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THE INFLUENCE OF PARTICLEBOARD SQUARENESS ON THE EDGE BONDING QUALITY

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ABSTRACT

This paper shows the influence of the squareness of wood-based panels on the quality of edge bonding. Edge bonding of wood-based panels can be done by applying different types of adhesives and using different types of edge materials. The number of factors that affect the quality of bonding is large. Analysis of wood-based panels squareness after processing by pre-cutters, as well as the position of the roller for applying glue to the panels, was analysed. The static analysis showed that there is a significant influence of the measured parameters on the strength of the edge bonding quality. Variation of the observed factor leads to a change in the quality of the bonding quality. The highest strength of the glued joint was shown by the samples with the smallest angular deviation of the edge to the wider side of the panel. The minimum strength that the edge bonding should require is not defined by the standard.

Keywords: wood-based panels, edge bonding, squareness, internal bond

1. INTRODUCTION

Edge bonding refers to the process of gluing edge material to the narrow sides of wood-based panels. Covering the narrow sides with edging material can be done before or after covering the wider sides of the panels (by coating or lamination processes), depending on the aesthetic effect that should be achieved. In the modern wood industry, the process of covering the narrow sides of wood-based panels is carried out on automatic edge banding machines using hot-melt adhesives. The basic characteristic of hot-melt adhesives, which qualifies them for this type of bonding, is the lack of evaporative components, so hot-melt adhesives harden by cooling, which makes them suitable for joining different types of materials. The gluing process set up this way is very effective both from a productivity point of view as well as from aesthetic requirements and achieved durability during the use of the product. Depending on the shape of the board and its profile of the narrow side, we distinguish the covering of boards with a prismatic base, linear line, and flat surfaces; boards with a curved base, linear line, and flat surfaces; and the boards with a prismatic base, linear line, and profiled surfaces (soft forming procedure). The technological process of covering the narrow sides of the boards can be carried out on all types of wood-based boards: solid wood panels, fibre and chip wood panels (chipboards, fibre boards, and composite boards), and layered wood panels (panel panels and plywood panels). The edging material that covers the narrow sides can be of natural or synthetic origin. The edges can be covered with solid wood up to 25 mm thickness, veneer, PVC, ABS, HPL, and CPL tapes. Depending on the type of base (panel), the type of edging material, as well as the resistance requirements during exploitation, three types of adhesives can be applied: ethyl-vinyl-acetate adhesives (EVA), polyphenol-based adhesives (PO), and isocyanate adhesives known as reactive polyurethane binders (HMPUR).

The quality of edge banding depends on a large number of factors that have been investigated by a number of authors. According to Jianhua et al. (2017), as well as according to Miškinite and Jukneleričius (2021), the quality of the glued connection is influenced by the following factors: properties of the panel, properties of the glue, properties of the edging material, angularity of the boards, and gluing parameters. According to previous research (Iuan et al., 2011; Ven et al., 2012), bonding quality is influenced by the gluing parameters (glue temperature and method of application), panel moisture (Sacli 2015), as well as the feed speed of the panel in edge banding machines. In their work (Tankut Tankut, 2010), they explained the correlation between pressure and tension forces on adhesive tapes and the quality of furniture. The paper proved that a clear correlation between the thickness of the tape edge and the joint strength could not be determined.

In MMS (micro-medium-small) companies, because of deformation of the boards due to inadequate storage conditions (cold flow of the boards), as well as the lack of levelling of the machines, the loss of squareness and edge straightness can affect the quality of the gluing between edging material and panel. A part of these problems is addressed in the work of Zhang et al. (2007), where the permissible size of angularity deviation is not clearly defined. On the other hand, the standard that regulates this subject (EN 324-2) defines the method of measurement, while the permitted deviations are only partially defined. Namely, the standard defines permitted deviations in terms of squareness on the wider side, but not in relation to the thickness of the board. In order to better understand the influence of this parameter on the quality of the glued connection, the influence of the squareness of the board on the quality of the glued connection was analysed when lining the narrow sides of the particle board. The subject of his research is particleboards coated with melamine foil and aligned with PVC edge band; these are the most commonly used materials in MMS companies.

