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Effects of cutting directions on the bonding strength in some wood types

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HIGHLIGHTS

- The highest bonding strength was found in beech.
- The highest bonding strength was obtained in Di-TR.
- K_{303} adhesive performance was obtained better than K_{305} adhesive.

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ABSTRACT

The aim of this study was to investigate the cutting direction in some wood types used in wood products industry on the bonding strength of wood-to-wood joint. The samples with different cutting directions prepared from the woods of Oriental beech (*Fagus orientalis* Lipsky), European oak (*Quercus petraea* (Mattu.) Liebl.), Scotch pine (*Pinus sylvestris* Lipsky) and Toros cedar (*Cedrus libani* A. Rich) have been glued with the Klebit–303 (K_{303}) and Kleiberit–305 (K_{305}) in diagonally tangential-radial (Di-TR), diagonally tangential-tangential (Di-TT), plain grain-grain (P-GG) joints of I-Type examples (by axial tension test) and diagonal miter joint (Di-MJ), diagonally tangential-grain (Di-TG), diagonal radial-grain (Di-RG) joints of L-Type examples (by diagonal tensile test) have been performed according to ISO 6237 standard. The results showed that the highest bonding strength was found to be 16.60 N/mm^2 in Oriental beech with the K_{303} in Di-TR and the lowest to be 2.227 N/mm^2 in Toros cedar with the K_{305} in P-GG by axial tension test, and the highest value was 10.98 N/mm^2 in Oriental beech with the K_{303} in P-RG the lowest value was 3.197 N/mm^2 in Scotch pine with the K_{305} in Di-MJ by diagonal tensile test. Thus, applying the Di-TR and Di-RG cutting order with the glue K_{303} for bonding massive wood pieces without using auxiliary bonding elements (tenon, rabbet, dowel, dovetail etc.) may offer advantages over others.

1. Introduction

The introduction of synthetic resins has led to technical and structural changes in the wood products industry. For example, synthetic resin-based glues replaced mechanical bonding (nails, screws, etc.) in the production of massive sheets (panel type). Synthetic resin-based glues with different characteristics which can be used in workshops, which come in hot or cold forms suitable for mass production and which can be used in damp environments are available. Research has been continuing to determine the optimal usage principles and the most suitable usage areas of glues in order to prevent quality and material loss in the furniture industry. Having been bonded with Desmodur-VTKA glue, Scots pine wood (*Pinus sylvestris* Lipsky) impregnated according to Tanalit CBC filled cell method was subjected to bonding strength test. A decrease in the bonding strength of the glues in the impregnated samples has been reported [1].

Wood products are mostly constructed by combining a few pieces of wood and the pieces are held together by various joining techniques [2]. Adhesive bonding is a joining technique that enables to hold together such a few pieces of wooden materials. This is an important advantage of adhesive bonding [3,4]. It is possible to say that adhesives play an important role in the production of a lot of wood products, such as furniture and furnishings, musical instruments and construction materials. Furthermore, adhesives are widely used as binders in the production of wood-based composite products, such as fiberboard, particleboard and plywood [2]. It can be said that adhesives are among the main inputs of wood products industry and account for a substantial part of manufacturing costs [5].

The samples from Oriental beech, Scotchpine and European oak woods prepared by using Desmodur-VTKA glue were subjected to

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bonding strength after the processes of climatization, holding in cold and hot water, boiling and alternating boiling. Results showed that they can be used in dry or damp internal and external settings [6]. Plain, rabbeted and 45° angled edge joints have been done on 19 mm thick particleboards by using UF (Urea–formaldehyde) and PVAc (polyvinylacetate) glues. The bonding strength values measured at the bonding points were the highest for the one done with UV glue and rabbeted edge joint (16.1 N/mm^2), average for the 45° angled edge joint (12.2 N/mm^2), and the lowest for the plain edge joints (10.6 N/mm^2) [7]. Bondings of wood material, particleboard with unadulterated phenol resin that hardens when cold and the phenol resin modified with glass, wood, crust, porcelain flour, cellulose and their bonding strengths were tested. It has been reported that bonding strength of the modified phenol resin decreased compared with that of the unadulterated phenol resin [8].

The woods from Oriental beech, European oak, Scots pine and Toros cedar were glued with Desmodur-VTKA glue and particleboards and fibreboards with massive edges and non massive edges were glued with PVAc glue and their bonding strengths were measured. The highest bonding strength in Oriental beech was obtained as (4.403 N/mm^2) in the widthwise direction and as (5.818 N/mm^2) in fibreboards with massive edge [9]. The highest bonding strength in the woods from Oriental beech, Scotch pine, and European oak which were glued with K_{303}, K_{305} and Superlackleim 308 was obtained in Oriental beech glued with K_{303} as (8.9 N/mm^2) [10]. Among the beech, pine, oak woods that have been processed with such general purpose woodworking machines as planing, band sawing and circular sawing machines and glued with PVAc, the highest bonding strength was observed on beech wood in tangential and radial cutting direction processed with circular sawing machine [11].

