner planks
- Middle logs, outer planks

The inner planks are the planks nearest the pith, while the outer planks are nearest the bark. The butt logs and the middle logs did not come from the same stems.

The planks were dried at a constant wet bulb temperature of 55-56 °C, with an increasing dry bulb temperature during the drying phase, from 58 °C in the beginning to 67-68 °C at the end. Finally, a conditioning phase of 12 hours was performed after the drying phase.

The moisture content was measured by the oven dry method (according to EN 13183-1) before and after drying, both in the top and butt end of each plank.

After drying, the casehardening level was measured by using the 2-slice method (according to ENV 14464), and the twist was measured in mm rise over a length of 3 m. The density was determined on cross section slices from each plank by weighing the test slices, and measuring the volume by immersion in water.

After drying, the planks were cleaved into three panel boards, which is a typical way of producing indoor panel boards in Norway. This production was performed at the planing mill Bjertnæs Sag AS. After cleaving and planing, the boards were graded by the authorized grading personnel at the company in three grades (1. grade, 2. grade and reject).

3 Results and discussion

3.1 Moisture content

In Table 1 and 2 the moisture content before and after drying are given respectively.

Table 1: Moisture content before drying for different categories of the research material.

Group			Mean [%]	St.dev. [%]	Min. [%]	Max. [%]	No. obs.
Entire material			58.0	27.3	31.6	147.4	120
Inner planks			40.3	10.0	31.6	81.9	60
Outer planks			75.7	27.6	32.9	147.4	60
Butt logs	Inner planks		40.3	9.0	31.6	74.7	30
	Outer planks		70.3	30.9	32.9	147.4	30
Middle logs	Inner planks		40.3	11.0	32.6	81.9	30
	Outer planks		81.1	23.0	38.6	129.9	30
Butt logs	Inner planks	Butt end	39.6	6.5	30.8	56.5	30
		Top end	40.9	14.2	28.5	92.8	30
	Outer planks	Butt end	56.9	28.4	32.7	150.3	30
		Top end	83.7	37.5	33.2	153.4	30
Middle logs	Inner planks	Butt end	38.8	16.8	31.9	124.8	30
		Top end	41.7	11.9	32.2	73.4	30
	Outer planks	Butt end	59.9	23.3	32.7	107.2	30
		Top end	102.2	28.3	43.9	154.4	30

As expected, the moisture content in the inner planks, which contain a high portion of heartwood, is lower compared to the outer planks. It is also of interest to notice the big difference in moisture content from butt end to top end for some of the plank groups.

Table 2: Moisture content after drying for different categories of the research material.

Groups			Mean [%]	St.dev. [%]	Min. [%]	Max. [%]	No.obs.
Entire material			17.6	0.8	16.2	20.2	120
Inner planks			17.4	0.5	16.3	19.0	60
Outer planks			17.9	0.9	16.2	20.2	60
Butt logs	Inner planks		17.5	0.5	16.6	18.6	30
	Outer planks		17.8	1.0	16.2	20.2	30
Middle logs	Inner planks		17.3	0.5	16.3	19.0	30
	Outer planks		18.0	0.8	16.7	19.6	30
Butt logs	Inner planks	Butt end	17.6	0.9	16.3	20.1	30
		Top end	17.4	0.6	16.5	18.9	30
	Outer planks	Butt end	17.7	1.2	16.0	21.5	30
		Top end	17.9	0.9	16.2	20.5	30
Middle logs	Inner planks	Butt end	17.3	0.8	16.3	20.0	30
		Top end	17.3	0.6	16.3	18.9	30
	Outer planks	Butt end	17.9	1.0	16.3	19.9	30
		Top end	18.1	0.7	16.8	19.3	30

As can be seen, the variation in the moisture content is rather small. This is also due to the fact that the entire research material was located in one package, and not distributed in the entire kiln chamber.

