How Planer Settings Affect Timber Properties

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There are different reasons for planing timber. One is to adjust the cross-sectional dimensions of thickness and width. Another is to adjust the timber's outer shape, usually in order to reduce warp resulting from drying and having the forms of cup, twist, bow, and crook. The end-result depends on the properties of the timber before planing and on the planer design and settings. In the present work it was found that increasing or decreasing the forces exerted on the timber by a four-sided planer does not affect the cutting depth or the twist reduction. The pressure settings do not affect the rectangularity or the amount of unplaned areas on the surfaces either. The possibility to impact the result with this type of planer, apart from the cutting depth and planed dimensions, is slim to none.

Keywords: Drying deformation; Planer misses; Planer settings: Planing and milling rectangularity; Warp; Wood; Wood quality

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INTRODUCTION

Its forests are one of Sweden's most valuable natural resources. The wood is used as construction material, for packaging, and for production of pulp, paper, furniture, and energy. In sawmills logs are disjoined into sawn timber, *i.e.* planks and boards. Some sawmills are also engaged in further processing such as planing, for example.

When planed timber is being discussed, there are many different quality aspects, *e.g.* surface roughness and dimensional accuracy. In this study, rectangularity, planer misses, and twist are key concepts.

When a log is disjoined in a sawmill, the external vibrations, dynamical stability in the saw blades, and irregularities in the wood make the saw kerf deviate from a straight pattern, giving rise to sawing variations (Steele 1984). When calculating the target size, the allowance for planing has to be large enough to remove possible planer misses due to these dimensional differences. Models predicting proper targets of size to avoid planer misses with considerations to sawing variations have been developed by *e.g.* Wang (1984). Another property that is included in Wang's model is drying shrinkage. As wood is an orthotropic material with varying shrinkage characteristics in different directions, the amount of shrinkage depends on *e.g.* distance from pith in the sawing pattern. If the distance from the pith increases, then the amount of drying shrinkage of the width also increases, while the drying shrinkage of the thickness decreases (Grönlund *et al.* 2009).

The difference in shrinkage characteristics between tangential and radial directions causes the wood to cup, and as the distance from the pith affects the curvature of the growth rings, the amount of cup decreases further from the pith (Ekevad *et al.* 2011). The allowance for planing has to be large enough to remove the cup; otherwise the planed timber will have planer misses. An additional effect of the orthotropic material properties is twist, which is considered as the worst type of drying distortion by the end users (Johansson *et al.* 1994).

The origin of twist is the spiral growth habit of the grain of wood (Warensjö and Rune 2004). Just as the amount of drying shrinkage and cup is affected by the location in the cross-section, the location also influences twist (Johansson and Ormarsson 2009). As twist can cause planer misses and lower the rectangularity of the timbers cross-sections (Axelsson 2013), it also has to be kept in mind when the allowance for planing is calculated.

Although public research on planing beyond surface quality is scarce, logical reasoning can be used to formulate hypothesis about the outcome of various scenarios. If the force exerted on the timber by the planer's various pressure elements were extremely high, then all drying distortions would be straightened during planing. The result would be timber with a better surface quality and with the sawing variations removed but with the amount of drying distortions unaltered as they would spring back after the planing process. As the sawing variation would be the only factor to be considered when calculating the necessary cutting depth, the allowance for planing and by extension the waste could be low. If it was possible to plane the timber without any forces straightening the timber at all, then the result would be decreased drying distortions, *i.e.*, joint timber. If planer misses are to be non-occurring, the allowance for planing has to be adjusted, and probably increased for timber that are most likely to become twisted. In extension, this could lead to a large amount of waste, so it is essential that the allowance for planing is not too large.

The aim of this study was to investigate if it is possible to adjust the pressure settings on a four-sided planer in order to modify the outcome of the properties rectangularity, planer misses, and twist, as well as to determine how pressure settings influence the cutting depth.

EXPERIMENTAL

Materials

In this study, the center yield from 15 Norway spruce (*Picea abies*) logs was used. All of the selected logs had a length close to 4.1 m and a top diameter in the interval 185 – 242 mm. The logs were sawn with a square sawing pattern following the pith with a horns down – crook up orientation to timber with a dry target size of 50 × 125 mm at a sawmill in central Sweden (Fig. 1). The timber had been dried with a standard drying scheme (Fredriksson *et al* 2014).

