CHIP AND CHIPLESS WOODWORKING PROCESSES, 10(1): 11–16, 2016
Zvolen, Technical University in Zvolen, ISSN 1339-8350 (online), ISSN 2453-904X (print)

INFLUENCE OF MECHANICAL PROCESSING OF PARTICLEBOARD EDGES BEFORE THEIR EDGEBANDING OVER THE HOT MELT ADHESIVE STRENGTH

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Abstract

Careful machining is essential in preparing substrate surface for edgebanding. Edgebanding machines with pre-milling (aka "joint trimming") have been growing steadily in popularity over the past several years [5]. The pre-milling station can provide a clean, straight, razor-sharp edge to the panel, prior to glue and edgeband application. Generally this ensures a clean, tight glue joint, without chips in the panel surface, but there is no information on comparison of edgebanding adhesion strength with or without using "trimming" operation. In this relation, the purpose of the current study was to determine the influence of the mechanical processing of workpiece edges (cutting, milling) on the adhesion strength of used glue adhesive via through feed edgebanding with ABS edges (thickness 0,8 and 2 mm). the edge surfaces of particleboards samples have been machined as follows: surfaces cut by circular saw on sliding table saw; surfaces milled by straight cutterhead on spindle moulder; surfaces milled by two counter-rotational cutterheads on edgebanding machines with pre-milling station. After that they are edgebanded (ABS edging) and the adhesion strength of the glue adhesive is defined by peel-off test.

Key words: *particleboards, cutting, milling, edgebanding, ABS edges, adhesion strength*

INTRODUCTION

The edgebanding of furniture construction details is accomplished predominantly by applying hot melt adhesives (HMA) and cooling the adhesive layer during the pressing process afterwards. As it is known, this principle of binding (bonding) is executed on the basis of hot-melt adhesives. HMA are solvent-free thermoplastic solid materials which are characteristically solid at low temperatures (generally below 82 °C), are low-viscosity fluids at high temperatures (generally above 82 °C), and rapidly set upon cooling. A typical HMA is formulated with four main components: polymer (about 33%), tackifier/resin (about 33%), wax (about 32%), and antioxidant (about 1%) [2]. HMA can be used to bind various types of edge banding materials such as acrylonitrile butadiene styrene (ABS), (polyvinylchloride) PVC, melamine, solid wood or wood veneer. The two most important parameters, i.e. adhesion strength and durability are to be evaluated or measured after edgebanding.

Many factors affect adhesion strength and can be related to both the adhesives and the substrates. The basic requirements for good bonding are as follows: clean surfaces and good wetting-out (spreading) on the adherents by the adhesive; a thin film of adhesive

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correctly positioned on the surfaces; increased pressure before compression stage to increase penetration of the adhesive into porous stock; the thermal coefficients of expansion of the adhesive and adherents should be similar to prevent differential shrinkage on heating or cooling [4]. If these factors are constant, the good bonding will depends mainly on smoothness/roughness of the surface. By this reason, careful machining is essential in preparing substrate surface for edgebanding. For strongest joints, edge surfaces of substrate should be machined smooth with sharp tools, and be essentially free from machine marks, chipped or loosened grain, and other surface irregularities. Preferably, machining should be done just before gluing so that the surfaces are kept clean and are not distorted by moisture changes [1]. The smoothness of the surface will depend largely on the type of surface, and it is difficult to generalize. The more porous the substrate surface, the more adhesive will be required for the binding since, for a given quantity of adhesive applied, the more highly porous surfaces will absorb more, which will therefore not be available for bonding.

Wood-based panels for furniture are formatted by sliding table saws or beamsaws and then transported to the edgebander or edge processing line. Surfaces cut by circular saws are usually rougher than those processed by machines equipped with cutter heads [6]. Consequently, if inconspicuous glue joints of maximum strength are required, planed or jointed surfaces are generally more reliable.