2. MATERIAL AND METHODS OF WORK

The test was carried out on samples made of three-layer particleboard (18 mm thickness) covered with melamine foil from a renowned manufacturer. According to Jianhua et al. (2017), the quality of the edge bonding will depend on the density of the board (EN323), moisture content (EN322), and delamination strength of the layers (EN319). The properties of the particleboard from which the samples were made were not investigated, but the properties of the material were considered to correspond to the data provided by the manufacturer (Freehart and Hunt 2010). The samples were taken from the manufacturer's warehouse fifteen days after the production process so that longer storage of the samples in the warehouse space was avoided.

Before the edge-bending process, the samples were cut to certain dimensions on the beam saw. The samples for this test were taken from the middle of the boards, and their dimensions were controlled according to the EN 324-2 standard. The test was performed on samples with dimensions of 600x300x18 mm. Before the edge-bending process, the samples and the edge material were conditioned for 7 days in controlled conditions of relative air humidity (50±5%) and temperature (20±2°C). In order to simulate the loss of squareness of wood-based panels, the premilling cutters on the edge ender machine were excluded from processing. Before gluing the edge material, the samples were processed on a moulder joinery machine, where the 90° angle was reduced by 2 or 4 degrees (figure 1). The processing was carried out using a DP-tipped cutterhead with an alternate shear angle at the following processing parameters: feed speed of 12 m/min, cutting depth of 2 mm, and revolutions per minute of 9000 rpm.

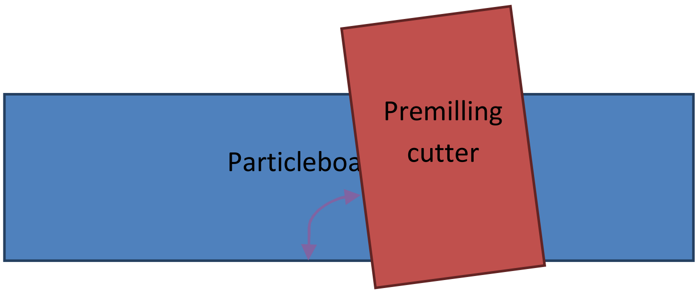

Figure 1: *Inclination of the edge towards the wider side*

Table 1 shows the angles, the size of the resulting gap, as well as the processing accuracy class according to DIN 68101.

Table 1: *Overview of samples by groups*

Group label	Angle deflection	Gap size	Accuracy class acc DIN68101	No.of samples by group
1	2	3	4	5
group 1	90°	0	/	20
group 2	88°	0.6mm	TD40	20
group 3	86°	1.3mm	TD100	20

After processing on a moulder joinery machine, an ABS edge band, with dimensions 22x3mm, was glued to the samples using Kleberit's EVA glue (HotMelt 774.4). Gluing was performed on an automatic edge banding machine with roller application manufactured by Biesse at the following gluing parameters: glue temperature: 210°C; application quantity: 110 g/m²; feed speed: 15 m/min. Within each group, 20 samples were made, for a total of 60 samples for the entire test.

After gluing the edge material, the samples were conditioned for 5 days under the same conditions as before processing. Methods of testing the strength of the glued connection between the panel and the edge material can be divided into two groups: tests that can be applied directly in production and tests that must be conducted in laboratories. As part of this research, the samples were tested in laboratory conditions in accordance with the standard EN ISO 4624:2017. A pull-off test was performed, verifying the force required to detach the edge band from the panel. In addition to this part of the test, the effect caused by the pull-off stress on the edge band is also monitored. After conditioning, dollies were attached to the samples using a two-component epoxy adhesive. Dollies were placed 200 mm from the face of the board to avoid undulations during milling, which could affect the test result, Figure 2.

