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Range in depth of wood damage caused by Valmet 360.2 harvester head feed rollers

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Abstract: *Damage to wood caused by spikes of the harvester head feed rollers are in the lateral part of round timber.* The difference between the deepest and the shallowest damage was called an range in depth of damage (RDD). The pine, spruce and alder logs damage done by 360.2 harvester head from middle and top parts of stems were examined. The average and maximum values of range were analyzed. It was hypothesized that for species with a different wood structure and different density, RDD will vary and will be smaller in soft wood and bigger in hard wood. The objective of the research was to measure and compare of RDD caused by feed rollers spikes on pine, spruce and alder logs. The range of average values (RAV) without division of logs for all examined species were at a similar level from 1.04 mm (in spruce wood) to 1.50 mm (in alder). The range of maximum values (RMV) was respectively higher from 1.68 mm (spruce) to 2.11 mm (alder). In coniferous species both RAV and RMV in the middle logs were higher than in the top logs. Knowledge of the size of RDD can facilitate the wood quality control in terms of damage done by spikes of a harvester head. For pine, spruce and alder wood the same number of the depth of damage measurements may be adopted.

Keywords: wood defects, harvester head, feed rollers, wood quality, scots pine, spruce, alder

INTRODUCTION

Dents in wood caused by spikes of the harvester head feed rollers are in the lateral part of round timber. It's also caused by a measuring roller, although in this case their depth are significantly lower [1]. The depth of damage (dents) is different throughout the course of the stem, both axially and circumferentially. The variation of the depth of the damage in the axial direction can be associated with different thickness of bark, which depends on the height of a tree (particularly in older trees) and decreasing density of wood from the butt end to the top [2]. Lateral stem at a given height may be damaged to various extent due to the presence of defects in wood, such as open and covered knots and scars. The diameter of the timber can also influence the depth of damage. The differences in depth of damage in pine, spruce and alder wood processed by head 360.2 were statistically significant, although generally damage depth did not exceed 1 cm [3]. The shallowest damage was observed in alder wood.

An interesting feature, not considered so far in studied literature, is range of damage depth (RDD) caused by feed rollers spikes. RDD in this case is understood as difference between smallest and biggest dent depth within one measurement group of damage: minimum and maximum (further explanation of measurement groups in section: Material and methods). These RDDs give information about feed rollers spikes behavior when are in contact with soft wood (pine or spruce) or hard wood (alder), and are considered in this case as the basic research in order to understand or predict that phenomena.

It was hypothesized that for species with a different wood structure and different density, RDD will vary and will be smaller in soft wood and bigger in hard wood. This was based on understanding, that softer tissue (wood) will make smaller resistance and feed rollers spikes will denture wood with better accuracy, while harder wood will make it less certain. Therefore, the objective of the research was to measure and compare of RDD caused by feed rollers spikes on pine, spruce and alder logs.

MATERIALS AND METHODS

The study was carried out in four different stands: pine (80-y.o.), spruce (75-y.o.), alder I (84-y.o.) and alder II (91-y.o.). In each stand trees were cut in the Summer season by a Valmet 911.4 harvester equipped with a 360.2 head. For measurements of dents,64 pine, spruce and alder logs from middle and top parts of stems were selected.

The depth of the damage was measured in six *windows* (bark removed) on each log: three *windows* on one side and three on the opposite side of the log. On each side of a log one *window* was at the bottom (the thickest point), one in the central section and one at the top (the thinnest point). Six measurements were taken within area of one window. From these six data, depths were divided into two measurement groups: 1) average (from six measurements) and 3) maximum (the deepest dent from every *window*). Further analysis for each species were considered for: 1) the range of average values (RAV) from every log, and 2) the range of maximum values (RMV) from every log.

The values of ranges were statistically analysed. Each of the respective variance analyses were performed by checking equality of variance (Bartlett's test) and the compatibility of the characteristic of the normal distribution (test Cramér–von Mises). The significance level for analysis was $\alpha=0.05$. Statistical data was processed using R software. Standard significant code 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 was applied throughout.

RESULTS

RANGE WITH NO DIVISION OF LOGS

RAV without division of logs for all examined species were at a similar level from 1.04 mm (in spruce wood) to 1.50 mm (in alder II). RMV was respectively higher from 1.68 mm (spruce) to 2.11 mm (alder II) (Fig. 1). Analysis of variance for the range without division on logs for all species showed no significant differences in this parameter, both for RAV ($p = 0.344$) and RMV ($p = 0.680$).

