Efficiency of Sanding Belts for Beech and Oak Sanding

Alena Očkajová,[a] Martin Kučerka,[a] Luboš Krišťák,[b] Ivan Ružiak,[b] and Milan Gaff [c]

The effects of wear on the performance of sanding belts were determined for European beech (*Fagus sylvatica* L.) and English oak (*Quercus robur*). These measurements are presented as a function of the defined sanding time of 480 min on a manual sanding belt machine. Sanding belt pressure on the piece surface (6600, 10400, 14700, and 18600 Pa), sanding direction (cutting speed vector with reference to wood fibers equal to 0°, 60° and 90°), wood hydrothermal treatment, and sanding belts from various manufacturers were the variables. The sanding belt wear was monitored by means of specific wood removal rate ($g/cm^2.min$) in 20-min intervals by the means of reference samples with size of 50 x 50 x 50 mm, which were sanded for 1 min. The resulting curves for the sanding belts, as well as the statistical models of the wood removal rate, decreased as a function of the sanding time, described by the function $y = a + b.e^{-ct}$. This work also describes the impact of wood species, optimum pressure, and grinding time on the characteristics to abrasion.

INTRODUCTION

Sanding is a time-demanding and expensive operation (Taylor *et al.* 1999). Research in this field is important to determine the processed piece quality, sanding belt performance, and electricity consumption (Pahlitzsch 1970; Stewart 1976; Matsumoto and Murase 1999; Saloni *et al.* 2005, 2011). Research into the labor environment quality and worker safety is also necessary; when sanding dust particles do not sediment or sediment very slowly, they create high dust levels that have adverse health effects on employees (Rogozinski *et al.* 2015; Mračková *et al.* 2016). Finally, at certain concentrations, sanding dust may become explosive when mixed with air (Mračková *et al.* 2016). Sanding is the most essential process operation for wood products before surface finishing. During wood processing, sanding is carried out with the purpose of pre-grinding, calibration, paint adhesion increase, fine grinding, and smoothing.

Abrasive machining is an important investment because the sanding belt per-unit price is high, and the abrasive belt lifetime is short. Saloni *et al.* (2010) estimated that a typical wide belt sanding abrasive machine costs $75 per h of processing, which is substantially more than knife machining. Any solution increasing the sanding belt lifetime would benefit the wood industry by saving electricity, creating more sustainable sanding belts, and reducing the time needed for the sanding belts replacement.

The sanding belt performance is quantified by the material removal rate, which is defined as a removal per time unit (specific, per-min, overall). A greater material removal

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rate and sanding time represent greater performance. The substrate material, abrasive material, abrasive grit size, spread type, sanding belt shape (belt, cylinder, or disk), softening, adjustment, and storage are factors influencing the wood removal rate. Aside from these basic features, the sanding performance is also affected by the sanded material type (various wood species and materials), sanding direction (which influences the resulting chip shape with rounded edges or very articulate chips forming clusters (Očkajová *et al.* 2010)), and the sanding pressure and speed. Varying these factors for specific sanding tasks should result in a higher quality of the resulting product, lower electricity consumption, and the maximum possible durability and lifetime of the sanding belt (Očkajová *et al.* 2014).

The abrasive grit size proportionally affects the wood removal rate (Pahlitzsch and Dziobek 1959; Pahlitzsch and Meyer 1968; Gurau 2004) when comparing the soft wood species with hard ones (or the wood species with lower density) at any abrasive grit size (Pahlitzsch 1970; Taylor *et al.* 1999), sanding pressure on the processed piece at constant conditions (Pahlitzsch and Dziobek 1959; Pahlitzsch and Meyer 1968; Kato and Fukui 1976a,b; Stewart 1978; Matsumoto and Murase 1999; Taylor *et al.* 1999; Saloni *et al.* 2005), and sanding speed (Pahlitzsch and Dziobek 1959; Pahlitzsch and Meyer 1968; Saloni *et al.* 2005). On the other hand, a chip generated at low feed speeds develops low centrifugal force, filling the inter-chip space and choking the individual abrasive grit tips, thus reducing the removal rate (Ljubimov 1974). A longer sanding time is associated with a lower removal rate, which results in sanding belt wear. In general, wear can be described as gradual and small changes in geometry of machining tools or abrasive grit, which cause the reduction of its ability to cut effectively (Kminiak *et al*. 2015).