Pine wood at the smooth surface, in the radial cutting direction is obtained by four leaf cutter blades [12].

The aim of the study is to find out best bonding in wood material. Bonding strengths in the different cutting directions of Oriental beech, European oak, Scotch pine and Toros cedar wood bonded with commonly used glues in the industry Klebit–303 (K_{303}) and Kleiberit–305 (K_{305}) and with no other auxiliary elements have been compared in this study.

2. Materials and methods

2.1. Materials

Experimental materials are choosen from the wood commonly used for the production of massive and box-type furniture. Scotch pine (*Pinus sylvestris* Lipsky), Toros cedar (*Cedrus libani* A. Rich), Oriental beech (*Fagus orientalis* Lipsky) and European oak (*Quercus petraea* (Mattu.) Liebl.) have been randomly selected and obtained in Turkey in accordance with the principles specified in TS 2470 [13]. The fact that the fibres are regular and the timbers are knotless has been taken into consideration when wooden materials are selected.

The adhesives used in the experiment are the glues with one component, which emerged in the market in recent years and used mostly in assemblies and which do not contain solvents.

Klebit 303 (K_{303}) adhesive can be used hot or cold in woodwork, wooden screens, multi-layered solid wood, slip joints. The producing company informs that its density is 1.10–1.13 g/cm^3, its pH is around 3, viscosity 13.000 ± 2.000 mPa and it hardens under 65% relative moisture and 20 °C temperature conditions in 24 h. It is recommended that the pieces of wood to be glued should be dry, cleared of dust and oil and an average amount of 120–200 g/m^2 glue should be put on surfaces to be glued and the waiting period should be between 6 and 10 min [14].

Kleiberit 305 (K_{305}) is a glue that can be used hot or cold and whose pressing time is short. It is reported that it can be used for assemblies, gluing furniture frames, multi-layered sheets, pressing with high frequency, middle layer plywood pressing, gluing sheathing edges, hard and soft woodwork. This PVAc-based glue's density is 1.20 g/cm^3, pH is around 3 and viscosity 13.000 ± 2.000 mPa at 20 °C and it hardens under 65% relative moisture and 20 °C temperature conditions in 6–10 min. It is elastic and moisture resistant and can be applied with hand tools. It is recommended that the pieces of wood to be glued should be dry, cleared of dust and oil and both surfaces should be applied a glue amount of 150–200 g/m^2 and an open period of 10 min. Storage time in a closed container at 20 °C is 1 year the waiting period should be between 6 and 10 min [15].

2.2. Experimental design

The samples prepared in tangential and radial cutting directions and in rough dimensions of (30 × 30 × 220 mm) were kept in climatization chamber under relative moisture conditions of 65% and a temperature of 20 ± 2 °C until a balance of moisture was achieved. Thus, initial differences of moisture was eliminated and an average moisture of 8% was maintained. Then, a total number of 480 samples were prepared; in dimensions of 20 × 20 × 220 mm and in tangential, radial cutting directions and in compliance with TS 5430 EN 204 [16] and TS 2470 [13] principles, 2 glue types, 10 pieces with dimensions of (4 × 2 × 6) for each type of 6 l type and L type joint. After the surfaces were glued, bondings were realized with a cold pressing pressure of 0.2 N/mm^2 and a pressing period of 60 min. L-Type examples are shown in Fig. 1 and I-type in Fig. 2. The prepared samples had been kept for a month in an environment in which the temperature was 20 °C and the relative moisture 65% and their moisture was determined in compliance with TS 2471 [17].

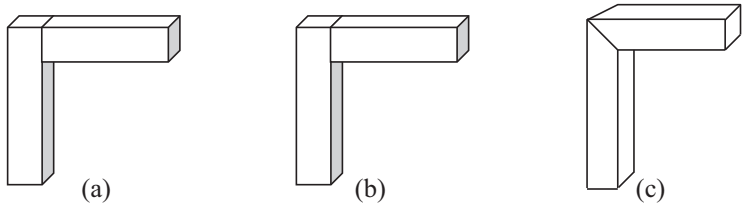

Fig. 1. L-Type examples (by diagonal tensile test).

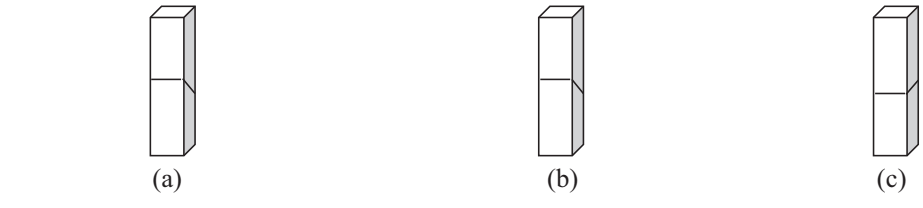

Fig. 2. I-Type examples (by axial tension test).