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Research on Power Consumption for Sanding Process with Abrasive Brushes to Solid Spruce and MDF Panels

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Abstract

The objective of the experimental research presented in this paper was to analyze the relationship between the cutting power and the roughness parameters characterizing the Spruce wood and MDF panel, brush sanded with two grit sizes, namely P180 and P220. Sets of samples were analyzed for each sanding conditions. The variables of the processing parameters were considered to be the feed speed and the rotation speed. The power consumption was measured using a power monitor device. The roughness was measured on a stylus based detector. The assessment of the quality of the sanded surfaces and the optimum energy was carried out by comparing these parameters, depending on the applied processing parameters.

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Nomenclature

n	revolution speed
u	feed speed (similarly with f)
Rk	parameter that assesses the processing roughness
Rpk	parameter that assesses the raised fibres of wood
Hci	height of initial contact
Mv	revolution electromotor
Mu	feed electromotor
h	wood height
AlO	Aluminium Oxide
SiC	Silicon Carbide
P	power

1. Introduction

In industrial environment the intensive energy consumption has drawn attention due to its adverse impact and the exhaustion of natural resources [1]. In addition, recently rising costs for energy and natural resources imprint responsibility for large amount of manufacturing companies all over the world. Therefore from economic and environmental perspectives, is required an improvement of energy efficient manufacturing.

Machining processes, applied in many manufacturing companies, are considered to be the most of energy consumption. Thus reducing the energy usability of machine tools can effectively help companies to accomplish green production [2].

Besides by sanding wooden articles with wide belts severe problems have been observed when trying to create a particularly smooth surface. It is well known that sanded wooden pieces show a significant number of loose fibers, these fibers are typically 10-50 μm in length and they are the cause for the following problem: these fibers are essentially loose when the surface is coated with lacquer. They tend to lift up and cause protrusions in the lacquer layer, especially if this is thin enough so that either a thicker layer of lacquer is needed or an additional sanding operation [9].

Quality of surfaces is the target for the wood furniture producers [6], as a consequence the brush sanding is becoming a necessity to improve the obtained sanded surfaces and for achieving less consumption of coating materials and better finishing results. This paper presents an approach which incorporates both the energy consumption and required surface quality for brush sanding processes.

The conducted research was made on the Spruce wood and MDF panel. Wooden samples were sanded with abrasive brushes using different feed speeds and revolving speeds, using grit sizes of P150, P180 and P220 of two different abrasive types Silicon Carbide and Aluminium Oxide, at the same time were taken data's of the power consumption of the experimental stand, measurements were taken by a data acquisition board. Further were investigated the roughness using Mitutoyo Surftest SJ-201 equipment, using a stylus detector. The results conducted to low energy consumption and high quality surfaces obtained by brush sanding in comparison with the wide belts, the power consumption being 90% lower and roughness parameters being 10 times smaller.

2. Objectives

The main objective of this paper is to investigate the effects of different cutting parameters (Cutting Speed, feed rate, abrasive type, processed material) on surface roughness and Power Consumption. The assessment of the quality of the sanded surfaces and the optimum energy was carried out by comparing these parameters, depending on the applied processing parameters.

3. Method, materials and equipment

The material used within the present research consisted of radial timber specimens of Spruce (Picea abies L.), and the MDF panel. The moisture content of the specimens after drying, determined by means of an Pin-Free moisture meter was 10-12% for Spruce wood and 9 to 11% for MDF panel.

Moisture content of wood at the time of processing is one of the most important factors affecting surface roughness of the MDF panels. Previous studies showed that surface roughness increase with increasing moisture content. For this reason, it stated that the most appropriate moisture content should be around 6 % [5].

Initially all the solid wood samples were sanded with wide belt at a speed of the belt 18m/s, while the feed speed was 4.5 m/min, done in several passes with an abrasive paper grit P80+P120+P150. One third of the parts were then put apart while the other samples were sanded in a single pass with an abrasive paper grit of P180. Out of these, the samples were placed apart hereinafter, while the remaining samples were sanded with abrasive paper grit P220.

For the MDF panel was used different procedure because all the surface faces come from the factory sanded to P150 grit.

Each wooden board was trimmed into parts of approximately equal sizes (Length x Width x Thickness: 185 x 50 x 18 mm), so a total of 240 samples was obtained.

The samples which were sanded with wide belt of grit size P150 were further sanded with abrasive brush of the grit P150, the other samples sanded with wide belt of grit P180 were sanded with brush of the grit of P180 and the ones sanded with wide belt of grit P220 were sanded with brush of grit P220.