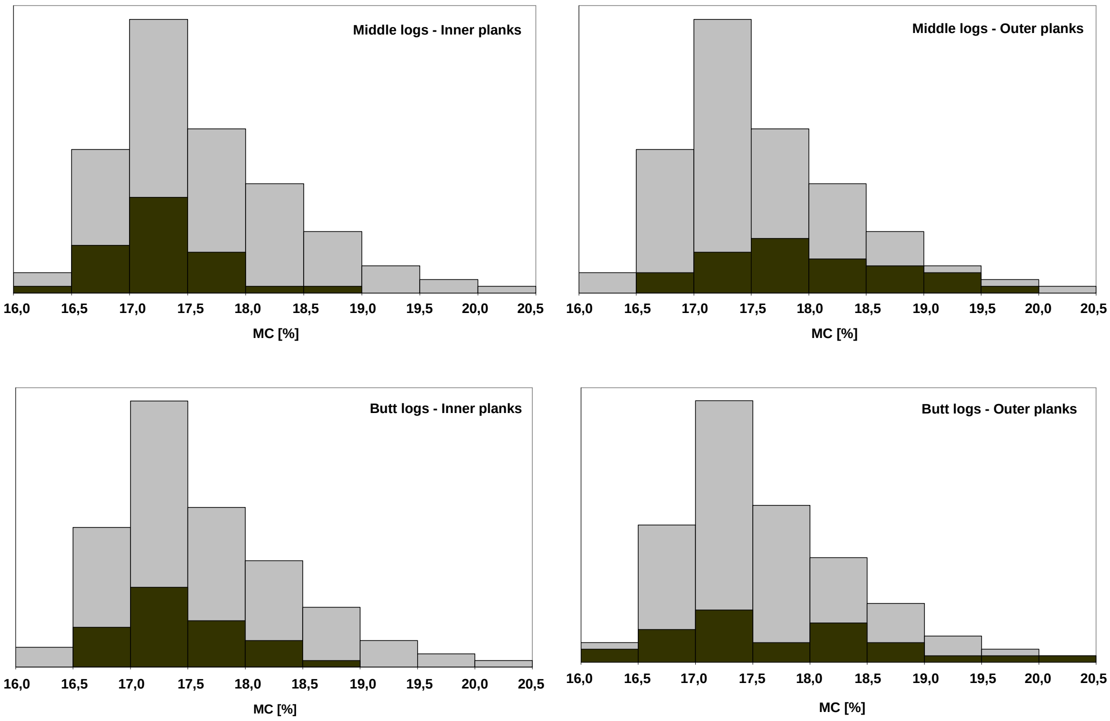

Figure 1: The moisture content distribution of the entire research material (light) and for each category (dark). The horizontal axis indicates the moisture content after drying.

Figure 1 shows the variation in moisture content for each plank group compared to the variation in the entire material. As can be seen, the distribution is wider for the outer planks compared to the inner planks, which shows a potential to reduce the variation in moisture content after drying, at this moisture content level, by sorting the material before drying.

In Figure 2 the relation between moisture content after drying and density is given, both for inner and outer planks. As can be seen, the moisture content is to some extent dependent on the wood density, even if the R^2-value is rather low. The relation is, however, statistical significant both for the inner (F=24.5, Prob>F <0.0001, DF=1-58) and outer (F=6.9, Prob>F=0.011, DF=1-58) planks.