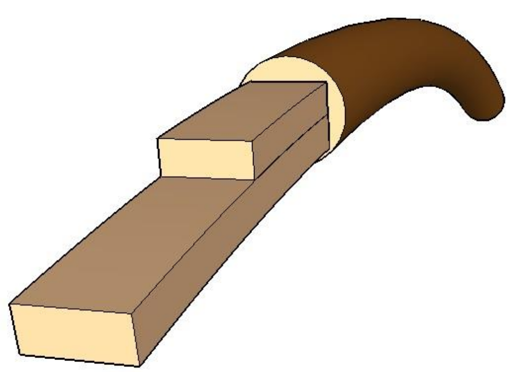

Fig. 1. Log with exaggerated crook oriented in the horns down position with center yield timber

Methods

The sawn timber was planed down to a target size of 45 × 120 mm after several months of indoor storage. Before planing, however, the timber was divided into three groups whereby one sample from every log formed one group, which was planed in a normal fashion with medium pressure acting on the timber from the pressure elements. The other samples from each log were divided into two groups, one of which was planed with excessive force and the other with barely any force (Fig. 2, Table 1). All planing was performed on a four-sided high-speed series planer (Waco 3000) in northern Sweden, and the pressure of the pressure rollers above the under cutter was 0.3 kN. The sawn timber was planed top ends first and sapwood face down; as a result the sapwood face was planed first, followed by the pith face. Then the right edge in the direction of feed was planed, and lastly the left edge.

Table 1. Pressure Settings for the Three Groups

Unit	Low	Medium	High
1: Feeding rollers	3 kN	4 kN	5 kN
2: Pressure plate	0.1 kN	0.3 kN	0.6 kN

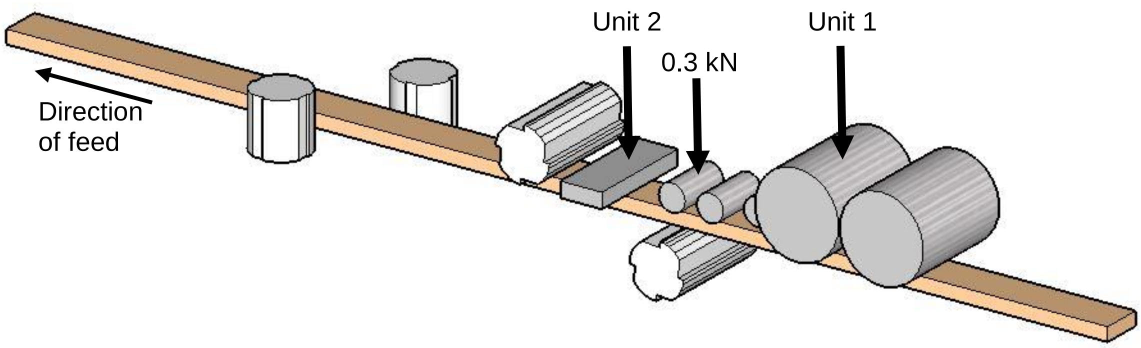

Fig. 2. Schematic planer with four cutters and the pressure units where the pressure forces were measured

Cross-sections located 10, 30, and 50 cm from both ends and one cross-section located in the middle of the timber length, *i.e.* seven cross-sections in total, were selected for closer examination. The cross-section numbering ranged from CS1 at the top end to CS7 at the butt end. The cross-sections were scanned in a Siemens Somatom Emotion CT scanner before and after planing. The image-processing software program ImageJ was employed for subsequent measurement of the CT images.

Timber thicknesses and widths were measured from the obtained CT images. Roughly 15 mm deep holes (Fig. 3) bored with a five mm drill in the cross-sections were used to determine cutting depths. On the sapwood face and on the right edge (in terms of feeding direction), cutting depths were calculated by subtracting the depth of the holes after planing from the measured depths of the holes before planing. All hole depths were obtained by measurements in the CT images. On the pith face and the left edge, cutting depths were derived by comparing the dimensions before and after planing, with the measuring points marked by the aforementioned holes.

