"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

GERMANY

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2011
Brasov, 26-28 May 2011

EXPERIMENTAL RESEARCH CONCERNING THE POWER CONSUMTION DURING THE SANDING PROCESS OF BIRCH WOOD

Adriana FOTIN*, Ivan CISMARU, Mátyás MARTHY***, Luminița BRENCI****, Camelia COȘEREANU*******

*Faculty of Wood Engineering, Transylvania University of Brasov, Brasov, Romania, ** Faculty of Wood Engineering, Transylvania University of Brasov, Brasov, Romania, *** Faculty of Wood Engineering, Transylvania University of Brasov, Brasov, Romania, **** Faculty of Wood Engineering, Transylvania University of Brasov, Brasov, Romania, ***** Faculty of Wood Engineering, Transylvania University of Brasov, Brasov, Romania

Abstract: *The paper presents the results of some experimental research studies concerning the power consumption during the sanding process of birch wood with grit sizes of 60, 80, 100 and 120 respecting three processing directions (parallel, perpendicular and at 45º angle to the wood structure orientation). The industrial experiments were performed at NIKMOB Company from Nehoiu, on the wide belt sander machine using an electronic device and a data acquisition logger in order to record the power consumption. The factorial experiment with two variables (feed speed and cutting depth) was used. All data were processed with Delphi and DataFit software using the nonlinear regression. The analysis upon the power consumption during the sanding process with respect to the three processing directions, confirmed its increase with the increase of feed speed and cutting depth, respectively.*

Keywords: *birch, sanding, feed speed, cutting depth, power consumption*

1. INTRODUCTION

The technological process of sanding has the purpose to flatten all the previous processing irregularities and to confer a suitable surface quality for the finishing operations. Sanding is the last one out of the cutting operations applied to wooden surfaces.

Most of researchers performed during time various studies upon the sanding process.

The importance of the sanding schedule parameters was intensively analysed by the specialists from the wood processing department. It was established that the grit size has a decisive role within the sanding process upon the surface quality, as well as the fact that the technological factors (speeds, pressures, oscillations) do not present critical influence upon quality [7] and they are to be selected depending on the expected productivity, the generalization of wide belt sanders [1,11] and the cutting schedule personalized for each wood species being recommended.

After Carrano [2] and Saloni [8] the increse of material removal rate as well as power consumption with the increase of sanding pressure were confirmed. Even if the wood industry is not the highest power consumer, it is considered an important consumer and out of all the processing processes, sanding seems to consume the most. Within this research area Saloni [9] is representative, its studies indicating that the power consumed during sanding increases with the belt speed and feed speed while the cutting depth presents a lower influence. Generally, the higher the grit size is, the higher the power is, recording different values when processing parallel and perpendicular to the grain direction [5,10] showed that the wood species has the lowest influence upon the power consumption, but the pressing force, the cutting direction to the fibres and the sanding speed had an overwhelming influence upon the cutting power and force implicitely.

The paper objective consists on the analysis of power consumed during the sanding process of birch wood, on the wide belt sander machine, using grit sizes of 60, 80, 100 and 180, on three processing directions (parallel, perpendicular and at 45º angle to the wood structure orientation) based on a factorial experiment with two variables (feed speed and cutting depth). The obtained results are processed with the help of Delphi and DataFit software through the method of nonlinear regression.

2. MATERIAL AND METHOD

Samples made of birch wood (*Betula pendula*) rarely used within the wood processing department from our country were used for the experiments.

The samples dimensions were 300 x 95 x 16 mm and their moisture content of about 8%. Pieces were processed by sanding at NICKMOB Company from Nehoiu, on the SANDING MASTER wide belt sander endowed with two working heads (Fig. 1). The second head with pressure bar used for the finishing process of solid wood surfaces was selected for processing.

Fig. 1. SANDING MASTER wide belt sander

The sanding machine is endowed with pneumatic oscillation system and belt self-cleaning system. The sander technical characteristics (pressure bar unit) are presented within Table 1.

Table 1. Main technical characteristics of the SANDING MASTER wide belt sander (pressure bar unit)

No	Characteristic	UM	Value
1	Working width	mm	1100
2	Abrasive belt dimensions	mm	1900x1130
3	Sanding speed (against the feed direction)	m/s	16
4	Power of main motor	kW	15
5	Power of conveyor motor	kW	2,2
6	Feed speed	m/min	4-20

The schedule parameters used for sanding are presented in Table 2.