- 80 samples sanded with brush sanding of P150, the Spruce wood initially sanded with wide belt of grit size P80+120+150, the MDF surfaces are provided from factory sanded with grit size of P150
- 80 samples sanded with brush sanding of P180, initially sanded with wide belt of grit size P80+120+150+180, MDF panel was sanded only with P180
- 80 samples sanded with brush sanding of P220, initially sanded with wide belt of grit size P80+120+150+220, MDF panel was sanded only with P180 and P220

The sanding with brushes was performed on an experimental stand composed from a belt conveyor table driven by an electric motor developing a feed speed between 3 and 6 m/min, and the cutting tool attached to an electric motor positioned on an height adjustable stand, the sanding brush having a rotation speed between 450 and 700 rpm.
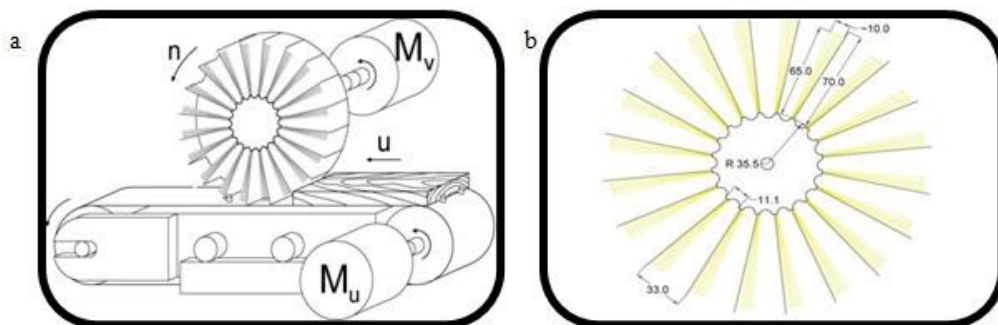

Fig. 1. (a)Experimental stand, (b) Dimensions of the sanding brush.

The main technical characteristics of the Experimental stand with brush sanding machine are as follows:

- Abrasive type: Aluminum Oxide and Silicon Carbide
- Abrasive grits: P150, P180, P220
- Brush size: Radius x width = 105.5 x 49 mm
- Lamellae length x width: 70 x 7 mm

- Sanding height: Hci (Height of initial contact) = 18 mm
- Sanding speed: n = 450 – 700 rpm
- Feed speed: u = 3 and 6m/min

According to the recommendation of the author [4] the brush sanding was done in two steps, first sanding against the direction of wood grain and second sanding with the grain direction, that method is applied to assure a cleaner cut, by first sanding against the grain direction the majority of microfibers will be cut, raised up or bended, and by sanding in the direction of grain all the raised/bended microfibers will be removed.

3.1. Energy characteristics

The energy model describes the amount of energy required to remove a unit of material under different process conditions. In general, the layout of the block scheme for measuring the energy consumption is composed as shown in the Fig. 2.

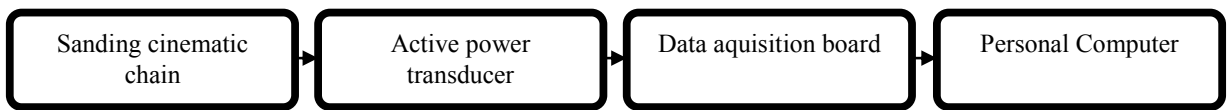| Sanding cinematic chain | → | Active power transducer | → | Data aquisition board | → | Personal Computer |

Fig. 2. Block layout of experimental stand.

In order to develop the energy model for the experimental stand, power measurements were performed under various cutting parameter settings. The measured data was acquired with the data acquisition board Velleman K8047 connected to the PC and visualized through the software PClab 2000SE.

4. Results and discussions

Table 1 shows the results of Average Effectively Energy Consumption (AEEC) for Spruce and MDF under varying cutting parameters.

Table 1.Power consumption values of sanding brushes for Spruce.