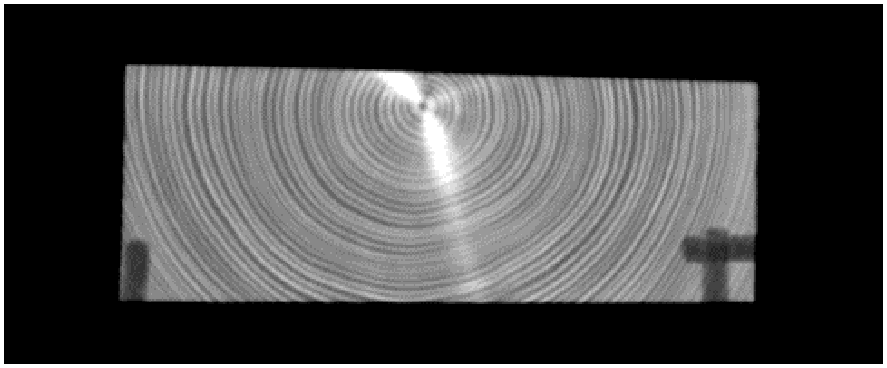

Fig. 3. Sample of a planed skewed cross-section with holes used for measuring cutting depth. For this cross-section the rectangularity was 0.97.

Standard SS-EN 1310 (Swedish Standards Institute 1997) was used to measure maximum twist which is the maximum deviation in mm from a flat surface for a 2 m long wood section.

The extent of planer misses was measured with a folding ruler to the nearest cm, and planer misses owed to wane were excluded from the analysis. To determine the proportion of the timber length with planer misses, the length of a face or edge with planer misses was divided by the total length of the planed timber in question.

Rectangularity *R* was defined as the ratio between the area of a cross-section and that of its minimum bounding rectangle (Rosin 1999). The rectangularity of a perfect rectangle corresponds to one.

RESULTS

For all samples in the study, the planer trimmed an average thickness of 50.2 ± 0.7 mm to 45.0 ± 0.6 mm. The average width was trimmed down from 126.8 ± 1.0 mm to 119.9 ± 0.7 mm. Twist was decreased by planing from 6.0 ± 3.6 mm/2 m to 4.1 ± 2.4 mm/2 m. An overview of the average values for the properties of the timber in the three groups is given in Table 2.

There was no significant difference between the average dimensions between the three pressure groups after planing. The difference in cutting depths was not significant either. The most prominent difference was the spread for the cutting depth on the right edge, which was more than twice as large for the group planed with low pressure than for the two other groups.

As for the cutting depth, there was no significant difference between the rectangularity of the three groups; the average rectangularity was actually the same. The standard deviations for rectangularity seems, however, to have been affected by the pressure settings. When average rectangularity is broken down into the seven cross-sections, as in Fig. 4, it shows that the difference in rectangularity between the high pressure group and the medium pressure group was larger at the top end of the timber and decreasing towards the butt end. The average rectangularity for the low pressure group and the medium pressure group on the other hand increased towards the butt end of the timber.

Table 2. Properties of the Timber Divided into Groups

Pressure setting		Low	Medium	High
Number of samples		7	15	8
Thickness (mm)	Rough	50.0 (0.7)	50.2 (0.7)	50.4 (0.6)
	Planed	44.9 (0.6)	45.0 (0.5)	45.1 (0.5)
Width (mm)	Rough	127.1 (1.0)	126.7 (1.1)	126.7 (0.8)
	Planed	119.7 (0.8)	120.0 (0.5)	119.8 (0.7)
Cutting depth (mm)	Sapwood face	1.7 (0.8)	1.9 (0.8)	1.8 (0.7)
	Pith face	5.1 (0.8)	5.2 (0.8)	5.2 (0.7)
	Right edge	1.0 (1.9)	0.7 (0.6)	0.7 (0.7)
	Left edge	7.4 (1.3)	6.7 (1.2)	6.9 (1.0)
Rectangularity	Planed	0.98 (0.0089)	0.98 (0.0080)	0.98 (0.0070)
Share of length with planer misses (%)	Sapwood face	9 (8)	5 (6)	4 (5)
	Pith face	-	-	-
	Right edge	23 (15)	21 (18)	23 (17)
	Left edge	-	-	-
Maximum twist (mm/2 m)	Rough	6.9 (4.5)	5.6 (2.9)	5.9 (4.1)
	Planed	4.5 (3.0)	4.0 (2.1)	4.1 (2.8)