Edgebanding machines with pre-milling stations (aka “joint trimming”) have been growing steadily in popularity over the past several years [5]. The advantages of the above mentioned processing are enormous when used in cases with higher possibility for storage and transport edge damages so thus to eliminate those damages. This technology consists of two counter-rotational (to prevent blowout) cutterheads. Pre-milling station usually consist of two spindles, which are preferably equipped with diamond-cutting tools. The first spindle moves the workpiece towards the opposite direction. This spindle mills only a small piece of the workpiece edge and moves away from it, to avoid an avulsion at the end of the workpiece edge. The second spindle rotates to the workpiece in the same direction and cuts the edge planar to the end. The pre-milling station can provide a clean, straight, razor-sharp edge to the panel, prior to glue and edgeband application. Generally this ensures a clean, tight glue joint, without chips in the panel surface, but there is no information on comparison of edgebanding adhesion strength with or without using “trimming” operation. In this relation, the purpose of the current study was to determine the influence of the mechanical processing of workpiece edges (cutting, milling) on the adhesion strength of used glue adhesive via through feed edgebanding with ABS edges.

For the fulfillment of the above purpose the edge surfaces of particleboards samples have been machined as follows: surfaces cut by circular saw on sliding table saw; surfaces milled by straight cutterhead on spindle moulder; surfaces milled by two counter-rotational cutterheads on edgebanding machines with pre-milling station. After that they are edgebanded (ABS edging) and the adhesion strength of the glue adhesive is defined by peel-off test.

EXPERIMENTAL SECTION

Materials

The particleboard panels (by “Egger” - Austria) with dimensions of 2800/ 2070/18 mm and ABS edge banding materials (by “Hranipex” –Czech Republic) with a width of 22 mm & two different thickness sizes (0,8 and 2 mm) have been used in this study. For edgebanding we used a hotmelt adhesive system (Technomelt Dorus KS 351 by “Henkel”)

based on ethylene vinyl acetate (EVA). The glue system has a melting point approximately 110 °C and a viscosity of 75 000 mPa s/200°C. The operating temperature, recommended by the manufacturer is between 180° C to 200° C.

Preparation of the samples

A total of 48 samples (50/70/18 mm) have been used in this study. The edge surfaces of the samples have been processed as follows:

- 16 samples have been machined (edge surfaced) with circular saw blade and scoring blade on sliding table saw ''ASTRA SE 300 NT'' – Italy at 5 m/min feeding speed. The main parameters of used circular saw blade are: diameter (D) - 300 mm; numbers of teeth (z) - 72 flat/trapeze shaped; Revolutions per minute (rpm) - 4000. The main parameters of used scoring saw blades are: diameter (D) - 100 mm; 12+12 numbers of teeth (flat shaped); rpm - 8000.
- 16 samples have been machined (edge surfaced) with planning cuterhead ''CMT'' – Italy on vertical spindle moulder with sliding table ''MX5118B''– China at 5 m/min feeding speed. The main parameters of used cuterhead are: diameter (D) - 140 mm; numbers of teeth (z) -2; rpm - 6000.
- 16 samples have been machined (edge surfaced) with pre-milling station with two cutter heads (diamond-cutting tools) on edgebanding machine ''BRANDT Optimat KDF 430 C'' - Germany at 5 m/min feeding speed. The main parameters of used diamond-cutting tools are: diameter – 100 mm; numbers of teeth -2x4; rpm - 15 000.

The specimen details were laminated via through feed at an edgebanding machine ''BRANDT Optimat KDF 430 C''- Germany. The operating system of the machine regulates the main technological factors as follows: the glue temperature (190 °C), the feeding speed (11 m/min), quantity of glue (300 g/m^2) and force of metal rollers (862 N). The samples with edge temperature at approximately 25°C and 10% moisture content enter then the edgebanding area. Hotmelt glue is applied onto panel edge surface a few seconds before ABS edge material is bound on it. Control system provides the accurate glue line. As the substrate passes through the edgebanding area, many metal rollers pressure it. After that trimming stations remove any ABS edge overhang.

Test method

The adhesion strength is the bond between overlay and substrate, which can be the weakest link of the system. Various test methods for adhesion property or bonding quality are available. The current study has used a method by which the adhesive compound is applied with a tensile load perpendicularly to the edgebanding surface [3]. Developed by Merdjanov, V., this method is similar to the pull-off test for coating adhesion and it is presented in Figure 1. The tensile forces are spread via T-shape steel body (stamp), attached to the edge material by a cyanoacrylate adhesive. On both sides of the stamp (3) the edge material is interrupted by a cutting in depth equal to the depth of the coating material and the adhesive. Next to the mobile bar (7) of the testing machine ''Heckert – FP 100'' – Germany are attached "U"–shaped clip (6). The fixed part of the machine is embedded with a chain (1), which second end is gripped to the steel body via a nail (2) that passes through the chain and stamp holes. The clip shoulders are gripped to the sample from the side of the cut edgebanding material. The speed at which the adhesive compound is tensile loaded is 20 mm.min^{-1}. The load applied to the sample is increased gradually until the ABS edge is separated (peeled off) from the particleboard. The destruction of the adhesive compound can be adhesive (between the substrate and adhesive layer) or cohesive (within the adhesive layer itself). By the reported destruction force we determine the adhesive strength of the edgebanding compound.

