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THE IMPACT OF SANDING SYSTEM ON THE SURFACE ROUGHNESS OF MEDIUM DENSITY FIBREBOARD

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Abstract

This paper examines the impact of the sanding system on automatic sanding machine in real production conditions on the surface roughness of medium density fibreboard (MDF). The surface of samples was egalized by sanding on wide–belt sanding machine using P80 grit sanding belt. Afterwards, the samples were sanded on the 4 aggregate automatic sanding machine at sanding speed of 14 m/s in a two-step process with the following sanding belt grits: P120+P150 and P120+P180, using two conveyor speeds: 8 and 12 m/min. In the first stage of sanding, the samples were sanded by narrow belt aggregate, with sanding direction perpendicular towards the processing direction of sample in sanding machine. The second stage of sanding was conducted on the wide-belt aggregate, with sanding direction parallel towards the processing direction of sample in sanding machine. The surface roughness was measured by the contact-mechanical gauge and expressed by parameters R_a, R_z and R_t. As expected, results confirmed that sanding belt grit in the last stage of sanding had significant effect on the surface roughness of MDF. On the other hand, variation of speed of conveyor did not affect the surface roughness of MDF, for both combinations of sanding belt grits.

Keywords: MDF, Sanding, Surface roughness, Sanding belt grit, Speed of conveyor

1. Introduction

Most often sanding is the first operation in the technological process of surface finishing of wood and wood-based products. Nowadays, the sanding of flat panels is usually done on the automatic sanding machines in several following steps (stages), ensuring gradual removal of the irregularities on the surface and thus achieving the minimum required roughness and uniform quality of the surface on the entire panel. The uniform roughness of the surface layer of the substrate is a prerequisite for the quality surface finishing of the wood and wood-based products. Most of the defects in the surface layer of the substrate become apparent after the application of the surface treatment material (coatings, etc.). In those cases, the correction of the transferred defects from the substrate, often involves total removal of the material surface layer to the raw substrate. Any additional step in technological process of wood surface finishing means additional costs, in regards to processing time and cost of materials. Those costs are enlarged by the costs of the re-processing of the substrate after total removal of the film coating with defects. Therefore, it is necessary to pay special attention to the selection of the optimal sanding program, according to the type of substrate and type of finishing material, but also in regards to the further purpose of the finished product.

The surface roughness of wood products is depending on many factors related both to wood properties and wood working operational parameters (Gurau et al. 2007; Magoss E. 2008). It is known that during sanding the processing roughness of the wood surface is affected by number of factors: grit-size of sanding belts (Ratnasingam et al. 2002; Saloni et al. 2005; Hendarto et al. 2006; Kilic et al. 2006; de Moura and Hernández 2006; Salcă and Hiziroglu 2012; Varasquim et al. 2012; de Sampaio Alves et al. 2015; Laina et al. 2017), sanding speed (de Moura and Hernández 2006; Varasquim et al. 2012), speed of the conveyor (Ratnasingam et al. 2002; de Moura and Hernández 2006; Škaljić et al. 2009; Salcă and Hiziroglu 2012), type of abrasive material (Ratnasingam et al. 2002; Saloni et al. 2005; de Moura and Hernández 2006), direction of sanding, sanding pressure (Saloni et al. 2005; Varasquim et al. 2012), operating time of the sanding belt

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(Ratnasingam et al. 2002; Palija et al. 2014), hardness of the rubber contact roller (Ratnasingam et al. 2002) etc.

Medium density fiberfboard (MDF) is an engineering product obtained by hot-pressing of fine glued wood fibers at certain regimes (temperature, pressure and time). Due to lower impact of irregularities that are result of anatomical structure of pressed fibers, initial surface roughness of MDF is generally lower in comparison to surface roughness of wood. It is assumed that the factors that affect the roughness of the wood during sanding will affect the roughness of the MDF as well. Previous research confirmed that surface roughness of sanded MDF is affected by: grit-size of sanding belts (Kiliç et al. 2009; Ayrilmis et al. 2010); sanding speed and feed speed (WILKOWSKI et al. 2015), fibers wood species (Gurau et al. 2017), fineness of wood fibers and relative humidity of exposure (Ozdemir et al. 2009).