Table 2. Processing parameters during sanding

Schedule parameters	Values
Sanding speed, m/s	v = 16
Pressure, bar	p = 4,5
Feed speed, m/min	u = 4; 8; 12; 16; 20
Cutting depth, mm	h = 0.1; 0.2; 0.3; 0.4; 0.5

The factorial experiment [6] with two variables (feed speed and cutting depth) was used. 16 sets, each one of 13 samples, for the three processing directions (parallel, perpendicular and at 45º angle to the wood structure orientation) were prepared. All samples were codified, weighted before and after each sanding process and wetted on half of their surfaces before sanding, in order to subsequently analyses the wetting influence upon the roughness of sanded surfaces (Fig. 2 a). In order to respect the processing direction when feeding the sander (parallel, perpendicular and at 45º angle to the wood structure orientation), special devices made of fir wood (Fig.2 b şi c) were used.

16 sanding programs obtained from the combination of 5 grit sizes (80, 100, 120, 150 and 180) were used, the samples being firstly calibrated with the grit size of 60 on the same sanding machine. Out of these programs, that ones comprising the grit sizes of 60, 80, 100 and 120 were selected for the present study and they are presented in Table 3. All abrasive papers used for sanding are made of corundum granules and they are produced by HERMES Company.


a


b


c

Fig.2 Codification of samples (a) and devices used for sanding birch wood with respect to the three processing directions (b and c)(3)

Table 3. Codification of sanding programs using 60, 80, 100 and 120 grit sizes

Sanding program	Grit sizes
P 3	60 + 80 + 100
P 4	60 + 80 + 120
P 7	60 + 100
P 8	60 + 100 + 120
P 11	60 + 120

In order to record the power consumed during sanding and feeding (at millisecond) an electronic device and an acquisition board were used (Fig. 3). PICOLOG program allows to display data as tables and charts as presented in Fig. 4.

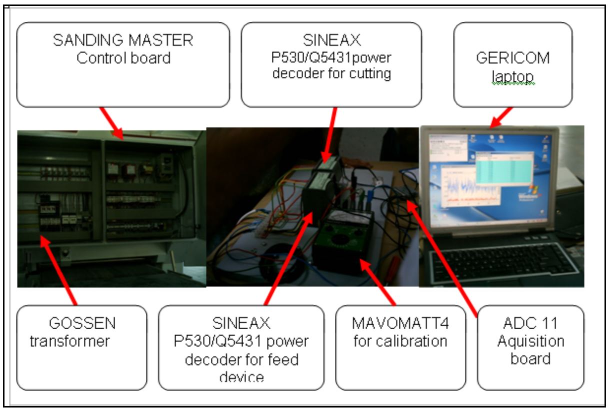


Fig. 3. SANDING MASTER and the record device for power [3,4]

The effective sanding power was calculated as difference between the power recorded during sanding and the power during idle running, determined for each one of the samples. Data were processed with Delphi through the regression method, using a nonlinear model expressed by the following function $Y=a+bx_1+cx_2+dx_1x_2+ex_1^2+fx_2^2$ and DataFit was selected in order to verify the model which had a coefficient of determination (R2) of about 0.87-0.91, indicating the correct regression function.

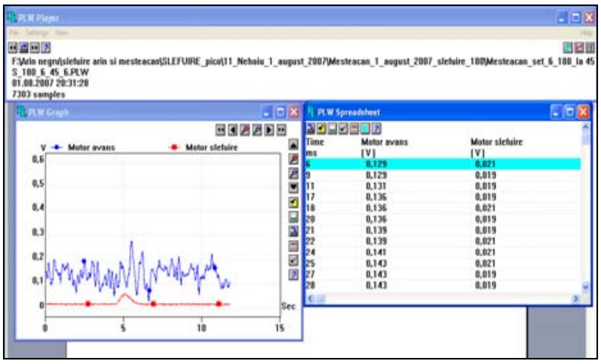


Fig.4 PICOLOG display (recorders presented as table and chart)

3. RESULTS AND DISCUSSIONS

Influence of processing program (feed speed and depth of cut) to power consumption was graphically represented for each one of the sanding programs on the three processing directions (parallel - a, perpendicular - b and at 45° angle to the wood structure orientation - c) (Fig.5, Fig.6).