According to Saloni *et al.* (2005), the main factors affecting the wood removal rate are the wood species, sanding pressure, abrasive material type, abrasive grit size, and feed speed. If a high removal rate is set regardless of other outcomes, favorable results can be achieved by high pressure, high sanding speed, and the use of aluminum oxide. Porankiewicz *et al.* (2010) emphasized that for the optimum performance of the sanding belt, the various sanding parameters in function of the wood species should be considered. Tian and Li (2014) worked on a standard for the sanding belt lifetime assessment. Although they did not confirm proportionality between the sanding performance and surface quality as a function of the sanded material, sanding direction, and sanding belt abrasive grit size, the sanding belt was replaced whenever the removal rate dropped to certain value to achieve better product quality and better economic value. Also, the sanding belt loading substantially affected its performance. Ratnasingam *et al.* (1999; 2002) indicated that the higher material removal rate unavoidably increases the temperature, which may result in greater belt load and reduction of its lifetime by its eventual breakage. Saloni *et al.* (2011) considers the sanding belt load and the belt lifetime as the critical variables of sanding, suggesting a sanding belt check system including optical (loading), temperature (safety), and acoustic emission (belt life) sensors. These measures extend the lifetime and reduce sanding costs by reducing the setting times, consumption of materials for the sanding belts cleaning, providing longer belt lifetime, and increasing material removal rate (Saloni *et al*. 2011). The optical sensor signal measures the belt loading level and sends the information to the control system to determine the action required (cleaning). The acoustic sensor monitors the belt condition in terms of wear and warns the user when the belt should be replaced.

If the material removal rate is decreasing with time, then sanding belt mechanical wear is taking place. The dulling occurs due to the breaking of abrasive grit with unfit

orientation. Their rounding off and gradual choking of inter-chip space with the deformed chip particles give place to direct contact and friction between the material placed among the abrasive grit and the surface to be processed. In this case, the tool is losing its cutting ability and ceases to grind the material.

Even if the sanding belt cannot be re-sharpened in the same way as tools with standard wedge geometry, it also can exhibit a certain capability of self-sharpening, that occurs after whole abrasive grit or particles are broken from the binder. After the binder crumbles, new abrasive grit begins to work; the tool contact area is regenerated continually. However, the chip may be released from the space between the individual abrasive grit particles due to significant centrifugal force from the high cutting speed (Mračková *et. al.* 2016).

In the case of a tool that cannot be re-sharpened, the durability and lifetime are identical. The sanding belt wear can be expressed by a wear curve, which shows the reduction of material removal rate *vs.* sanding time. The curve has three typical phases (Pahlitzsch 1970). In the first phase of initial sharpness, the wear curve has a digressively decreasing tendency. Here, sanding grit particles are rupturing and breaking off. Dulling increases the number of effective cutting wedges. In the second phase of working sharpness, the line is decreasing proportionally. In this zone, the sanding belt decreases in aggressivity, but the sanding process remains stable. In the third phase, dulling, the curve has a strongly progressive tendency for decrease. Dulling takes place due to more intensive rounding off of the abrasive grit tips and choking of these tips with accumulated ground chips.

Popov (1965) expresses the sanding belt durability as the total length able to participate in sanding S (m) until the sanding belt is dulled, when the maximum removal rate Z' *vs.* feed speed ratio achieves 50% of the initial value. According to Pahlitzsch (1952), the durability is given by the grinding time T (min) until the removal rate Z' is less than 0.05 g.cm^{-2}.min^{-1}.

EXPERIMENTAL

Materials
Wood samples

European beech (*Fagus sylvatica* L.) and English oak (*Quercus robur*) were chosen as the test materials. Both woods are important to the furniture industry due to their excellent physical and mechanical properties. Because beech is a key species for bent furniture fabrication, treated beech wood was also tested in the sanding experiments.

Radial samples with dimensions of $50 \times 50 \times 50$ mm were made in a manner giving the angle between the cutting speed vector direction and the fibers orientation the angles of 0°, 60°, and 90°. The samples were conditioned at 20 °C and 65% relative humidity to a moisture content of 12%. Part of the beech timber underwent hydrothermal adjustment in the Bučina Zvolen factory. The steaming took place in 3 traditional cycles as applied for the fabrication of bent balks. Samples from this timber were formed in a manner identical to those from natural wood. Density was calculated according to ISO 13061-2 (2014) and was as follows: natural beech, 0.686 g.cm^{-3}; beech with hydrothermal treatment, 0.684 g.cm^{-3}; and oak, 0.672 g.cm^{-3}.