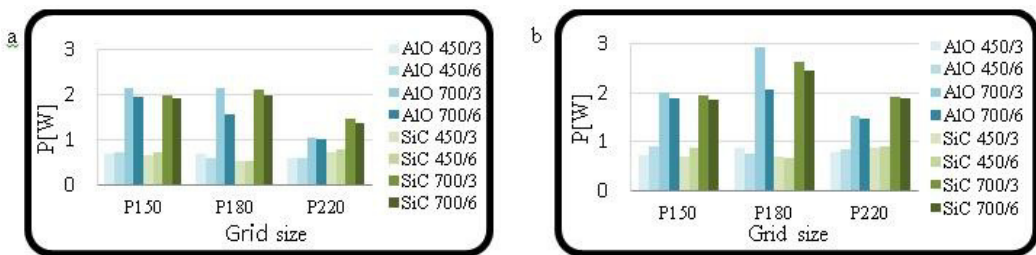| Grid size	Aluminum Oxide – P[W]				Silicon Carbide – P[W]			
n[rpm]	450		700		450		700	
u[m/min]	3	6	3	6	3	6	3	6
P150	0.6808	0.7314	2.1482	1.9596	0.6486	0.7176	1.9734	1.9044
P180	0.6854	0.598	2.1344	1.5778	0.5474	0.5428	2.1206	1.978
P220	0.6026	0.598	1.0442	1.0212	0.7314	0.7774	1.4628	1.3708

Fig. 3. Power consumption of the brush sanding for: (a) Spruce; (b) MDF.

Table 2. Power consumption values of sanding brushes for MDF.

Grid size	Aluminum Oxide – P[W]				Silicon Carbide – P[W]			
n[rpm]	450		700		450		700	
u[m/min]	3	6	3	6	3	6	3	6
P150	0.7268	0.9154	2.0102	1.8814	0.7038	0.8878	1.9412	1.8676
P180	0.8648	0.7636	2.9394	2.07	0.6854	0.667	2.6404	2.4472
P220	0.7866	0.8602	1.518	1.472	0.8878	0.8924	1.9274	1.8814

4.1. Influence of Roughness

The roughness of the 240 surfaces was investigated using Mitutoyo Surftest SJ-201 equipment with stylus detector, which scans the analysed samples. The working parameters of the equipment were as follows:

- scan speed: 0.5 mm/s
- the measured length: 12.5 mm
- cut – off: 2.5mm
- number of data in a sampling length: 1666
- resolution: 3µm
- standard: ISO 1997
- filter: PC50
- profile: R

The roughness profile was obtained after filtering the data with a Gaussian filter, automatically applied by the software of the measuring device. The roughness parameters analysed in this paper are Rk - Core roughness depth (parameter that assesses the processing roughness) and Rpk - mean height of the peaks protruding from the roughness core profile[11], (parameter that assesses the raised fibers of wood) according to SR EN ISO 13565-2:1999, as recommended by the [3],[10].

After eliminating the aberrant errors and arranging in increasing order, the roughness values obtained for the 120 surfaces look as shown in Tables 3 and 4.

By observing the value series, it can be noticed that there is no correlation between the Rk roughness and the Rpk roughness, respectively between the processing-specific roughness and the one which characterizes the raised fibres. This can be easily noticed on the graphic representation of the two similar series (obtained by sanding with the same grit or grit sequence), as shown in Fig.5.

Table 3. Roughness values of Rk and Rpk parameter for grid size P220 for Spruce.

Sample	Aluminium Oxide – Rk/Rpk[µm]								Silicon Carbide – Rk/Rpk[µm]							
n[rpm]	450				700				450				700			
u[m/min]	3		6		3		6		3		6		3		6	
1.	8,70	2,53	8,59	3,30	9,58	2,42	9,18	2,44	8,03	3,12	8,03	1,70	9,22	2,08	9,04	1,91
2.	8,74	2,54	8,65	3,32	9,71	2,51	9,31	2,49	8,04	3,14	8,03	1,84	9,37	2,10	9,04	1,93
3.	8,92	2,61	8,69	3,37	9,73	2,51	9,31	2,51	8,11	3,14	8,18	1,84	9,45	2,15	9,08	1,98
4.	9,18	2,63	8,71	3,38	9,81	2,55	9,39	2,54	8,16	3,17	8,26	2,02	9,49	2,17	9,11	2,03
5.	9,18	2,74	8,83	3,43	9,99	2,58	9,43	2,54	8,23	3,24	8,33	2,04	9,55	2,19	9,13	2,03
6.	9,26	2,77	8,95	3,45	10,03	2,59	9,70	2,55	8,36	3,25	8,37	2,13	9,56	2,20	9,25	2,07
7.	9,46	2,84	9,01	3,47	10,11	2,63	9,74	2,59	8,36	3,27	8,44	2,17	9,60	2,21	9,26	2,07
8.	9,55	2,90	9,06	3,48	10,17	2,63	9,76	2,63	8,37	3,29	8,56	2,18	9,90	2,23	9,27	2,21
9.	9,56	2,90	9,24	3,48	10,18	2,68	9,78	2,70	8,37	3,30	8,58	2,25	9,94	2,24	9,34	2,34
10.	9,65	2,94	9,37	3,49	10,18	2,72	9,86	2,75	8,43	3,33	8,58	2,29	9,95	2,28	9,37	2,40
11.	9,65	2,95	9,42	3,50	10,19	2,73	9,88	2,77	8,52	3,33	8,59	2,33	10,04	2,30	9,40	2,43
12.	9,76	2,97	9,51	3,52	10,30	2,75	9,91	2,78	8,55	3,39	8,68	2,43	10,16	2,39	9,42	2,44
13.	9,77	3,10	9,61	3,54	10,31	2,76	9,93	2,81	8,63	3,45	8,76	2,51	10,20	2,40	9,42	2,46
14.	9,88	3,17	9,65	3,58	10,34	2,77	9,94	2,81	8,68	3,46	8,79	2,58	10,21	2,43	9,48	2,46
15.	10,04	3,28	9,73	3,59	10,35	2,77	10,00	2,83	8,71	3,50	8,98	2,59	10,23	2,43	9,54	2,54