3.1.Processing sets 3 and 7

The two sets ends their sanding at 100 grit, for the 7 set, directly after calibration with 60 grit size and the 3 set, after an intermediate sanding prior 80 grit before final sanding with 100 grit. The study showed the increase of the power consumption simultaneous with the increase of the feed speed at the same depth of cut, but increasing the depth of cutting at the same feed speed for all three directions of processing [3].

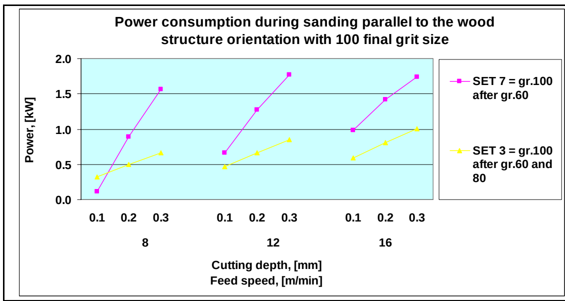
When the sanding process is performed at 45° angle to the wood structure orientation is found a parabolic increase of the power consumption, increased feed speed deeper in the set 7 (60, 100) than the set 3 (60, 80, 100) and also a linear increase with the same slope, with the increase of the depth cutting for the set 7 (60, 100) and a slower variation for the set 3 (60, 80, 100), which also produces the lowest power consumption (0.098 kW) at feed speed 8 m/min and 0.1 mm depth of cut. At constant feed speed, the cutting power to both sets grows relatively linear with the increase of the depth cutting.

At the parallel processing of the same sets, a increase of the power cutting was observed simultaneous with the feed speed and the depth of cut for all the regimes used, greater on the 7 set (60, 100) than for the 3 set (60, 80, 100). The minimum value of cutting power (0.111 kW) on the parallel processing was reported for the set 7 (60, 100) advance at a speed of 8 m/min and 0.1 mm depth of cut.

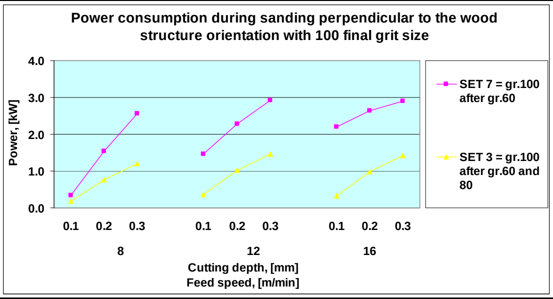
When the sanding process was performed perpendicular to the wood structure orientation a increase of the power cutting was observed simultaneous with the feed speed and the depth of cut, for both sets the minimum value of power (0.188 kW) is indicated for the set 3 (60, 80, 100) to speed advance of 8 m/min and 0.1 mm depth of cut.

3.2.Processing sets 4, 8 and 11

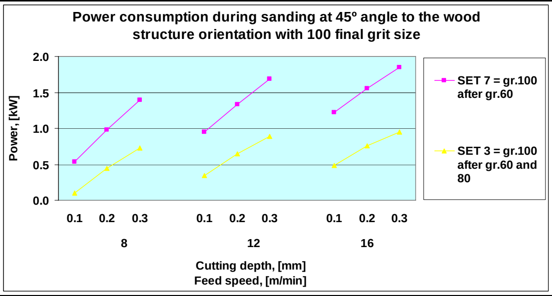
These three sets have been sanded with the final grit size 120, but differs from previous sanding grit size, respectively for the 4 set, sanding with the final grit size 120 is achieved after 60 and 80 grit sizes, for the 8 set, is made after 60 and 100 grit sizes, and for the 11 set, the final sanding with 120 grit size is achieved after 60 grit size.