Table 1. Properties of used Endless Sanding Belt

Parameters	UNION-VIS sanding belt ABRATEX BTX-22-3	Klingspor sanding belt LS 309 XH
sanding belt dimensions	100 x 610 mm	100 x 610 mm
abrasive grit size	80	80
abrasive material	synthetic corundum (aluminum oxide)	synthetic corundum (aluminum oxide)
binder	synthetic resin	synthetic resin
substrate material	heavy cotton fabric	cotton fabric with PETF coating on the rear side
spread	dense	dense

The sanding belt properties are listed in Table 1. Prior to testing, the sanding belts were conditioned at 20 °C and 65% relative humidity. For the 24 h before the experiment, the belts were stored in the room where the experiments took place.

Based on this analysis, sanding belt wear was evaluated within the time range from 0 to 480 min (1 working shift) by the means of the wear curves.

Two wood species, beech and oak, were sanded using a Bosch hand sanding belt machine GBS 100AE in function in Table 2.

Table 2. Treatment and Measuring Parameters

Sanding belt	Parameters	Oak	Beech
LS 309 XH	pressure	10400 Pa and 14700 Pa and 18600Pa	6600 Pa; 10400 Pa and 14700 Pa
	Sending direction	60°	60°
LS 309 XH	pressure	10400 Pa	10400 Pa
	Sending direction	0°, 60° and 90°	0°, 60° and 90°
LS 309 XH (hydrothermal modification)	pressure	14700 Pa	-
	Sending direction	60°	-
ABRATEX BTX-22-3	pressure	14700 Pa	14700 Pa
	Sending direction	60°	60°

Test Equipment

The experiments utilized equipment designed for monitoring of contact phenomena (Porankiewicz *et al.* 2010), which was based on a Bosch GBS 100 AE manual sanding belt machine (Robert Bosch GmbH, Gerlingen, Germany). The exhaustion was carried out by Rowenta exhauster into single-use paper bags. The experimental conditions included a feed speed of 7.8 m.s^{-1} and specific pressure between the processed piece and the sanding belt of 6600, 10400, 14700, or 18600 Pa.

Methods

To measure the sanding belt performance for 480 min, beech and oak reference samples were prepared with approximately the same number of annual rings on the transverse section and approximately the same mass, and with no apparent defects, *i.e.*, knots. The check measurements of the sanding belt performance were carried out at 20-min intervals, using three reference samples that were sanded for 1 min each. A Radwag WPS 510/C/2 digital lab scale with an accuracy class of 0.001 g (Jakarta, Indonesia) was used to determine the sample mass before and after sanding. The obtained values were

converted to specific removal rate (g.cm^{-2}.min^{-1}). As one triplet of samples was not sufficient for all check measurements during 480 min, various triplets were made. These values were the basis for determining sanding belt wear. Between the reference samples, the remaining samples were sanded for 20 min, such that identical samples were prepared for all experiment variables. The whole cycle was repeated 3 times for each variant.

RESULTS AND DISCUSSION

A non-linear regression was used to process the results obtained for sanding belt wear at the individual sanding variants. To compute the regression function, a modified method of minimum squares was used,

$$y = a + b.e^{-ct} \tag{1}$$

where *y* is the wood removal rate, *a* + *b* is the initial removal rate, *a* is the limitary removal rate, *b* is the removal rate drop from initial to limit lower value, |*c*| is the removal rate drop speed from initial to limit lower value, and *t* is the sanding time (min). The experiment outcomes are the statistical models and wear curves for the sanding belts for the selected sanding variants.

The sanding belt pressure (Klingspor's LS 309 XH) on the sanded piece (beech, oak) was optimized as a function of the sanding time of 480 min and sanding direction under a 60° angle to the wood fibers. After short-term preliminary tests, the possible pressures selected for beech wood species were 10400, 14700, and 18600 Pa. For oak wood species, the selected pressures were 6600, 10400, and 14700 Pa (Table 3).