This research examines the technological process of the surface preparation of MDF in real production conditions. The aim of this paper was to determine the optimal sanding program of MDF in terms of the grit of the sanding belts in the two-stage process and the speed of conveyor belt, expressed by the lowest surface roughness of MDF.

2. Materials and Methods

For this research 12 samples of the commercially manufactured MDF dimensions: 750x300x4 mm, were used. To ensure a safe passage through the sanding machine, MDF samples were glued to calibrated 34 mm-thick blind frame. Surface preparation of MDF carried out in real production conditions on automatic sanding machines. Calibration of the glued MDF samples was done on the wide–belt sanding machine with contact rubber roller (model LMF 1300 RRRR, manufacturer Egurko-Ortza), using 80-grit sanding paper. After calibration, fine sanding of samples was carried out on the 4 aggregate wide-belt sanding machine (model Rita 4CT EL, manufacturer Viet): first aggregate with narrow sanding belt and following aggregates with wide sanding belt. All sanding aggregates were equipped with flat sanding platen. The calibrated samples were divided into 4 group, according to program of fine sanding of MDF surface (Table 1). Each group consisted of 3 samples. During sanding the sanding speed was set constant: 14 m/s, while conveyor speed was varied. One half of all samples was sanded at 8 m/min conveyor speed, while the other half was sanded at conveyor speed of 12 m/min. The indicated speed of sanding and speeds of conveyor were in accordance with the recommendations of the sanding belt manufacturer for sanding of MDF and other wood-based panels (Web-1). Sanding was conducted in two-step process by activation of the first and second aggregate. In first step sanding was conducted perpendicular to the processing direction of sample in sanding machine, while in second step sanding was parallel to the processing direction of sample. This combination of sanding directions enables the raising of the wood fibers from the surface in first step and its removal in the following step. Sanding was carried out using two combinations of grits of the sanding belts: P120+P150 and P120+P180. The sanding pressure was 0.5 bar.

Table 1: Groups of samples

Group of samples	**I**	**II**	**III**	**IV**
Gritof sanding belt	P120+P150		P120+P180	
Speed of conveyor (m/min)	8	12	8	12

After sanding, surface roughness of the sample was determined by measuring the roughness parameters: R_a, R_z and R_t, in accordance with standard ISO 4287:1997. The measurement of surface roughness was carried out by stylus contact tester (model TimeSurf TR200, manufacturer Beijing TIME High Technology Ltd.), Figure 1. The diameter of the diamond stylus tip was 2 μm, and the stylus was pressed on the surface by the force of 4 mN. Reference length was 2.5 mm, which is in accordance with the recommendation of the standard ISO 4288: 1996. Measurements were made perpendicular to the direction of of the movement of the samples in the machine (perpendicular to the final sanding step). 6 measurements of surface roughness parameters were measured for each sample, which make total of 72 measurements (6x3x4).

Figure 1: Measurement of surafece roughness parameters of MDF by stylius contact tester

3. Results

Table 2 shows the results of surface roughness of sanded MDF according to the groups of samples.

Table 2: Surface roughness of sanded MDF for different conveyor speed and combination of sanding belt grits

	Group of samples			
Surface roughness parameter (µm)	***I***	***II***	***III***	***IV***
R_a	7.091 (1.03)	7.787 (1.79)	5.327 (0.54)	5.719 (0.71)
R_z	48.50 (6.36)	51.45 (8.92)	37.86 (4.02)	40.13 (5.14)
R_t	65.30 (12.13)	65.57 (22.04)	49.02 (7.67)	52.22 (9.29)

Values of standard deviation are written in parentheses

‘ The use of lower conveyor speed (u = 8 m/min) resulted in lower surface roughness of MDF samples in comparison to the use of higher conveyor speed (u = 12 m/min), for both combinations of sanding bet grits: P120+P150 and P120+P180. In addition to lower values of surface roughness parameters, values of the standard deviation were lower for the samples that were sanded at lower feed, in comparison to samples sanded at higher feed speed and with same grits of sanding papers. These results can be explained by the longer contact of the abrasive grains and the surface layer of the panel at lower conveyor speed, which contributed to more uniformity and lower roughness of the surface substrate. These results are in line with finding of paper on quality of sanded surfaces of sugar maple wood, where increasing feed speed led to rougher surfaces due to higher fibrillation of cell walls in surface layer of wood (de Moura and Hernández 2006). Increasing the feed speed (from 6 to 18 m/min) during sanding of black alder led to general increase of the processing roughness expressed by the R_k (Salcă and Hiziroglu 2012).