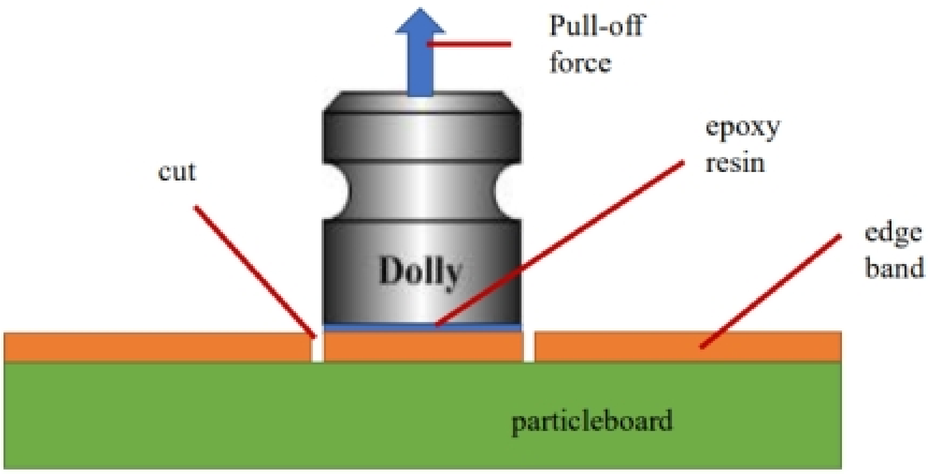

Figure 2: *The sample with the dolly*

The dollies were placed on each sample (two dollies). Considering that the diameter of the dolly was 20 mm, and the thickness of the plate was 18 mm, the contact surface under the dolly was recalculated (from full circle) to the surface of the narrow side of the board covered by the dolly. The samples were tested for tension on a universal tearing machine by applying a force that was constantly and evenly increased to the point of separation of the edge material from the board. The load speed on the device was about 0.5 N/sec.

3. RESULTS AND DISCUSSION

The samples were divided into three groups. The first group represents the control group, where there was no deviation of the angle in relation to the wider sides of the board. During the statistical analysis of the given data, the SPSS v.20 program with the basic data package was used. Table 2 provides some basic data of descriptive statistics for the mentioned samples.

Table 2: *Descriptive statistics by sample groups*

group label	Average (N/mm²)	Max/min (N/mm²)	Standard deviation	Variance
1	2	3	4	5
group 1	1.102	1.21/0.05	0.055	0.00045
group 2	0.966	1.05/0.88	0.03	0.0018
group 3	0.87	0.95/0.8	0.02	0.0008

By analysing the normal distribution, the Shapiro-Wilk test showed that all groups met the basic requirement of normality, which enables further statistical tests. After confirming that not all groups are subject to a normal frequency distribution, an analysis was performed using a t-test to determine whether there is a significant difference in the variances between the groups, i.e., whether the size of the gap (loss of squareness) affects the final strength of the glued connection. Further analysis revealed that there was a difference in the variances between the groups. Using Levene's Test for Equality of Variance, it was established that there is an equal variances assumption.

Based on the obtained results of the size of the strength of the glued connection, it can be seen that the highest mean tear value was obtained by control group 1, where there was no slope between the narrow and wide sides. The average value is 1.1 N/mm^2. A slightly lower value was shown by the samples of the second group, where the gap was made at a 2° slope. It is interesting to note that an inclination of 2° creates a gap of about 0.6 mm on average. According to the manufacturer of the glue, EVA glues allow a greater layer thickness and can fill the resulting gap without any problems. However, from the point of view of joint strength, the joints of the second group gave less strength by about 12%. The lowest value of the strength of the glued connection was obtained from the samples of 3 groups where the joint was made at an inclination of 4°, i.e., with a gap of 1.3 mm on average. The joints of this group gave lower strength by about 30% compared to the first control group, Figure 3.