**Table 3.** Statistical Models for Individual Pressures

Parameter	Pressure (Pa)					
	6600	**10400**		**14700**		**18600**
	oak	**oak**	**beech**	**oak**	**beech**	**beech**
a (g.cm^{-2}.m^{-1})	0.022	0.025	0.259	0.206	0.334	0.310
b [g.cm^{-2}.m^{-1}]	0.213	0.402	0.147	0.276	0.158	0.204
c (min^{-1})	65.56 x 10^{-3}	8.895 x 10^{-3}	9.304 x 10^{-3}	16.35 x 10^{-3}	5.068 x 10^{-3}	3.568 x 10^{-3}
t (min)	240	460	480	80	480	420

A significantly limit lower value of the removal rate based on "*a*" values was observed for oak compared with beech.

The |*c*| value gives the removal rate drop until stabilization takes place. The first phase of sanding is deemed undesirable, as during its course, the sanding parameters are changing dramatically. It takes a certain amount of time to stabilize the process and enter into the second phase: that of working sharpness, which should be as long as possible, as far as the sanding tool durability (lifetime) is concerned. Based on the statistical models and |*c*| values, the duration of first phase was approximately the same for the beech, and the curve was entering gradually in the second phase. For the oak, these values were in higher orders, which entailed a shorter first phase (pressure of 6600 Pa and 14700 Pa). It was assumed that these conditions were selected more advantageously; however, this result

was not in conformity with the great removal rate drop during the transition from the first to the second phase, to as little as 0.022 g.cm^{-2}.min^{-1} (after 40 min, pressure 6600 Pa) or 0.206 g.cm^{-2}.min^{-1}(14700 Pa) after 80 min and the sanding belt breaking. For the beech sanding, the limit lower value never dropped below 50% of the original removal rate value.

The statistical models were complementary to the diagrams in Fig. 1, which show the removal rate drop *vs.* time for all monitored pressures for beech and oak. Higher removal rates were achieved for beech at the highest selected pressure (18600 Pa); however, the wear curve for the selected sanding time (480 min) was plotted for the pressures of 10400 Pa and 14700 Pa. The wear curve for the sanding belt at the pressure of 18600 Pa was plotted for the interval from 0 to 420 min. The difference in removal rate values was significant in the case of combination of 10400 Pa and 14700 Pa as well as for the combination of 10400 Pa and 18600 Pa. The difference in removal rate values for the combination of 14700 Pa and 18600 Pa was not significant.
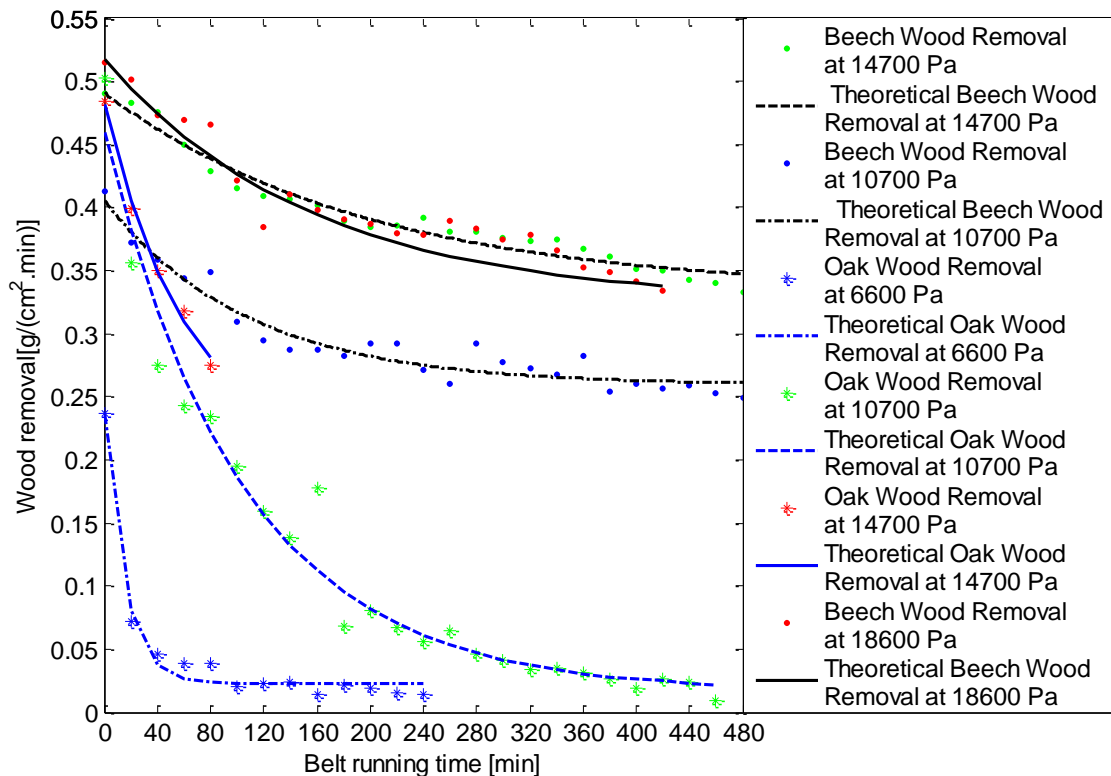
Fig. 1. The influence of interface pressure on wood removal rate with a sanding belt running time of 480 min and sanding direction 60°