Along with sanding, the increase of the conveyor speed in other working processes leads to higher surface roughness of wood and wood-based substrate. Thus the increase of feed rate (from 6 to 24 m/min) during planning of beech, oak and fir wood resulted in the increase of R_a (Škaljić et al. 2009). In the research of surface roughness aspects in milling of MDF, it was found that as the speed of the conveyor increased (from 0.5 to 5 m/min), the roughness parameters: R_a, R_z and R_t increased (Davim et al. 2009). Sanding of MDF at constant rotational spindle speed (n = 8000 rpm) showed tendency to increase of surface roughness with increase of feed per revolution (WILKOWSKI et al. 2015).

On the other hand, the results of the independent t-test (for P120+P150: t = (27.157) = - 1.427, p = 0.163 for R_a; t = (34) = - 1.144, p = 0.261 for R_z; t = (26.426) = - 0.045, p = 0.964 for R_t and for P120+P180: t = (34) = - 1.873, p = 0.07 for R_a; t = (34) = - 1.478, p = 0.149 for R_z; t = (34) = - 1.129, p = 0.267 for R_t) showed that there is no statistically significant difference between the surface roughness parameter: R_a, R_z, and R_t for different speed of the conveyor belt, for both combinations of the sanding belt grits .

Due to the absence of the statistically significant differences in surface roughness of MDF samples sanded at different conveyor speeds, the results of surface roughness parameters were further analyzed independently of the conveyor speed, Table 3. When comparing the surface roughness of sanded MDF samples using two combinations of the sanding belt grits, it is clear that the use of smaller abrasive grains in the final step of sanding resulted in the lower surface roughness expressed by all three roughness parameters (R_a, R_z, R_t). The results of independent t-test confirmed that the difference in values of all three observed roughness parameters for two combinations of the sanding belt grits was statistically significant ($t(43.650)=-6.717$, $p\leq0.05$ for R_a, $t(50.418)=-6.804$, $p\leq0.05$ for R_z and $t(48.257)=-4.728$, $p\leq0.05$ for R_t), This results were expected since sandpaper with higher grit size contains finer abrasive thus produces finer sanded surface (Tan et al. 2010).

Table 3: Surface roughness of sanded MDF for different combination of the sanding belt grits

Surface roughness parameter (μm)	***Grit of sanding paper***		Decrease of roughness (%)
	120+150	120+180	
R_a	7.439 (1.48)	5.523 (0.65)	25.76
R_z	49.97 (7.78)	38.99 (4.69)	21.97
R_t	65.44 (17.54)	50.62 (8.55)	22.65

Values of standard deviation are written in parentheses

In the research of the impact of sanding of MDF panels made from R. ponticum wood using P60 + P80 + P120 sanding bets (Ayrilmis et al., 2010), values of surface roughness parameters (R_a = 4.15μm, R_z = 30.76μm and R_t = 38.60 μm) were lower in comparison to values of surface roughness parameters that were obtained in our research, when using higher grits of sanding paper in final stage (P150 or P180). This disagreement confirms that the surface roughness of MDF is affected by characteristics of the raw materials used in production, production conditions and machining characteristics (Kiliç et al. 2009). Thus in support of that, after sanding of MDF made of thermally treated rubberwood fibers, with P120 and P150 grit sanding belts, values of surface roughness parameters (R_a = 6.93 μm, R_z = 41.15μm and R_t = 52.08 μm) were slightly lower than the values obtained in this study, which can be explained by type of fibers, thermal treatment of fibers and pressing regimes (Jarusombuti et al., 2010).