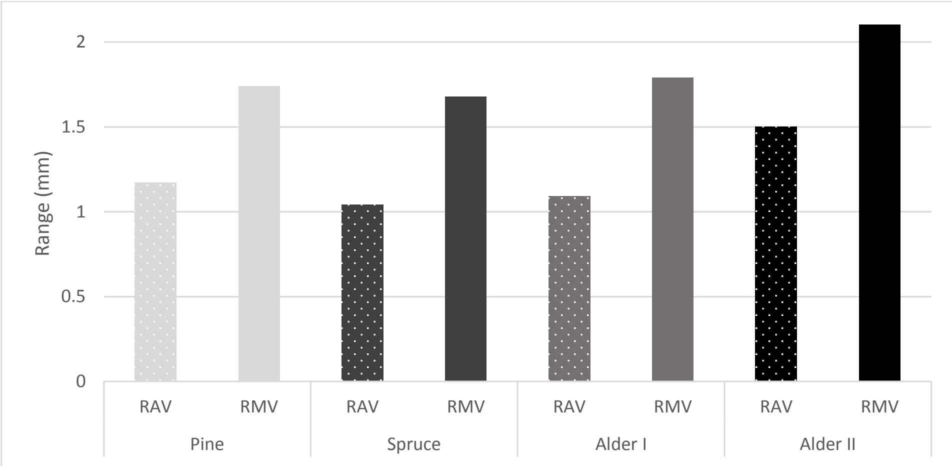

Fig 1. Range with no division on middle and top logs in pine, spruce and alder wood

RANGE WITH DIVISION on Middle logs and top LOGS

In coniferous species both RAV and RMV in the middle logs were slightly higher than in the top logs. But in alder logs divergent results were obtained for two types of tested logs, as well as for wood from various locations (tab. 1).

Table 1. Range values for pine, spruce and alder wood with 95 percent confidence limits

Logs	Pine		Spruce		Alder I		Alder II	
	RAV (mm) ± 0.69	RMV (mm) ± 0.65	RAV (mm) ± 0.34	RMV (mm) ± 0.60	RAV (mm) ± 0.54	RMV (mm) ± 0.85	RAV (mm) ± 0.54	RMV (mm) ± 0.85
Middle logs	1.65	2.00	1.37	2.52	0.91	1.47	1.77	2.08
Top logs	0.68	1.48	0.71	0.84	1.27	2.12	1.23	2.15

In the pine wood there was an apparent tendency to the formation of bigger range in the middle logs (especially evident in the case of RAV, less for RMV). This trend was not statistically significant ($p = 0.050$ for testing the hypothesis of equality of RAV on the middle and top logs; $p = 0.250$ for the same hypothesis for RMV).

In spruce relationship between ranges were similar as in pine wood and the trend to bigger values of range on the middle logs was even more distinct (fig. 2 and fig 3). The size of RDD in spruce on the middle logs proved to be significantly higher than on the top logs (for RAV: $p = 0.010$ **; for RMV: $p = 0.001$ ***).

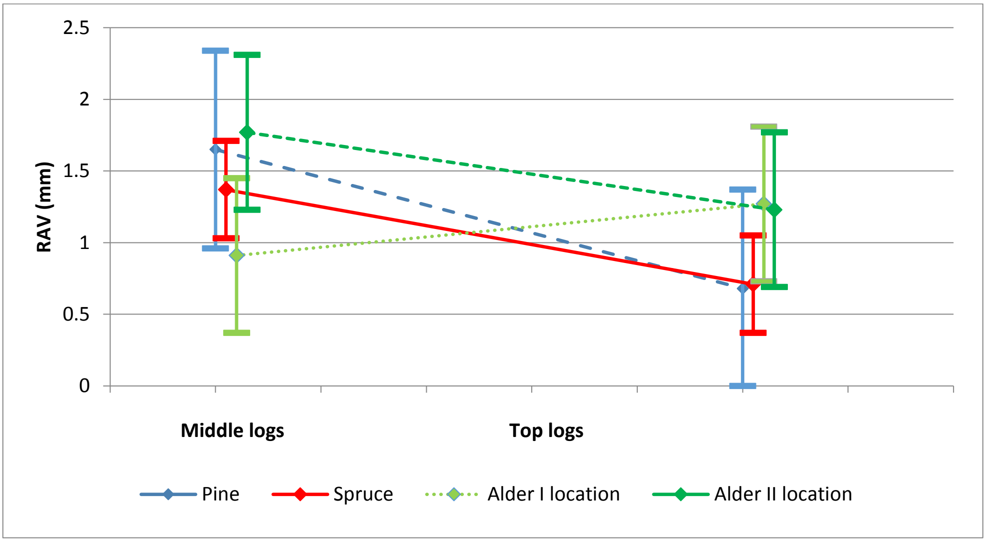

Fig. 2. The range of average values in the division on the middle and top logs for pine, spruce and alder