The highest removal rate values for the oak were achieved at the highest selected pressure (14700 Pa); however, the wear curve of the sanding belt was plotted in the interval from 0 to 80 min only. For the pressure of 10400 Pa, the wear curve was plotted in the interval from 0 to 460 min, and for the pressure of 6600 Pa in the interval from 0 to 240 min.

Interestingly, although the differences for the values of two neighboring pressures, for both beech and oak, were very similar (3800, 4300, and 3900 Pa), the removal rates for the lowest selected pressure for both beech and oak were significantly different from the removal rates at the higher selected pressures. This result indicates the need for correct selection of the pressure for each wood species and supports the conclusion that there is no

consistent and predictable relationship between MRR (material removal rate) and pressure (Saloni *et al.* 2005).

Every experimentally obtained curve was modeled by Eq. 1. Star curves represent experimentally obtained results for oak wood samples, whereas circle curves represent experimentally obtained results for beech wood samples. Solid lines correspond to model results at the highest pressure (oak at 14700 Pa and beech at 18600 Pa). Dot and dash lines correspond to model results at the lowest pressure (oak at 6600 Pa and beech at 10400 Pa), and dash lines correspond to model results at the pressure oak at 10400 Pa and beech at 14700 Pa.

In addition to the sanding time, a high-quality sanding belt is characterized by the amount of removed material. Based on the obtained values for beech sanding, the optimal pressure of the sanding belt on the processed piece surface was 14700 Pa, and for oak, it was 10400 Pa. This is in agreement with the results of Porankiewic *et al.* (2010), who emphasized that for the optimum performance of the sanding belt, the various sanding parameters as a function of the wood species should be considered.

The pressures of 14700 Pa and 6600 Pa for the oak were deemed inappropriate as far as the sanding time is concerned as well as from the point of view of the removal rate value. This is due to the fact that at the beginning of the first phase, quick choking of the spaces between the sanding grit particles by the outcoming chip and the rounding off of the sanding grit particles tips took place, and no typical self-sharpening of the sanding belt occurred (rupture of the broken abrasive grits, eventually the splitting of the existing abrasive grits). Simultaneously, the results obtained for the oak sanding confirmed the conclusions of Ratnasingam *et al.* (1999, 2002), who indicated that the increased material removal rate inevitably resulted in a temperature increase. This might load the sanding belt and reduce its lifetime, consequently breaking it. In this experiment, this occurred after 80 min at the pressure of 14700 Pa, and eventually after 240 min at 6600 Pa. Despite the wear curve for oak at pressure of 1.04 N.cm^{-2} having been plotted for 460 min, it was only after 240 min that the minimum removal rate was equal to 0.025 g.cm^{-2}.min^{-1} and the subsequent sanding belt breaking was observed.

The experiments demonstrated that the sanding belt lifetime during oak sanding was very low, not only as far as the sanding time was concerned, but also as far as the removal rate was concerned. These results indicate the need for an improved grinding process; for example, by the use of different sanding belt types, with open or semi-closed spreading. However, the fundamental solution of sanding belts performance and overall lifetime is the design of the checks system for the sanding belts during their operation, including their cleaning (Saloni *et al.* 2011).

**Table 4.** Comparison of Sanding Belts Performance

LS 309 XH and ABRATEX BTX-22-3	for the beech sanding at the pressure of 14700 Pa	sanding angle of 60°	time of 480 min
LS 309 XH	modified beech sanding at the pressure of 14700 Pa	hydrothermal treatment) modified beech sanding at the pressure of 14700 Pa	time of 480 min

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Table 5. Statistical Models for Individual Variants

Parameter	Variants		
	LS 309 XH	**LS 309 XH**	**ABRATEX BTX-22-3**
	beech (**treated**)	beech (**natural**)	beech (**natural**)
a (g.cm^{-2}.m^{-1})	0.340	0.334	0.221
b [g.cm^{-2}.m^{-1}]	0.171	0.158	0.164
c (min^{-1})	6.195×10^{-3}	5.068×10^{-3}	7.791×10^{-3}
t (min)	480	480	480

The results are provided in form of statistical models in Table 4 and wear curves of the sanding belt in Fig. 2.