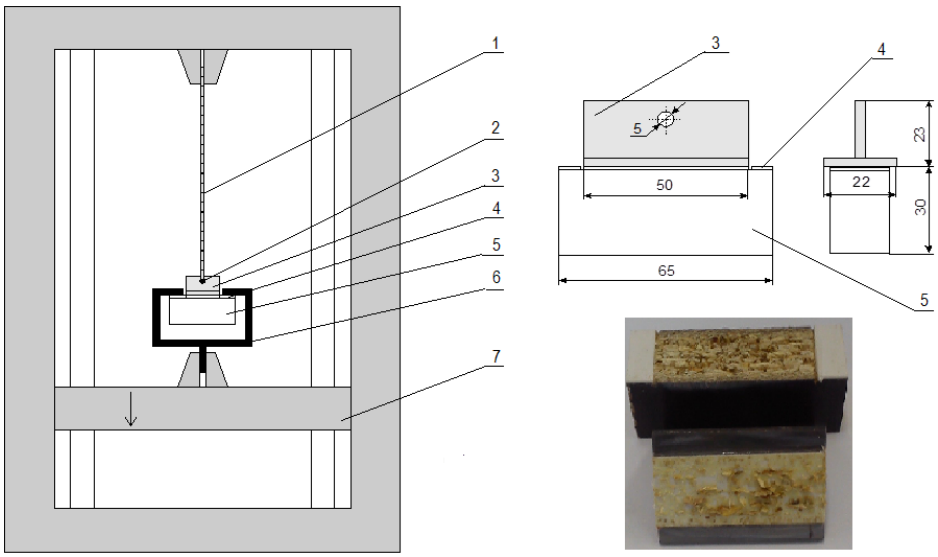

Figure 1 Test method and sample after ABS edge is peeled off (separated) from the particleboard

RESULTS AND DISCUSSION

The statistically processed test data are presented in tables 1 and 2 via the following indicators: average (X), standard deviation (S_x), standard error (m_x), variation coefficient (V_x) and coefficient of accuracy (P).

Table 1 Statistical values and average adhesion strength determined from applied tensile load perpendicularly to the sample edge with 0,8 mm thick ABS edgebanding

mechanical treatment of edges before edgebanding	Aver. N/mm^2	S_x, N/mm^2	m_x, N/mm^2	V_x, %	P_x, %
planning cuterhead	2,16	0,152	0,062	7,044	2,876
two counter-rotational cutterheads	1,96	0,097	0,04	5,162	2,107
circular saw blade	0,92	0,068	0,028	9,471	3,866

The reported result is that the outward appearance of the edgebanding compounds with milling surfaces is better that those of the ones processed with circle saws. On the surface and edges of the first ones there are no failure traces in the produced furniture details.

Table 2 Statistical values and average adhesion strength determined from applied tensile load perpendicularly to the sample edge with 2 mm thick ABS edgebanding

mechanical treatment of edges before edgebanding	Aver. N/mm^2	S_x, N/mm^2	m_x, N/mm^2	V_x, %	P_x, %
planning cuterhead	1,79	0,063	0,026	3,500	1,429
two counter-rotational cutterheads	1,71	0,060	0,025	3,389	1,384
circular saw blade	0,7	0,074	0,030	9,725	3,97

