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Evaluation the effects of edge banding type and thickness on the strength of corner joints in case-type furniture

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ABSTRACT

Edge banding is used to cover the exposed sides of wood materials such as plywood, particleboard or medium-density fiberboard, giving the appearance of a solid (or more valuable) material. This study was carried out to determine the effects of the edge banding material, namely polyvinyl chloride (PVC), melamine and wood veneer, thickness of edge banding material (0.4, 1, and 2 mm), and wood composite panel type on the diagonal compression and tension strength properties of particleboard surfaced with synthetic resin sheet (LamPb) and MDF surfaced with synthetic resin sheet (LamMDF).

The diagonal tension strength was greater than the diagonal compression strength of all L-type corner joints. Samples with edge banding gave higher diagonal tension and compression strength than control samples. LamMDF corner joints were stronger than LamPb corner joints. As for the type of edge banding, melamin type edge banding material gave more diagonal tension and compression strength than others. The lowest tension and compression strength was obtained in PVC edge banding material. There were significant differences in strength in terms of type of edge banding and wood composite panel material. A clear relationship between edge banding thickness and strength could not be determined.

As case furniture constructions are under diagonal tension and compression forces, spline joint using 0.4 mm melamine edge banding can be recommended as the most robust corner joint type for case furniture produced from LamMDF panels.

1. Introduction

Over the past several years, industrial grade particleboard and medium-density fiberboard have been recognized through the furniture industry as an ideal substrate for laminated panel constructions, utilizing various types of overlay surfacing and edge banding materials. Edge banding is perceived as the most important accessory in furniture making. Laminates, wood, polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), acrylic, melamine, wood or wood veneer comprise the types of edge banding materials. The purpose of the edge banding will be to suppress the absorption of water and humidity and providing a contrasting finish for all decorative surfaces.

Interior fitment and furniture manufacturers are using increasing ratios of decorative edge banding materials for wood based panels (particleboard and medium-density fiberboard). Both of these panels are manufactured as uniform, flat panels that provide excellent surfaces for the application of coating materials. These coated panels are used in the construction of cabinets, furniture, paneling, kitchen worktops, and work surfaces in offices, educational establishments, laboratories, and other industrial product applications. The purposes of coating of wood-based materials like particleboard, medium-density fiberboard (MDF) and high density fiberboard (HDF) board surfaces with decorative overlays are to suppress the absorption of water and humidity, and esthetic [1]. The performance of the coated panels is dependent on the quality of wood based panel and the type of the coating material [2]. While particleboard and medium-density fiberboard make ideal substrates, the manufacturer must pay attention to the many factors that will affect surface quality in virtually every step of the manufacturing process [3].

The past years have seen the successful works within the coated panel industry. Akbulut and Dundar [4] reported that lamination on wood-based composite panel increased the abrasion and scratch resistance. In addition, it increased the resistance of wood-based composite panels against heat, light and chemicals. It was also reported that lamination improved wood based panels' mechanical properties. Lee and Kim [5] found that there was a significant increase in the modulus of elasticity of wood based composed panels due to coatings. Nemli [6] examined the effects of melamine-impregnated papers coating on the properties of

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particleboard and stated that surface coating improved the physical, mechanical properties and decreased the formaldehyde emission of particleboard. Also, Nemli et al. [7] reported that lamination increased the resistance against scratch, abrasion and chemicals.

Ozcifci [8] studied some corner joints obtained from particleboard, and covered their edges for case furniture with massive wood. And then, "L" test samples manufactured and jointed with dowel, rebated, tonque-and-rebated joint types by using polyvinyl acetate (Pvac) (Vinyl Acetate Homopolymer) adhesive. In the test, compression and tension strength tests were applied on the bonding area. As a result, the highest compression and tension strength were obtained in dowel joint.

Uysal [9] investigated the effects of the thickness of solid wood edge banding strips and the dowel diameter on the withdrawal strength of beech dowels in particleboard test samples with 5, 8, and 12 mm beech wood edge banding strips bonded with PVAc adhesive and the holes with 25 mm depth were drilled into the edges of the test samples. Withdrawal strengths were measured for the prepared test samples and the highest withdrawal strength was obtained in particleboards with12 mm edge banding thickness and with 6 mm diameter dowel. The aim of later study [10] was to determine the withdrawal strengths of 6, 8, and 10 mm diameter beech dowels embedded into matching holes drilled into the edges of medium-density fiberboard (MDF) and particleboard (PB) with solid wood edge banding of white oak with 5, 10, and 15 mm thickness, bonded with hot-melt, PVAc and Desmodur-VTKA (D-VTKA). The effects of edge banding thickness, dowel dimension, type of composite material and type of adhesive used for edge banding on the withdrawal strength were determined. Should the dowels be subjected to withdrawal, it is advised that a beech dowel should be used for MDF with solid oak edge banding with 10 mm thickness bonded with a hot-melt adhesive in furniture production and decoration applications.