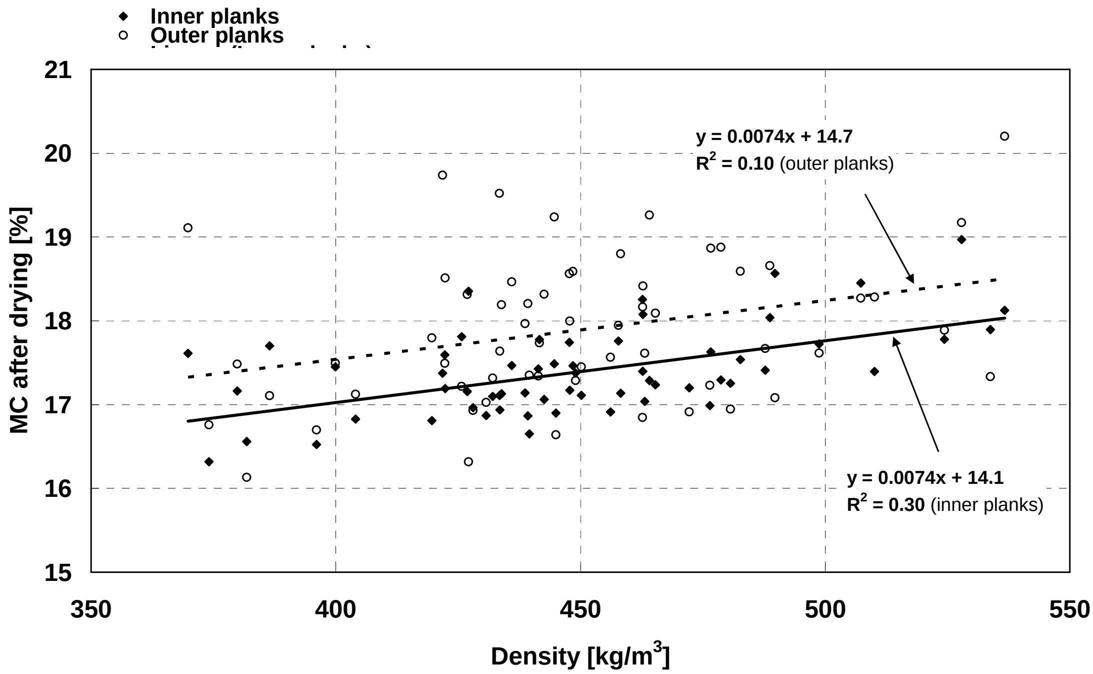

Figure 2: The relation between density (at 12 % MC) and moisture content, separately for inner and outer planks.

In Figure 3 the relations between moisture content before and after drying are given. As can be seen, the relation is very weak for the inner planks. For the outer planks, however, the relation is more evident, and also statistically significant (F=30.9, Prob>f <0.0001, DF=1-58).

A multiple regression based on moisture content before drying and density to predict the moisture content after drying gives a R^2-value of 0.49. This means that 49 % of the variation in moisture content after drying can be explained by these two factors. The cross product between the two parameters did not give any significant contribution to the model.

The model is shown in Equation 1 (based on MC in % and density in kg/m^3):

$$MC_{after\ drying} = 0.019 \cdot MC_{before\ drying} + 0.009 \cdot density_{12\%} + 12.8 \qquad \text{Equation 1}$$

In the analyses, one plank per log is randomly chosen to avoid dependence between the observations.

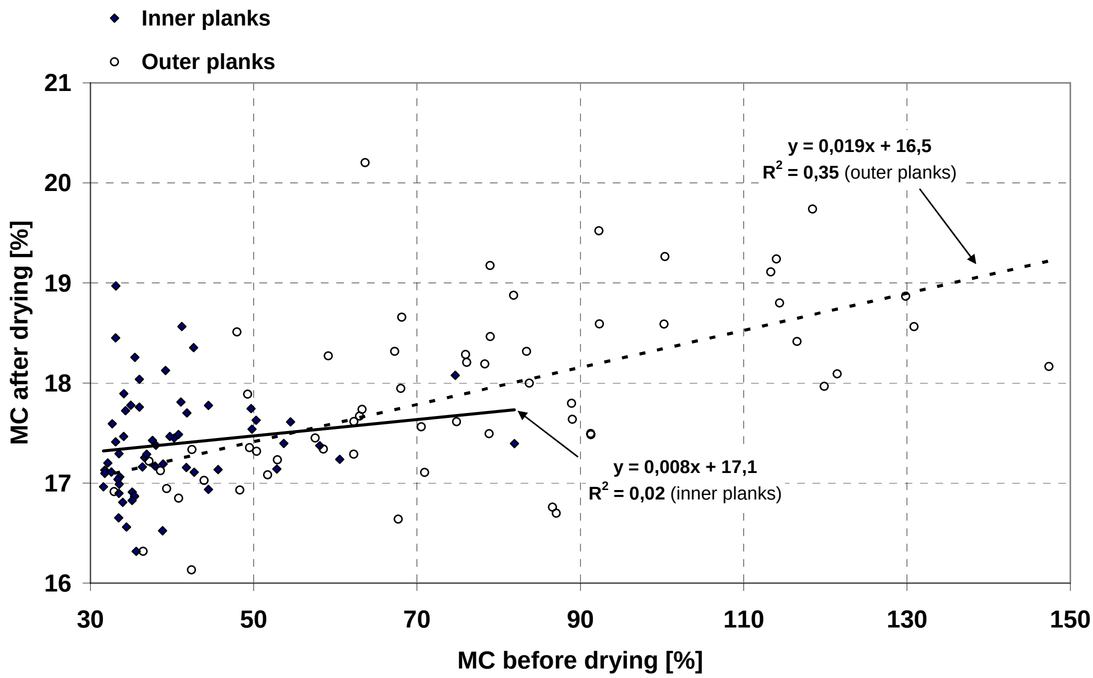

Figure 3: The relation between moisture content before and after drying, separately for inner and outer planks.

