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Effects of Some Sanding Factors on the Surface Roughness of Particleboard

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Effects of the grit sizes of the sand belt, feeding speed and the feed power of the heads of the sander on the surface roughness of the particleboard panels were investigated. Two surface roughness parameters, average roughness (R_a) and mean peak-to-valley height (R_z), obtained from board surfaces were used in the analysis. Sanding factors were found to have a significant effect on the surface roughness of the particleboard. Better results were obtained with 40 m/min of feeding speed, 40-60-80-120 of grit sizes, and 67 kW of the feed power of the heads of the sander.

Keywords Particleboard, sanding, surface roughness, power, grit size, feeding speed
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1 Introduction

Particleboard is widely used as substrate for thin overlays such as resin-impregnated papers, foils, laminates, veneers, rice papers, other decorative overlays and direct finish to the surface uses including furniture, desk and counter tops, cabinets, floor, wall, ceiling panels, office dividers and door skin. The aims of the coating board surfaces are to eliminate the formaldehyde emission and to increase the dimensional stability and mechanical properties of the panels (Rybaczyk and Wojciechowski 1978, Chow and Redmond 1981, Vansteenkiste 1981, Grigoriou 1987, Sparkes 1993, Nemli and Çolakoglu 2005, Nemli et al. 2005a, Tanritanir et al. 2006).

Roughness is a measure of the fine irregularities on a surface. The width, height and shape of the irregularities on a surface establish surface quality of a product. The surface roughness of the panel plays an important role since any surface irregularities may show through thin overlays reducing the final quality of the panel (Hiziroglu and Kosonkorn 2006). Fine irregularities on the board surface will show through overlays and, this affects product grade, quality, finishing and gluing (Hiziroglu 1996). The degree of surface roughness is a function of both raw material properties and production processes. Particle size, resin content, pressing, moisture content of the mat, wood dust usage, raw material type, shelling ratio, density and sanding are the major parameters affecting surface quality of the final product (Nemli et al. 2005b, Nemli et al. 2007).

Most uses for particleboard require a uniform thickness from edge to edge and a smooth flat surface that is attained through sanding. The fabricator needs to recognize and understand the key factors and variables that affect selection of sanding system, sanding equipment, sanding quality and the ultimate performance of the finished product. Board properties, sanding equipment, coated abrasive belt specifications; production scheduling and correct machine setup are the main considerations for successful sanding operation (Beaty 1983, NPA 1993).

The aim of this study is to determine the effects of feeding speed of the sanding machine, grit sizes of the sander, the feed power of the heads of the sander on the surface roughness of particleboard.

Table 1. Sampling schedule.

Type	Feeding speed (m/min)	Grit Size	Power (kW)
1	40	40-50-60-80	50
2	50	40-50-60-80	50
3	60	40-50-60-80	50
4	40	40-50-60-80	57
5	50	40-50-60-80	57
6	60	40-50-60-80	57
7	40	40-50-60-80	67
8	50	40-50-60-80	67
9	60	40-50-60-80	67
10	40	40-50-80-100	50
11	50	40-50-80-100	50
12	60	40-50-80-100	50
13	40	40-50-80-100	57
14	50	40-50-80-100	57
15	60	40-50-80-100	57
16	40	40-50-80-100	67
17	50	40-50-80-100	67
18	60	40-50-80-100	67
19	40	40-60-80-120	50
20	50	40-60-80-120	50
21	60	40-60-80-120	50
22	40	40-60-80-120	57
23	50	40-60-80-120	57
24	60	40-60-80-120	57
25	40	40-60-80-120	67
26	50	40-60-80-120	67
27	60	40-60-80-120	67

2 Materials and Methods

2.1 Manufacturing of the Particleboard Panels

Beech (*Fagus orientalis* Lipsky.), poplar (*Populus tremula* L.), pine (*Pinus sylvestris* L.) and oak (*Quercus cerris* L.) were used as raw materials in the production of the particleboard panels. The wood was passed through a chipper and a rink flaker. The particles (furnish of a mixture of wood species) were dried to moisture content of 1%. A screening machine through meshes with 1 and 0.25 mm apertures and pneumatic system were used to remove undersized ones and to separate the core and surface layer particles. The ratio of the face thickness to the total thickness, known as the shelling ratio, was 0.33 for all boards.