| 16. | 10,11 | 3,35 | 9,73 | 3,74 | 10,43 | 2,78 | 10,05 | 2,88 | 8,79 | 3,61 | 9,06 | 2,66 | 10,24 | 2,43 | 9,59 | 2,57 |
17.	10,75	3,35	9,76	3,76	10,57	2,80	10,10	2,88	8,80	3,66	9,08	2,67	10,40	2,48	9,63	2,63
18.	10,92	3,37	9,81	3,83	10,60	2,88	10,11	2,97	8,87	3,68	9,19	2,84	10,40	2,56	9,69	2,64
19.	11,01	3,39	9,89	3,85	10,67	2,90	10,13	2,98	8,90	3,68	9,25	3,05	10,44	2,60	9,71	2,73
20.	11,02	3,44	9,94	3,88	10,70	2,97	10,16	3,16	8,99	3,68	9,27	3,07	10,44	2,63	9,78	2,76
Average values	9,76	2,99	9,31	3,55	10,20	2,7	9,78	2,73	8,50	3,38	8,65	2,36	9,94	2,32	9,38	2,33
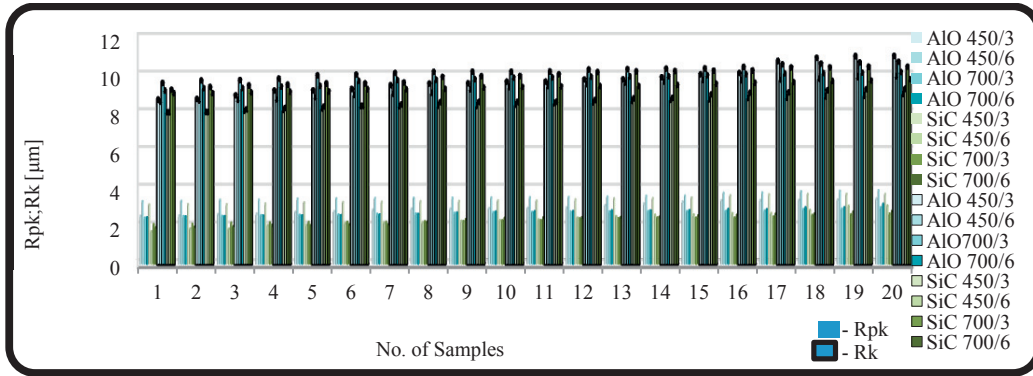
Fig. 4. Roughness values of Rk and Rpk parameter for grid size P220 for Spruce.

By brush sanding with grit size P150 the roughness parameter Rpk is varying between 2.5 to 7.7μm. The best results were obtained by revolution speed of 700 rpm and feed speed of 6 m/min using Aluminium Oxide where the average value of Rpk is 2.99 μm. For sanding with abrasive grit of P180 the Rpk values are obtained between 2.5 and 5.2 μm. In this case the average was of 2.88 μm, with the best sanding regime being obtained by revolution speed of 450 rpm and feed speed of 6 m/min using Aluminium Oxide for the Spruce species. For grit size P220 were obtained average values of Rpk with the lowest being 2.32 μm and highest of 3.38 μm, the lowest result was obtained by sanding with Silicon Carbide using a revolution speed of 700 rpm and feed speed of 6 m/min.

The roughness parameter Rk for the grit sizes P150 and P180 were between 10.5 and 25.5 μm, respectively 9.6 and 21.5 μm. For brush sanding with grit size P150 the revolution speed of 450 rpm and feed speed of 6 m/min the average was of 11.75μm, using Silicon Carbide. In case of brush sanding with grit size of P180 with the same sanding regime the average value of Rk was of 10.9 μm. For the grit size P220 the Rk average values are between 8.5 and 10.2 μm.