3.2 Casehardening

In Figure 4 the casehardening level in the planks is shown. The casehardening level is higher in the outer planks compared to the inner planks. Further analysis also shows that the casehardening level is higher in the top end than in the butt end of the planks. A factorial ANOVA shows that both the difference between outer and inner planks, and top end and butt end, is significant (F=49.1, Prob>F <0.0001, DF=1-177 and F=4.5, Prob>F=0.0358, DF=1-177, respectively).

The reason for the significant difference in casehardening between outer and inner planks can be due to the higher moisture content in the outer planks. The moisture gradient will then be more evident, with more casehardening as a result. Another effect is the annual ring orientation. In the inner planks, the portion of radial shrinkage is higher, with less potential for restrained shrinkage, and then less casehardening, as result.

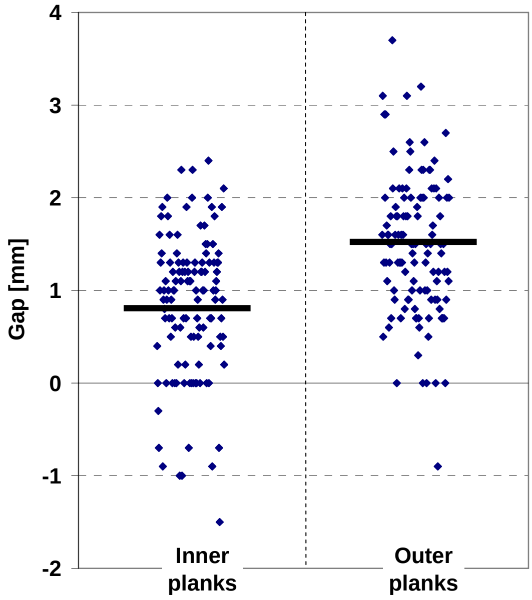

Figure 4: The casehardening level, expressed as gap, in inner and outer planks. Mean values (lines) together with individual values (observations both from top end and butt end are included in the figure).

3.3 Twist

The twist values are shown in Figure 5. As expected, the amount of twist is higher in the inner planks compared to the outer planks, and a two-way ANOVA shows that the difference is significant (F=9.4, Prob>F=0.0032, DF=1-59).

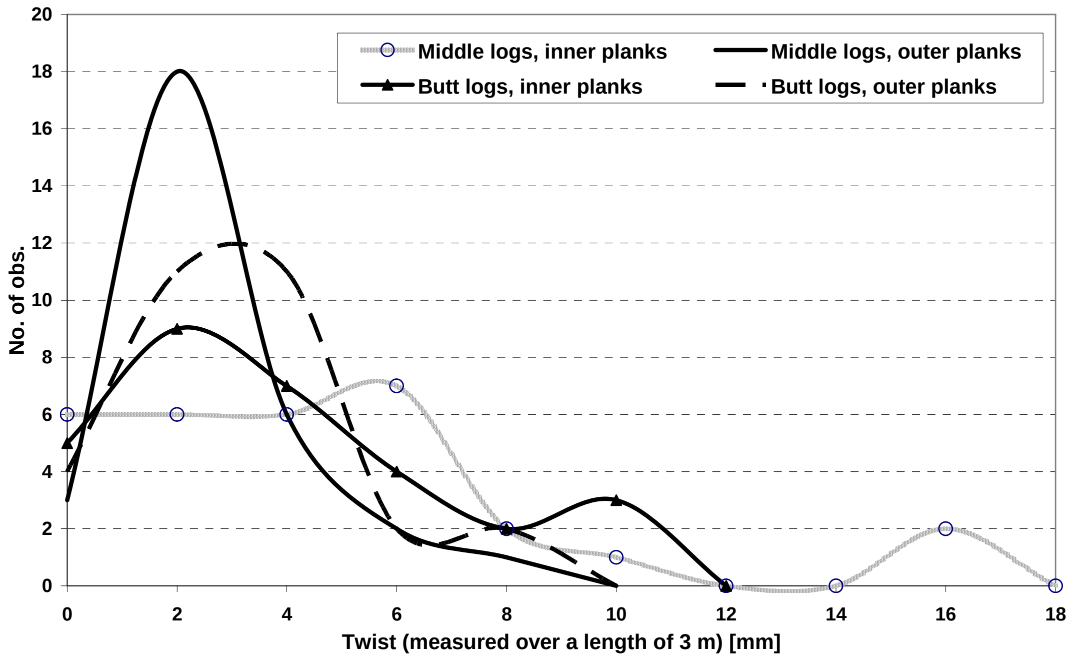

Figure 5: Frequency distribution of twist for the different timber categories.