Standard deviations are given in parentheses

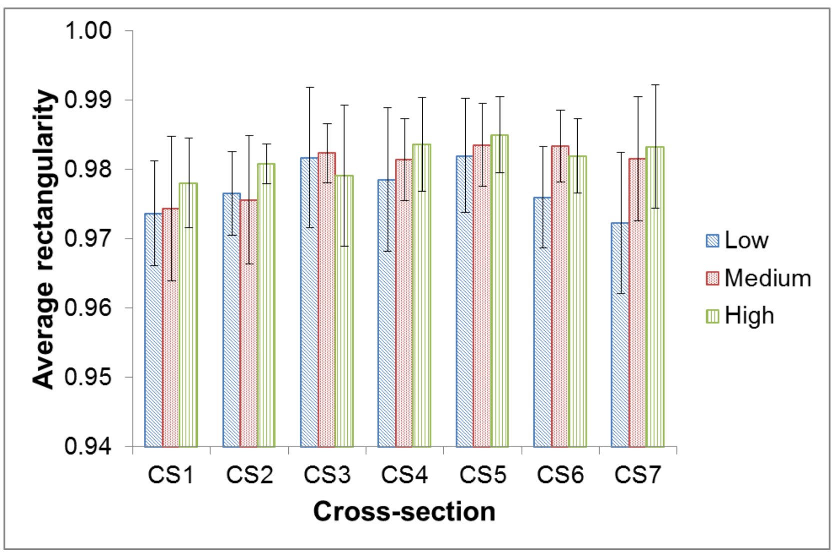

Fig. 4. Average rectangularity of the three groups

All planer misses on the planed timber were located on the sapwood faces and right edges, with pith faces and left edges exhibiting no such problems

For the sapwood face, the average share of length with planer misses decreased with increasing pressure but there was no significant difference between the groups, as the spread was large. Planer misses on the right edge did not show any consistent tendencies to any influence of pressure settings.

There were no significant differences in average twist reduction between the groups (Table 2), and a linear regression analysis of the three separate groups showed close to parallel coefficients of slope (Eqs. 1 to 3, Fig. 3). The coefficients of determination, R^2, were 0.96, 0.89, and 0.94 for the low, medium, and high pressure group, respectively.

Low: $$Twist_P = 0.65 * Twist_R + 0.025 \quad (1)$$

Medium: $$Twist_P = 0.69 * Twist_R + 0.083 \quad (2)$$

High: $$Twist_P = 0.66 * Twist_R + 0.16 \quad (3)$$

In Eqs. 1 to 3, $Twist_P$ is twist after planing in mm/2 m, and $Twist_R$ is rough twist in mm/2 m.

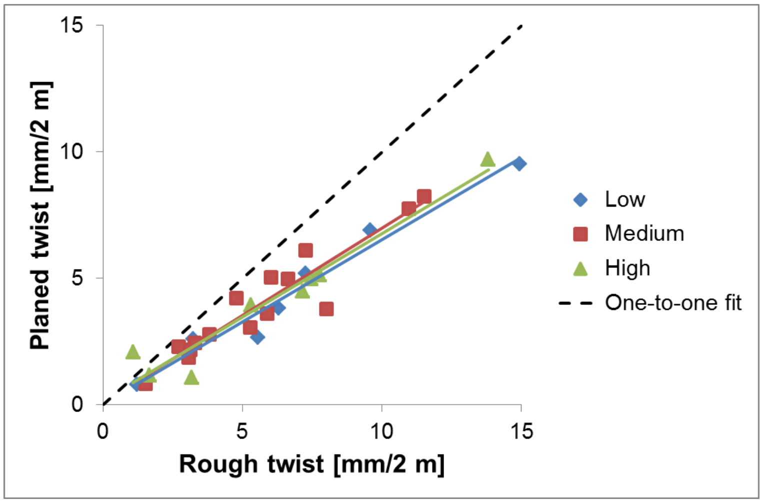

Fig. 5. Comparison of twist for the rough and planed timber for the three different planing configurations

DISCUSSION

According to the results, it is apparent that changing pressure settings on the planer used in this study did not affect cutting depth, rectangularity, amount of planer misses, or twist reduction.