Table 4. Roughness values of Rk and Rpk parameter for grid size P220 for MDF.

Sample	Aluminium Oxide – Rk/Rpk[μm]								Silicon Carbide – Rk/Rpk[μm]							
n[rpm]	450				700				450				700			
u[m/min]	3		6		3		6		3		6		3		6	
1.	8,16	2,11	7,5	1,91	10	1,79	9,04	1,52	5,58	1,52	7,31	1,43	6,64	1,22	7,05	1,56
2.	8,17	2,13	7,74	1,91	10,44	1,81	9,12	1,53	5,59	1,64	7,34	1,44	6,7	1,24	7,2	1,57
3.	8,27	2,13	7,78	1,92	10,82	1,97	9,14	1,62	5,6	1,65	7,43	1,45	6,71	1,43	7,24	1,57
4.	8,29	2,14	7,88	1,93	10,89	2,03	9,36	1,7	5,66	1,66	7,59	1,52	6,75	1,51	7,27	1,61
5.	8,51	2,19	7,9	1,93	11,38	2,19	9,41	1,81	5,73	1,67	7,61	1,56	6,8	1,57	7,36	1,61
6.	8,59	2,23	7,91	1,95	11,39	2,21	9,56	1,82	5,74	1,67	7,81	1,68	6,89	1,58	7,4	1,62
7.	8,64	2,24	7,97	1,96	11,48	2,23	9,85	1,84	5,75	1,7	7,87	1,79	6,9	1,64	7,41	1,66
8.	8,67	2,26	7,98	1,97	11,52	2,23	10,34	1,96	5,79	1,73	8,04	1,85	6,93	1,66	7,43	1,66
9.	8,87	2,27	8,11	1,99	11,55	2,4	10,4	2,1	5,8	1,74	8,09	1,86	7,06	1,68	7,52	1,67
10.	9,08	2,28	8,18	2	11,59	2,42	10,41	2,14	5,81	1,75	8,12	1,9	7,08	1,75	7,58	1,71
11.	9,1	2,29	8,31	2,01	11,6	2,77	10,52	2,15	5,84	1,77	8,13	1,91	7,11	1,75	7,65	1,72
12.	9,11	2,3	8,35	2,03	11,82	3,01	10,8	2,25	5,86	1,82	8,2	1,96	7,18	1,8	7,67	1,73
13.	9,13	2,31	8,38	2,03	11,85	3,03	10,8	2,28	5,86	1,85	8,24	2	7,21	1,83	7,78	1,75
14.	9,25	2,32	8,79	2,06	11,92	3,09	10,86	2,32	5,88	1,88	8,24	2,01	7,26	1,85	7,79	1,75
15.	9,32	2,32	8,81	2,07	11,95	3,1	10,92	2,41	5,94	1,9	8,25	2,04	7,29	1,87	7,8	1,76
16.	9,36	2,37	8,87	2,09	12,33	3,17	11,06	2,42	5,99	1,92	8,51	2,05	7,47	1,95	7,91	1,77
17.	9,4	2,37	8,98	2,1	12,55	3,19	11,25	2,53	6	1,93	8,56	2,08	7,5	2,01	7,98	1,81

18.	9,48	2,38	9	2,13	12,61	3,19	11,49	2,68	6,07	1,93	8,7	2,08	7,53	2,06	8	1,84
19.	9,56	2,4	9,07	2,17	12,66	3,2	11,74	2,76	6,14	1,93	8,73	2,21	7,54	2,07	8	1,84
20.	9,68	2,41	9,12	2,18	12,77	3,57	11,8	2,77	6,16	1,93	8,89	2,22	7,59	2,13	8,02	1,86
Average values	8,93	2,27	8,11	1,98	11,66	2,63	10,39	2,13	5,84	1,78	8,08	1,85	7,11	1,73	7,6	1,70
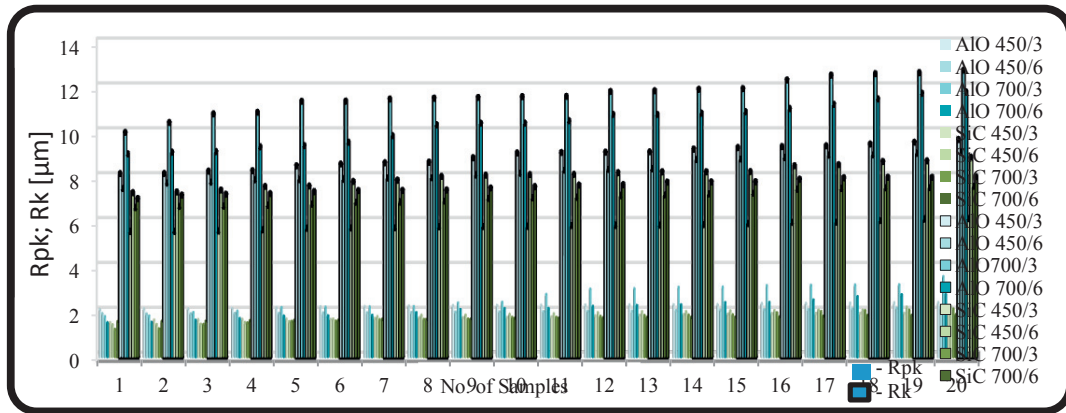
Fig. 5. Roughness values of Rk and Rpk parameter for grid size P220 for MDF.