3.4 Quality of panel boards

The quality distribution of the panel boards is given in Figure 6.

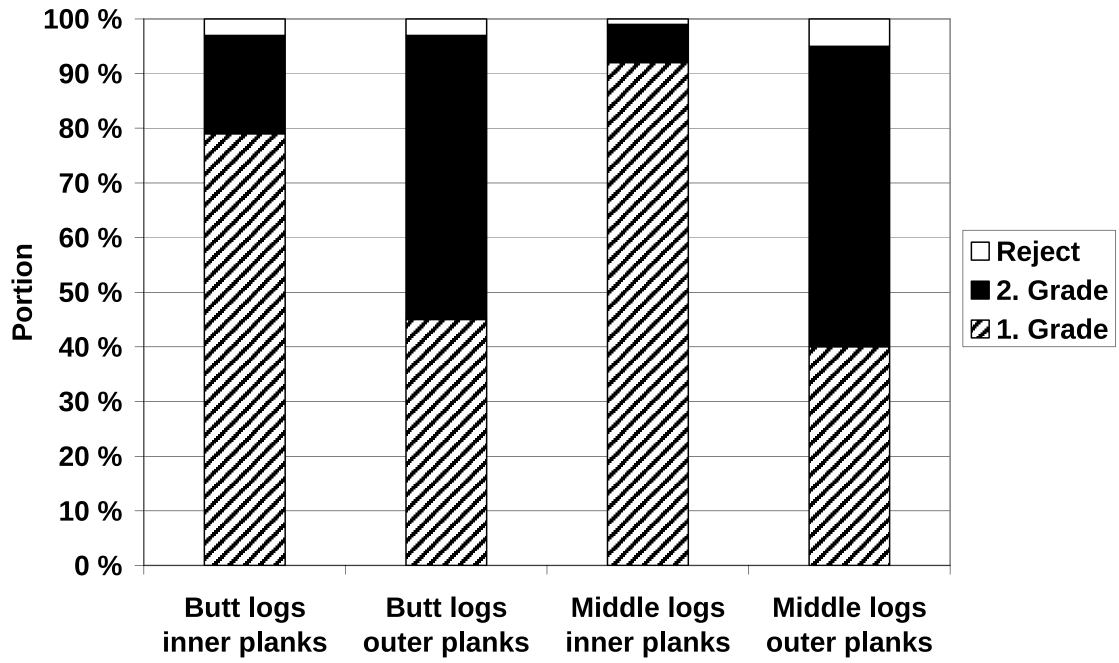

Figure 6: Quality distribution of the panel boards when cleaving the different plank categories.

The quality is considerably better for the panel boards coming from the inner planks, and especially from the inner planks in the middle logs. This is mainly due to the knot pattern in the stem, with sound knots in the inner planks and a higher occurrence of dead knots/black knots in the outer planks. The knot size of the sound knots is also increasing from inner to the outer planks.

4 Conclusions

The conclusions from the research work are:

- The variation in moisture content after drying can be reduced by separating the inner and outer planks before drying (the effect is not investigated for MC levels below 16-18 %). In addition, this will also make it possible to adjust the drying schedules more precisely to the wood properties, with a possible improved quality and higher drying capacity in the kilns as a result.

- Variation in density contributes to variation in moisture content after drying, and the variation in density and moisture content before drying explains about half of the variation in the moisture content after drying.

- The casehardening level is slightly higher in the outer planks, even after a conditioning phase, and will therefore require some additional conditioning effect to attain the same casehardening level as the inner planks.

- The quality of the panel boards is considerably higher for the inner planks, and especially the inner planks from the middle logs.

- A system that only considers the location of the planks in the log cross section, without any consideration of the quality of the sawn logs, is a very effective and easy way to sort out the suitable raw material for panel board production. In fact, based on the results from this research work, the planing mill that participated in the project started to specify that the raw material for panel board production shall be inner planks from middle logs.

References

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