The statistical models show that during the sanding of both natural and hydrothermally treated beech, very similar values of the individual parameters were achieved, with a greater difference in values (mainly for the removal rate limit lower value "a") at the beech sanding with sanding belts ABRATEX BTX-22-3. The |c| value of the removal rate until its stabilization remained approximately equal for each of the three variants.
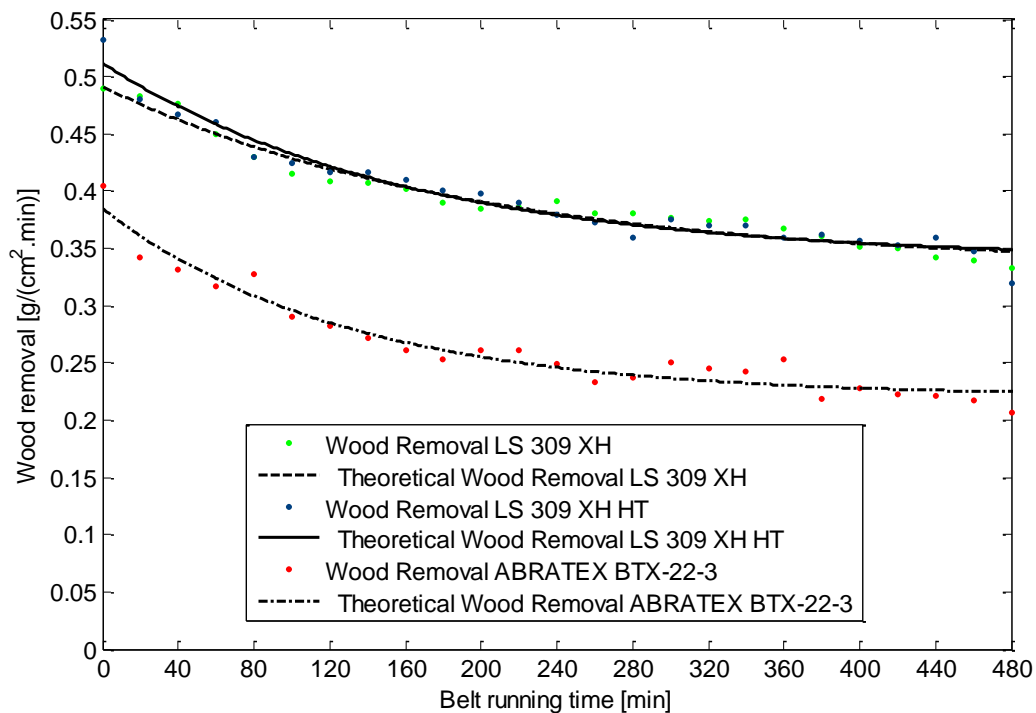
Fig. 2. The influence of variants (natural and hydrothermally treated beech, 2 kinds of belts) on wood removal rate – sanding belt running time 480 min, interface pressure 14700 Pa, sanding direction 60°

Figure 2 presents the results for sanding belts LS 309 XH, ABRATEX BTX-22-3, and HT. Experimentally obtained results were parametrically fitted by model (1). The green curve represents the wood removal for sanding belt LS 309 XH, and the dashed line represents the modeled one.

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The blue curve represents the wood removal for sanding belt LS 309 XH for HT, and the solid line represents the modeled one. The red curve represents the wood removal for sanding belt ABRATEX BTX-22-3, and the dot and dash line represents the modeled one.

The diagrams in Fig. 2 show the removal rate drop as a function of time for each monitored variant. The highest removal rate values were achieved for the sanding of hydrothermally modified beech wood; however, these corresponded closely with the removal rate values of the natural beech wood sanding as early as the second phase, where the curves were already identical. Based on results of numerous studies (Hlásková *et al.* 2015; Dzurenda *et al.* 2010), a greater difference is expected between the removal rates of hydrothermally treated wood and natural beech wood. The former becomes more fragile, with altered physical properties; the analyzed chip, sawdust and/or particles of the resulting dust are smaller than in the case of the same processing methods on natural wood. Up to a certain degree, this was also confirmed in the first phase of the wear curve. After the sanding process stabilization (working sharpness phase), the difference in removal rate values was minimal.