The roughness parameter Rpk for the MDF is varying between 2.8 and 4.7 μm after sanding with brush of grit size P150. The best value was obtained by revolution speed 450 rpm and feed speed of 6 m/min using Silicon Carbide, the average being of 3.04 μm. The obtained values for the grit size P180 were between 2.1 and 4.1 μm with an average of 2.3 μm, using the same sanding regime as for the grit size P150. For the grit size of P220 were obtained average values between 1.7 and 2.6 μm, the lowest value is obtained by using Silicon Carbide with a rotation speed of 700 rpm and a feed speed of 6 m/min.

The roughness Rk for the grit size P150 and P180 were between 9 and 18.8 μm, respectively 7.5 and 17 μm. The average value for the grit size P150 and revolution speed of 450 rpm and feed speed of 6 m/min was of 10.43 μm using Silicon Carbide. In the case of grit size P180 with the same sanding regime the average value of Rk was of 8.16 μm for MDF. For the grit size of P220 are obtained values between 7.6 and 11.66 μm the lowest value is obtained by using Silicon Carbide with a rotation speed of 700 rpm and a feed speed of 6 m/min.

4.2. Relationship between the power consumption and surface roughness

Table 5. Relationship between Power consumption and Roughness Rpk, parameter values of Spruce wood processed with Aluminium Oxide.

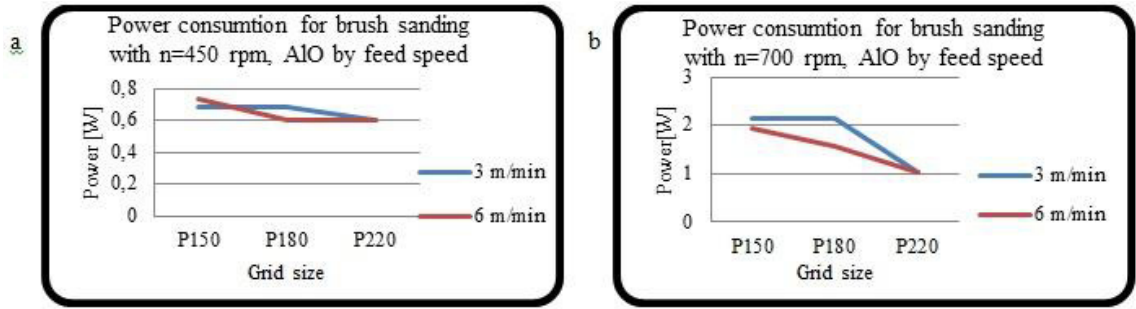| Grid size	Power[W]				Roughness Rpk[um]			
n[rpm]	450		700		450		700	
u[m/min]	3	6	3	6	3	6	3	6
P150	0.6808	0.7314	2.1482	1.9596	3.423	3.399	5.990	2,994
P180	0.6854	0.598	2.1344	1.5778	2.933	2.880	3,696	3,159
P220	0.6026	0.598	1.0442	1.0212	2,989	3.548	2.697	2,731

Fig. 6. Power consumption by feed speed for Spruce for rotation speed of : (a) 450 rpm; (b) 700 rpm.