The particles of the above materials were used to make 16 mm thick, three-layer particleboard panels. The particles were blended with E_2 grade urea formaldehyde adhesive with a solid content of 65%. Ammonium chloride and paraffin were used in the manufacturing of the particleboard panels as hardener and hydrophobic substance, respectively. The mats were pressed at 235ºC for 100 sec with a continuous press. All panels were sanded during the manufacturing with a four-head sander. The specimens were conditioned in a room at 65% relative humidity and 20ºC. The experimental design parameter of this study is illustrated in Table 1.

2.2 Surface Roughness Test

Surface roughness was measured by using a stylus type profilometer (Mitutoyo SJ-301). A total of 540 measurements, 270 along the sand marks and 270 across the sand marks, were taken

Table 2. Arithmetic means of surface roughness (R) and thickness (T) of the panels.

Type	R_a µm	R_z µm	$T^{1)}$ mm	$T^{2)}$ mm
1	10.38	69.62	16.60	15.68
2	11.43	73.14	16.58	15.86
3	10.40	67.55	16.59	16.02
4	8.84	61.44	16.57	15.54
5	9.11	62.98	16.56	15.66
6	10.61	71.38	16.58	15.85
7	9.05	61.19	16.60	15.32
8	9.54	63.50	16.59	15.44
9	9.55	64.92	16.57	15.67
10	7.61	56.40	16.60	15.95
11	10.89	70.81	16.58	16.08
12	12.04	77.03	16.57	16.12
13	8.62	62.93	16.59	15.83
14	9.87	67.98	16.56	15.96
15	10.47	69.54	16.60	16.01
16	7.06	54.47	16.58	15.69
17	7.12	53.38	16.56	15.86
18	9.92	66.75	16.59	15.90
19	12.02	74.16	16.57	16.18
20	9.08	61.80	16.58	16.33
21	11.12	72.82	16.60	16.53
22	8.32	56.81	16.55	16.02
23	7.86	56.10	16.56	16.24
24	8.95	63.46	16.60	16.47
25	6.91	52.55	16.58	15.74
26	7.16	53.69	16.59	16.06
27	7.50	54.66	16.57	16.27

Note: 1) Before sanding process, 2) After sanding process

from each face of the specimens. Two roughness parameters characterized by ISO 4287 (1997) standard, respectively, average roughness (R_a), and mean peak-to-valley height (R_z) were considered to evaluate the surface characteristics of the panels. Roughness values were measured with an accuracy of 0.5 µm. Measuring force of the scanning arm on the specimens was 4 mN (0.4 gf). The length of tracing line, the cut-off, measuring speed, pin diameter and pin top angle of the tool were 12.5 mm, 2.5 mm, 10 mm/min, 4 µm and 90 º, respectively. Measurements were conducted at room temperature and pin was calibrated before the tests (DIN 4768 1990).

Table 3. Newman-Keuls test results.

Factors / Average Roughness	R_a µm	R_z µm	T^2 mm
Feeding speed: 40 m/min	8.75 a	61.30 a	15.77 a
Feeding speed: 50 m/min	9.12 b	64.70 b	15.94 b
Feeding speed: 60 m/min	10.06 c	67.58 c	16.09 c
Energy: 50 kW	10.55 a	69.23 a	16.05 a
Energy: 57 kW	9.18 b	63.81 b	15.94 b
Energy: 67 kW	8.20 c	58.54 c	15.76 c
Grits: 40-50-60-80	9.88 a	66.40 a	15.67 a
Grits: 40-50-80-100	9.28 b	64.25 b	15.93 b
Grits: 40-60-80-120	8.77 c	60.93 c	16.20 c

Note: Different letters represent statistical differences at 95 % confidence level ($p < 0.05$

2.3 Determination of the Thickness of the Test Panels

The thickness (T) test was conducted according to TS EN 323/1 (1999) standard. Ten specimens were used for each type panel. Five different measuring points were determined for each specimen. A total of 1350 measurements were done.