Several investigations have been made on corner joints that have yielded valuable design information for case type of furniture. Joints are generally the weakest part of a piece of furniture and they are the primary cause of failure [11]. The strength and the stiffness of joints used in furniture construction would normally determine the furniture's strength and rigidity [12]. Eckelman and Munz [13] have stated that most of joints used in furniture construction are in fact semirigid because under a bending load the joint rotates slightly. Ganowicz and Kwiatkowski [14], Lin [15] and Tankut [16] investigated the effects of various types of joints with varying degrees of rigidity on case stiffness. It is stated that joint strength was strongly influenced by the type of particleboard used [17]. Similarly, Wang [18] found that bending strength of corner joints constructed with particleboard was strongly related to board density. It was determined that the stiffness of corner joints is increased with the use of greater numbers of fasteners [19,20]. Tankut [21] presented results of evaluating dowel spacing effect on bending moment capacity of L-type corner joints in 32 mm case construction.

Edge break out strength, accordingly, appears to be an important material property of composites used in the construction of cases. Research carried out by several researches indicates that when cases constructed of composites are subjected to racing forces, material in the joints fail in one of two ways – either the end of one member splits or a section of the edge of the adjoining member essentially "breaks out" of the wall of the case [22–24]. The work of Rajak and Eckelman [23] showed that in effect there is a relatively close balance between wall breaking strength and end splitting strength. The variability in edge breaking strength obtained for various boards included in one study indicate that there is a need for a test to evaluate this property of composites. Significant differences in strength exist from board to board, and further tests are justified in order to develop a method to determine which boards have properties best suited for use in furniture [25].

This study was performed (1) to evaluate the effects of the edge banding material, namely PVC, melamine and wood veneer, and thickness of edge banding material (0.4, 1, and 2 mm) on the strength of the furniture corner joints, (2) to determine the effects of wood composite panel type, namely, LamPb (particleboard surfaced with synthetic resin sheet) and LamMDF (MDF surfaced with synthetic resin sheet) on the strength of L-type furniture corner joints.

2. Materials and methods

2.1. Materials

2.1.1. Wood composite materials

Eighteen millimeter thick LamPb and LamMDF were selected for this study because of their common use by the Turkish cabinet manufacturers. In preparing specimens, 188 by 366 cm full-sized board sheets were first cut into face and butt member strips. These strips were subsequently cut into the desired member lengths. Members for joints were randomly selected from this common supply. LamMDF board produced according to TS EN 622-3 standard [26] was purchased from a local merchant. A particleboard produced according to TS EN 312-1 [27].

2.1.2. Adhesives

Desmodur-VTKA is a polyurethane-based one-component, solvent-free adhesive which is widely used for the assembly process in the furniture industry. Its viscosity was 14 ± 3 Pa s at 25 °C; density 1.11 ± 0.02 g/cm^3. Its application is especially recommended in locations subjected to high level humidity. D-VTKA adhesive was supplied Wurth. It is utilized because of its useful properties such as cold application, easy spreading, rapid drying, being scentless and fireproof, and being preferred in the production of the furniture products [28].

Hot-melt adhesive used in this study is a thermoplastic-based synthetic resin. Its application is recommended in locations subjected to 8–10% relative humidity. Hot-melt adhesives are environmentally friendly glues containing no solvents. They find key applications in the manufacture of office and home furniture, particularly in the edges of melamine, polyester and wood materials for table and kitchen worktops. They are solid at normal ambient temperatures and need to be heated to a liquid state before application. They must remain sufficiently fluid to wet out the two surfaces during bonding. As the adhesive cools, it will revert to its solid state, completing the bond. With hot-melt adhesives, the change from solid to liquid is reversible, and controlled by temperature. In one respect this is an advantage—it enables a surface to be pre-coated with adhesive, and later reactivated by heat before bonding. It can be used in cold temperatures and solidified quickly. Its application is very easy and does not damage the tools during the cutting process [29].

Although some people still have concerns about their limited high temperature resistance, The Furniture Industry Research Association (FIRA's) experience is that edge bond failures are invariably due to a breakdown in adhesion between adhesive and edging rather than due to the adhesive softening and rupturing. Adhesive failures, therefore, are generally the result of using poor edge banding procedures during manufacture rather than the adhesive having an unreasonably low softening temperature [29].