a - parallel to the wood structure orientation



b - perpendicular to the wood structure orientation

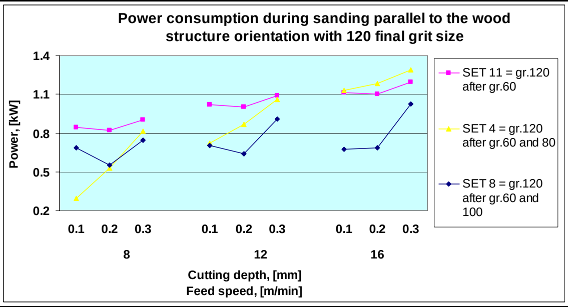


c - at 45° angle to the wood structure orientation

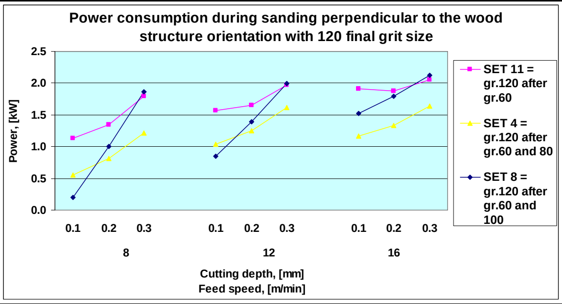
Fig. 5. Variation of power consumption during sanding the birch wood using the sanding program no. 3 with 60, 80 and 100 grit sizes compared with program no. 7 with 60 and 100, depending on the feed speed and cutting depth

When the sanding process was performed at 45° angle to the wood structure orientation, it's observe a increase of the cutting power, once with the increase of the feed speed and of the depth cutting for all three sets under study, the minimum value of the power cutting were achieved for the 8 set (60, 100, 120), having the value 0.479 kW, for the processing regime with 16 m / min of the feed speed and with cutting depth of 0.1 mm.

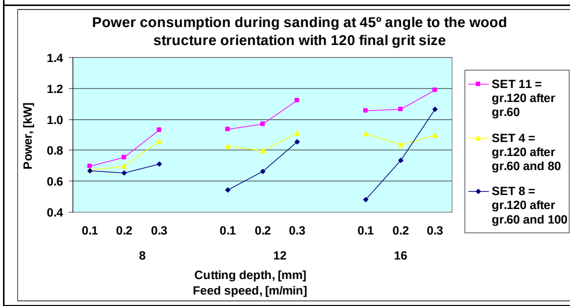
In parallel processing, for the 4 set (60, 80, 120) it's observed a significant increase acceleration of the cutting power, for both the feed speed and cutting depth, and minimum power consumption was also recorded for the 4 set (0.296 kW) at a feed speed of 8 m/min and a depth cut of 0.1 mm.



a - parallel to the wood structure orientation



b - perpendicular to the wood structure orientation



c - at 45° angle to the wood structure orientation

Fig. 6. Variation of power consumption during sanding the birch wood using the sanding program no. 4 with 60, 80 and 120 grit sizes compared with program no. 11 with 60 and 120 and program no. 8 with 60, 100 and 120 grit sizes, depending on the feed speed and cutting depth

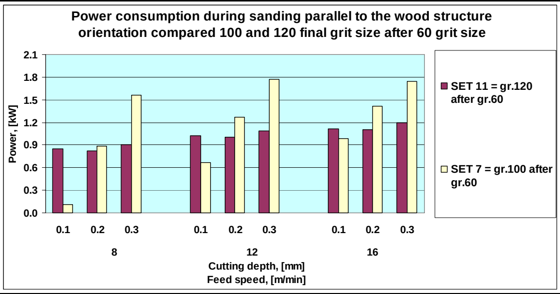
At the perpendicular processing the lowest value of the cutting power (0.199 kW) was reported for the 8 set (60, 100 and 120) sanding at the feed speed of 8 m/min and the depth cutting of 0.1 mm. The trend of increasing power consumption with increasing depth of processing was more intense for set 8, compared with the other sets.

3. CONCLUSIONS & ACKNOWLEDGMENT

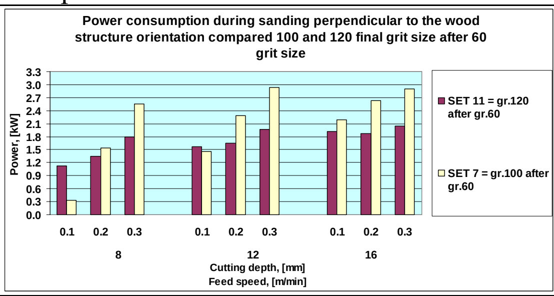
By analyzing the charts in Fig.7 can say that in all cases, the power consumed during the sanding process was higher in grit sanding with 100 grit size after 60, while Fig.8 shows that the highest power consumption was recorded for grit by sanding with 120 grit size after 60 and 80 grit sizes.