2.4 Statistical Analysis

Data for each test were statistically analyzed. Analysis of variance (ANOVA) was used ($\alpha = 0.05$) to test the significant difference between factors and levels. When the ANOVA indicated a significant difference among the factors and levels, a comparison of the means was done employing a Newman-Keuls test to identify which groups were significantly different from others assuming a 95 percent of confidence level.

3 Results and Discussion

Tables 2–3 display the results of surface roughness and thickness of the particleboard panels and Newman-Keuls test results for the effects of the feeding speed of the sanding machine, grit sizes of the sand, and the feed power of the heads of the sander on the surface roughness and thickness of particleboard.

Results of the Newman-Keuls tests indicate a significant difference between R_a and R_z values

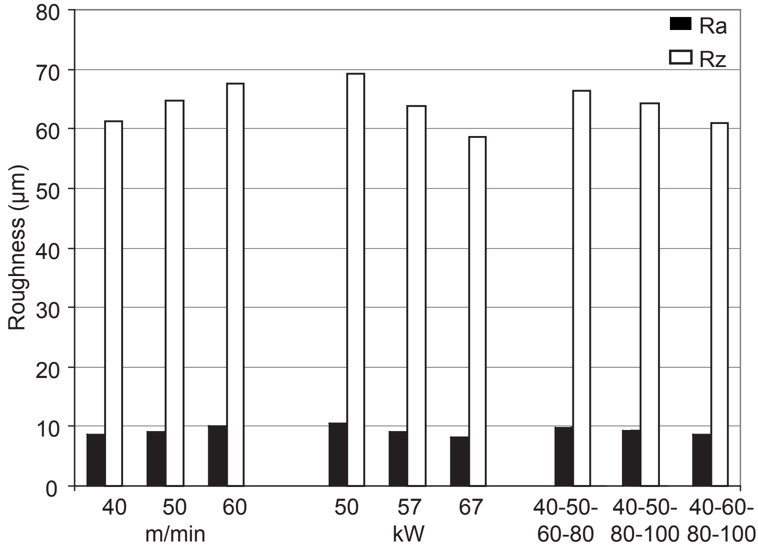

Fig. 1. Effects of some sanding factors on the surface roughness ofthe particleboard.

of panels sanded with 40, 50 and 60 m/min of feeding speeds. Increasing the feeding speed significantly caused rougher surfaces. This can be due to having more spent time of the panels in the sanding machine of the panels at lower feeding speeds. For this reason, removing of the dust and other residues and smoothing of the surfaces will be more efficient at low feeding speeds. As it can be seen from Table 3, the thickness of the test panels were found 15.77 mm, 15.94 mm and 16.09 mm for 40 m/min, 50 m/min and 60 m/min of the feeding speeds, respectively. A decrease in the feeding speed increased the amount of removed material. Too fast infeed of the board to the sanding machine causes sanding chatter, belts run off machine, belts crease or fold and barrel-shaped board thickness problems. These defects increase the surface roughness of the panels (NPA 1993, Nemli et al. 1998).

The feed power of the heads of the sander was found to affect the surface roughness, significantly. Increasing the energy value improved the roughness of the test panels. This may be due to increasing sanding pressure on the surface related to the increasing of the energy. The lowness of the sanding machine power causes a vibration in the machine (Nemli et al. 1998). This vibration may be the reason of the increasing surface roughness related to the applied low machine energy. The amount of removed material from the surfaces is more for the higher energy degree and pressures. The thickness values of the test panels support this result. As it can be seen from Table 3, thickness of the panels decreased with increasing of the machine energy. Fig. 1 shows the effects of the some sanding factors on the surface roughness of particleboard.