While comparing the performance of 2 types of sanding belts (different producers) with very similar initial parameters, the wear curve was plotted for the entire monitored interval of 480 min. However, the removal rate values for ABRATEX BTX-22-3 achieved only 65% of those for LS 309 XH, with conditions remaining the same.

The performance of sanding belts LS 309 XH for both beech and oak sanding in function of the individual sanding angles (0°, 60° and 90°) for the sanding belt selected pressure 10400 Pa and sanding time of 480 min. A pressure of 10400 Pa was selected to allow the wear curve comparison in function of the sanding angle for both beech and oak. The results are provided in in Table 6 and Fig. 3.

Based on statistical models, great differences between the "*a*" removal rate values for beech and oak can be observed. These (mainly in case of sanding alongside the fibers), as well as |*c*| values, were greater for beech. Thus, the duration of the first phase for beech was shorter, and the sanding process was stabilized earlier, while passing into the second phase (working sharpness). For oak, the duration of the first phase was longer for each sanding angle than for the beech; the transition to the second phase was gradual but with great drop in removal rate. For any of the three sanding directions, the limit lower value of the removal rate dropped under 50% of the initial value.

Table 6. Statistical Models for Individual Sanding Angles

Parameter	Sanding direction					
	0°		60°		90°	
	oak	beech	oak	beech	oak	beech
a (g.cm^{-2}.m^{-1})	0	0.203	0.025	0.259	0.101	0.341
b [g.cm^{-2}.m^{-1}]	0.304	0.128	0.402	0.147	0.351	0.192
c (min^{-1})	3.57 x 10^{-3}	23.52 x 10^{-3}	8.90 x 10^{-3}	9.30 x 10^{-3}	13.40 x 10^{-3}	40.14 x 10^{-3}
t (min)	480	320	460	480	380	460
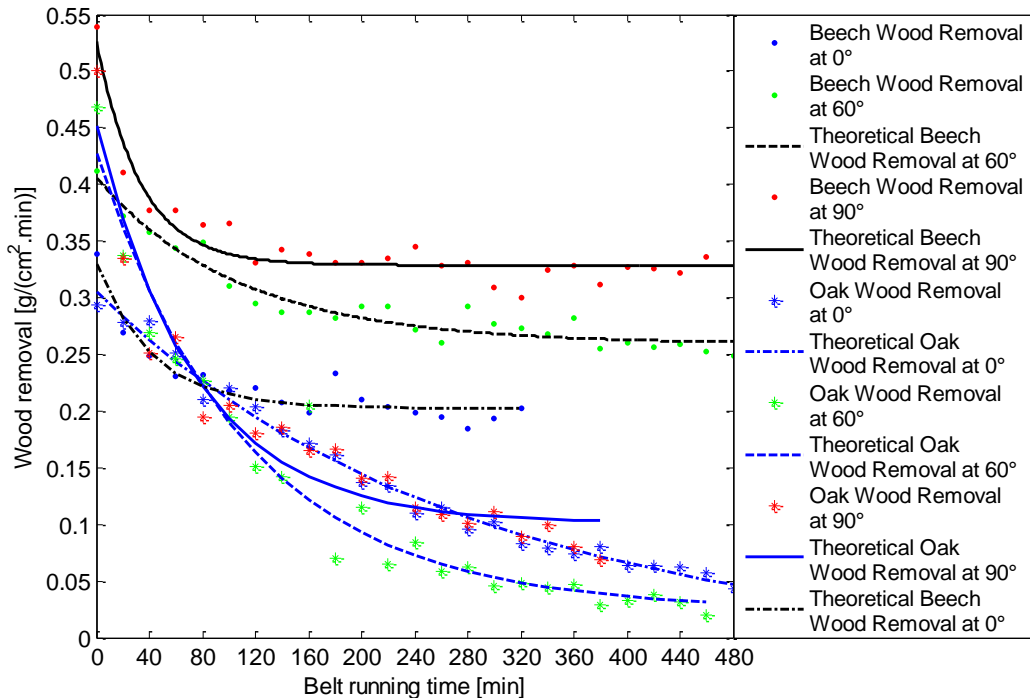
Fig. 3. The influence of sanding direction on wood removal rate with a sanding belt running time of 480 min and interface pressure of 10400 Pa

Every experimentally obtained curve was modeled by Eq. 1. Star curves represent experimentally obtained results for oak, whereas circle curves represent experimentally obtained results for beech wood. Solid lines correspond to model results at sanding direction 90°; dash lines correspond to model results at sanding direction of 60°. Dotted and dashed lines correspond to model results at sanding direction of 0°.