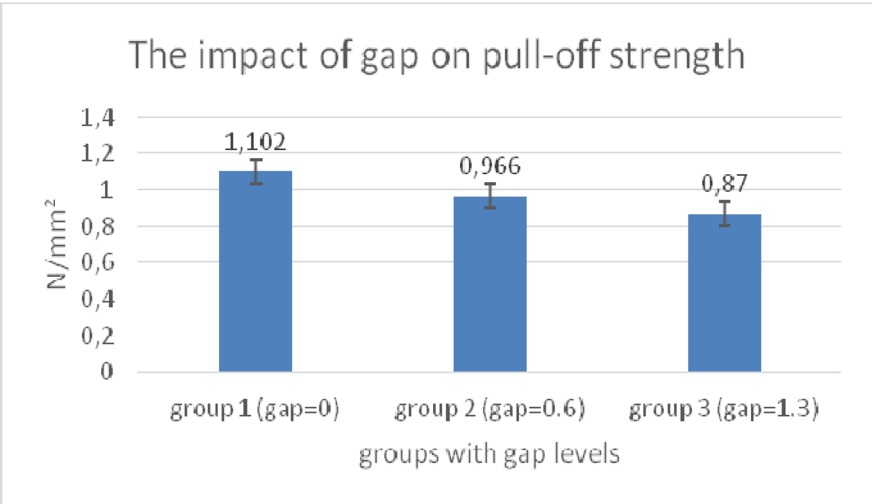

Figure 3: *Mean values of adhesion strength of glued edge band according to groups of samples*

Characteristic damage after testing is shown in figure 4. In the case of samples of the first group, it is clearly visible that the damaged glued joint occurred along the gluing line. Within the sample of the first group, during the removal of the dolls, the whole edge band was removed together with some chips from the panel. In contrast to the samples of the first group, on the samples of the second and third groups, you can see uneven layers of glue, which are caused by the size of the gap between the edge material and the application roller. Damages recorded on the samples of the second group (where the gap was around 0.6 mm from one edge of the panel) show that there are some tracks of the hot-melt adhesive, together with chips and stripes of the panel. Samples of the third group revealed even more tracks of hot-melt adhesive where the quantity and position of the hot-melt adhesive differed from sample to sample.

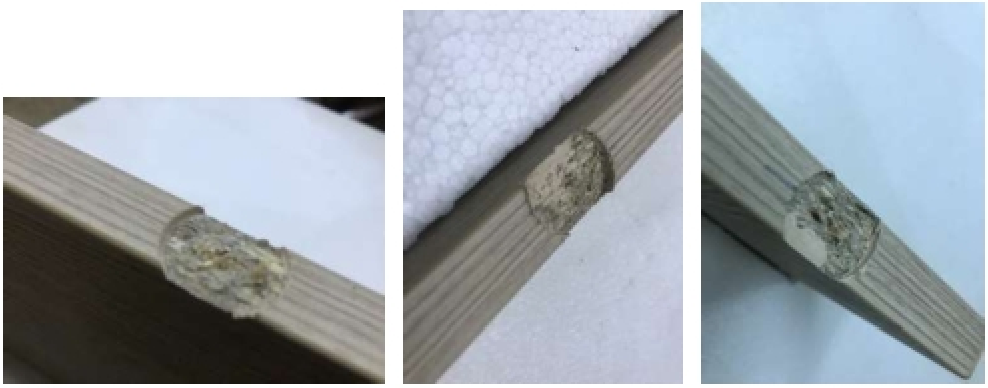

Figure 4: *Characteristic damage of the samples after the test (from left to right, samples of group 1 to group 3)*

Looking at the results presented on the graph in Figure 3, the influence of the factors on the gluing strength is clearly visible. The joint's strength reduces as the space and angle under the slope between the narrow and wide sides increase. The comparison of the obtained results with the data obtained by other researchers is hardly applicable due to the different values in which the results were expressed and different testing methods. For example, the work of Miškinyte and Juknelevičius (2021) conducted research using the peel-off test and expressed the results in N, while Jianhua et al. (2017), Zhang et al. (2007), and Yuan et al. (2010, 2011) expressed their results in N/m, although they also tested the samples through the peel-off test. In addition to this, the standard does not define the methods that regulate this area, nor are there any recommendations on the values that the joint should fulfil in the works. Also, this information is not available in the technical data presented by the manufacturer of glues for edge banding machines. Considering the lack of results, it can be concluded that this segment of the wood industry is not fully examined.