The other important sanding factor is the grit size. The results showed that finer grit sizes usage improved the surface roughness of the test panels. Coarser sand belt usage causes scratch pattern problem. One solution of this problem is sanding with finer grit abrasive (NPA 1993). As can be observed from Table 3, coarser grits decreased the thickness of the test panels compared to finer sand belt. Although high amount of waste material was removed from the surfaces, coarser sand belt also caused damage on the board surfaces.

The thickness swelling tolerance is ±0.30 mm according to TS EN 312 (2005) standard. Except for 1, 4, 5, 7, 8, 9, 16, 20, 21 and 24th types of the panels, the other groups met the required level of the thickness tolerance. Statistical analysis showed that sanding factors significantly affected the thickness of the panels. An increase in the power decreased the thickness while an increase

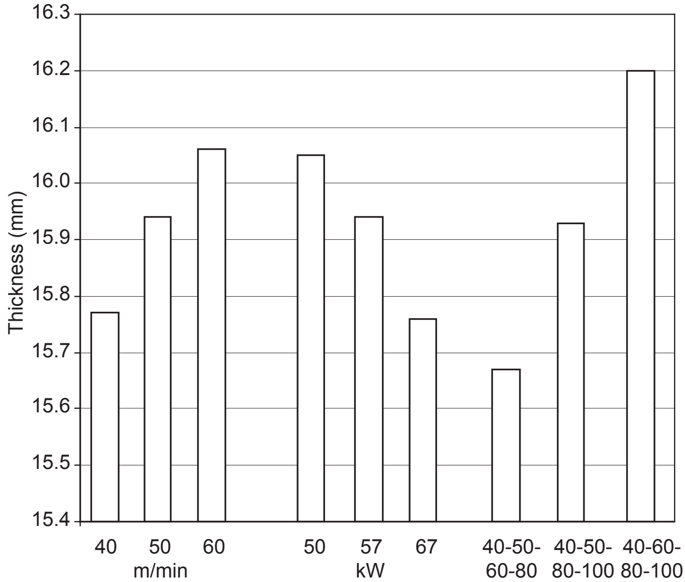

Fig. 2. Effects of some sanding factors on the thickness of the particleboard.

in the feeding speed increases it. As it would be expected, thicker panels were produced with finer sand belt usage compared to coarse sand belt. Effects of the sanding factors on the thickness of the particleboard panels are illustrated in Fig. 2.

4 Conclusions

The targeted end use applications for particleboard are the major factor determining selection of the sanding system. This study shows that grit sizes of the belts, feeding speed of the panels and the feed power of the heads of the sander are the main considerations for a successful sanding operation. Favourable results in this study are obtained with 40 m/min of feeding speed, 40-60-80-120 of grit sizes, and 67 kW of energy applied from heads of the sander. Surface quality of the particleboard panels is affected by the sanding equipment's conditions. Grit sizes should not be selected any coarser than needed to accomplish the objective. While the smooth surfaces are preferred for the end use applications of the particleboard panels, the thickness of the panels also should be in the acceptable levels. For this reason, sanding machine setups such as feeding speed, grit sizes and power should be selected attentively. When the 40-50-60-80 grit sizes were used as an abrasive, feeding speed and the energy should be 60 m/min and 50 kW, respectively. These show that feeding speed and power should be increased and decreased, respectively, when the coarse sand belt was used. A four-head top and bottom sander might use 40 and 50 grit for the primary sanding and 80 and 100 grit for the finishing with 50 m/min of the feeding speed, and 67 kW of the energy for the producing of the particleboard panels in the acceptable surface quality and thickness tolerance.

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