There are some possible explanations for the lack of difference between the three pressure groups. For one thing, the pressure applied to the timber by the pressure roller above the under cutter was the same for all samples, so that there were no difference between the three groups for the first machined surface, *i.e.* the sapwood face. The pressure exerted on the timber by the pressure roller might not have been large enough to straighten it before the second surface (the pith face) was machined by the upper cutter.

In this study, no horizontal settings were altered, so the machining of the edges should have been similar for all samples. There were, however, two small differences between the pressure groups. The standard deviation for the cutting depth on the right edge, as well as the standard deviation for rectangularity was a lot larger for the low pressure group, which indicates that the pressure settings do have an effect on the feeding, as higher pressure seemed to bring less sideways motion of the timber during planing and hence a more homogeneous result (Table 2).

One positive effect with the lack of dependency of pressure settings is that it should be possible to adjust the cutting depths so that the amount of planer misses could be customized without the need to consider the present settings. In this study all planer misses were located on the sapwood faces and right edges as the cutting depths were too small, while all pith faces and left edges were machined. Since the planing allowance was more than sufficient, some of these planer misses could have been avoided by increasing the cutting depth on the sapwood face and right edge.

Possibilities to influence the rectangularity or twist reduction of planed timber are more likely a planer design than a planer setting issue. In the planer used in this study there was a distance between opposing cutters both between the upper and the lower cutter, as well as between the right and the left side cutters. Since the distance between the cutters permits temporarily straightened timber to spring back as the timber moves forward in the planer, the alignment between two opposite surfaces can become nonparallel, resulting in a skewed cross-section with low rectangularity. If the distance between the opposing cutters were to decrease, the possibility of a spring back effect should be reduced with a higher rectangularity as an effect. Another possibility to increase the average rectangularity is planing timber with an excessive length and then cross-cutting to the final length after planing as rectangularity generally is higher a distance from the ends.

When maximum twist reduction is the main objective, using a straightening table is a potential solution, but the effect of such equipment was not studied in this experiment. According to Fig. 3, the twist reduction behavior seems to be roughly linear, so it is possible that twist could be further decreased by planing twisted timber several times. This would probably require a larger planing allowance and hence a larger target size when planing timber that is prone to twist.

One major contributor to the low twist reduction could be the high pressure exerted on the timber from the feeding rollers, as it was approximately 10 times larger than from the other pressure elements. The major feeding rollers could be moved further away from the first planing tool so that their impact would be reduced. Moving the rollers might however result in feeding problems towards the end of each batch, a problem that could be circumvented by quick machine settings during operation so that it is possible for the planer to run continuously.

Considering the nonexistent effect that changing pressure settings have on the properties investigated in this study, they can be set to meet other requirements, like the material flow. During the planing operation in this study there were some difficulties with feeding, resulting in burned surfaces. Although a major part of the problem was due to the small batches, the operation was smoothest for the group planed with medium pressure settings.

This study did not consider how surface properties were affected by the alteration of the planer settings and there is a possibility that the high pressure might have damaged the cell structure near the surface of the wood. It only investigated a small number of samples with the same dimensions made by the same species of wood planed in the same planer, so the absolute numbers are not universal.

CONCLUSIONS

Conclusions that can be drawn from this study are that when planing 50 × 125 mm spruce timber in a four-sided high-speed series planer:

1. Pressure settings do not affect the properties rectangularity, planer misses, or twist reduction;
2. Pressure settings have a small impact on the stability of the lateral movements of the timber;
3. Cutting depth can be adjusted to reduce or avoid planer misses without regarding pressure settings, and
4. Pressure settings should be adjusted to facilitate smooth feeding.

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