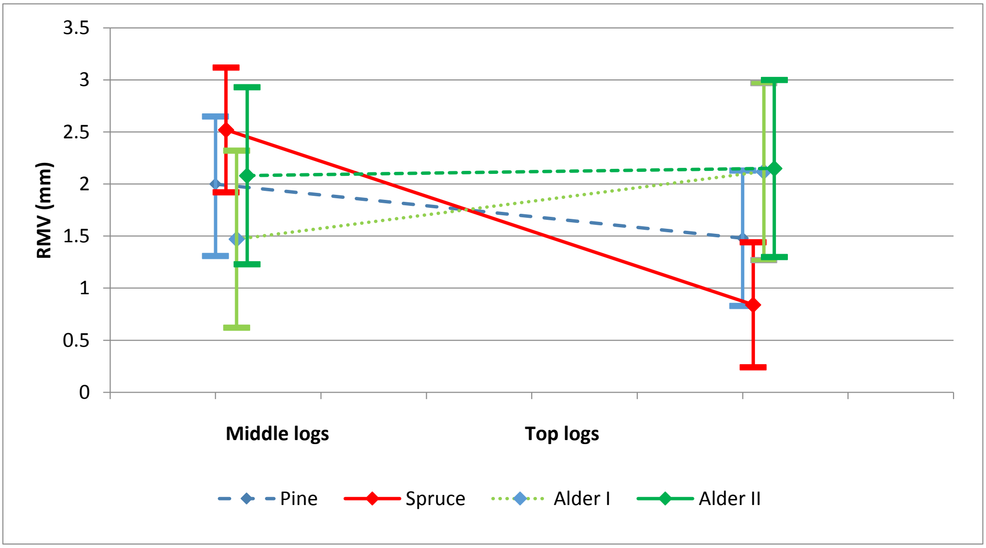

Fig. 3. The range of maximum value in the division on the middle and top logs for pine, spruce and alder

In the case of RDDs in alder wood it was impossible to point clear trends out. Two-way analysis of variance did not reveal significant differences neither in RDDs on the middle and top logs (RAV $p = 0.716$; RMV $p = 0.388$), nor due to alder location (respectively $p = 0.127$ and $p = 0.444$).

Potential cause of range differences between the middle and top logs within a species may be the diameter of processed logs. The larger diameter of the log gives a better distribution of the feed roller spikes on the surface of roundwood. Spikes from the center trace may get more deeply into the wood, while spikes from outer traces get shallower, because the feed roller is circle shaped. Top spruce logs had the smallest diameter (15.7 cm on average, compared with 18 cm for other tested species), so the damage in wood was concentrated in a few rows left centrally by spikes. They were of a similar depth, so the range were smaller. With a decreasing diameter of the logs, the range may decrease. The depth of damage will be more balanced, albeit deeper.

Also a work of harvesting head and its grip of the raw wood may affect the size of range on logs. During processing of middle logs the head holds longer part of a stem with a tree crown. The wood with a grip position may have a deeper damage, than these resulting from the continuous move of timber. These relationships can also occur on the top logs, but their scale may be smaller by a lower weight of the processed raw material.

Range may have a practical meaning and application. The smaller they are for selected species, the more accurately one can specify the wood damage done by feeding rollers with fewer measurements done on the lateral part of a stem. In the case of bigger values of RDD, a number of measurement should be increased to minimize the risk of an inaccurate determination of the damage from spikes. The results, which not confirm the hypothesis of a bigger range in softwood indicate however that the number of measurements of RDD can be the same during a quality control of pine, spruce and alder wood.

CONCLUSIONS

The range in depth of damage without a division on the middle and top logs was at a similar level in tested wood species harvested with Valmet 360.2 head. The range of maximum values were higher than the range of average ones.

The significantly different range in depth of damage was recognized on the middle spruce logs compared to the spruce top logs. In pine and alder wood no similar correlations were found.

Knowledge of the size of range of damage depth can facilitate the wood quality control in terms of damage by the harvester head spikes. For pine, spruce and alder wood the same number of the range of in depth of damage measurements may be adopted.

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Streszczenie: *Rozstęp w głębokości uszkodzeń drewna spowodowanych walcami podającymi głowicy Valmet 360.2.* Uszkodzenia drewna spowodowane kolcami walców podających głowicy harwestera występują w obwodowej części drewna okrągłego. Różnicę pomiędzy najpłytszym i najgłębszym uszkodzeniem nazwano rozstępem uszkodzenia. Analizowano wałki sosnowe, świerkowe oraz olszowe pozyskane ze środkowych i wierzchołkowych części pnia przez harwester Valmet z głowicą 360.2. Rozstępy wyliczono dla wartości średnich oraz maksymalnych dla każdego wałka. Postanowiono sprawdzić, czy uszkodzenia w drewnie różnych gatunków mieszczą się w podobnych zakresach różnic między wartościami minimalnymi a maksymalnymi. Przyjęto hipotezę, że rozstępy w drewnie iglastym będą większe ze względu na odmienną budowę i gęstość drewna. Celem pracy był pomiar i porównanie rozstępów w drewnie sosny, świerka i olszy. Średnie wartości rozstępów bez podziału na wałki kształtowały się na zbliżonym poziomie od 1,04 mm (świerk) do 1,50 mm (olsza) dla wszystkich zbadanych gatunków. Wartości maksymalne były odpowiednio wyższe i mieściły się w zakresie od 1,68 mm (świerk) to 2,11 mm (olsza). W gatunkach iglastych rozstęp uszkodzeń, zarówno średnich, jak i maksymalnych, w wałkach środkowych był większy. Znajomość wielkości rozstępów głębokości uszkodzeń może ułatwiać kontrolę jakości surowca w aspekcie uszkodzeń drewna przez kolce głowicy harwestera. Dla drewna sosny, świerka i olszy można przyjąć tę samą liczbę pomiarów głębokości uszkodzeń.

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