As it is presented in Fig. 6 in both cases, for an increased feed speed the Power consumption is lower for Spruce species.
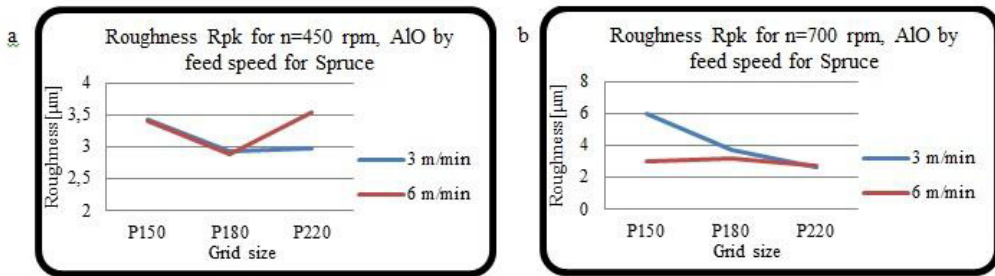

Fig. 7. Roughness variation by feed speed for Spruce for rotation speed of : (a) 450 rpm; (b) 700 rpm.

It can be noticed in the Fig. 7 that the Rpk parameter is lower in case of sanding with a greater feed speed the species of Spruce wood.

Table 6. Relationship between Power consumption and Roughness Rpk, parameter values of MDF panel processed with Aluminium Oxide.

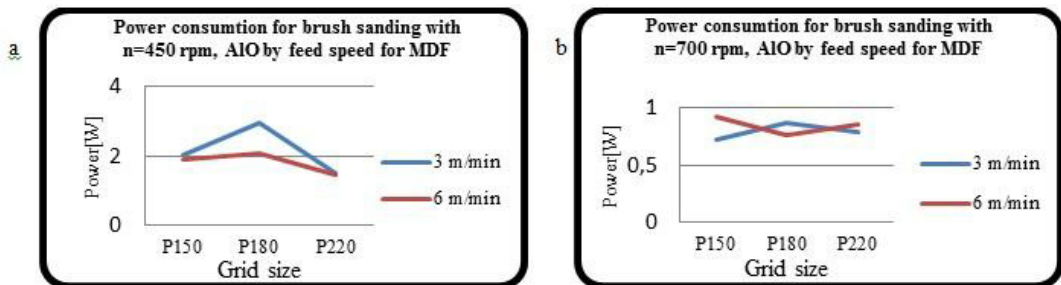| Grid size	Power[W]				Roughness Rpk[um]			
n[rpm]	450		700		450		700	
u[m/min]	3	6	3	6	3	6	3	6
P150	0.7268	0.9154	2.0102	1.8814	3,64	3,20	4,39	3,30
P180	0.8648	0.7636	2.9394	2.0700	2,90	2,42	3,73	2,53
P220	0.7866	0.8602	1.5180	1.4720	2,27	2,02	2,63	2,13

Fig. 8. Power consumption by feed speed for MDF for rotation speed of: (a) 450 rpm; (b) 700 rpm.

In Fig. 8 can be noticed that for a lower revolution speed and greater feed speed the Power consumption is
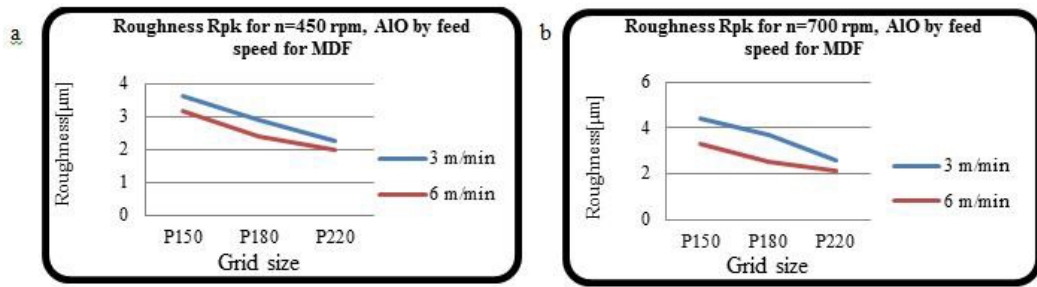
smaller.

Fig. 9. Roughness variation by feed speed for MDF for rotation speed of : (a) 450 rpm; (b) 700 rpm.

It can be noticed that in the case presented in Fig. 9, the roughness parameter Rpk is smaller when is applied a greater feed speed for the MDF board.

5. Conclusions

In industrial environment the intensive energy consumption by sanding with wide belts using finer grit sizes has drawn attention due to its adverse impact on the recently rising costs for energy, furthermore the obtained surfaces are characterized by the high presence of loose fibers which are causing troubles on the quality of the coated samples, also the abrasive belts are getting fast clogged and inhibits further abrasion. The result is a non-free cutting abrasive and increased frictional forces [8].