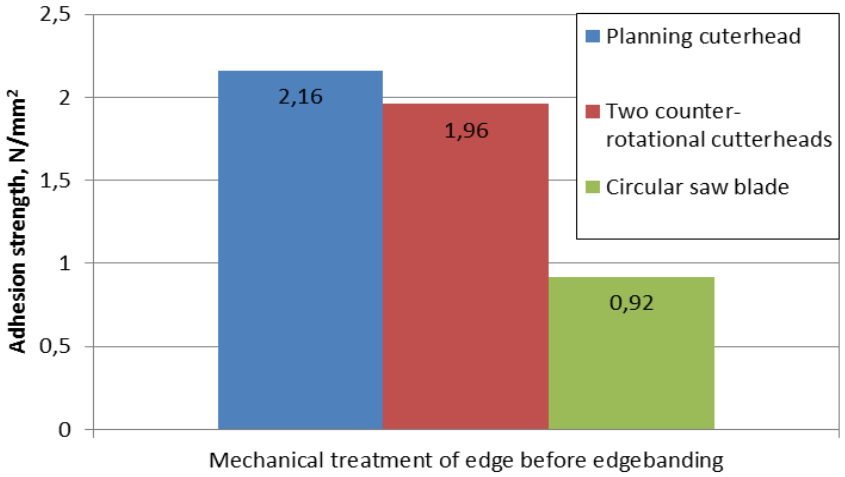

Figure 2 The adhesion strength of glue compound measured at particleboards samples with 0,8 mm thick ABS edgebanding

The measured adhesion strength of adhesive compounds for different mechanical treatments of edges of particleboard before their edgebanding with 0,8 and 2 mm ABS edges are shown in Figures 2 and 3. The adhesive strength of the edge compounds with preliminary milled surfaces is over two times bigger than of those processed with circle saws. The main reason for this is that the surfaces processed by saws are usually rougher than those processed by machines equipped with cutter heads. Besides, the lower adhesive strength of edge compounds on surfaces processed with circle saws is due also to the usage of scoring saw blades for limitation of the breaking off fractions on the laminate surface. Frequently, there are traces from the scoring saw blades on the edge surface of the details, which leads to additional decrease of the flatness and straightness of the edge surface. All of the above can result in unsmooth adhesive layer, considerable decrease of adhesive strength and deteriorated outward product appearance.

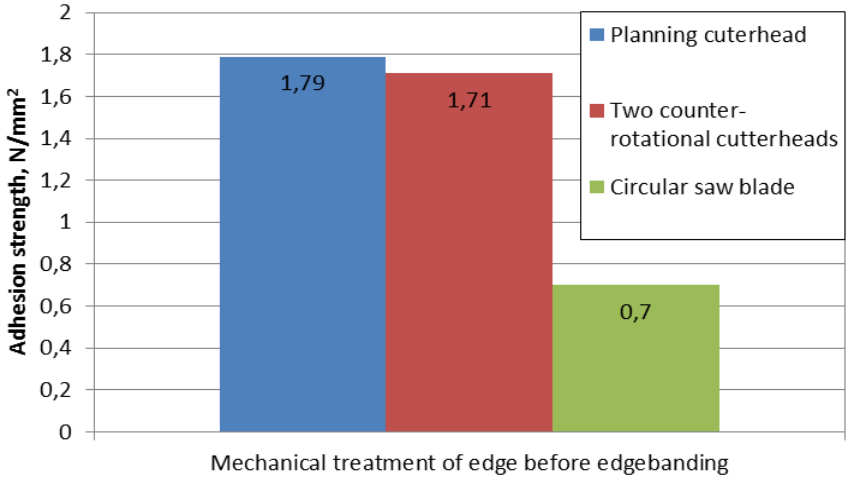

Figure 3 The adhesion strength of glue compound measured at particleboards samples with 2 mm thick ABS edgebanding

The way an edge surface is milled does not influence considerably on the adhesive strength. Nevertheless, the use of two pre-milling stations gives us possibility to work at higher feeding speed and to achieve higher adhesive strength of the edge compounds with perfect appearance.

At edge compounds with thinner ABS edge (0,8 mm) are achieved edge compounds with higher adhesive strength towards the thicker edge (2 mm). This is result of the higher flexibility of the thin edge materials. In addition, the thinner edges have less inside pressures deriving from the way the edge materials are stored in rolls.

CONCLUSIONS

Based on the research, the following conclusions could be made:

- The coating of edge surfaces mechanically processed with milling cutterheads achieves 2-times higher strength of adhesive compounds than the surfaces processed with circular saws. The main reason for this is that the surfaces cut by saws are usually rougher than those processed via machines equipped with cutter heads. In addition, the milled edge surfaces have significantly better smoothness than the surface processed with circular saw and scoring saw blade.
- The edge compounds made with ABS edge material with 0,8 mm thickness are with better adhesive strength than the ones made with 0.2mm edge thickness. This results from the bigger flexibility and the lower inside pressure in the thinner edge materials against the thicker ones.

Acknowledgement:
This work has been supported by the Scientific Sector in the University of Forestry (project No 65 /2014).

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