4. CONCLUSION

This paper shows the influence of the squareness of wood-based panels on the quality of edge bonding. The number of factors that affect the quality of edge bonding is large. Analysis of wood-based panels squareness after processing by pre-cutters, as well as the position of the roller for applying glue to the panels, was analysed. The standard does not define methods that can be used to test the strength of the glued connection between the edge band and the wood-based panel, so the test was performed by pull-off test according to EN ISO 4624:2017. A review of the available literature did not show much data on this type of adhesive bond.

The static analysis showed that there is a significant influence of the measured parameters on the strength of the edge bonding. Variation of the observed factors leads to a change in the quality of the bonding strength. The highest strength of the glued joint was shown by the samples with the smallest angular deviation of the edge to the wider side of the panel. In real production conditions, the deviation of the squareness can occur with boards of larger dimensions if the auxiliary work table is further away from the edge of the machine, if there is inadequate pressure of the upper conveyor or in the situation when the machine is not levelled. These factors should be the subject of an additional analysis.

The minimum strength required for the edge bonding of bands to narrow sides of wood-based panels is not defined by the standard.

REFERENCES

[1] Frihart, R.C., Hunt, G.C. (2010): Adhesives with Wood Materials, Contennial Edition, Forest Product Laboratory.

[2] Jianhua, L., Li, J., Ming, C. (2017): Influence of Temperature of Applaying Glue, Glue Dosage and Feet Rate on Peel Strength of Edge Band from Curved Edge Part. Materials Science and Engineering 274 012159 doi:10.1088/1757-899X/274/1/012159.

[3] Miškinyte, U., Juknelevičius, R., (2021): Quality Research of Edge Banding of Unit Furniture. 16th International Conference: Mechanotonic Systems and Materials, doi:10.1088/1757-899X/1239/1/012014.

[4] Qi, Y., Xu, B. (2007): Effect of Lay-by Time on Panel Furniture Edge Banding Quality. China Wood based Panel (9) 16-18.

[5] Sacli, C. (2015): The effect of time and edge banding type and thickness on the bending and tensile strength of melamine coated particleboard. Research for Furniture Industry, Turkey/ Creative Commons Attribution, p. 469–480

[6] Tankut, A.N., Tankut, N. (2010): Evaluation the effects of edge banding type and thickness on the strength of corner joints in case–type furniture. Materials and Design, p. 2956–2963.

[7] Yuan, N., Ding, W., Zhang, H., Zhu, Y. (2010): Peeling Properties of Edge Banded Parts of MDF. Furniture China Forest Products Industry. 37(6) 27-30.

[8] Yuan N, Ding W, Wen W, Zhu Y, Zhang H (2011): Peeling Properties of Edge-banded Parts of Particleboard. Furniture China Forest Products Industry 38(1) 32-34.

[9] Wen, C., Wu, Z,, Zhang, J. (2013): New exploration of peeling method for plastic edge banding on panel furniture. Furniture 34(4) 22-25.

[10] Zhang, J. Z.; Joseph, C.; Chen, E.; Kirby, D. (2007): Surface roughness optimization in an end-milling operation using the Taguchi design method. Journal of Materials Processing Technology. 184, pp. 233-239. DOI: 10.1016/j.jmatprotec.2006.11.029.

[11] DIN 68101:2012: Fundamental deviations and tolerance zones for wood working and wood processing.

[12] EN 324-2:1993: Wood based panels – Determination of dimensions of boards: Part 2: Determination of squareness and edge straightness

[13] EN ISO 4624:2017: Paints and varnishes – Pull-off test