Regarding the cutting power to the processing of the sets 3 and 4, was recorded where they made three successive sanding the first two identical, it is noted that in most cases, the sanding with 120 grit size generated higher values of the cutting power than sanding with 100 grit size.

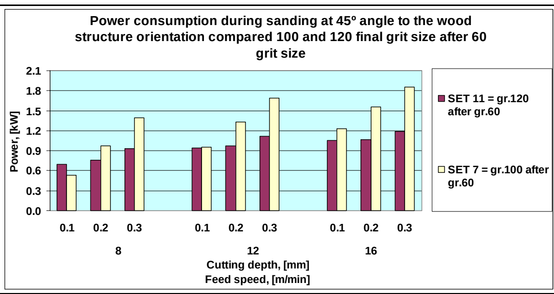
The analysis shows that this table is preferred, regardless the direction of the processing, feed speed of 8 m / min and 0.1 mm depth of cut, emphasizing that the regime has generated to the processing power sanded minimum the sanding programs and sets studied.



a - parallel to the wood structure orientation

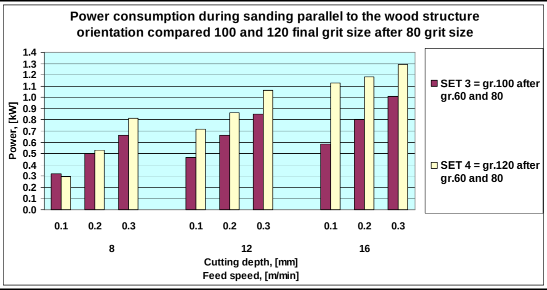


b - perpendicular to the wood structure orientation

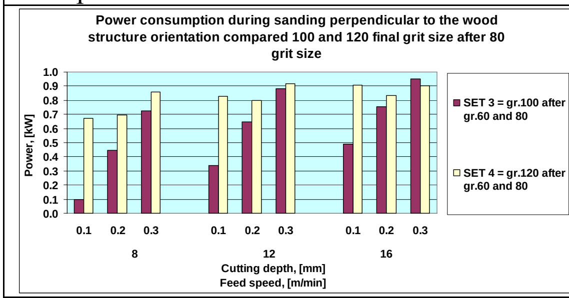


c - at 45^o angle to the wood structure orientation

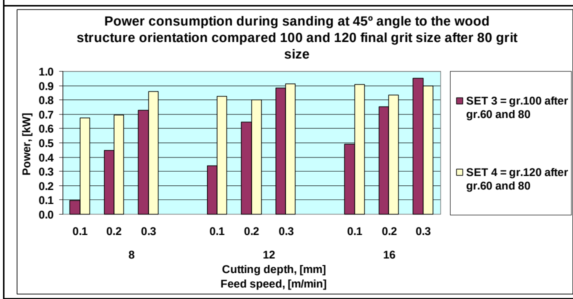
Fig. 7. Variation of power consumption during sanding the birch wood when compared the sanding programs no.7 (60, 100 grit sizes) with 11 (60, 120 grit sizes) depending on the feed speed and cutting depth, with respect to the three processing directions (a, b, c)



a - parallel to the wood structure orientation



b - perpendicular to the wood structure orientation



c - at 45^o angle to the wood structure orientation

Fig. 8. Variation of power consumption during sanding the birch wood when compared the sanding programs programs no.3 (60, 80, 100 grit sizes) with 4 (60, 80, 120 grit sizes), depending on the feed speed and cutting depth, with respect to the three processing directions (a, b, c)

As a result of these dependences, it is obvious that the highest power consumption was achieved when processing perpendicular to the grain, for all the three grit sizes used.