The values of surface roughness parameters of MDF sanded with P100 and P150 grit sanding paper in previous research (Ozdemir, Hiziroglu and Malkocoglu 2009) were lower in comparison with results that we obtained (R_a = 2.04 μm, R_z = 19.57μm and R_t = 23.73 μm, for samples made from unrefined fibers and exposed to 65% of relative humidity). This deviation can be related to the direction of sanding, since in mentioned research sanding was performed parallel to direction of the movement of the samples on the conveyor through the machine. In our research, the sanding was done perpendicular to the feed direction in the first step, and then parallel to the feed direction in second step. The combination of the perpendicular and parallel sanding in relation to the movement of the samples is recommendation for effective removal of wood fibers from the surface of the panel. In addition, prior to fine sanding, an equalization using 80grit sanding paper was carried out. According to the data of the sanding belt manufacturers, the size of grains of 80 grit sanding paper average about 200 μm. Knowing that the surface layer of MDF is compact, the use of 80 grit sanding paper in calibration of MDF had created scratches that was too depth for removal by subsequent higher grit sanding belts, resulting in higher values of surface roughness.

According to the data obtained from the practice, the value of parameter R_a of sanded wood samples is approximately 5 times lower than the parameter R_z, and the value parameter R_z is approximately 1.6 times lower than the parameter R_{max} (Janković, 1975). The ratio of parameters R_z to R_a of MDF samples sanded at different systems (P60; P60 + P80 and P60 + P80 + P120) ranged from 6.56 to 7.41(Ayrilmis et al. 2010), while the ratio of R_t and R_z varied from 1.24 to 1.25. The ratio R_z: R_a for sanded MDF samples in this research was 6.72 and 7.02 for sanding grits P120+P150 and P120+P180, respectively. The higher ratio of R_z to R_a in samples of MDF can be associated with a more compact structure of MDF, where the proportion of valleys of is smaller compared to the valleys in surface layer of sanded wood that are the result not only of sanding process, but also of structural roughness of wood surface. The ratio of R_t: R_z for sanded MDF in this research was 1.30 for P120+P150 and 1.31 for P120+P180. Similar values of R_z and R_t (lower ratio) indicate constant surface irregularities, while significant difference between them indicates a surface defect in an otherwise constant surface (Web-2). Thus, the lower ratio of R_t to R_z in MDF in relation to wood can be explained by the compact initial MDF structure prior to the sanding. The use of smaller abrasive grains in final stage of sanding created higher deviation between the average surface roughness and the maximum height of peak to valley (8.80 for sanding grits P120+P150 and 9.17 for sanding grits P120+P180).

Although all of measured parameters of surface roughness decreased when using P180 grit sanding paper, instead of P150 grit sanding paper in final stage of sanding, the largest change was in value of R_a parameter (25.8 %). Based on these results, the surface roughness parameter R_a can be recommended to be used for basic evaluation of surface roughness of MDF. For further research, it is necessary to include additional combinations of sanding papers grits to determine the most sensitive parameter for characterization of surface roughness of MDF after sanding.

4. Conclusion

Based on the results of this research, the following can be concluded:

- The increase of conveyor speed during sanding (from 8 to 12 m/min) did not led to statistically significant increase of surface roughness parameters, R_a, R_z and R_t.
- The lower surface roughness of MDF, expressed by R_a, R_z and R_t was achieved when using P120+P180 sanding grit sequence in comparison to P120+P150. In respect to these findings, the use of the higher speed of the conveyer and higher sanding grit in final sanding step is recommended. This proposed system ensures higher productivity of the sanding process without reducing the quality of the sanding process in term of the surface roughness. This recommendation should be related to the final use of the MDF and the properties of the material that would be applied on its surface in the following step.

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Web sites:

Web-1: https://www.siaabrasives.com/download/

Web-2: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwi3j4LLvcHcAhXQz4UKHYRmAPAQFjAAegQIABAC&url=http%3A%2F%2Fwww1.gantep.edu.tr%2F~bozdana%2FME472_5.pdf&usg=AOvVaw3US6zW-XS0LHuqRkKU-pH9