For both wood species, the removal rate decreased with time. The highest removal rate values were achieved for a sanding angle of 90°, while the lowest values were achieved for sanding angles of 0°. The beech removal rate values were higher than oak in all sanding directions. A wear curve throughout the entire monitored interval was plotted for beech and sanding angle of 60°. For 90°, it was plotted within the interval from 0 to 460 min; for 0°, it was plotted only from 0 to 320 min.

A wear curve throughout the entire monitored interval was plotted for oak and sanding angle of 0°; for 60°, it was plotted within the interval from 0 to 460 min. For 90°, it was plotted from 0 to 380 min, but only with very low limit lower values of removal rate.

These results showed that the sanding direction (even despite the sanding belts oscillation) had a great impact on the removal rate value. This effect was caused by the wood structure, as most of the cellular elements are configured longitudinally in the wood, and the chip-generating process varies for the given sanding models. A lesser degree of cellular element cutting takes place during longitudinal sanding. These elements are bound mostly by hydrogen bonds; the chip splits easier in strips, in the slip direction, having greater size but also filling the inter-chip space at a faster rate. For perpendicular cutting, the sanding grit particles overcome the stronger covalent bonds inside the cell walls. The resulting chip is smaller because it has low bending strength; the filling of the inter-chip space may become less intense.

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Different resulting wear of the sanding belts in the course of the beech and oak sanding are caused mainly by the microscopic structure of the wood, as well as by different physical and mechanical properties of these wood species. Beech is a dispersed-pore wood species with uniform structure in the spring and summer rings. Oak is a ring porous wood species with significant density differences between spring and summer rings; the hard summer wood forestalls the penetration of the sanding grit particles into the spring wood. Oak also has a relatively high fraction of extractive substances, which also affects the sanding. The extractive content ranges from 1.5 to 6.1%, depending on whether the sample is from the sapwood or the heartwood (Laurová *et al.* 2007).

The cellular elements with the highest proportion in the wood influence the wood properties in the highest degree. The wood pores are thin-walled cells. Their content in beech wood have a volume between 22 and 37%. The libriform fibers are thick-walled cells. Their content in the beech wood is under average, *i.e.*, from 37 to 44%. This also likely causes the beech to be an easy-to-sand wood species (Požgaj *et al.* 1997).

The analysis confirmed the importance of the sanding direction on the sanding belt wear. Thus, not only the wood species (Pahlitzsch, 1970), but also its anisotropic properties play a very significant role in the interaction with the tool.

CONCLUSIONS

1. Experimental measurements of beech (natural and hydrothermally treated) and oak sanding consisted of the sanding belt wear curves obtained by a gradual drop of the removal rate value in time for the selected sanding angles 0°, 60°, 90°, and pressures (6600 Pa; 10400 Pa and 14700 Pa – for oak, 10400 Pa; 14700 Pa and 18600 Pa – for beech). Statistical models of the removal rate drop in time were created for each of the investigated variants.

2. As far as the typical wear curve for the sanding belts is concerned, in no case was the third phase, that of dulling (when the curve tends to drop sharply) achieved, since the belt use was terminated in the second phase, that of working sharpness, after either the sanding time of 480 min elapsed (the belt was viable for further use) or the belt was broken before the selected time.

3. The optimum pressure of the sanding belt on the piece surface was not equal. For beech, the belt did not break and was fit for further use; for oak, the belt was broken.

4. The sanding direction, with other constant conditions (pressure), significantly affected the removal rate values.

5. The wood species had a significant impact on the sanding belt wear (for both removal rate and sanding time).

6. There was a great difference in the performance of the 2 types of sanding belts with identical input parameters.

7. Beech is an easy-to-sand wood species (at the properly selected pressure), and the sanding belt lifetime with simultaneous preserving of high removal rates is sufficiently long (1 working shift). In contrast, oak is a hard-to-sand wood species, and the sanding belt lifetime was, in certain variants, 480 min, with minimum removal rates (sanding process performance).

ACKNOWLEDGMENTS

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