Table 4. Table synthesis of choice sets the minimum power criterion

The compared sets after the final grit size		Processing direction according to the wood structure		
		at 45 angle	parallel	perpendicular
Programs 3 and 7 (100) - **3** at the final grit size 100 after 60 and 80 grit sizes - **7** at the final grit size 100 after 60 grit size	Set	**3**	**7**	**3**
	P, **kW**	**0,098**	**0,111**	**0,239**
	u, m/min	8	8	8
	h,mm	0,1	0,1	0,1
Programs 4, 8, 11 (120) - **4** at the final grit size 120 after 60 and 80 grit sizes - **8** at the final grit size 120 after 60 and 100 grit sizes - **11** at the final grit size 120 after 60 grit size	Set	**8**	**4**	**8**
	P, **kW**	**0,479**	**0,296**	**0,199**
	u, m/min	16	8	8
	h,mm	0,1	0,1	0,1

This type of sanding is not recommended in production, because under the same working conditions, the specific productivity represents 30-100% of the sanding process performed parallel to the grain, besides the disadvantage that most of wooden fibres are flattened and the power consumption is very high, but in some situations it can not be avoided.

Therefore it is economic to use the sanding program no.3 (60, 80, 100), than to apply directly the sanding program no.7 (60 and 100), when processing birch wood both parallel and at 45° angle to the wood structure orientation.

Similarly, the sanding program no. 8 (60, 100, 120 grit sizes) was selected to produce lower power consumption during sanding birch wood perpendicular and at 45° angle to the wood structure orientation.

For the parallel sanding processing to the wood structure orientation, was selected to produce lower power consumption the sanding program no.4 (60, 80, 120 grit sizes)

The optimum regime choosing will be done after the quality evaluating of machined surfaces correlating the power consumption with the quality of surfaces

The results of the present study can contribute to the promotion of birch wood, rarely used in our country, but with a real potential for the wood industry in Romania.

REFERENCES

1. BEGANU, N: *Contribuţii privind optimizarea structurilor tehnologice ale maşinilor de şlefuit cu bandă lată*. Teză de doctorat, Universitatea Transilvania din Braşov, (2001).
2. CARRANO, A:. *Quantification of the effect of process parameters and their interaction with respect to material removal rate and surface roughness for a wood sanding process in the furniture making industry*. MS thesis, Industrial Engineering Department North Carolina State University, (1997).

3. FOTIN, A. *Contribuții la optimizarea prelucrării prin frezare şi şlefuire a lemnului de mesteacăn în vederea utilizării în producția de mobilă şi alte produse din lemn. (Contributions to the optimization by milling and sanding of birch wood with a view to its utilization in furniture manufacturing and other wooden products*) Teza de doctorat, Universitatea Transilvania din Braşov (2009a).
4. FOTIN**, A.,** SALCĂ, E. CISMARU, I., CISMARU, M., *Variation of power consumption during sanding birch wood on wide belt sander***.** International Conference „Wood Science and Engineering in the Third Millennium", Faculty of Wood Industry, Transilvania University of Brasov, June 4 -6, (2009b).
5. JAVOREK, L.; HRIC, J.; VACEK V:. 2006. *The study of chosen parameters during sanding of spruce and beech wood. ProLigno*, Vol 2, Nr 4., (2006)
6. LAURENZI, W:. *Contribuții la modelarea şi optimizarea aşchierii lemnului cu pânze circulare în vederea conducerii procesului de tăiere cu ajutorul calculatorului*. Teza de doctorat, Universitatea Transilvania din Braşov, (2000).
7. PAHLITZSCH, G:. *International state of research in the field of sanding*. *Holz als Roh-und Werstoff*, (1970).
8. SALONI, D:. *Abrasive machining process characterization on material removal rate, final surface and power consumption when wood is used*. MS thesis. Integrated Manufacturing System Engineering, North Carolina State University, (2003).
9. SALONI, D.; LEMASTER, R.; JACKSON, S:. *Abrasive machining process characterization on material removal rate, final surface texture and power consumption for wood*. *Forest Products Journal*, Vol 55 No.12, p.35-41, (2005).
10. SAMOLEJ, A.; BARCIK, S: *Influence of specific pressure on cutting power and wood removal by disc sander*. *Drvna Industrija* 57 (1) 5-11, (2006).
11. ȚĂRAN, N:. *Maşini –unelte şi utilaje moderne pentru şlefuirea suprafețelor lemnoase*. Editura LUX LIBRIS Braşov, (2000). ISBN 973 – 9458 – 03 - 3.