As a solving solution for the described problems was implemented the actual research by using the abrasive brushes based on the principles of sanding by which the aggressive sanding is accomplished by the speed of the revolving tool [9].

Taking in comparison the sanding process between brush and wide belt, can be noticed that for a surface with width of 450 mm the wide belt requires an power consumption of minimum 3.08 kW for the Spruce wood and 1.26 kW for MDF panel [7], for the grit size P150, at the same time for sanding with brush the same surface requires a power consumption of 0,014 kW for Spruce and 0,013 kW for MDF.

As a first inference, can be stated that by sanding with abrasive brushes can be registered a decreased power consumption of about 99% comparing to the wide belt sanding. The value varies between 0.5 and 2 W for the abrasive brush compared with 1260 W to 3080 W in case of classical sanding method. According to that statement the authors are recommending the procurement for the sanding workshops with abrasive brushes machines, which will generate surfaces with roughness parameters Rpk and Rk having values between 2.32 to 2.5 μm, and 8.5 to 10.5 μm for the Spruce and 1.7 to 2.8 μm and 7.5 to 9 μm for MDF, the lowest values are obtained by sanding with grit size of P220, and the highest being the lowest values obtained by sanding with grit size P150. Hereby sanding with abrasive brushes can be eliminated the loose fibers and in consequence is not affecting the obtained surfaces after lacquering.

Another finding is that by sanding with grit size of P180 at feed speeds of 6 m/min are obtained surfaces with roughness parameters Rpk and Rk of lower values, and the power consumption being in that case reduced by 12%. An explanation for the obtained results can be the considerable decrease of friction forces at the same time with increasing the feed speed. Therewith can be noticed that by sanding with decreased feed speed the processed surfaces are deformed.

The last result is referred in the case of sanding the surfaces with grit sizes coarser than P220 – in studied case the P150, it is recommended the use of to higher values revolution speeds, because it was noticed the achievement of better results of the sanded surfaces. For sanding with abrasive brush of grit sizes finer than P150 – in studied case the P220, it is recommended the use of lower revolution speeds to avoid the deformation of the previously sanded surfaces with wide belt of grit size P220 which gives a smooth finish.

Therefore taking in consideration the interrelation of power consumption and the obtained surface roughness in the current study, the authors are recommending the previously stated sanding regimes which will influence the elimination of surface microfibers which are affecting the results obtained after lacquering.

Further researches are proposed on different type of sanding brushes, having variable lengths of lamellas, also investigation of data's after processing profiled wooden samples. The research will carry out the ability of the abrasive brush for denibbing according to the type of the tool and depending on the profiled wooden sample.

6. References

[1] International Energy Agency (IEA), Tracking industrial energy efficiency and CO2 emissions, 2007.
[2] M. Mori, M. Fujishima, Y. Inamasu, Y. Oda, A study on energy efficiency improvement for machine tools, CIRP Annals – Manufacturing Technology, 2011, Vol.60, No.1, pp.145 – 148.
[3] L. Gurau, The roughness of sanded wood surfaces, PhD Thesis Brunel University, Buckinghamshire Chilterns University College, 2004.
[4] P. Lundum,SlipCon Finishing Systems, Denmark, 2014.
[5] A. Kurtoğlu, Machinability of wood, Journal of the Faculty of Forestry, Istanbul University, 1981.
[6] N. Taran, Masini-unelte si utilaje modern pentru slefuirea suprafetelor lemnoase(Modern sanding machine-tools for wooden surfaces). Editura Lux Libris, Brasov, 2000.
[7] I. Darii, Contribution to optimization of sanding regime for solid wood and wood composites based on ecological principles, PhD Thesis Universitatea Transilvania Brasov, 2011.
[8] R. Albin, Grundlagen des Mobel und Innenausbaus, DRW-Verlag, pages 195, 196; 1991
[9] Fladder, Retreived 8 2011, from Fladder: http:www.fladder.com/
[10] L. Brenci, I. Cismaru, C. Cosereanu, I. Curtu, D. Lica, A. Fotin, The influence of the profiled milling parameters to the Quality of the surfaces, The 20[th]INTERNATIONAL DAAAM SYMPOSIUM "Intelligent Manufacturing &F06-PS7.2-01/ed.2, rev.7, Automation: Theory, Practice & Education", Vienna, Austria 2009, pag 0413-0415.
[11] B. Denkena, V. Böß, D. Nespor, A. Samp, Kinematic and Stochastic Surface Topography of Machined TiAl6V4-Parts by means of Ball Nose End Milling, Procedia Engineering 19 (2011) 81 – 87.